AI for Bioacoustics

Automated Detection & Classification

Neural network assisted pipelines for real-time alert systems, long term surveys, vocal sequence model

Chaire IA ADSIL DGA AID ANR,

ANR SYLVANIA, ANR ULPCOCHLEA, BIODIVERSA EUROPAM…

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« ADSIL : »
ADvanced underSea Intelligent Listening

https://bioacoustics.lis-lab.fr/

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Date de fin : dec 2024

Porteur : Hervé Glotin

Passive Acoustic Monitoring (PAM) ?

- Acoustics matter to cetaceans
  - echolocation, socialisation, songs
- Passive acoustic antennas
  - buoy, bottom mounted, towed arrays …
- Presence monitoring
  - population density, temporal / spatial trends
- Vocal sequence modelling
  - dialectic / cultural behaviors
- **Conservation management**


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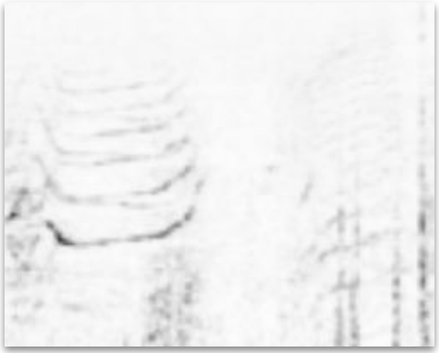
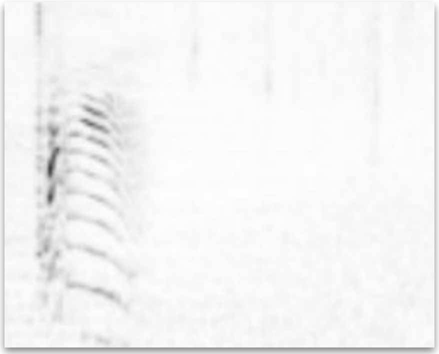
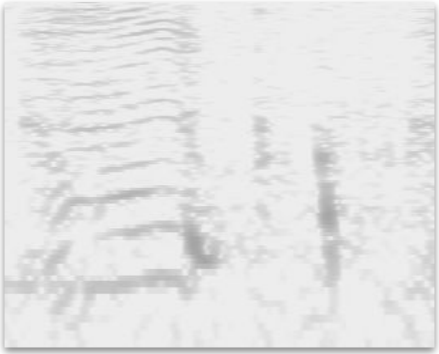
Introduction

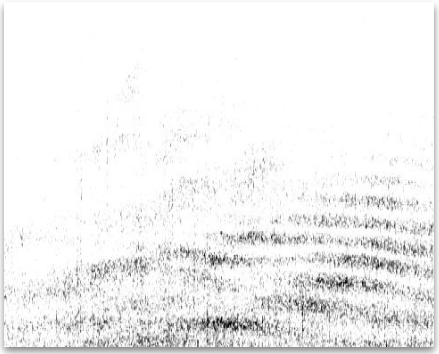
Metrics see ANNEX

Signal diversity



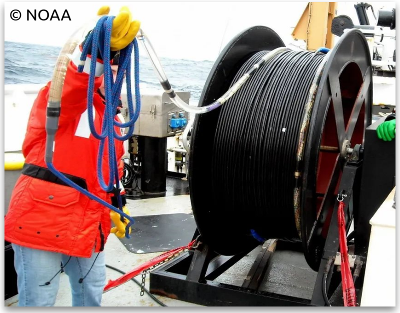


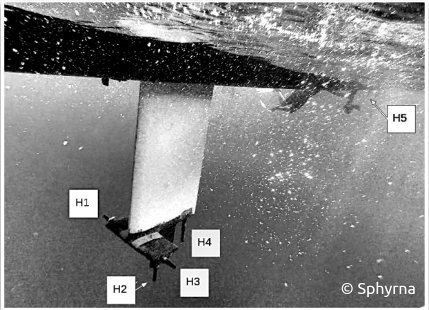


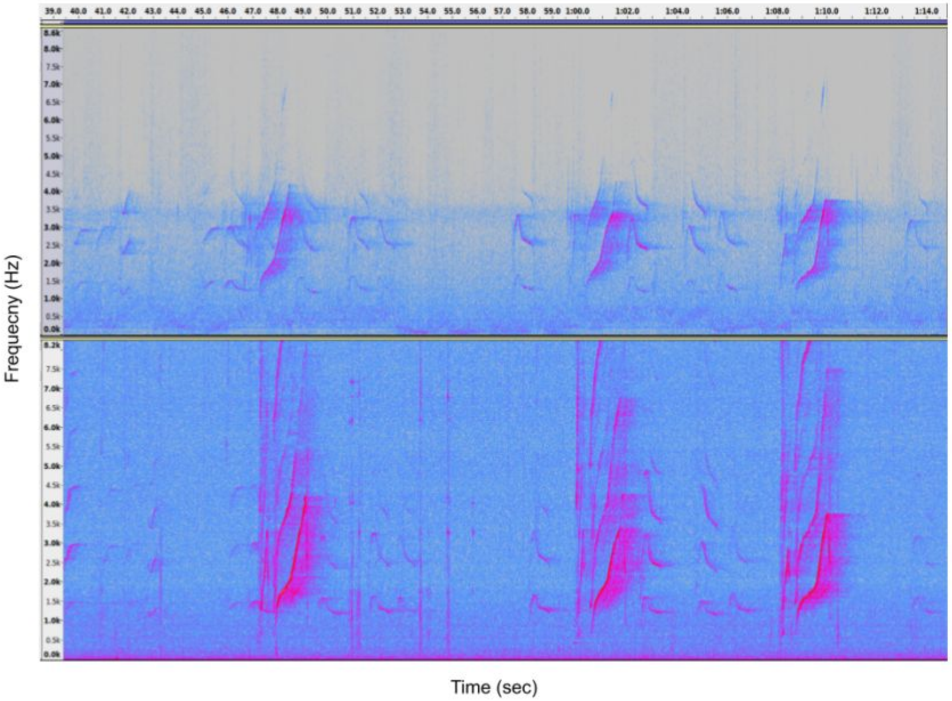


Need for robust detection mechanisms

Source diversity







Best, Paul, et al. "Deep learning and domain transfer for orca vocalization detection." 2020 International Joint Conference on Neural Networks (IJCNN). IEEE, 2020.

PART 2) CNNs for PAM

Mathematical formulation

- Signal s
- Vocalisation v
- Propagation p
- Noise n
- Recorder r
- Detector g
- Frontend f

$$s(t) = r(p \circ v(t) + n(t))$$

$$g(s(t)) = \begin{cases} 1 \; if \;\; v > SNR_{min} \\ 0 \; if \;\; v < SNR_{min} \end{cases}$$

$$g(s(t)) = g_k \circ g_{k-1} \circ \ldots \circ g_1 \circ f \circ s(t)$$

CNNs for PAM

Mathematical formulation

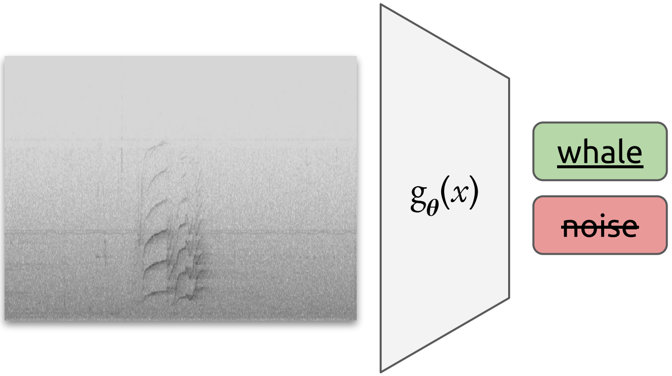
$$s(t) = r(p \circ v(t) + n(t))$$

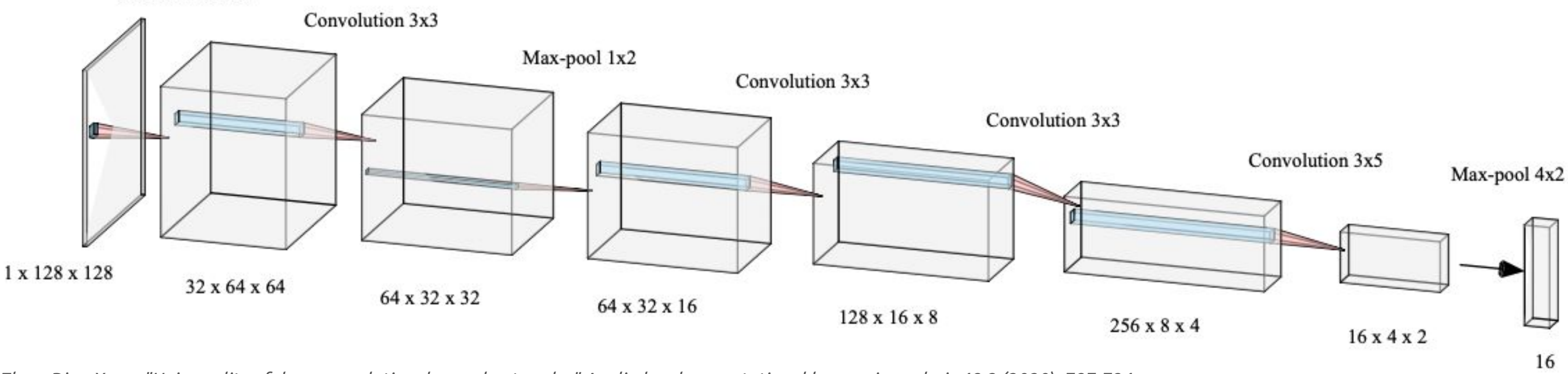
$$g(s(t)) = g_k \circ g_{k-1} \circ \dots \circ g_1 \circ f \circ s(t)$$

- Set the frontend and architecture (f, k, g_i) that suits the application
- Optimise g to be resilient to noises, recorders and propagation r, p and n

Convolutional Neural networks (CNN) ?

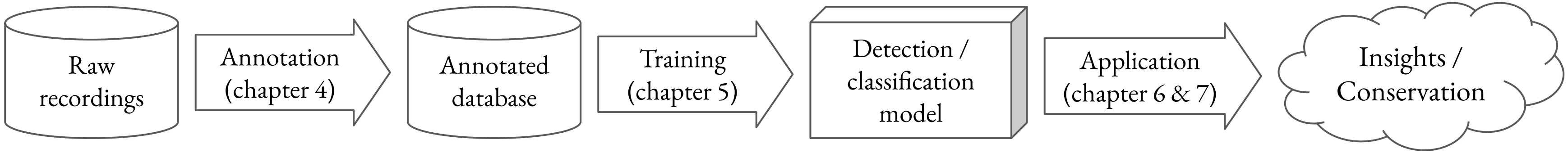
- Theoretically universal approximators *(Zhou 2020)*
- Optimises parameters for a given task
- Convolution allows for temporal invariance
- Greedy in data and computational power





Zhou, Ding-Xuan. "Universality of deep convolutional neural networks." Applied and computational harmonic analysis 48.2 (2020): 787-794.

From raw recordings to biological applications



Sperm whale clicks

- Annotation interface
- Complexity reduction
- Real time alert system

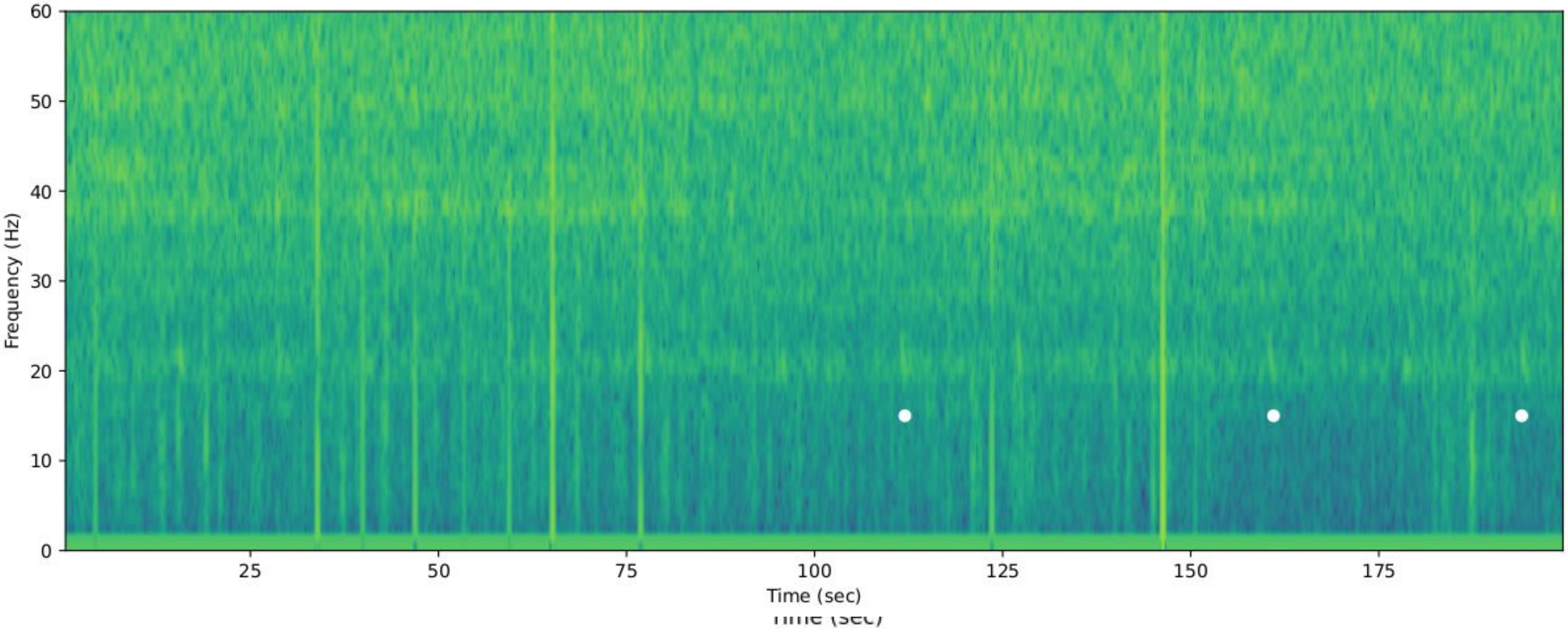
Fin whale 20Hz pulses

- Iterative annotation
- Song structure
- Temporal trends

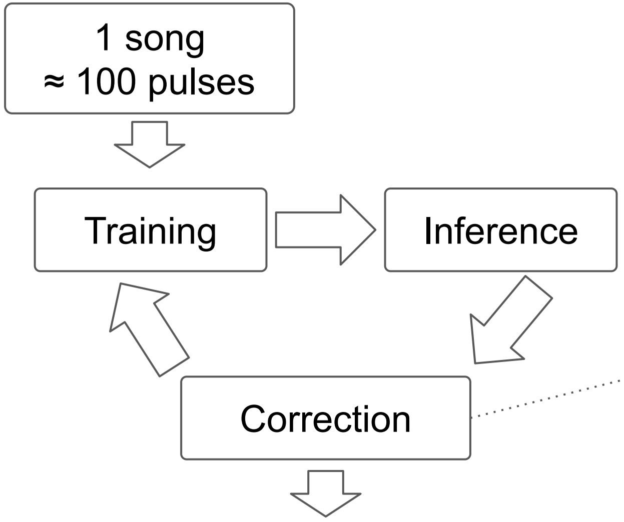
Orca pulsed calls

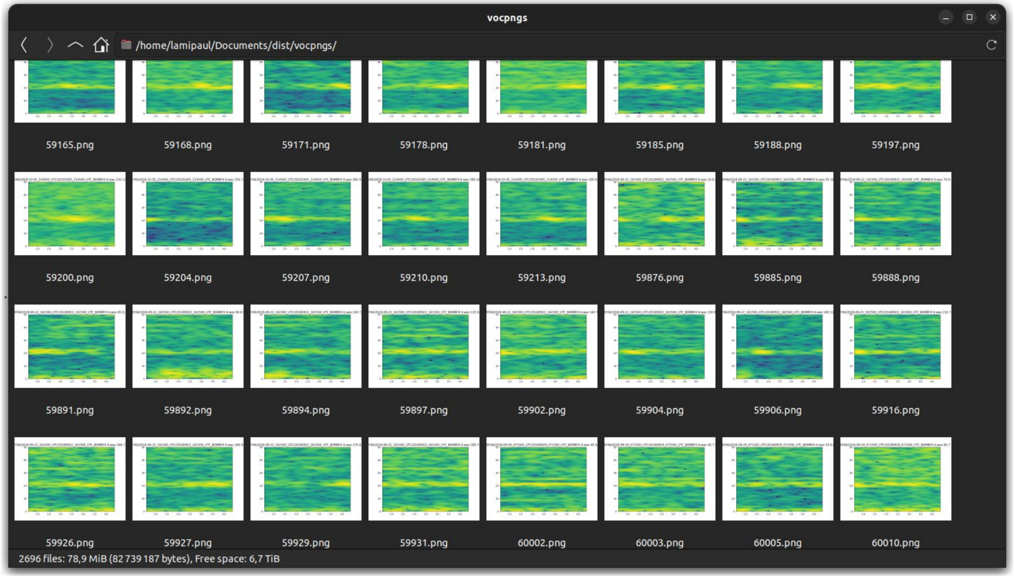
- Call type annotation
- Classif. with few labels
- Vocal sequence modelling

Fin whale 20Hz pulses



Iterative annotation





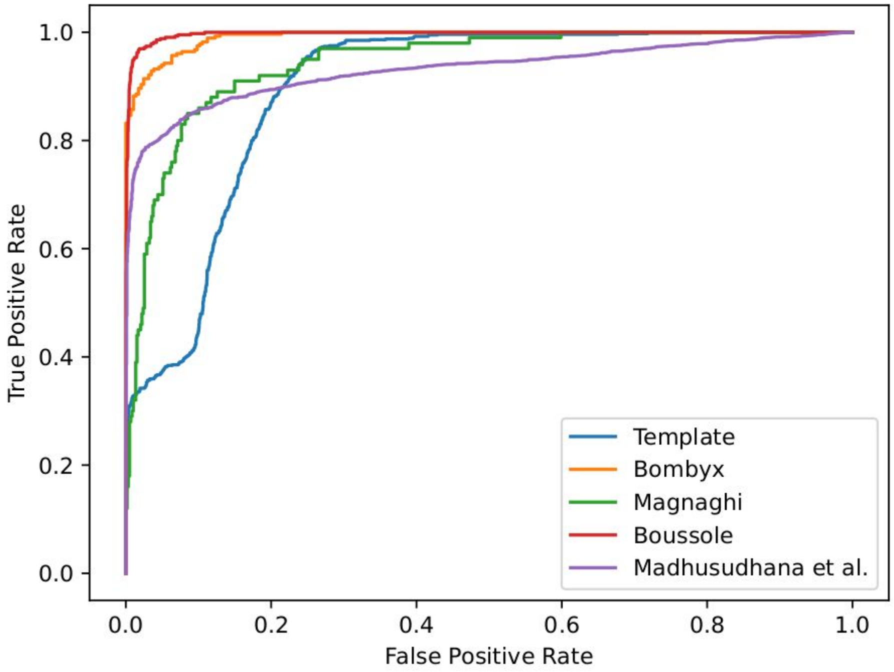
Data Source	Positives	Negatives	Total
1999	15%	85%	688
2008-2009	9%	91%	4,528
2015-2018	49%	51%	574
Total	14%	86%	5,790

Resulting performances

- Template matching : 0.90AUC-ROC
- 3-fold cross validation
  - split by data source
- Test on a foreign dataset

Test set AUC-ROC

1999	0.94
2008-2009	1
2015-2018	0.99
Madhusudhana et al. 2021	0.93



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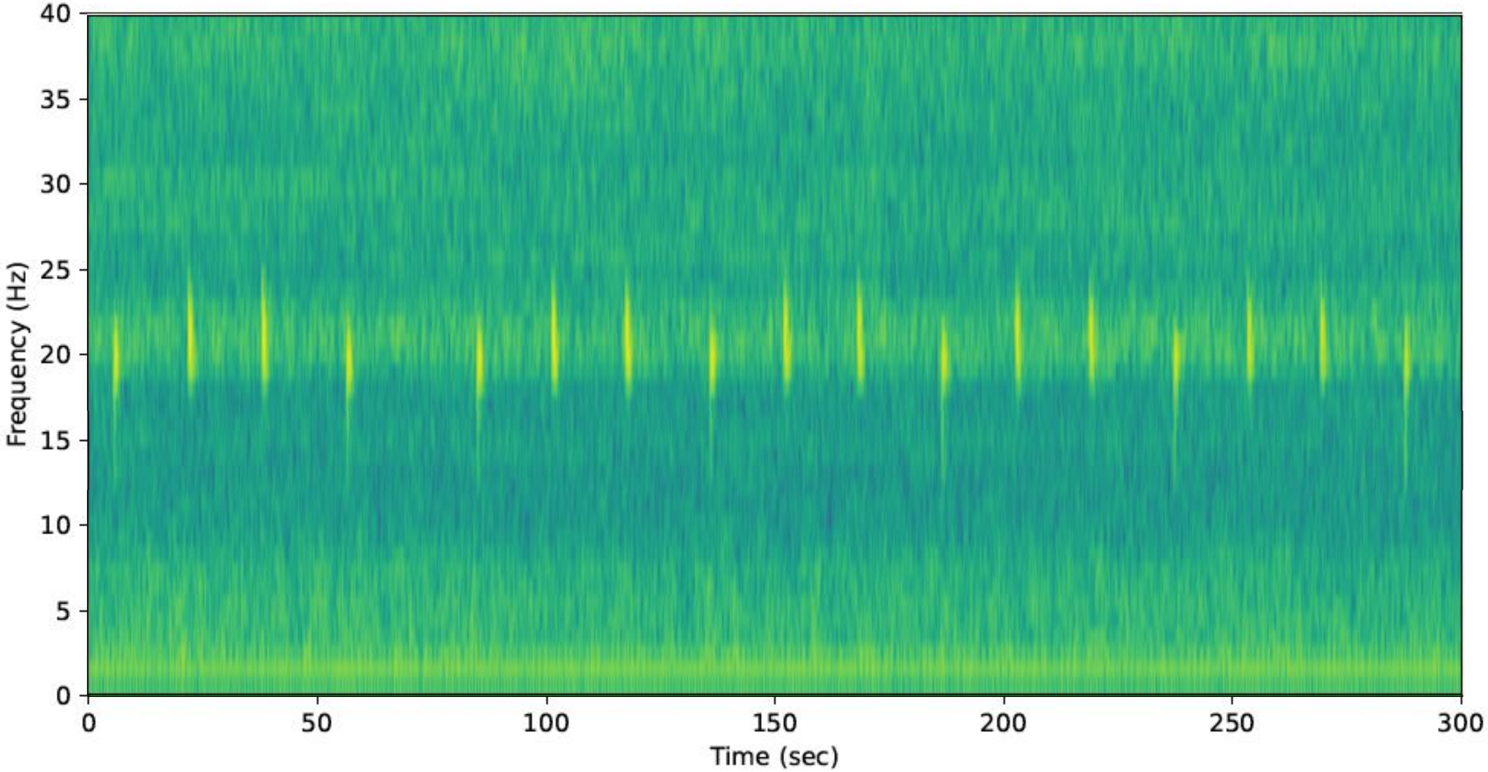
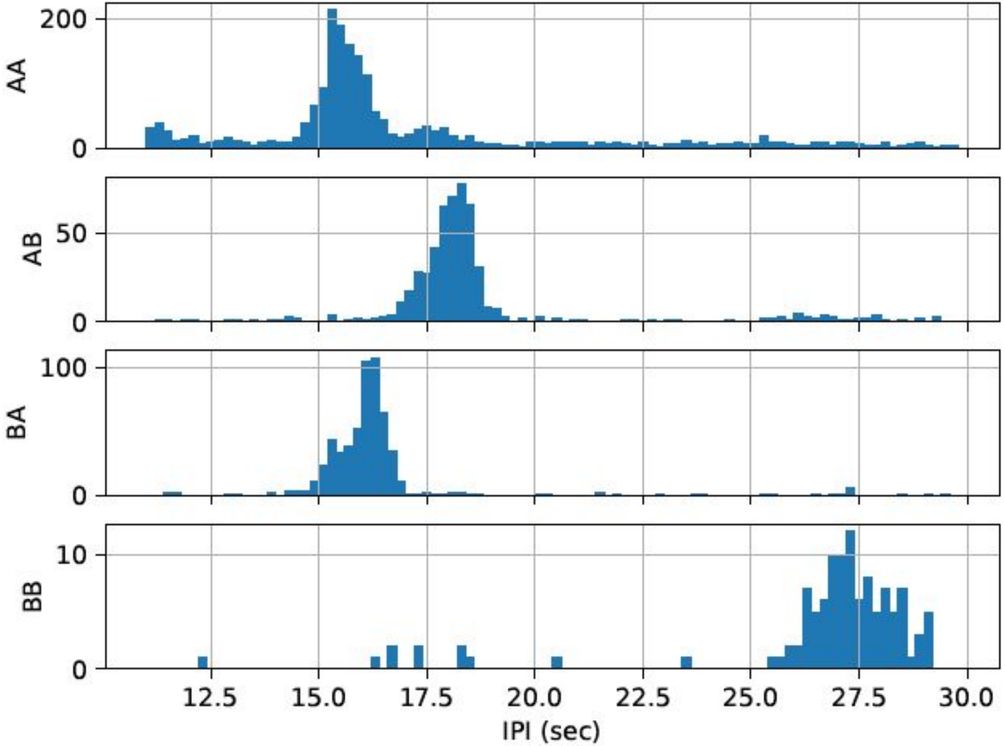
Song structure

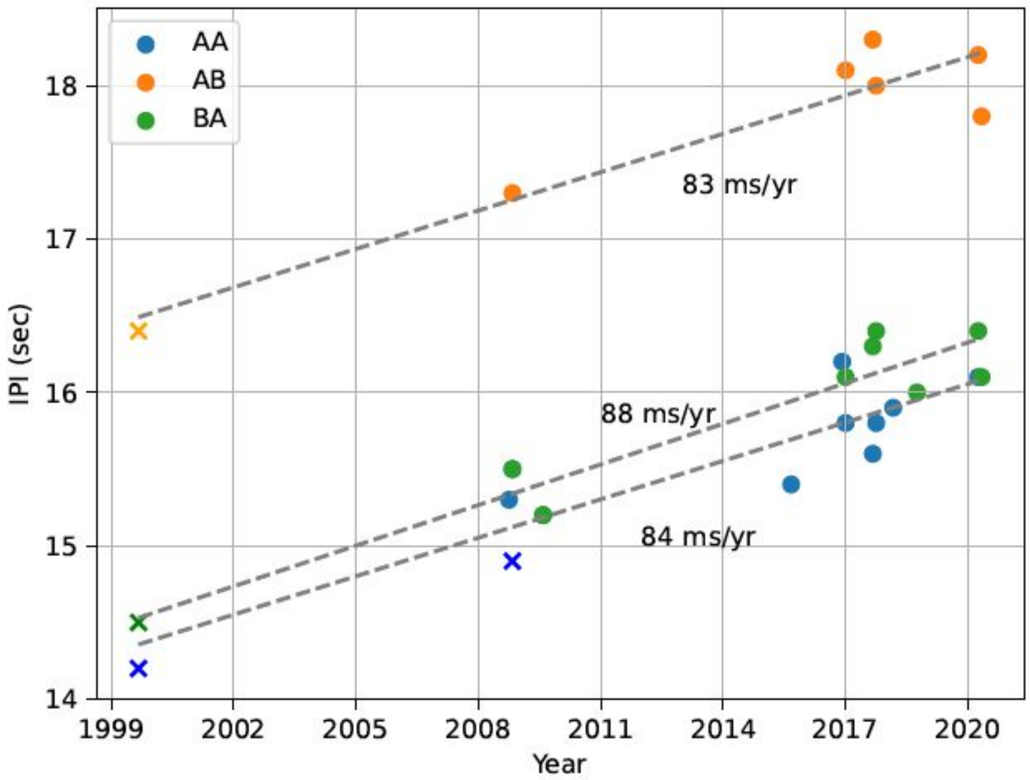


Inter Pulse Intervals (IPI) *(Clark et al. 2002)*



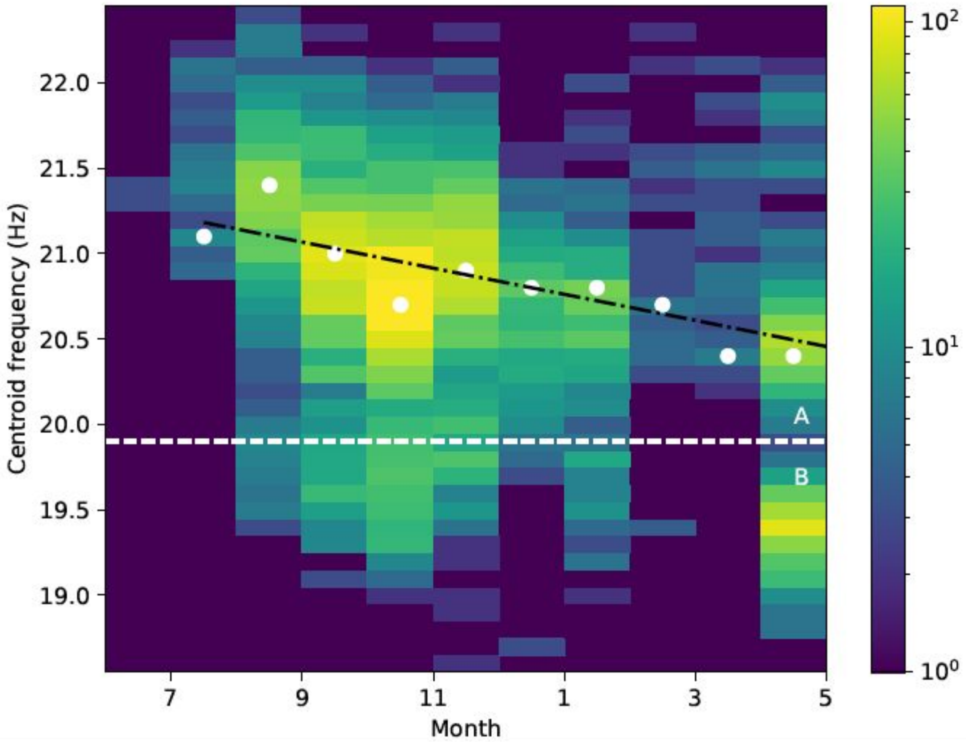
Clark, Christopher W., J. F. Borsani, and G. Notarbartolo-Di-sciara. "Vocal activity of fin whales, Balaenoptera physalus, in the Ligurian Sea." Marine Mammal Science 18.1 (2002): 286-295.

IPI increase over the years



Clark, Christopher W., J. F. Borsani, and G. Notarbartolo-Di-sciara. "Vocal activity of fin whales, Balaenoptera physalus, in the Ligurian Sea." Marine Mammal Science 18.1 (2002): 286-295.
Castellote, M., Clark C., and Lammers M.. "Fin whale (Balaenoptera physalus) population identity in the western Mediterranean Sea." Marine Mammal Science 28.2 (2012): 325-344.

Center frequencies decrease seasonnaly



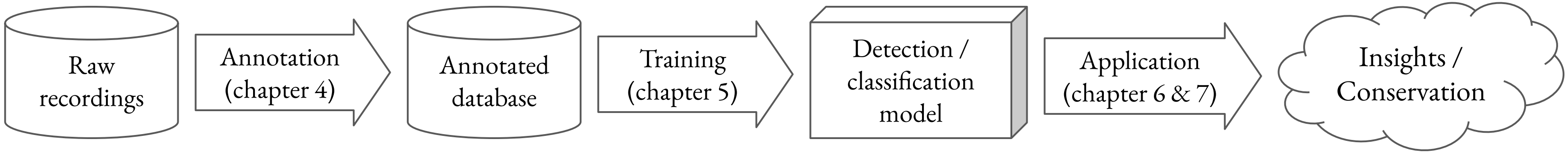
Best, P., Marxer, R., Paris, S., & Glotin, H. (2022). Temporal evolution of the Mediterranean fin whale song. Scientific reports, 12(1), 1-12.

Other fin whale song studies

		Inter-annual		Intra-annual	
Study	**Location**	**Frequency**	**IPI**	**Frequency**	**IPI**
Weirathmueller et al. [218]	N.E. Pacific	-0.17 Hz/yr	0.5-0.9 sec/yr	-	-
Oleson et al. [146]	N. Pacific	-	-	-	+7.5 sec
Leroy et al. [119]	Indian	-0.21 Hz/yr	-	~ -0.1 Hz/mth	-
Helble et al. [90]	N. Pacific	-	0.6-1.3 sec/yr	-	-
Morano et al. [138]	N.W. Atlantic	-	* 0.5 sec/yr	-	+5.5 sec
Watkins et al. [215]	N.W. Atlantic	-	-	-	+6 sec
Širović et al. [191]	Gulf of California	-	~ 1 sec/yr	-	~ +8 sec
Furumaki et al. [71]	Chukchi sea	-	~ 0.5 sec/yr	-	~ +1 sec
Wood and Širović [220]	W. Antarctic	-0.2 Hz/yr	0.1 sec/yr	-	-
self	W. Mediterranean	-	0.1 sec/yr	-0.1 Hz/mth	-

Best, P., Marxer, R., Paris, S., & Glotin, H. (2022). Temporal evolution of the Mediterranean fin whale song. Scientific reports, 12(1), 1-12.
Davenport, Andrew M., et al. "Pygmy Blue Whale Diving Behaviour Reflects Song Structure." Journal of Marine Science and Engineering 10.9 (2022): 1227.

From raw recordings to biological applications



Sperm whale clicks 1

- Annotation interface
- Complexity reduction
- Real time alert system

Fin whale 20Hz pulses 2

- Iterative annotation
- Song structure
- Temporal trends

Orca pulsed calls 3

- Call type annotation
- Classif. with few labels
- Vocal sequence modelling

Introduction

- Orca *(Orcinus Orca)* top predator of the marine food chain.
- The Northern resident killer whale community [1]
- Pods dialect: repertoire of 7-17 discrete calls.
- How describe the orca communication?
- Automatically detect orca calls emitted throughout 3 years of continuous recording from 2015 to 2017
- Influence of environmental data on orca vocalization ?

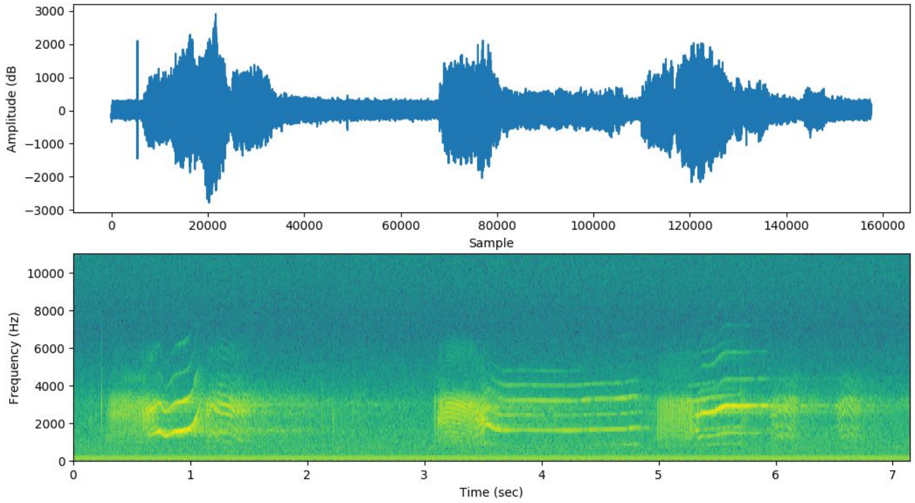


Fig 1: 7 seconds of vocalizations

Material

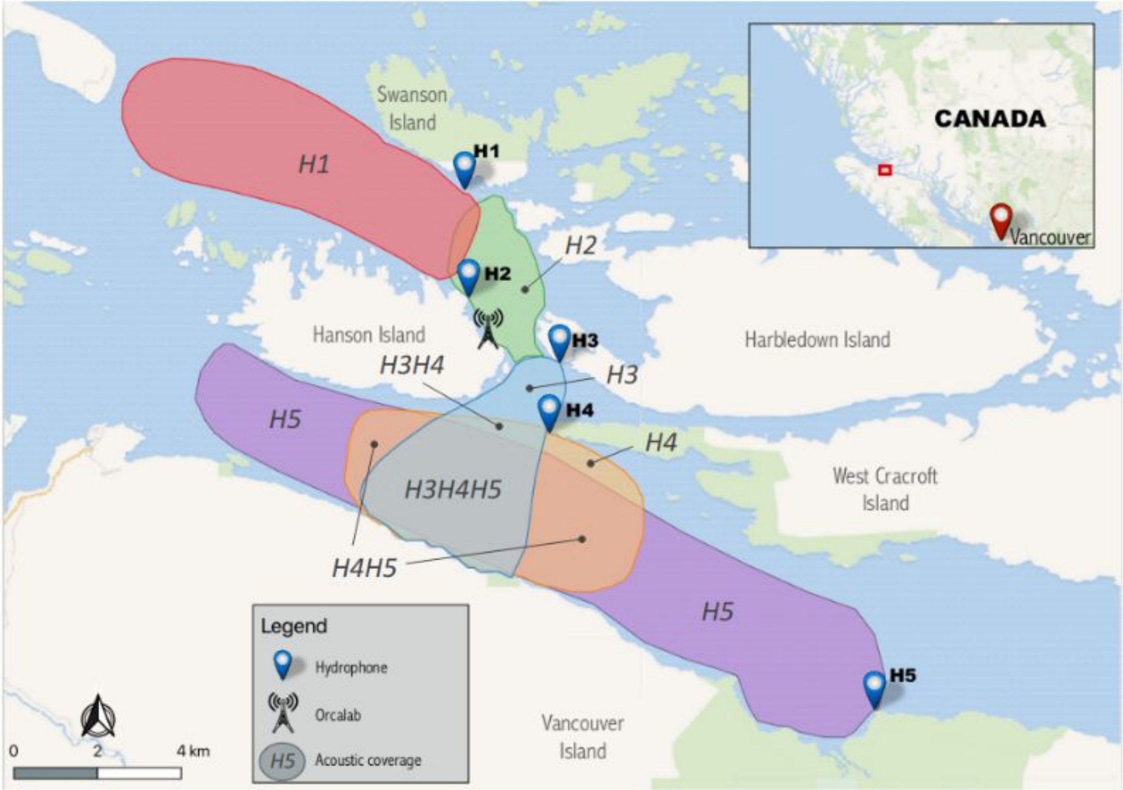


Fig 2: Map of the area and the listening range of the 5 hydrophones

Fig 3: Orcalab Station, Hanson Island, Canada

- The hydrophones record the soundscape continuously.
- Transmission of recordings to the Orcalab station in real time via VHF.
- Then digitized to a Presonus analog-to-digital converter (ADC) and sent to a PC in Orcalab.
- The recordings are then compacted in segments of 2 minutes including all 5 channels (.flac, 22050 Hz)
- Each segment is then sent to DYNI Toulon University big data NAS (Network Attached Storage) .
- In total, from July 2015 to 2017, around 50 TB of sound (about 14,500 h) was stored on our server.

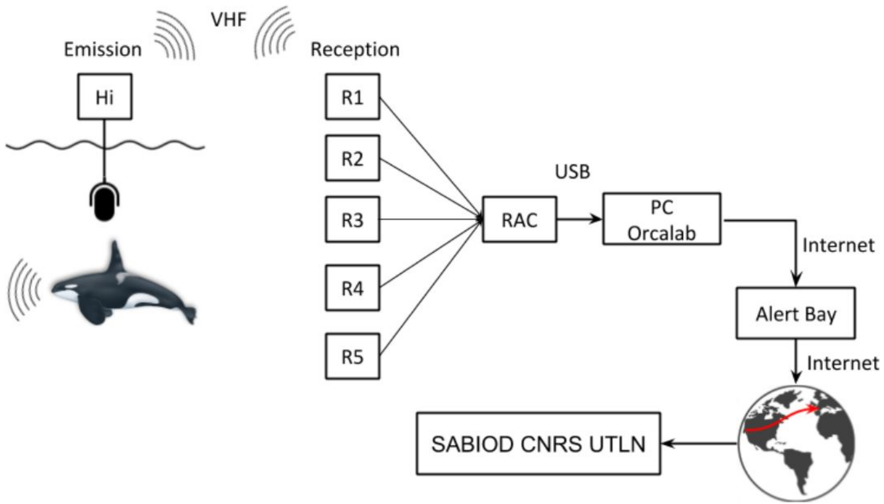
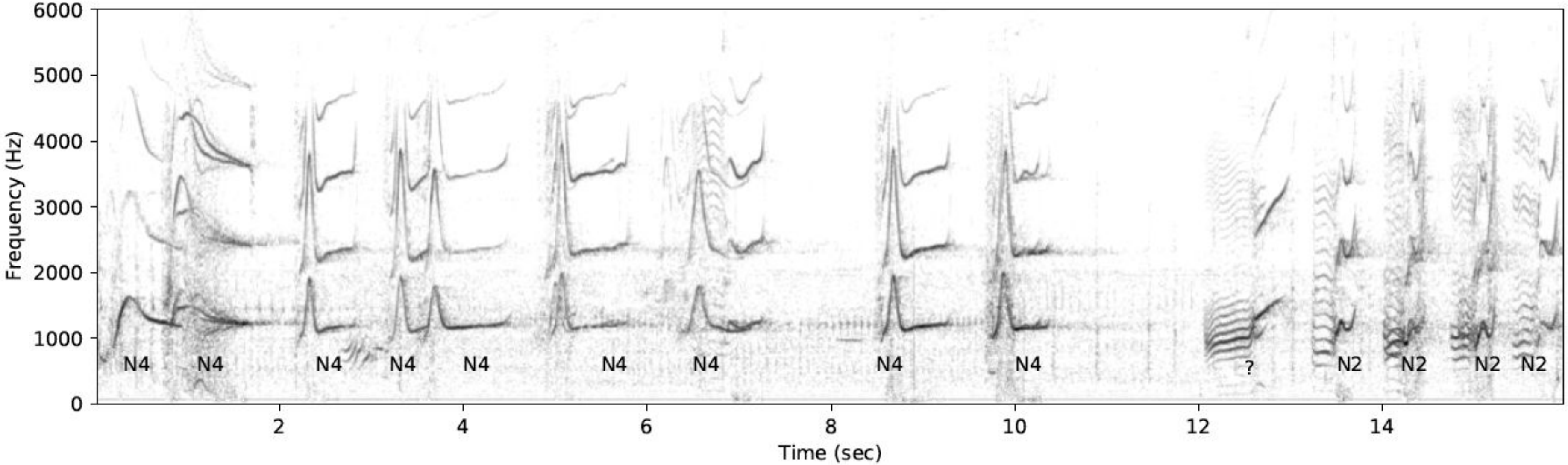


Fig 4: Representation of the data acquisition, from recording until storage on SABIOD CNRS UTLN server

Orca pulsed calls

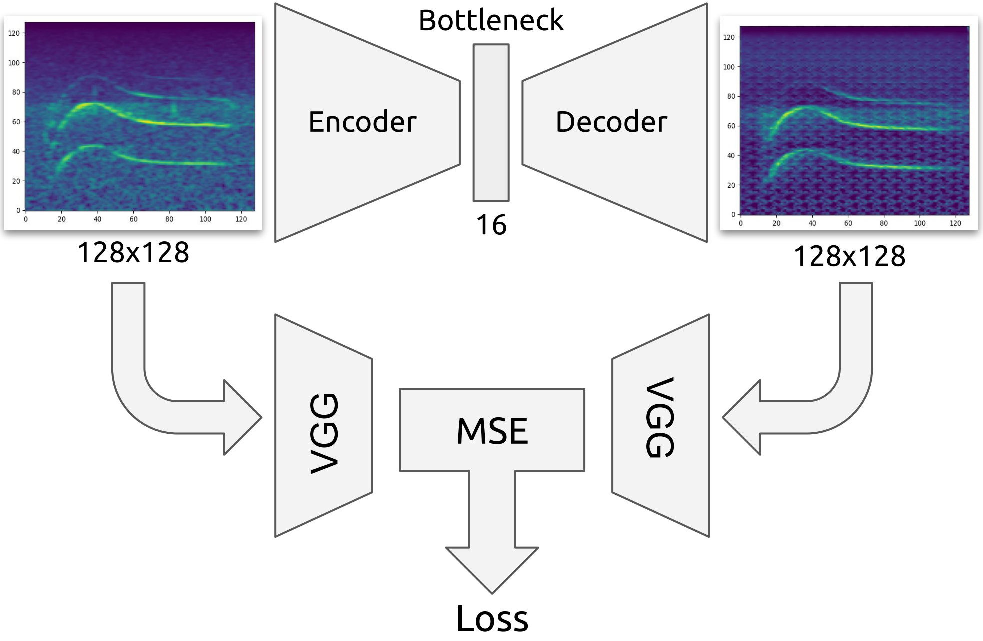


Learn a compact representation

Auto-Encoder (AE)

- 300k detected calls
- No call type annotations

↪ Learn a compact representation
↪ Cluster by frequency contour

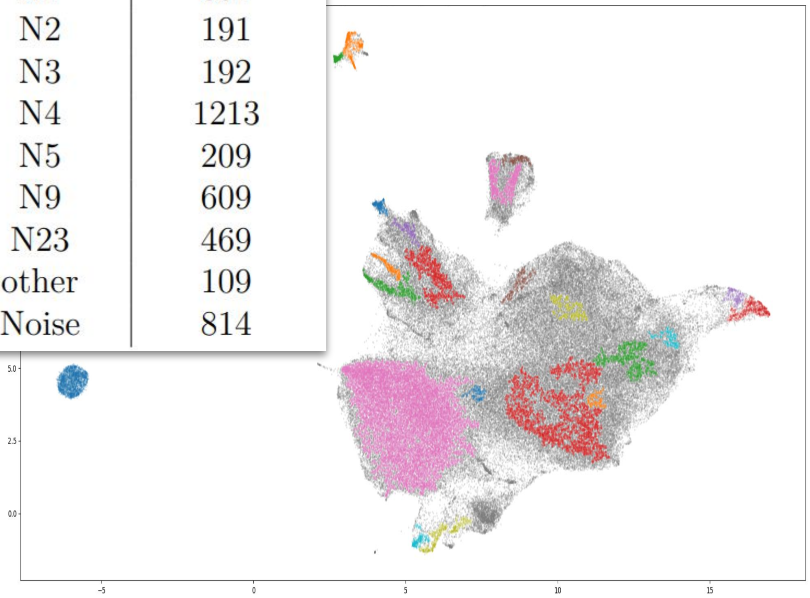


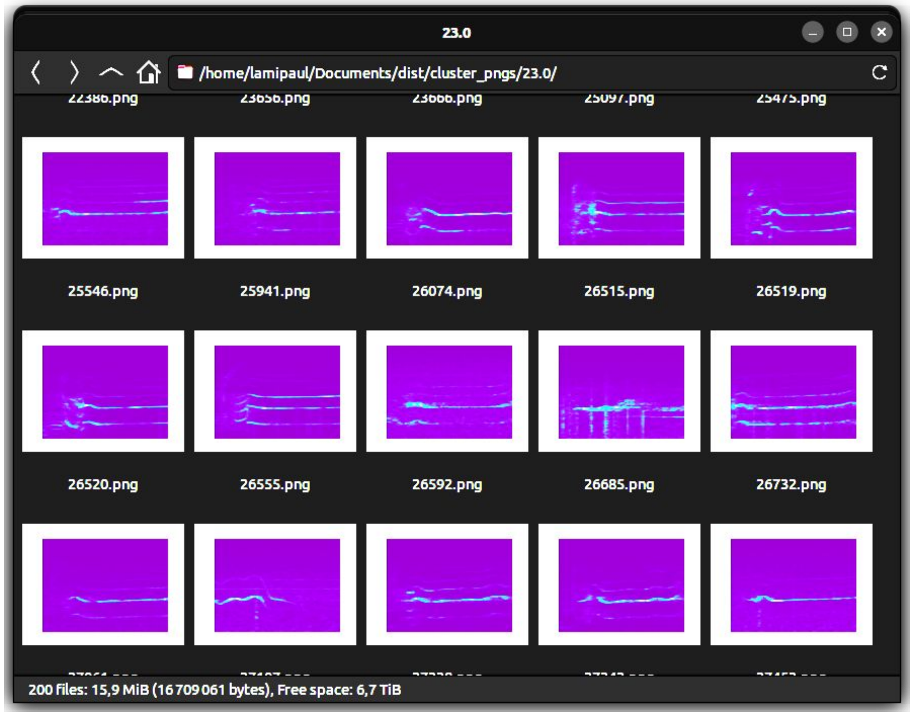
Johnson, Justin, Alexandre Alahi, and Li Fei-Fei. "Perceptual losses for real-time style transfer and super-resolution." European conference on computer vision. Springer, Cham, 2016.

Cluster AE embeddings

DBSCAN(UMAP(Encoder(x)))

call type	instances
N1	854
N2	191
N3	192
N4	1213
N5	209
N9	609
N23	469
other	109
Noise	814





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Ester, Martin, et al. "A density-based algorithm for discovering clusters in large spatial databases with noise." kdd. Vol. 96. No. 34. 1996.

Transition matrix

Ford - 10k call transitions
1978-1983

self - 100k call transitions
2015-2020

-> Paul Best, Paris, Glotin, Marxer, Scientific Report 2023

Large scale statistics

- 2 days of computation required for 2015-2017 data.

- Orcas are present (acoustically) mostly during summer (June, July, August and September)[4].

- orcas are abundant in Johnstone Strait between July and October, when salmon migrate into it.
- The second peak (October-December) may reflect the presence of Humpback whales [5].

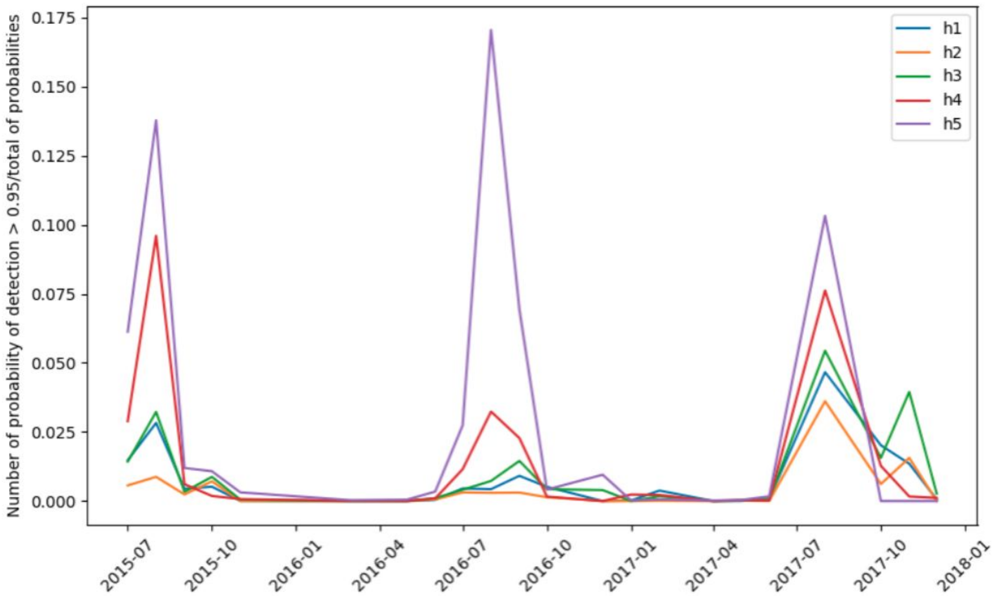
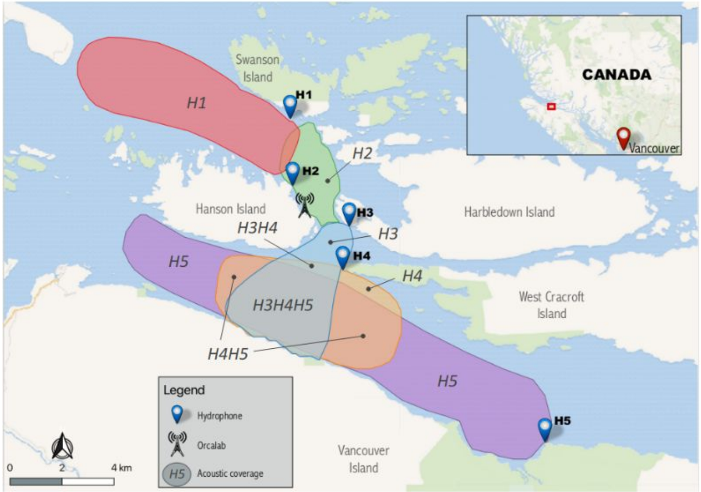


Fig 6: Proportion of two-minutes recordings with detected orca calls per month and hydrophone, from 2015 to 2017.

Trajectography

- Estimation of the acoustic activity of orcas in the range of each hydrophone over time.
- Example for August 24, 2017.



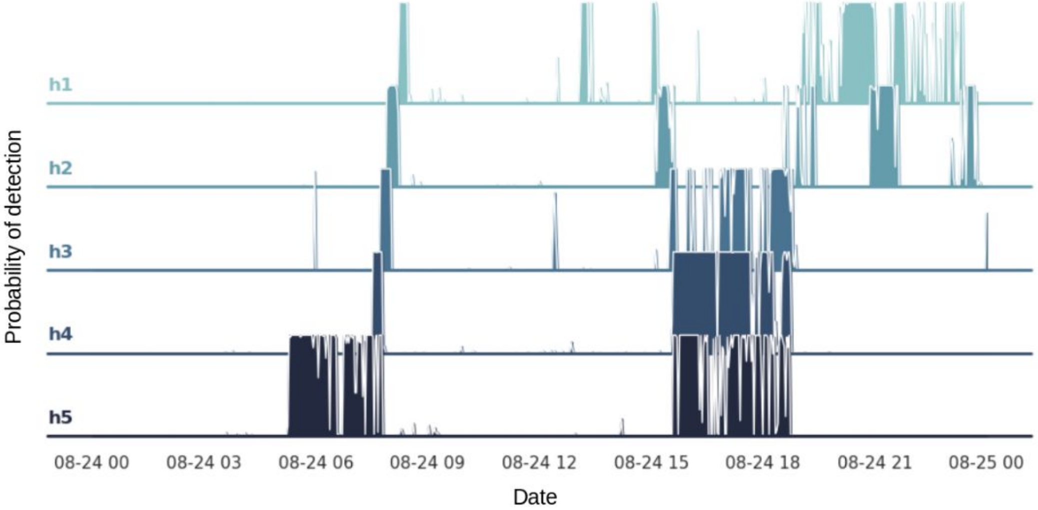
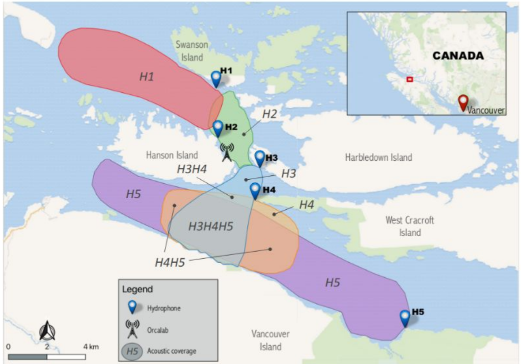


Fig 7: Example of the evolution of the probability of call detection for each hydrophone during one day (August 24, 2017). During the morning, a group of orcas comes from the east on H5, and is moving on H4, H3, H2 then on H1. Different round trips are made during the day.

Voicing statistics

- Zone transition probabilities
- 2015,2016,2017: 72109 5-channel recordings of 2 minutes (approximately 100 continuous days).



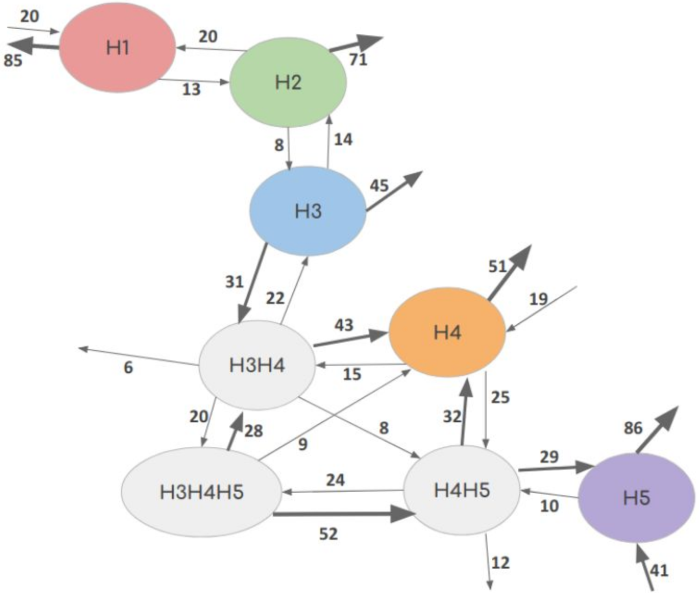


Fig 9: Directed graph of the main transition probabilities (%) between the detection zones of orca calls

- Estimation of the common travels done by the orcas
- probability to arrive to a zone coming from another one.

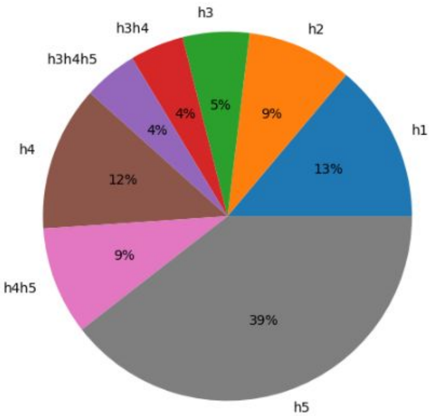


Fig 10: Proportion of recordings including orca calls per zone (%)

Voicing statistics

Analyze of the voicing activities according to:

- Day time/Night time.
- Full Moon time (from 4 days before to 4 days after a full moon) [6], new Moon time .
- Rising tide / falling tide.

- Detect orca calls in each zone during a given time interval.
- Global patterns of the orcas’ voicing activity in time and space variations in the voicing.
- Activities of up to a factor of four between conditions and zones.
- The biggest variation concerns the influence of tide and moon in zone H5 [7, 8, 9].

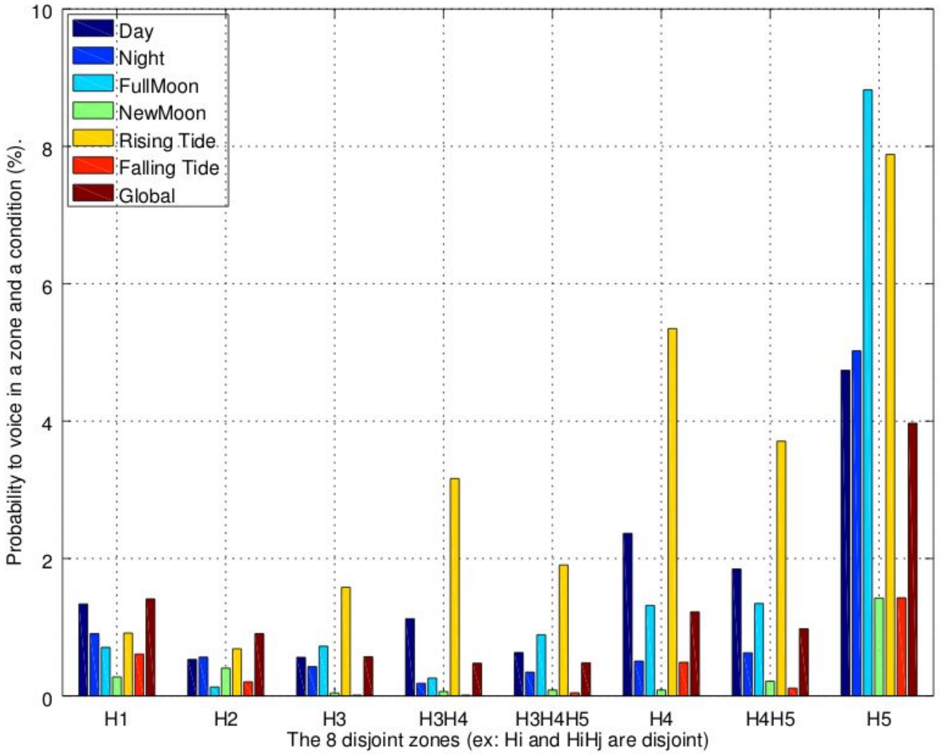
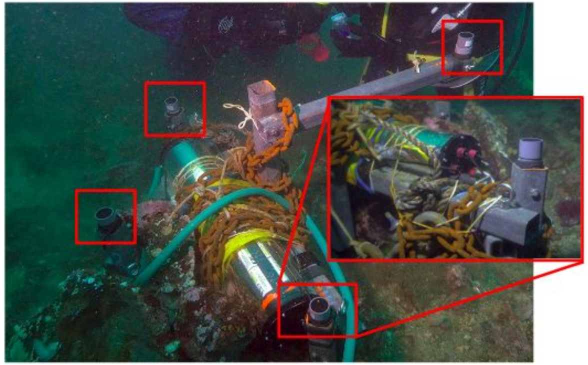
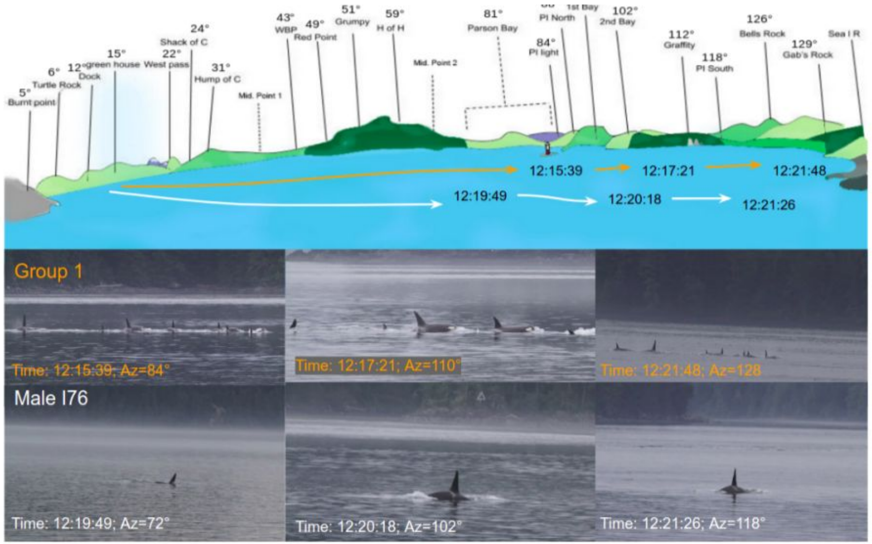
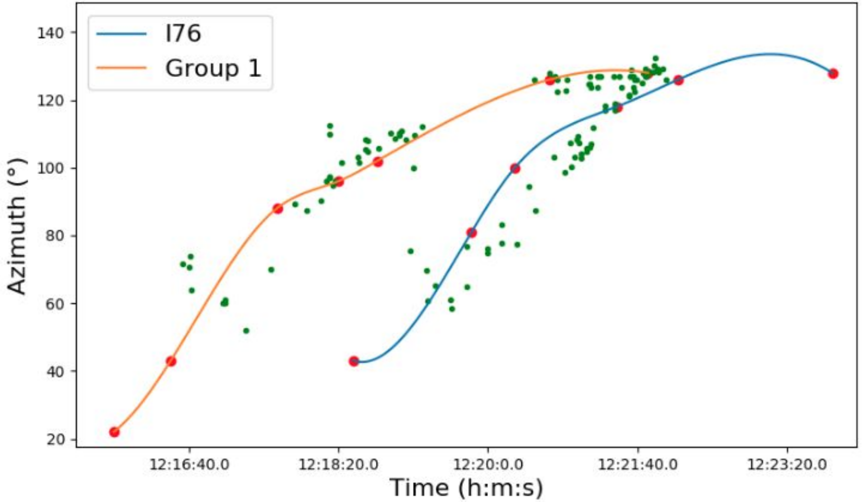


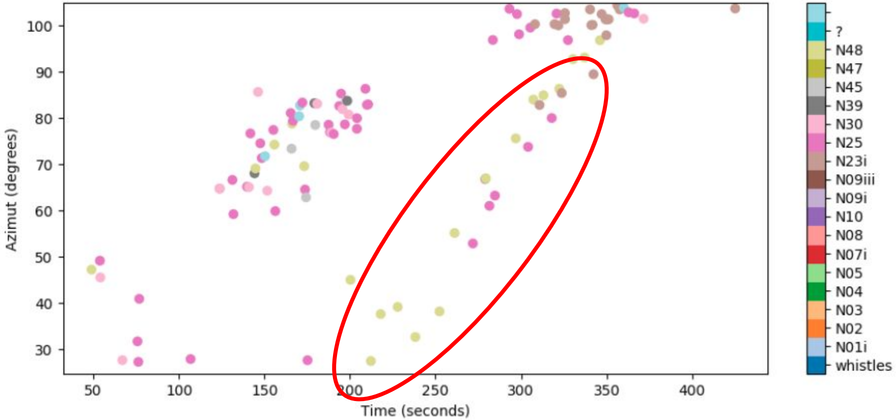
Fig 12: Probability of voicing of orca in a zone during a given condition.’Global’ refers to no specific condition.

Individual separation and identification of orcas calls in the wild: Individual signature learning ?









Poupard et al, Frontiers in Marine Sc

Discussion

- First automatic large scale ethoacoustic analysis on orcas.
- Influence of lunar phase on the orcas acoustic behavior [6]–[8]: correlated with preys that migrate vertically [16].
- Tides also have an influence on presence (25% vs. 3%) and movement (40% vs. 35%) of orcas: influence of the tide in a semi-enclosed environment [7].
- acoustic activity as well as the proportion of movements changed between day and night (13% vs. 9% and 42% vs. 34%, respectively) [10].

Trajectography and classification improvements

- The localization techniques presented here are quite inaccurate.
- Use the time difference of arrival (TDoA) between hydrophones to increase location accuracy [11], [12].
- draw precise trajectories following specific pods.
- A precise localization study will be set up for the orcas tracking with an antenna of 40 cm of size at 2 km away (to not interfere with animals) [13].
- extend our current detection model to a call type classifier.
- Use of expert annotation and unsupervised techniques.
- Acoustic classification of matrilines.
- Use of the pitch to classify vocalization.

Conclusion

- Preliminary long term study of orca acoustic activities
- Influence of the environmental factors (tidal, moon phase, and daily period) on the orcas’ acoustic activities

Perspectives:

- Orcas’ behavioural response to anthropogenic noise
- Correlating the orcas’ activities (position, speed, density of calls) with the anthropogenic noises in a larger scale could strongly support the current knowledge and may enable local measurements to mitigate the impact of human activity on the animals.

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[10] S. **Deconto** and E. Monteiro-Filho, “Day and night sounds of the guiana dolphin, sotalia guianensis (cetacea: Delphinidae) in southeastern brazil,”acta ethologica, vol. 19, no. 1, pp. 61–68, 2016

[11] P, **Giraudet** and H, Glotin, “Real-time 3d tracking of whales by echo-robust precise tdoa estimates with a widely-spaced hydrophone array,”Applied Acoustics, vol. 67, no. 11-12, pp. 1106–1117, 2006.

[12], H. **Glotin**, , F. Caudal, & , P. Giraudet (2008). Whale cocktail party: real-time multiple tracking and signal analyses. Canadian acoustics, 36(1), 139-145.

[13] M. Poupard, M. Ferrari, J. Schluter, R. Marxer, P Giraudet, , V. Giès, V. Barchasz, G. Pavan, and H. Glotin, “Real-time passive acoustic 3d tracking of deep diving cetacean by small non-uniform mobile surface antenna,” in Accepted to ICASSP, 2019

Automatic classification of humpback whale (*Megaptera novaeangliae*) vocalization in the Caribbean

Stéphane Chavin, Best Paul, Ferrari Maxence, Poupard Marion and Glotin Hervé

Université de Toulon, Aix Marseille Univ, CNRS, LIS, Marseille, France

Contact : **stephanechvn@gmail.com**

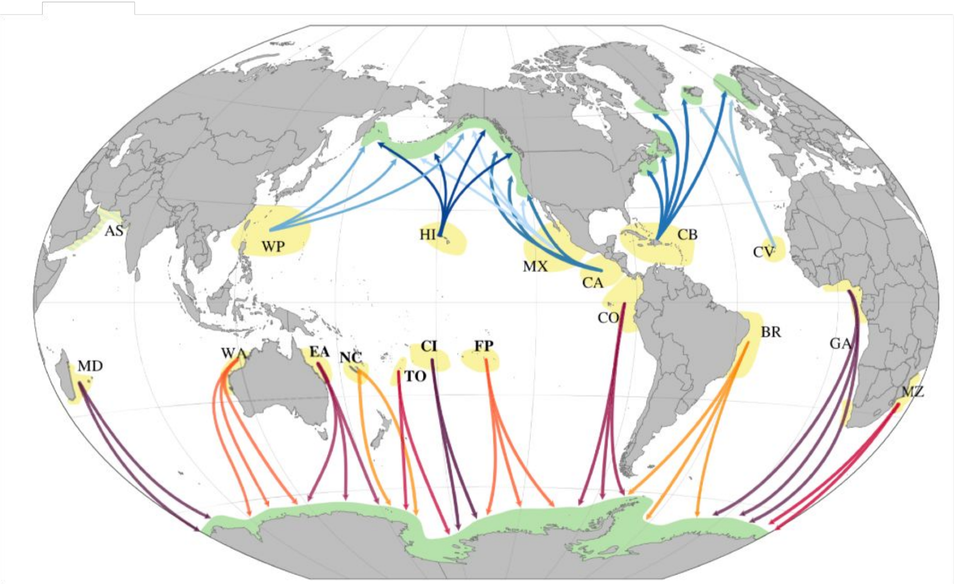


Figure 1. *Migration of humpback whales in the world*

Source : Zandberg, L., Lachlan, R. F., Lamoni, L., & Garland, E. C. (2021). Global cultural evolutionary model of humpback whale song. Philosophical Transactions of the Royal Society B, 376(1836), 20200242.

- **reproduction Area** *(tropics in winter) and* **feeding** *(Arctique for the rest of the year) north side*
- *Males* ***singers***
- *dialects*

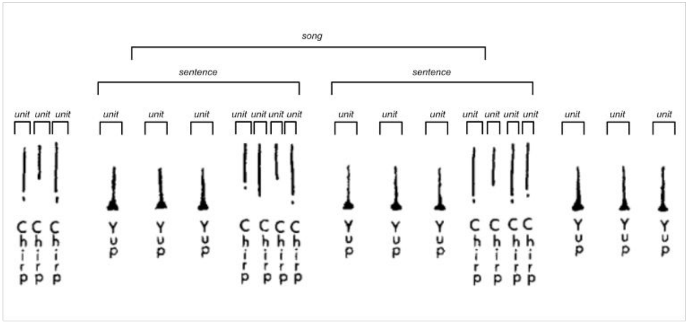


Figure 2. *Structure of a song*

H. E. Winn 1978, The Song of the Humpback Whale *Megaptera novaeangliae* in the West Indies, *Marine Biology*, volume 47, pages 97–114

- **Is it possible to find and classify automatically humpback whale vocalization with neural network so that it will be possible to analyse huge amount of data?**

- **60 diffrents units**

Pines, Howard (2018). "Mapping the phonetic structure of humpback whale song units: extraction, classification, and Shannon-Zipf confirmation of sixty sub-units". In: Proceedings of Meetings on Acoustics 35.1, p. 010003. doi: 10.1121/2.0000957.

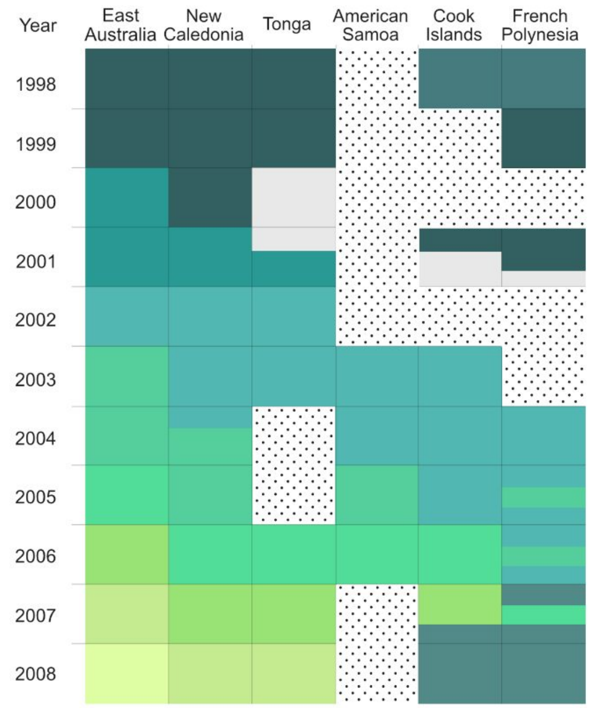
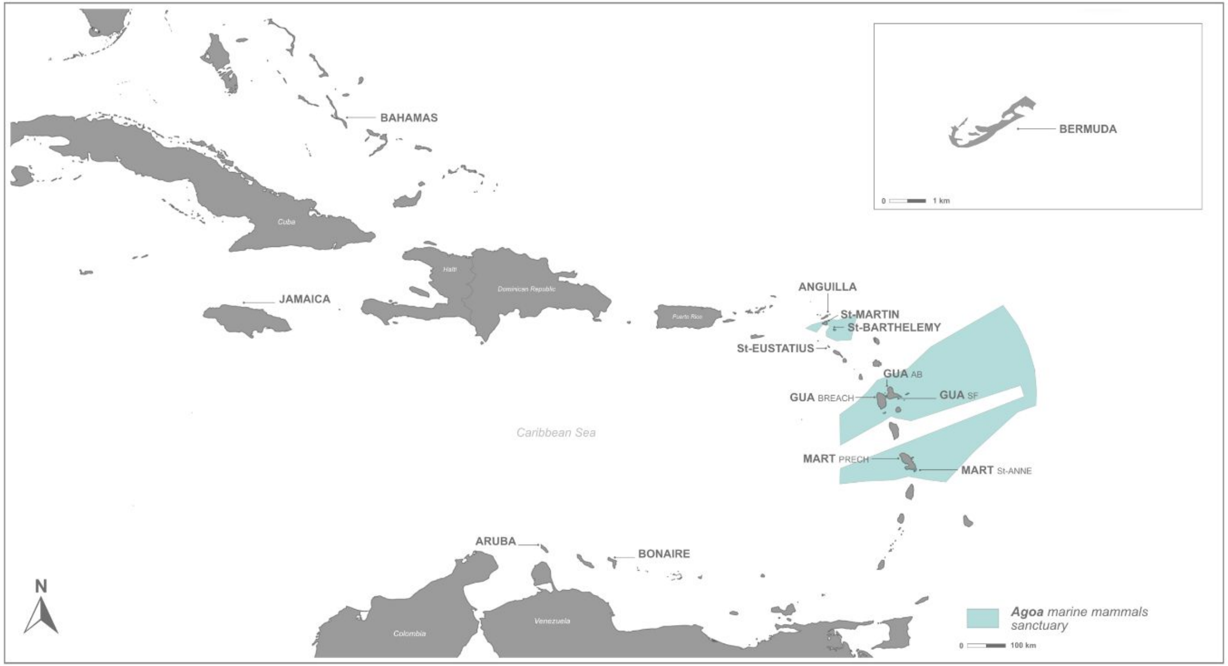


Figure 3. *Evolution of song through years*

Garland, Ellen C and Peter K McGregor (2020). "Cultural transmission, evolution, and revolution in vocal displays: insights from bird and whale song". In: Frontiers in Psychology 11, p. 544929.



Source : geopackage natural_earth_vector.gpkg

Figure 4. *Map with locations of the stations*

CARI'MAM *(Caribbean Marine Mammals Preservation Network) :*

- *Marine protected Area, the AGOA sanctuary*
- **15 stations**
- 40 days at ~ 20 m = **passive acoustic**
- **1 min / 5 min**
- 1,300 days in total = ~ **6,000 h recording**

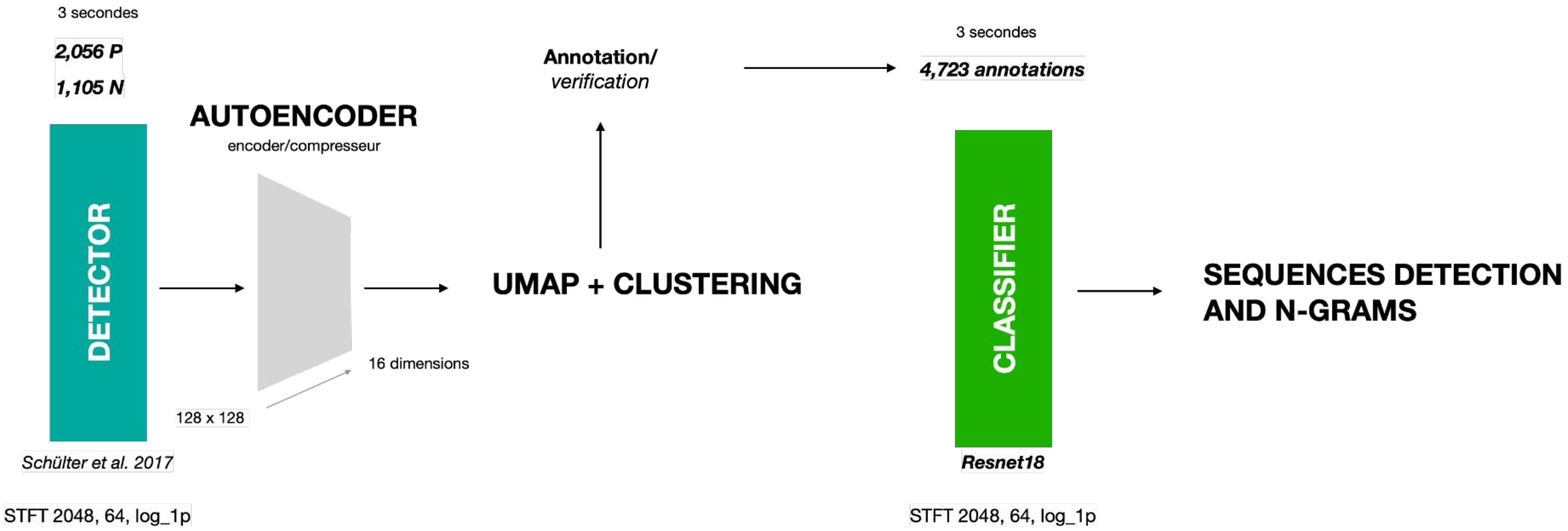
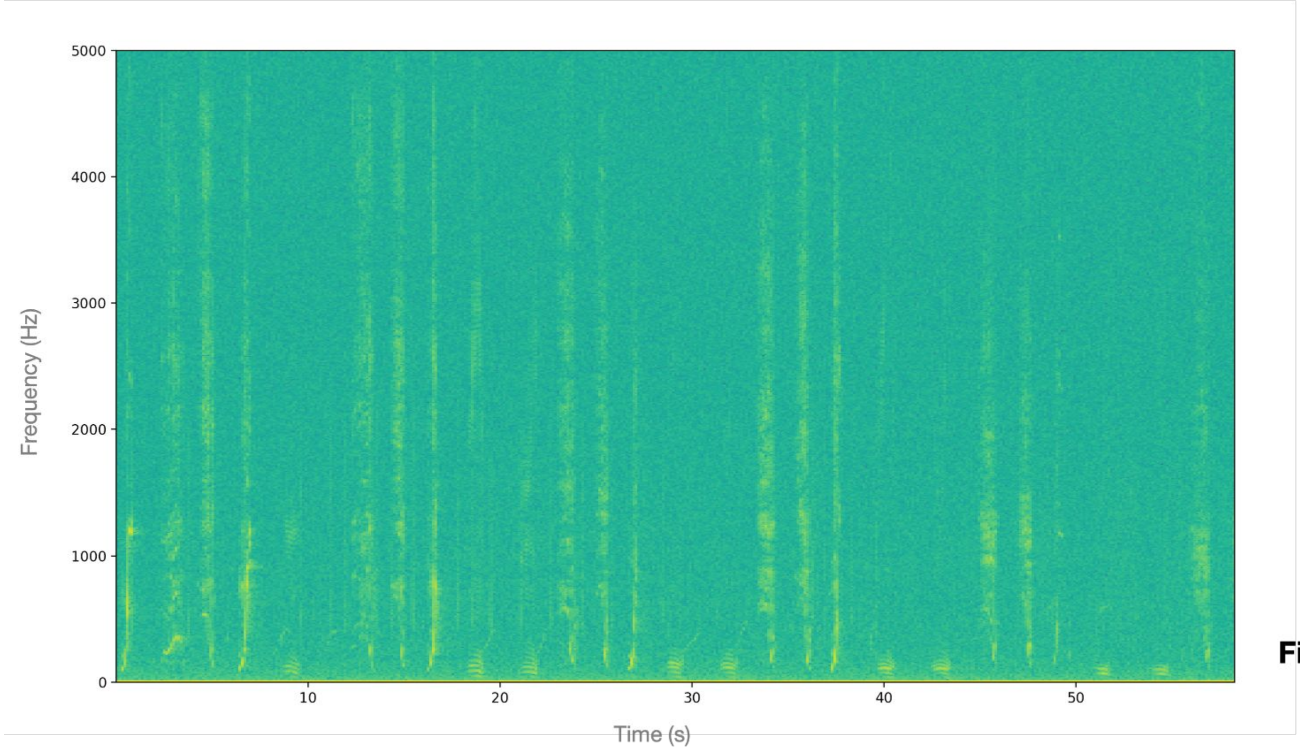


Figure 7. *Workflow*



- Sampling rate : **256 kHz** or **512 kHz**
- **annotations :** Audacity or ROI (*Scikit-maad*)

Figure 5. *Spectrogramme example*

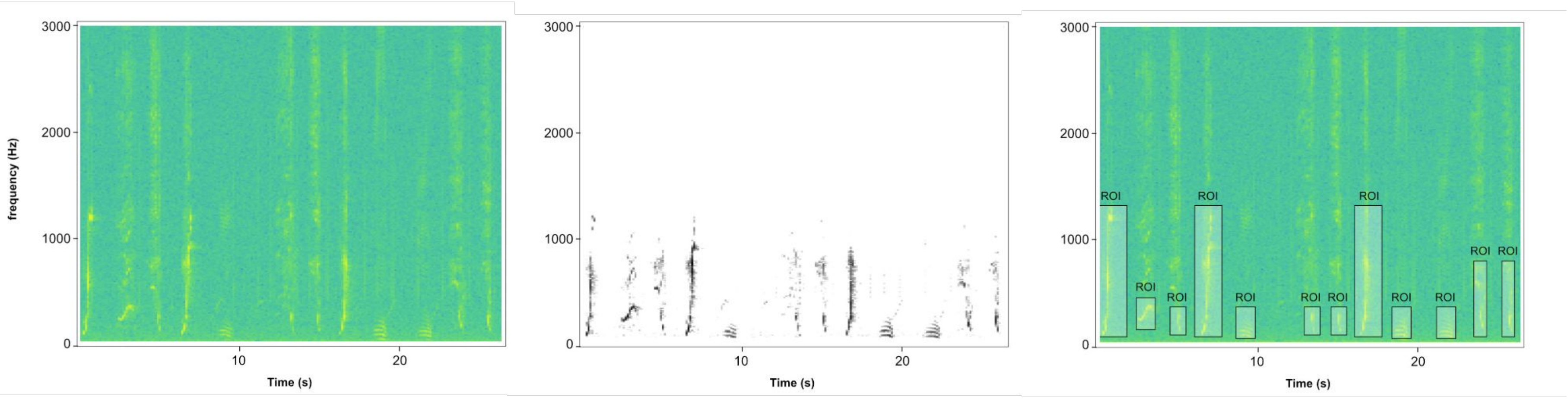
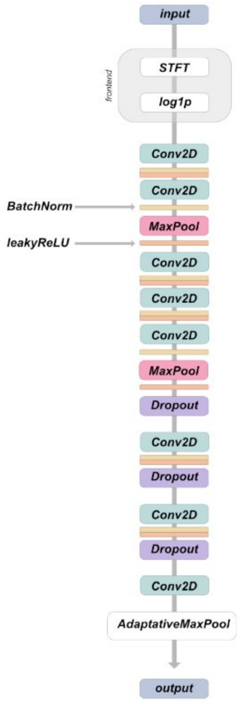


Figure 6. *Detection of regions of interest*



Input	1 x 1025 x 485
Conv2D (3x3)	32 x 1023 x 483
Conv2D (3x3)	32 x 1021 x 481
MaxPool (3x3)	32 x 340 x 160
Conv2D (3x3)	32 x 338 x 158
Conv2D (3x3)	32 x 336 x 156
Conv2D (3x16)	64 x 321 x 154
MaxPool (1x3)	64 x 321 x 51
Conv2D (9x1)	256 x 321 x 43
Conv2D (1x1)	64 x 321 x 43
Conv2D (1x1)	1 x 321 x 43
AdaptativeMaxPool	1 x 1 x 1

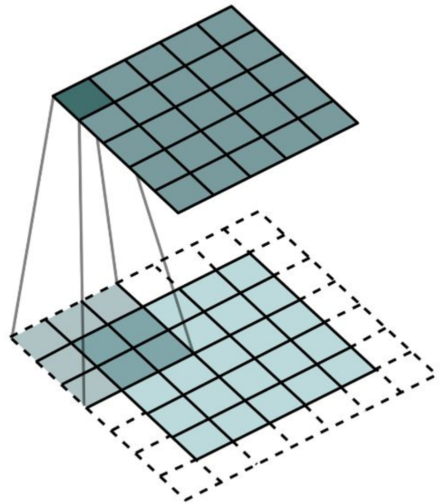


Figure 8. *Convolutional neural network*

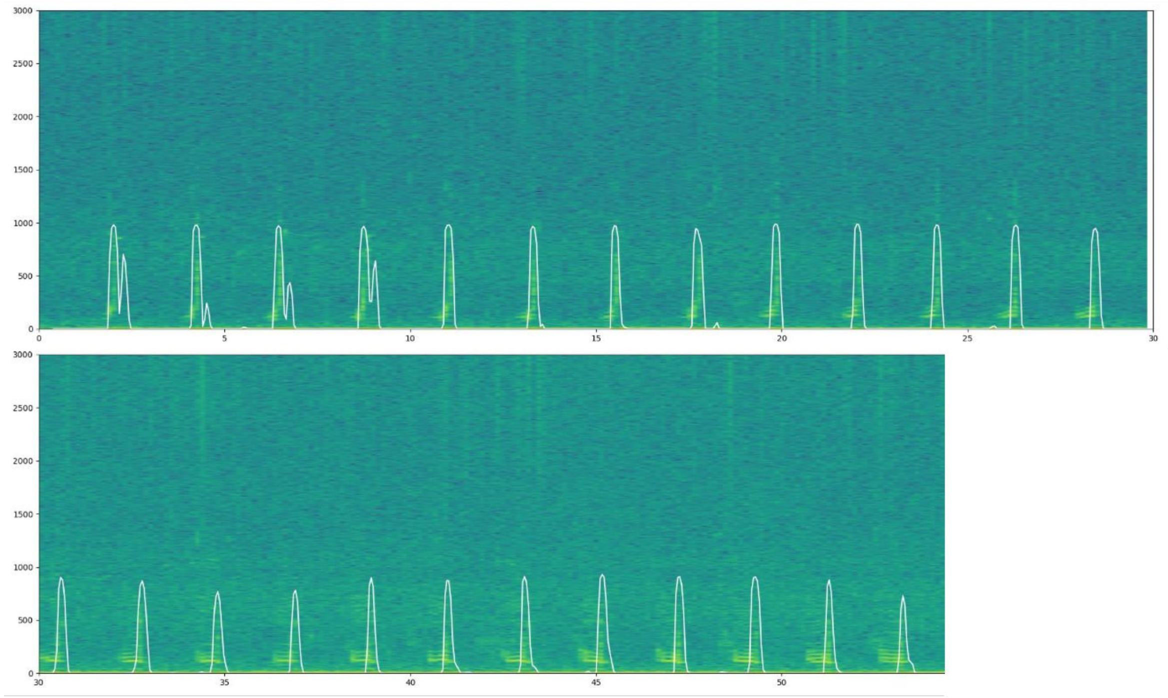


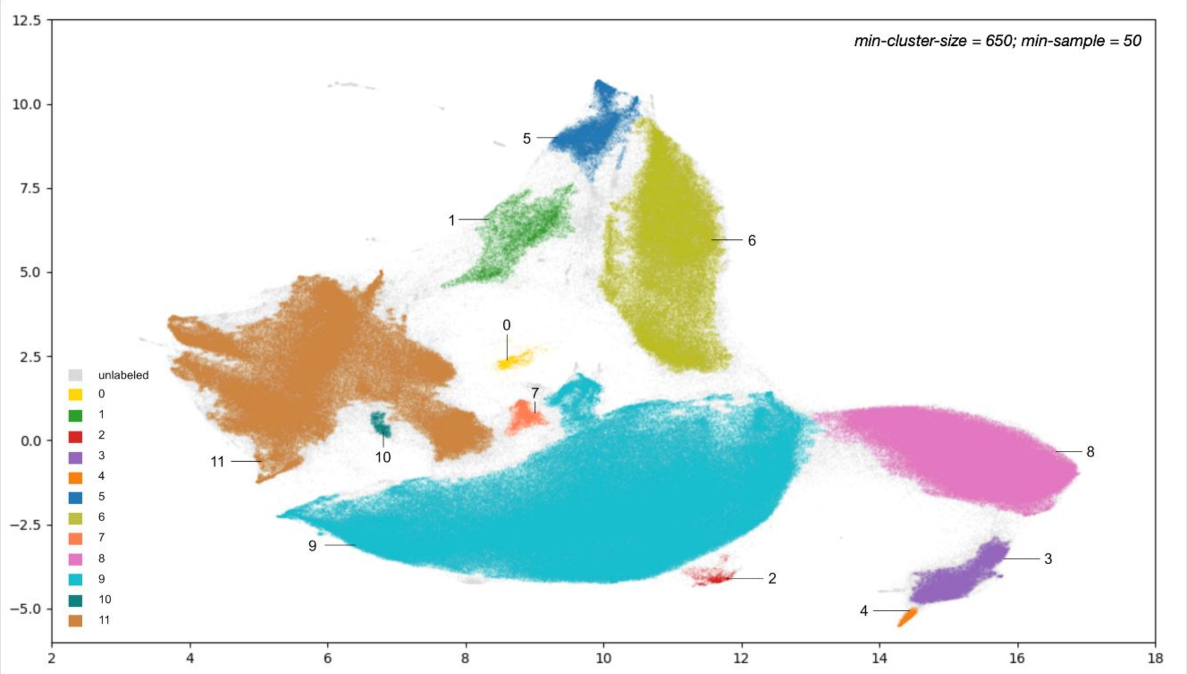
Figure 9. *Example of the prediction of the model*

DETECTOR :

- **1,026,235** vocalization
- **22.7% of the detections**
  = **Guadeloupe** Anse de Bertrand
  (293,181 detections ~ **2,000 detections per days of recording)**

Scores :

mAP	AUC
0.9948	**0.9886**



- ***12 differents units***

Figure 10. *Clustering HDBSCAN* over UMAP** representation*

* High Density-Based Spatial Clustering of Applications with Noise
** Uniform Manifold Approximation and Projection for Dimension Reduction

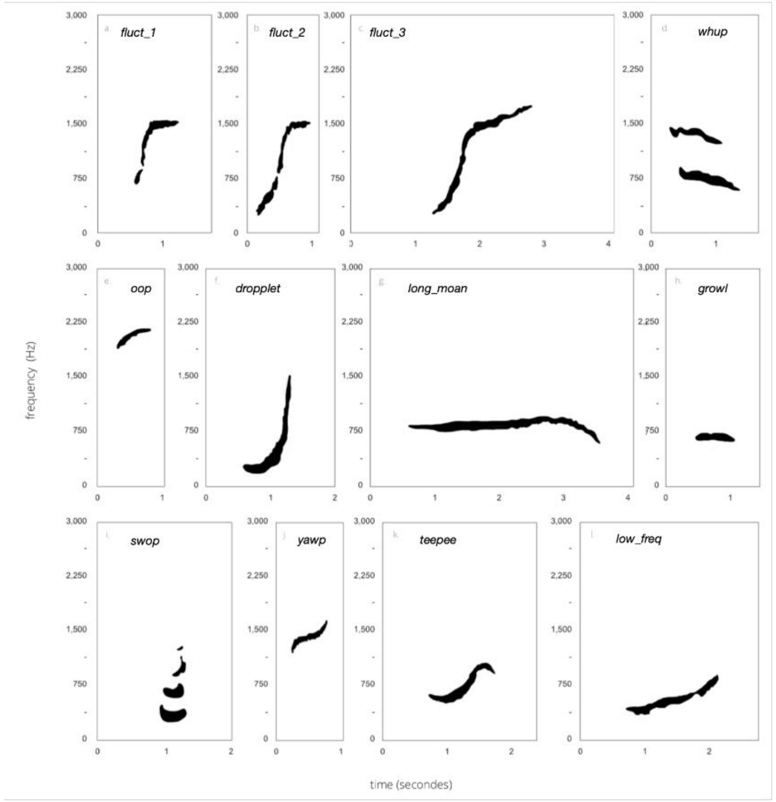


Figure 11. *Repertory*

M. Epp, M. Fournet, and G. Davoren 2021, H. Winn and L. Winn 1978, Cusano et al. 2021

Scores :

Accuracy	F1
0.83	**0.82**

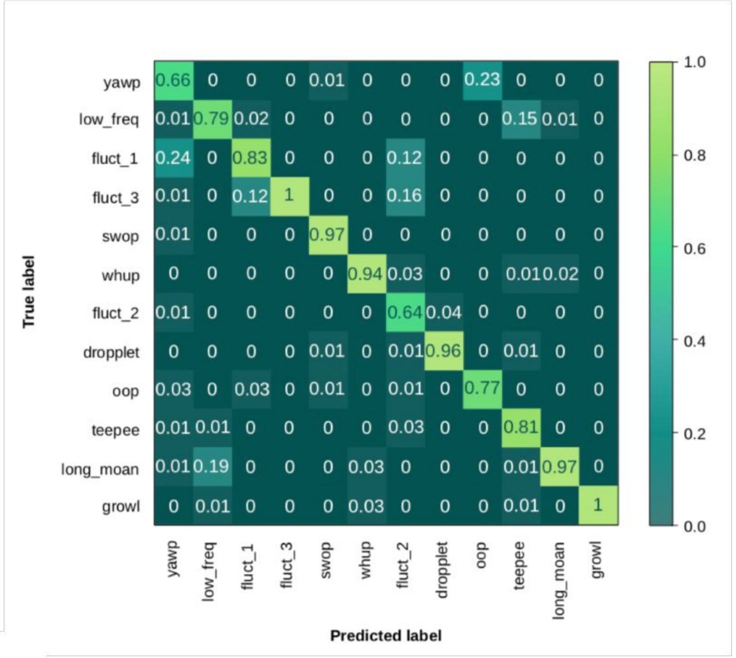


Figure 12. *Confusion matrix*

Figure 13. *Precision of the classifier*

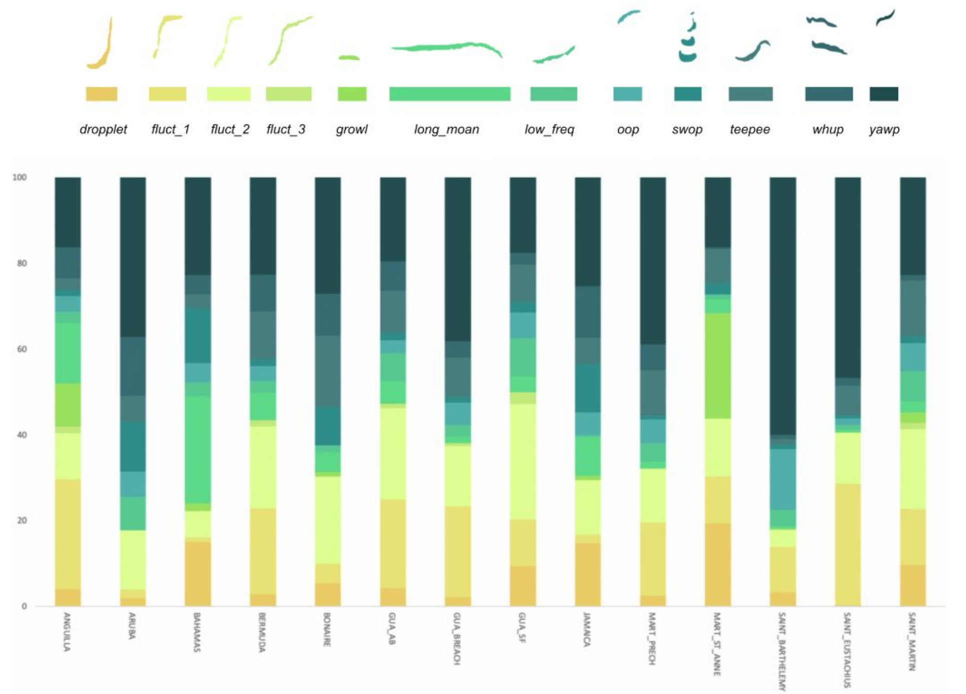


Figure 14. *Proportions of each unit in the recordings*

SEQUENCES :

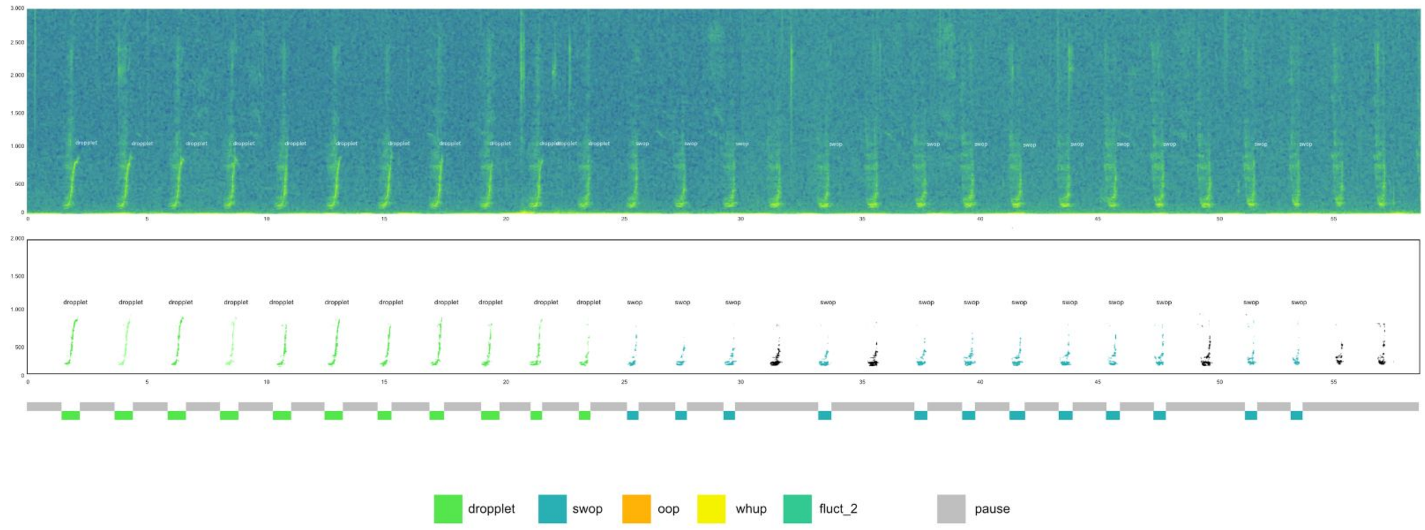


Figure 15. *Sequences examples*

SEQUENCES :

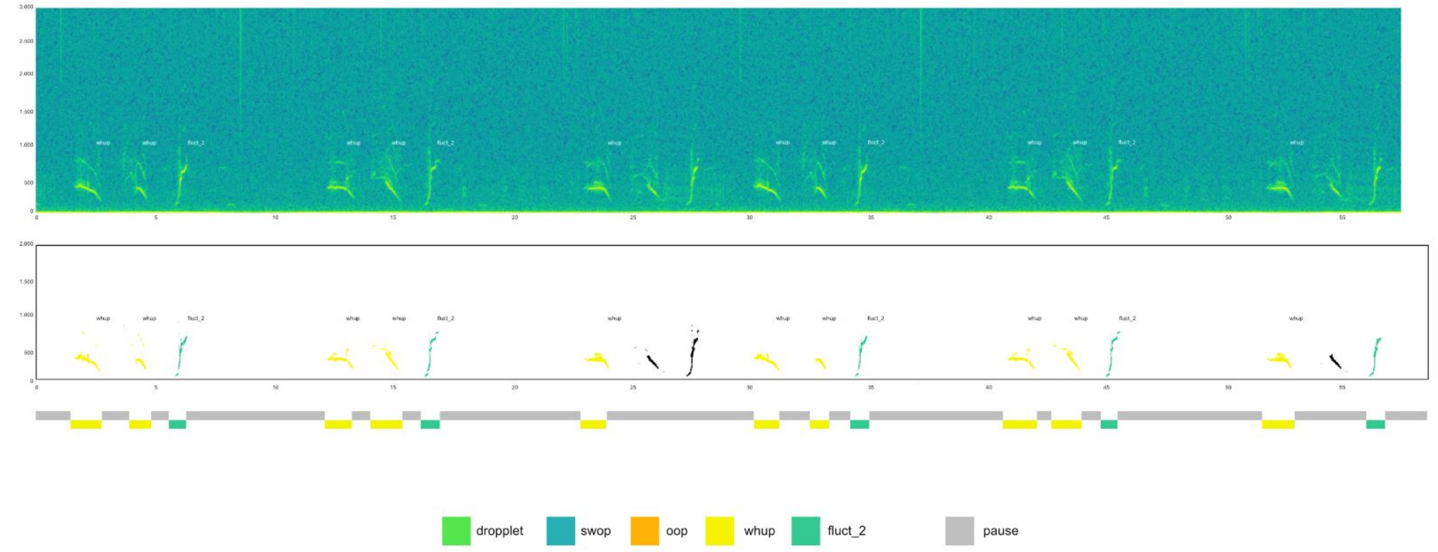


Figure 15. *Sequences examples*

AI Automatic detection
2D and 3D surveys

BOMBYX network : from Pelagos to PSSA Intelligent real-time listening sonobuoys for whale-ship collision mitigation & environmental awareness

Chair IA intelligent listening AID DGA ANR

GIAS MARITTIMO FEDER - Région Sud

Glotin Hervé, CNRS LIS Univ Toulon, & DYNI team
glotin@univ-tln.fr

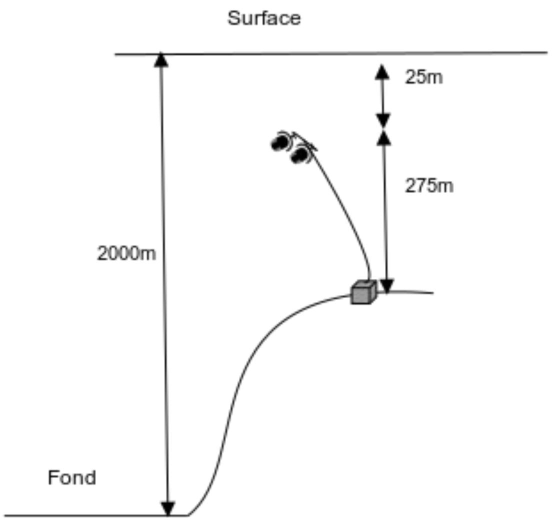
Historic of BOMBYX : 2015-2018

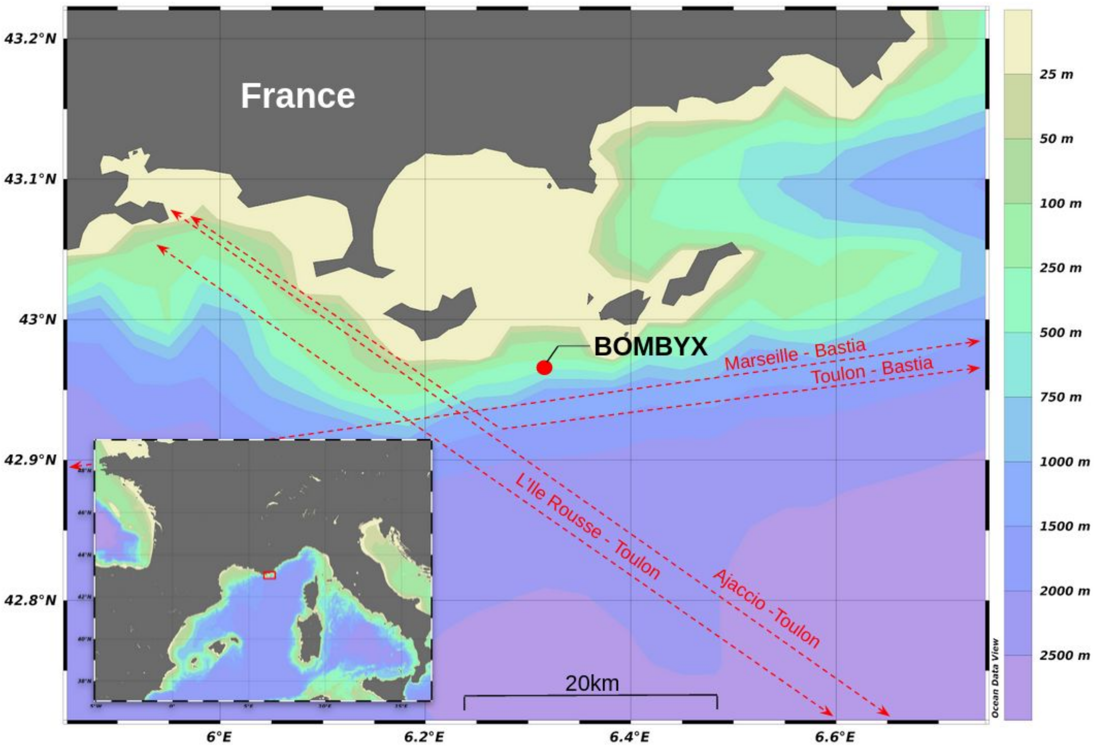
The first long term stereo Monitoring of Sperm Whales

DYNI LIS CNRS in coll. with MIO and PNPC

The BOMBYX 2015-2018

- Bombyx station, stereophonic
- 25 of depth
- Env 2700 hours of recordings, stereo
- Detection of sperm whales clics on Bombyx
- Data for future training



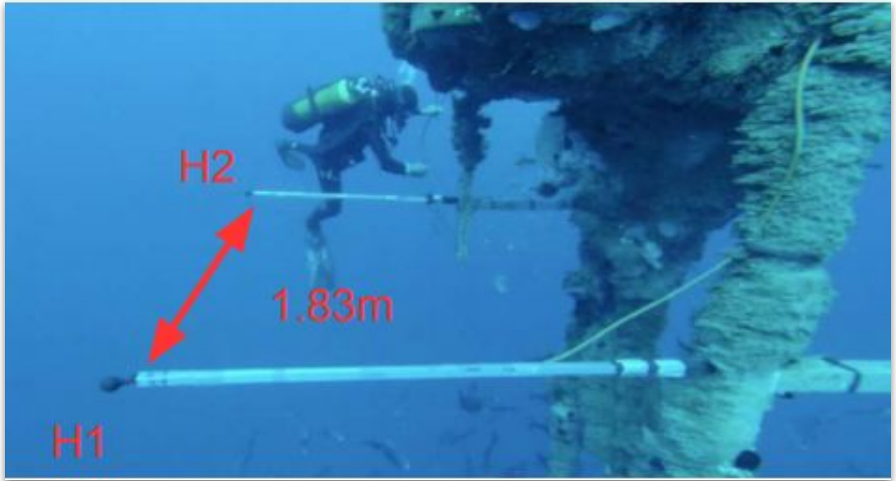


accepted in Nature, Scientific Report, Poupard,... Glotin, 2021

Bombyx 1

Data :

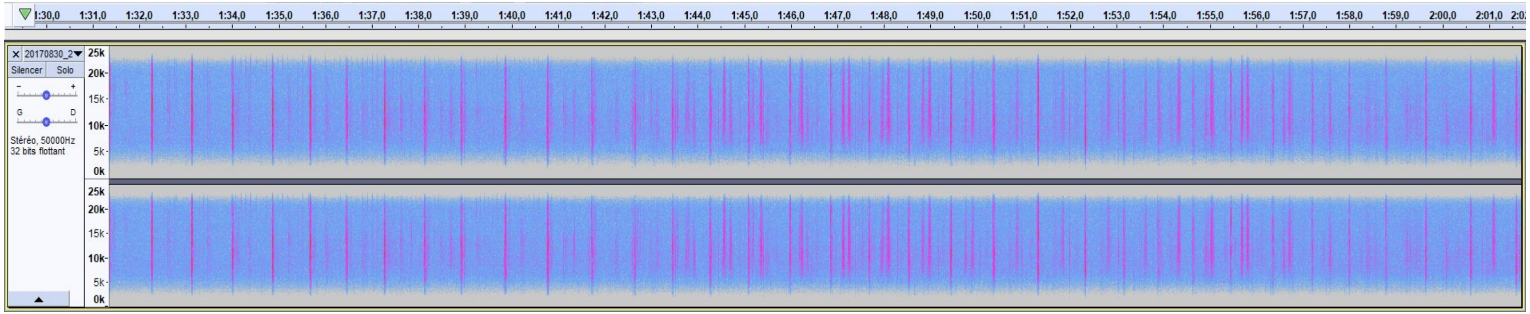
- Sparse recording from 2014 to 2018
- 2 channels (2 meters wide)
- 50kHz
- 25m deep hydrophones
- No annotation



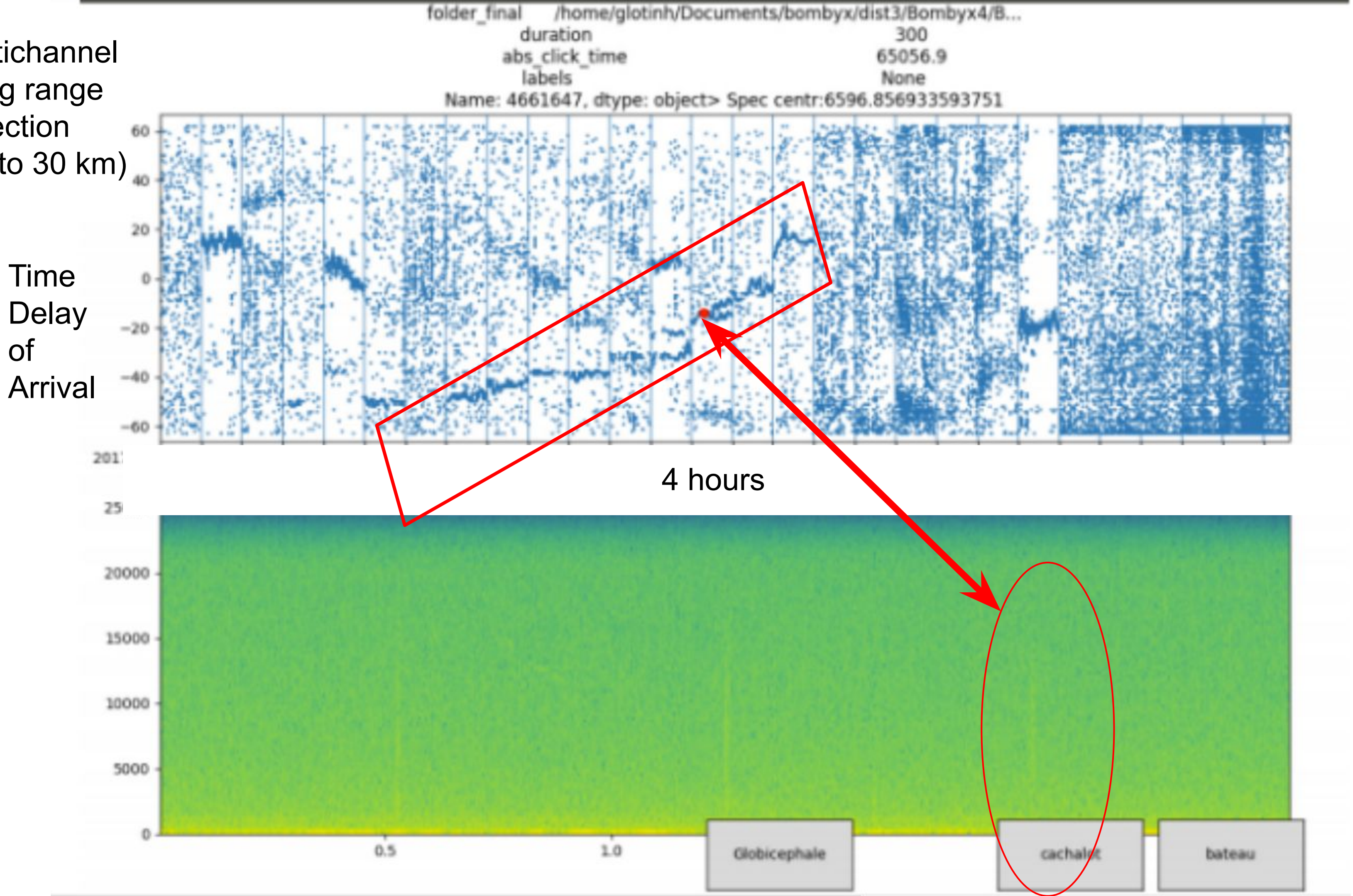
Objective :

- Noise robust sperm whale and fin whale detections

STEREO CHANNEL ALLOW robust detection and counting of individuals

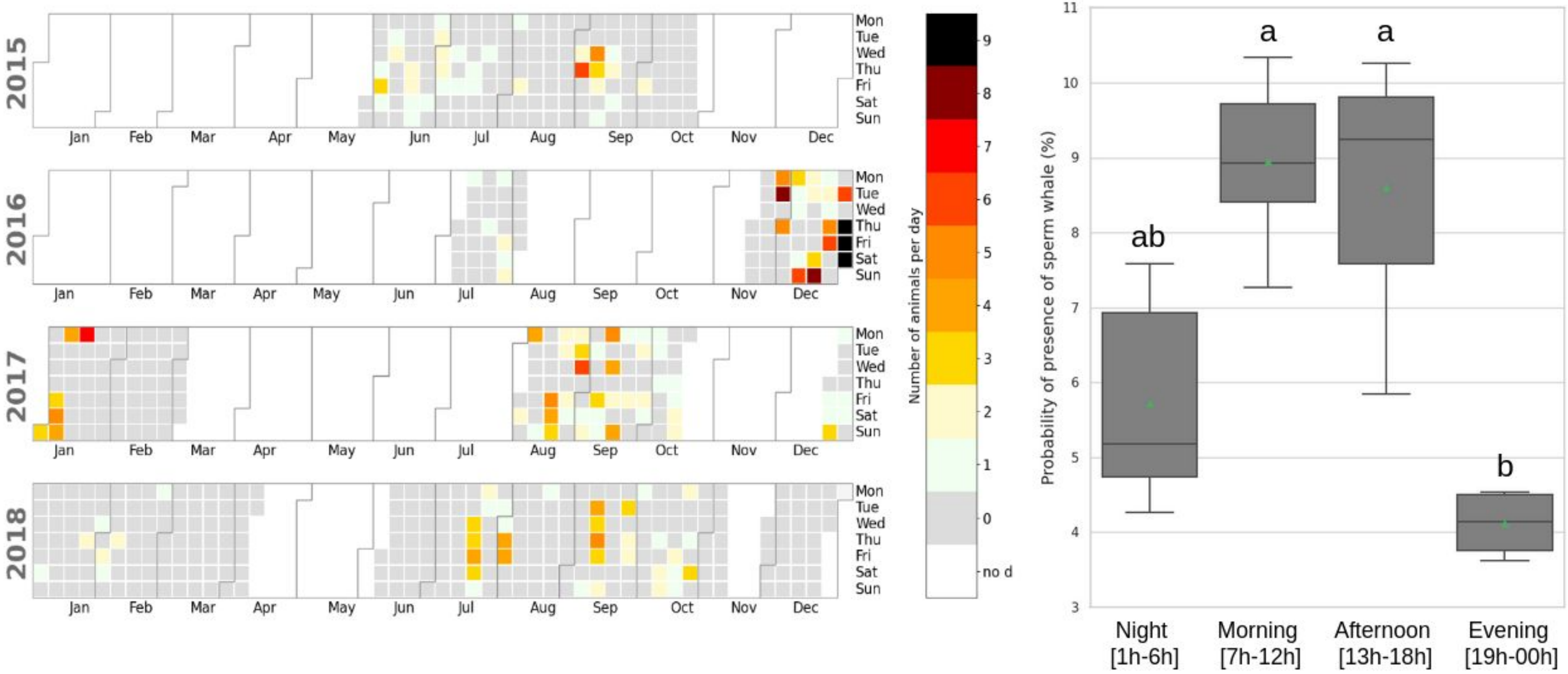


Multichannel = Big range detection (up to 30 km)



The BOMBYX 2015-2018 = Count of Sperm whales

Sperm whale acoustic detection and background noise

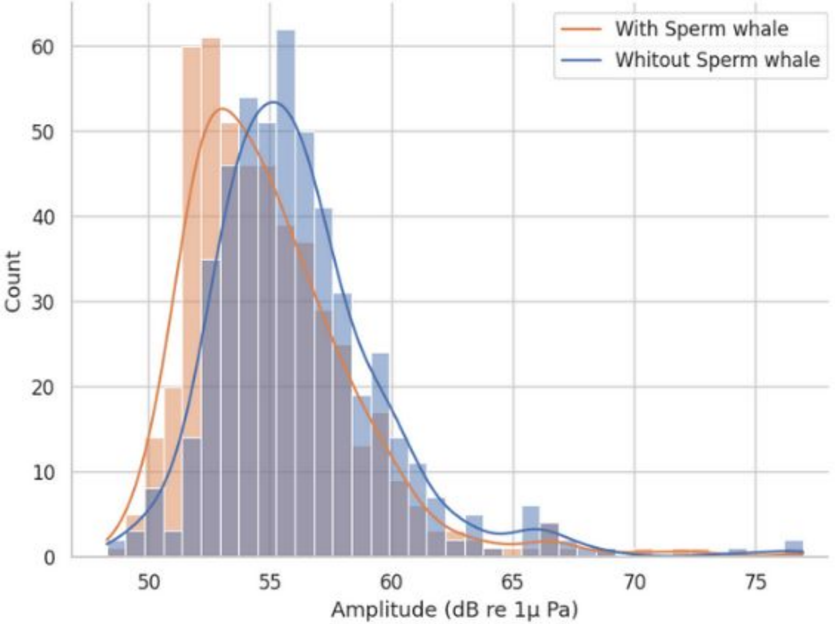


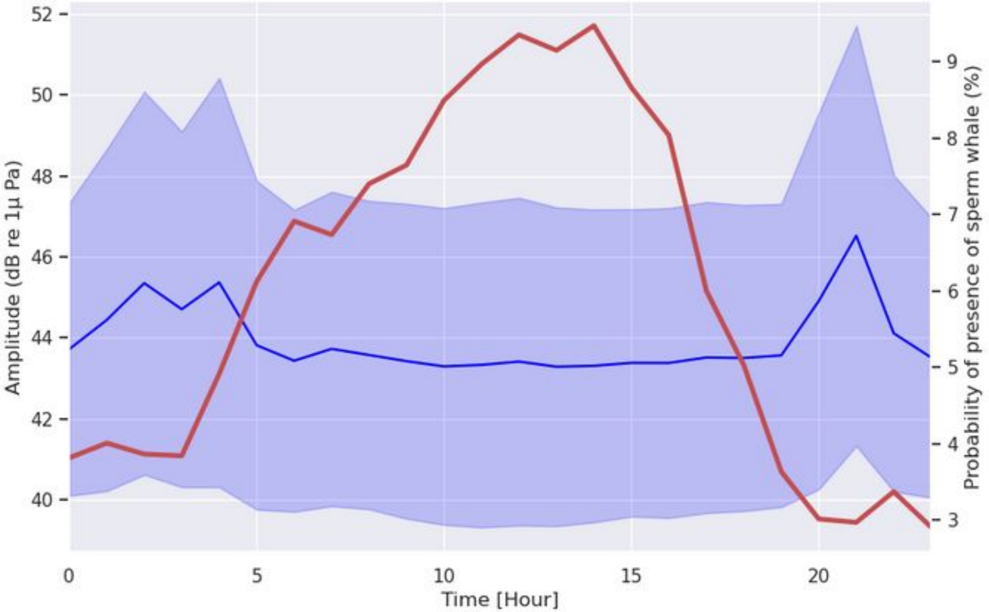
Left: Number of detected sperm whales per day during the 4 years of recordings (white region: no recording).Right: Mean of the probability of presence for each period of the day.

Accepted in Nature, Scientific Report, Poupard et al 2021

The BOMBYX 2015-2018

Sperm whale acoustic detection and background noise

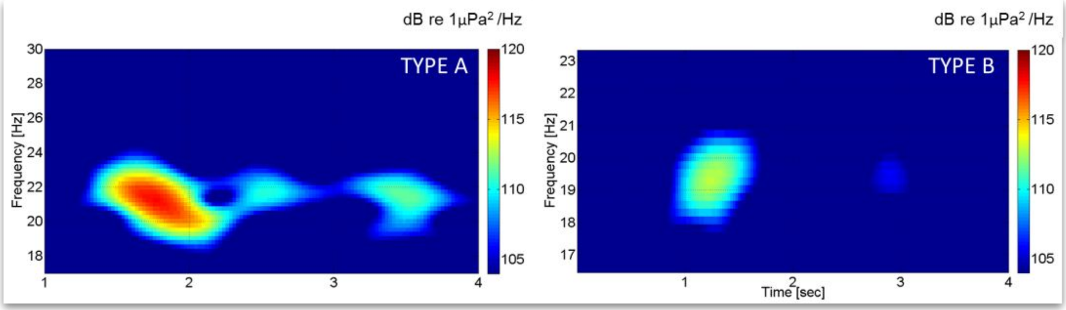




(Left) Distribution of the amplitude for the octave 12800 Hz according to presence/absence of sperm whales. (Right) Superposition of dial pattern of amplitudes for the octave 12800 Hz and probability of presence of sperm whales.

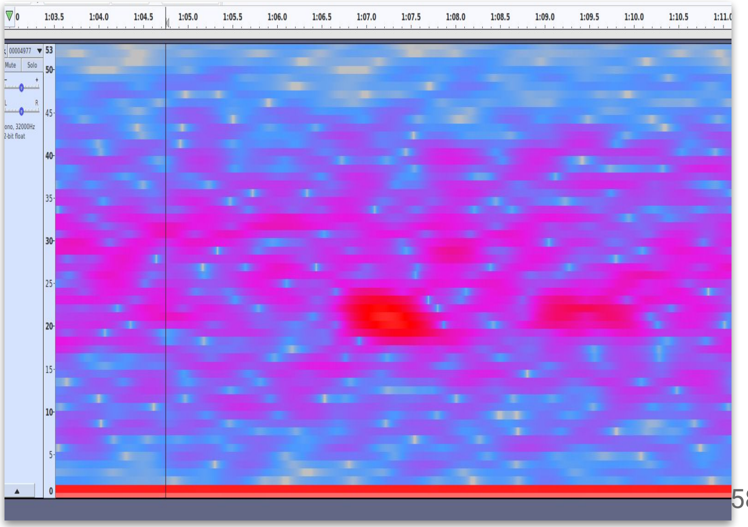
in Nature, Scientific Report, Poupard Ferrari Best, Glotin 2021

b) Fin whale pulse detection (low frequency)



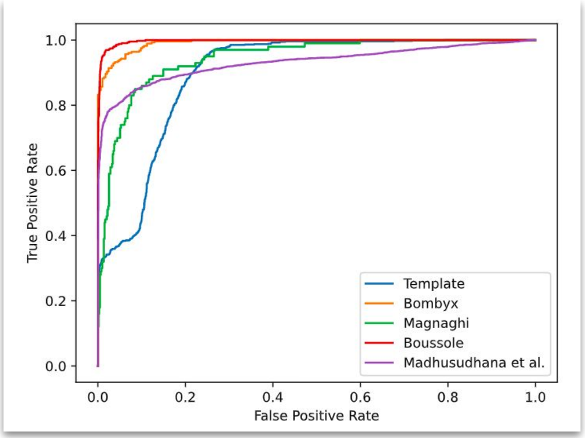
Monitoring fin whale (Balaenoptera physalus) acoustic presence by means of a low frequency seismic hydrophone in Western Ionian Sea - EMSO site. Gianni Pavan

- Low centroid frequency
- Bandwidth : 5-7Hz
- Length : 1sec
- Periodicity : 15-40sec



Sample from sonobuoy Boussole 2009 dataset

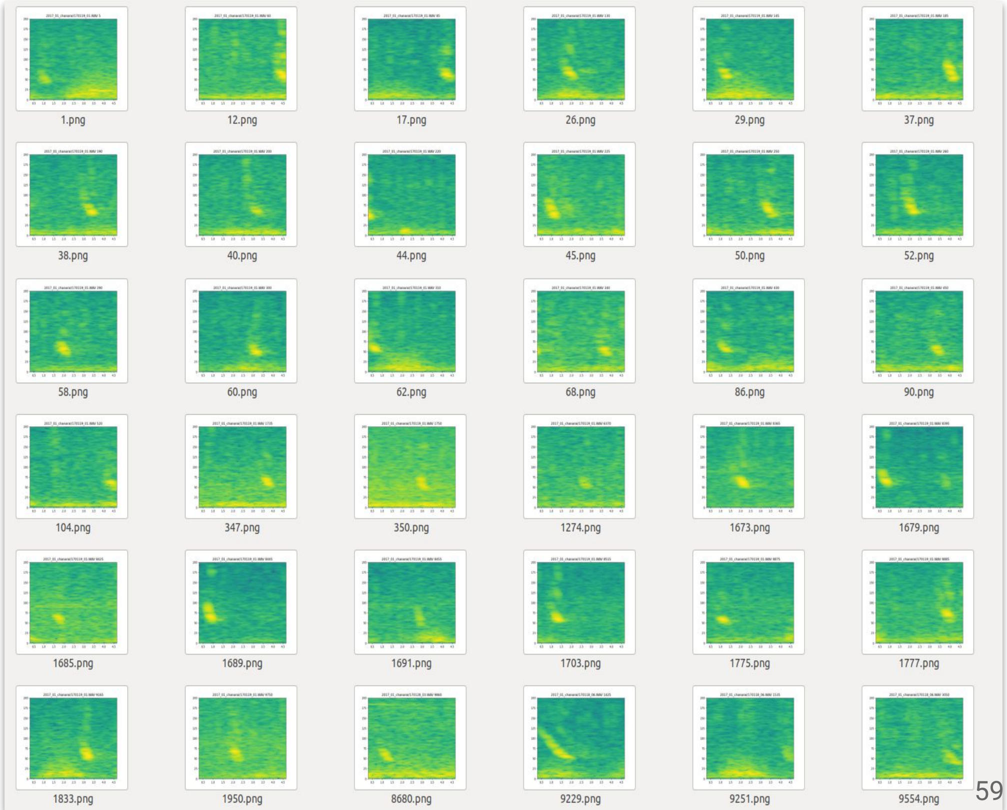
Low Frequency event classification : Fin whale pulse detection



- Sampling frequency = 200Hz
- STFT (winsize=256, hopsize=16)
- Mel (128 features from 0 to 100Hz)
- Log
- Conv 128 - 512
- Conv 512 - 512
- Conv 512 - 1
- MaxPool

Conv = batch norm, depthwise conv, dropout, Relu

Sample of high predictions over Chilian dataset
(rec. Patris, Malige, Glotin 2017, Chanaral, Humbold loop…)



Best et al 2021

The BOMBYX 2015-2018 = Count of Fin whales

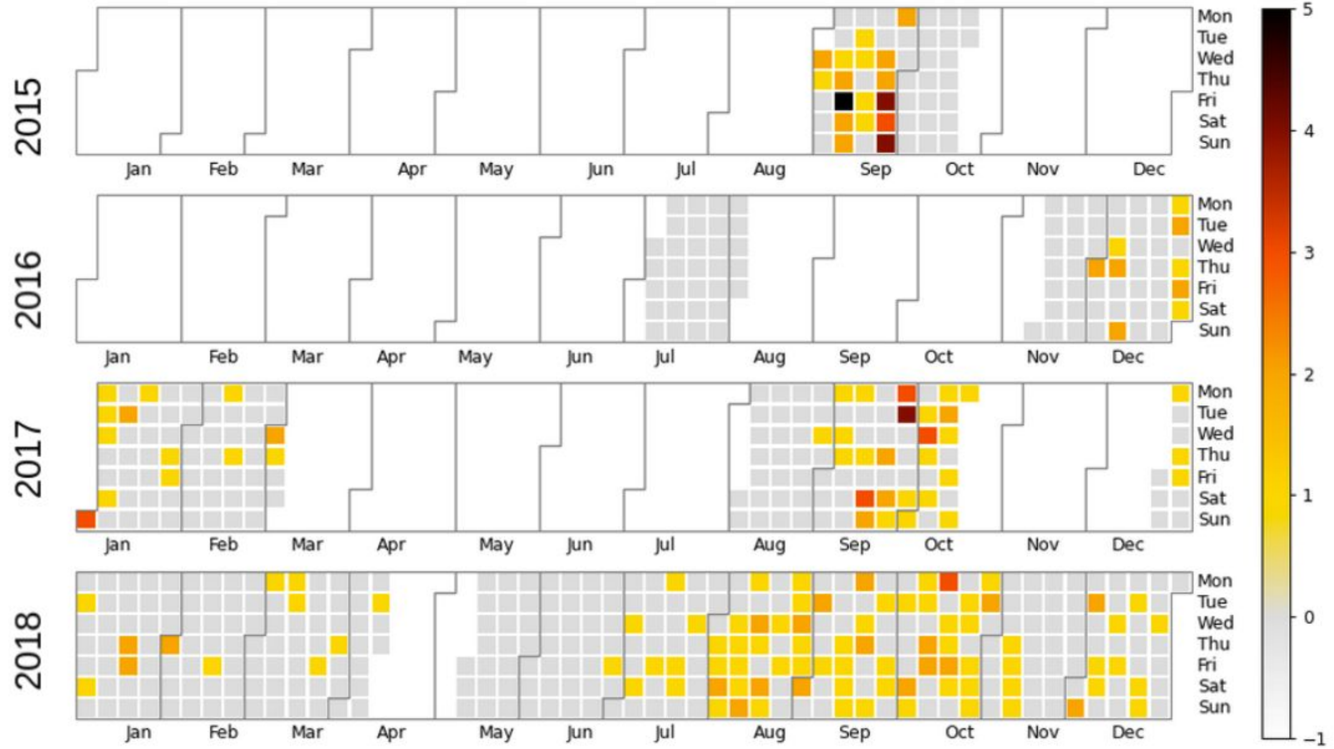
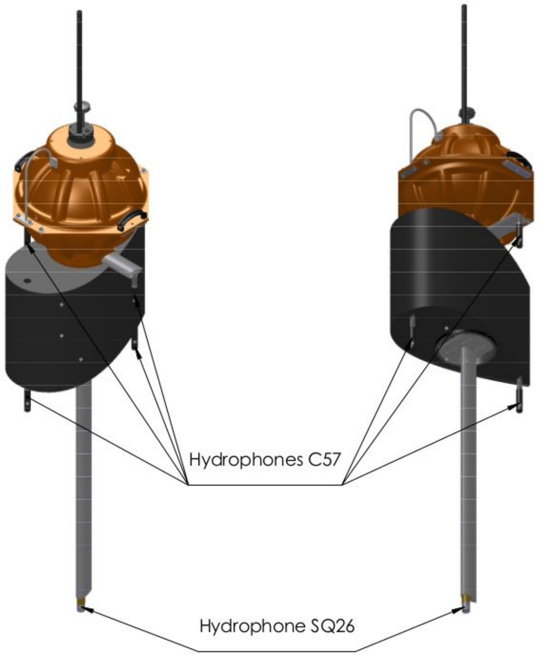


Figure : Calendar of the recorded days (grey cells). Shades of red denote the number of detected roqual (sequences) per day (ranging from 0 to 5)

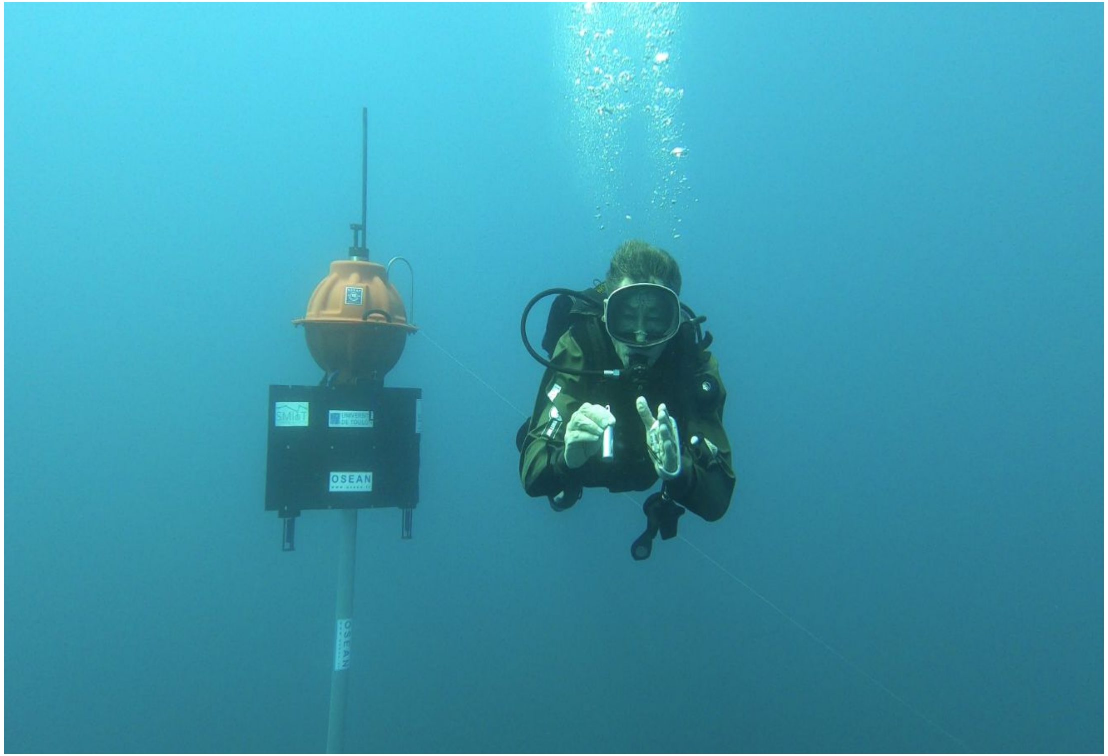
submitted to Nature Scientific Report “Temporal evolution of the Mediterranean fin whale songs”, Best, Marxer, Paris, Glotin, 2021

c) Putting all together into BOMBYX 2 : low power AI real-time alert

4G or IRIDIUM transmission



5 hydrophones intelligent listening

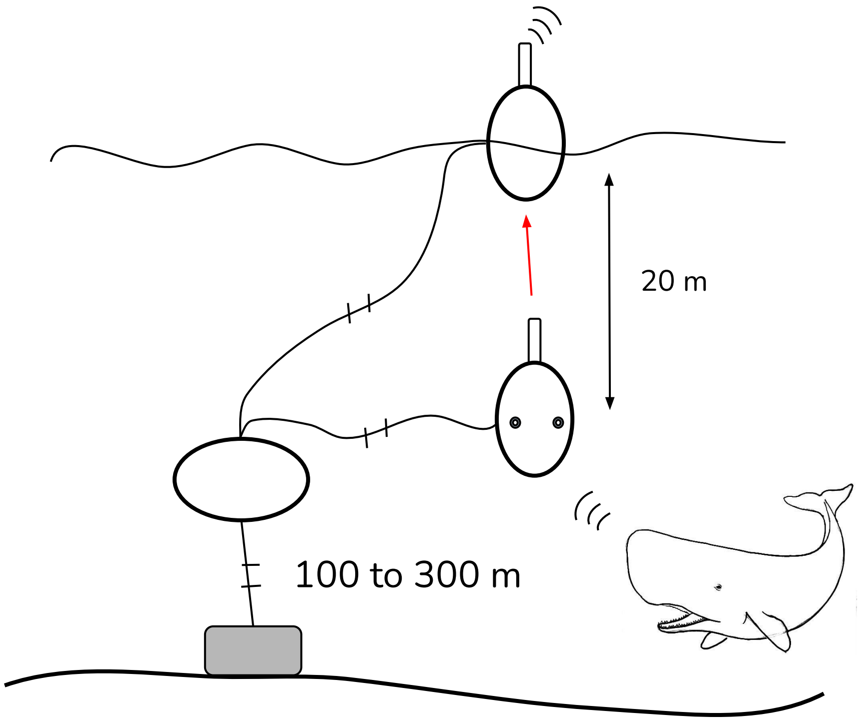


GIAS MARITTIMO Glotin et al 2018-2021, coll OSEAN, SMIoT

Application to Online AI Bombyx 2

4G emission to LIS, PELAGOS, PREMAR, REPCET

- To be placed in 2022
  - South of Port-Cros Island and Cape Corsica
- Floatability variation system
  - 20m deep recording and surface 4G communications
- Alert system for sperm whale and fin whale presence
  - Mitigate ship strikes risk
- 5 hydrophones
  - Azimuth and distance estimation
- Battery powered (approx. 6 month)
- PIC32-Mz microprocessor



Embeded AI
Bombyx2 - Analog wake-up

- Background noise estimation
- >8kHz Energy thresholding
- State Machine consistency validation
- 75% AUC on Bombyx 1
- Ultra low power **12.5µA**

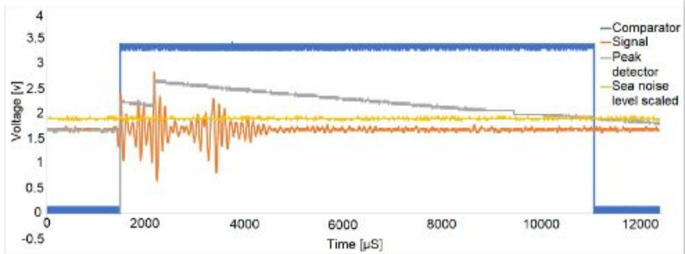


Fig. 7. Clicks of cetacean (Pm) with ULP processing, acquired on real signals (High-pass filtered input signal (orange), V_{Ref} (yellow), click envelope (grey), output of the comparator (blue)).

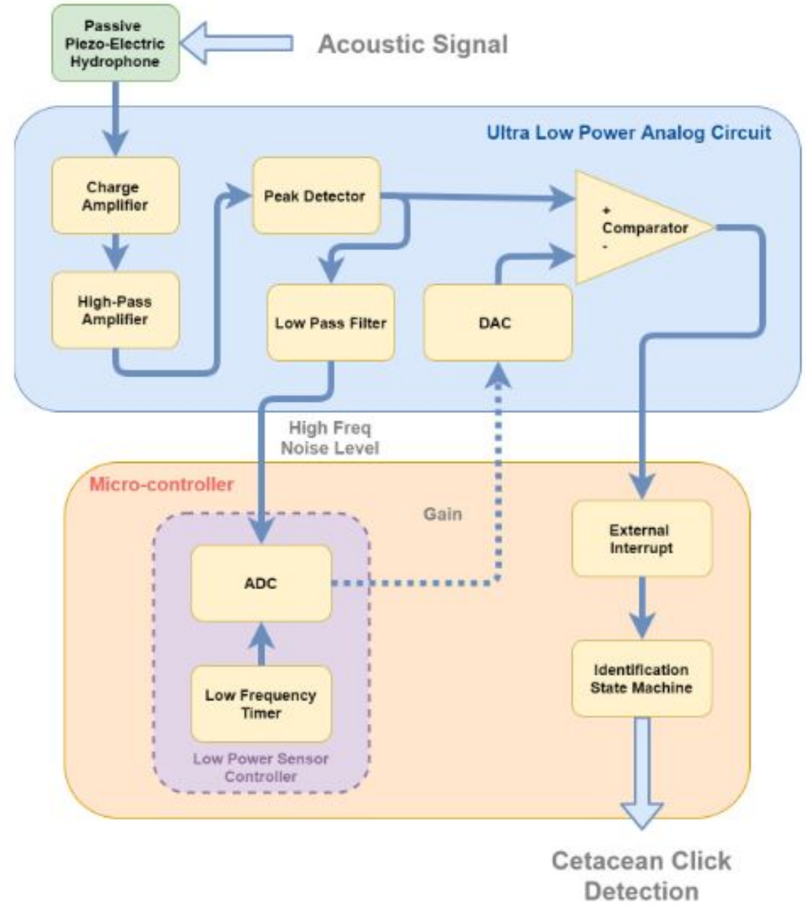
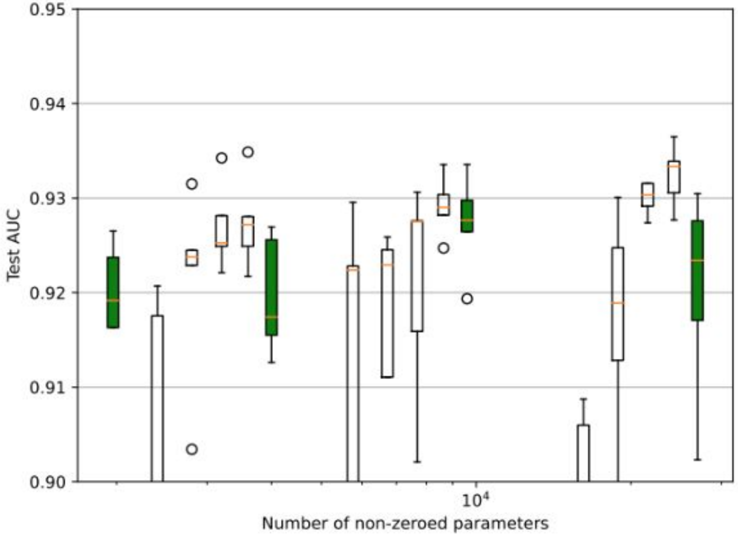


Fig. 4. Block diagram of the detector of a train of pulses of a Sperm Whale.

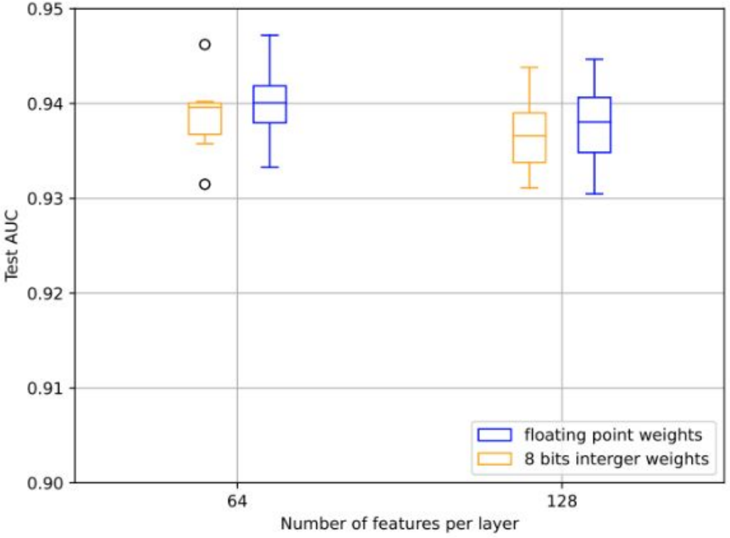
S. Marzetti, V. Gies, V Barchasz, P. Best, S. Paris, H. Barthelemy, H. Glotin (2020), Ultra-Low Power Wake-Up for Long-Term Biodiversity Monitoring, in proc. IEEE IoTAIS

Réduction de la complexité

Weight pruning



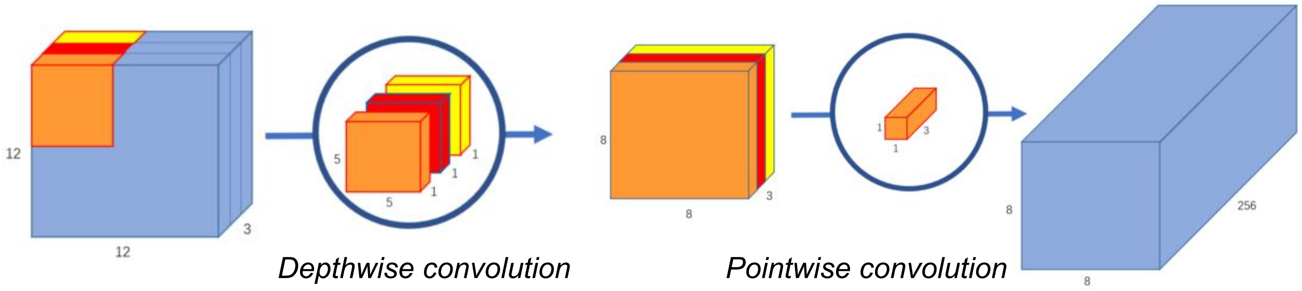
Weight quantisation



Guo, Yiwen, Anbang Yao, and Yurong Chen. "Dynamic network surgery for efficient dnns." Advances in neural information processing systems 29 (2016).

Hubara, Itay, et al. "Quantized neural networks: Training neural networks with low precision weights and activations." The Journal of Machine Learning Research 18.1 (2017): 6869-6898.

Embedded AI
Depthwise separable convolution, decimated CNN



Depthwise convolution   *Pointwise convolution*

Conv :   5 x 5 x 3 x 256
DW Conv : 5 x 5 x 3 + 3 x 256

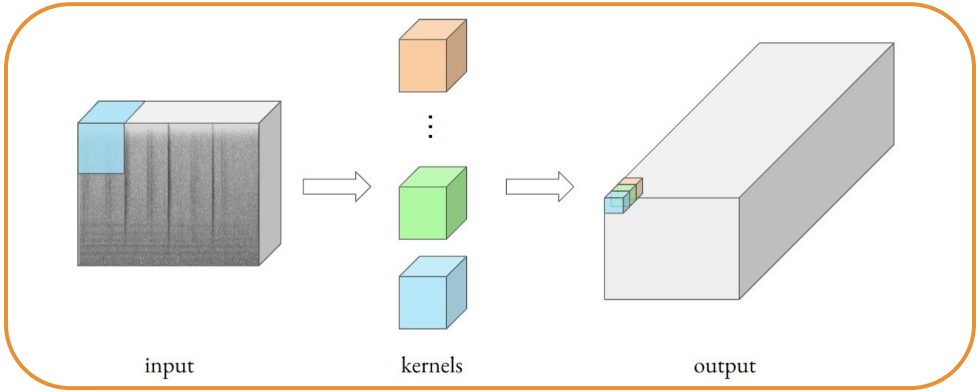
	# parameters	# mutliplications
Traditional	272 $x10^3$	309 $x10^6$
Depthwise	11 $x10^3$	13 $x10^6$

- Conv 64 - 512
- Conv 512 - 512
- Conv 512 - 1

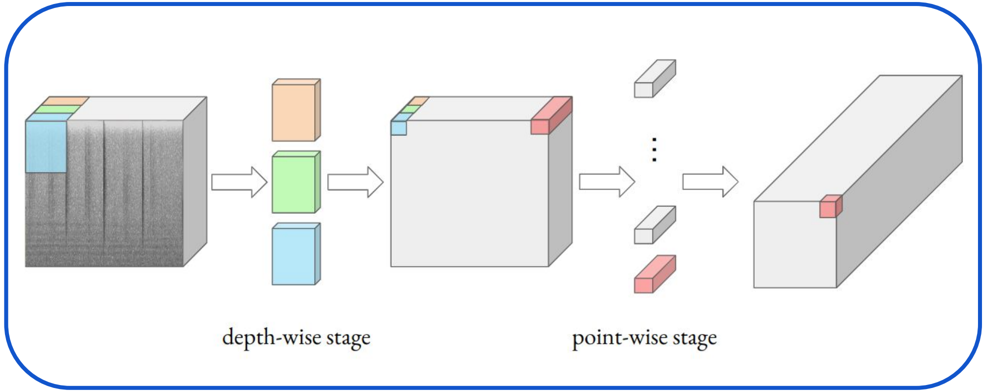
L. Bai, Y. Zhao and X. Huang, "A CNN Accelerator on FPGA Using Depthwise Separable Convolution," in *IEEE Transactions on Circuits and Systems II: Express Briefs*, vol. 65, no. 10, pp. 1415-1419, Oct. 2018, doi: 10.1109/TCSII.2018.2865896.

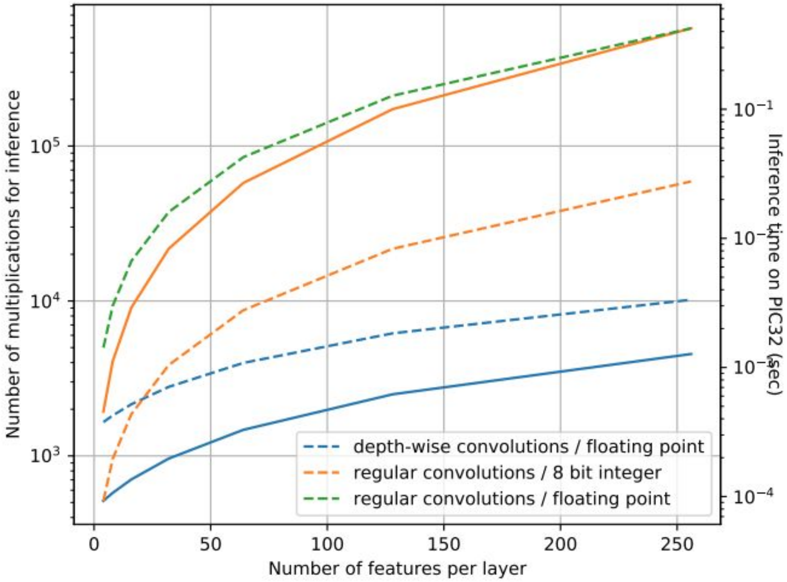
Depthwise separable convolutions

Regular conv.



Depthwise conv.

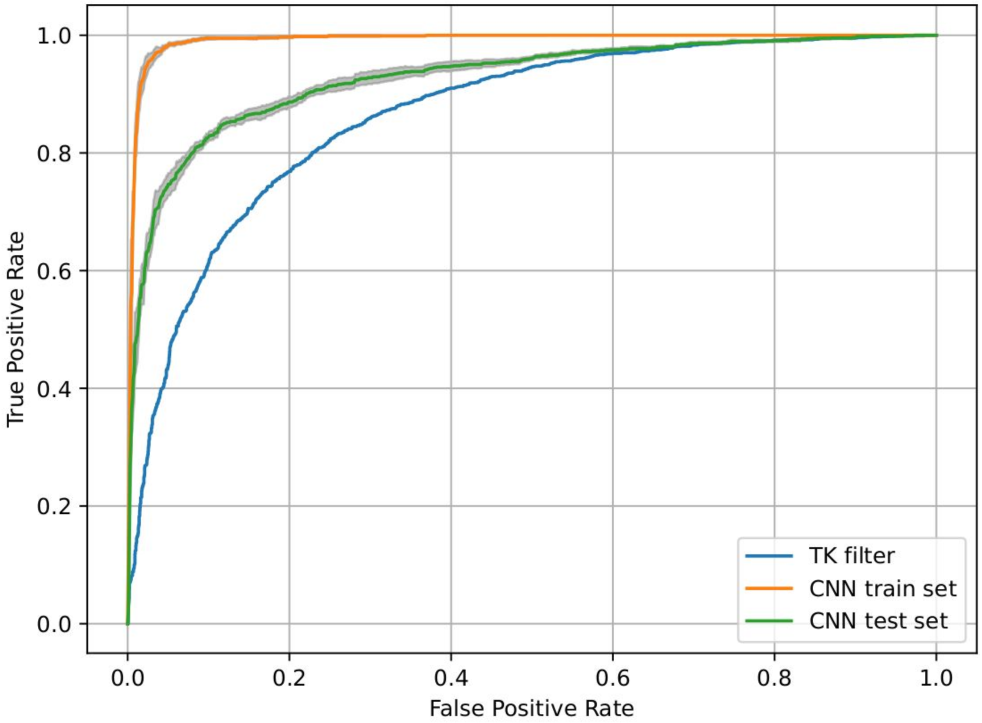




Chollet, François. "Xception: Deep learning with depthwise separable convolutions." Proceedings of the IEEE conference on computer vision and pattern recognition. 2017.

Performances de détection de clics de cachalots

Receiving Operating Characteristics (ROC)



Area Under the ROC Curve (AUC-ROC):

- Teager-Kaiser energy operator: 0.86
- Mel STFT + depthwise CNN: **0.93**

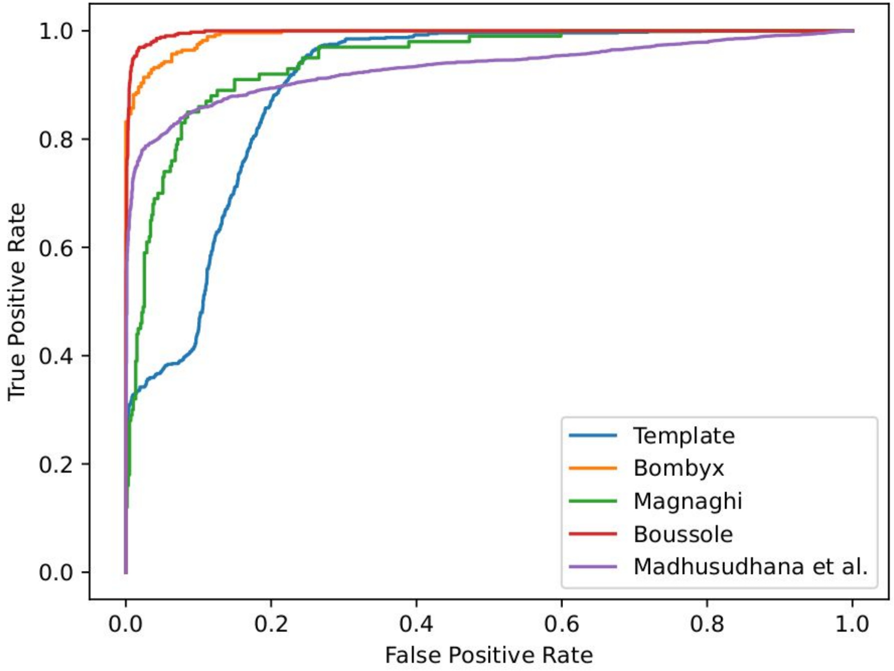
Kandia, V., and Y. Stylianou. "Detection of sperm whale clicks based on the Teager–Kaiser energy operator." Applied Acoustics 67.11-12 (2006): 1144-1163.

Performances de détection de pulses de rorqual

- Template matching : 0.90AUC-ROC

Test set AUC-ROC

1999	0.94
2008-2009	1
2015-2018	0.99
Madhusudhana et al. 2021	0.93



Madhusudhana, Shyam, et al. "Improve automatic detection of animal call sequences with temporal context." Journal of the Royal Society Interface 18.180 (2021): 20210297.

Bombyx 2

Low complexity CNNs

	params type	# params	poids params	# mutliplications
Depthwise	float32	11K	54Ko	13 M
Quantized	int8	272K	1.1Mo	309 M

- Sampling frequency = 50kHz
- STFT (winsize=512, hopsize=256)
- Mel (64 features from 2 to 25kHz)
- Log
- Conv 64 - 64
- Conv 64 - 64
- Conv 64 - 1
- MaxPool

Conv = batch norm, depthwise conv, dropout, Relu
Valid AUC = 93 %

Sperm whale binary classifier

- Sampling frequency = 200Hz
- STFT (winsize=256, hopsize=16)
- Mel (128 features from 0 to 100Hz)
- Log
- Conv 128 - 512
- Conv 512 - 512
- Conv 512 - 1
- MaxPool

Conv = batch norm, depthwise conv, dropout, Relu
Valid AUC = 90 %

Fin whale binary classifier

Embeded AI
Into Low power micro-processor (PIC)

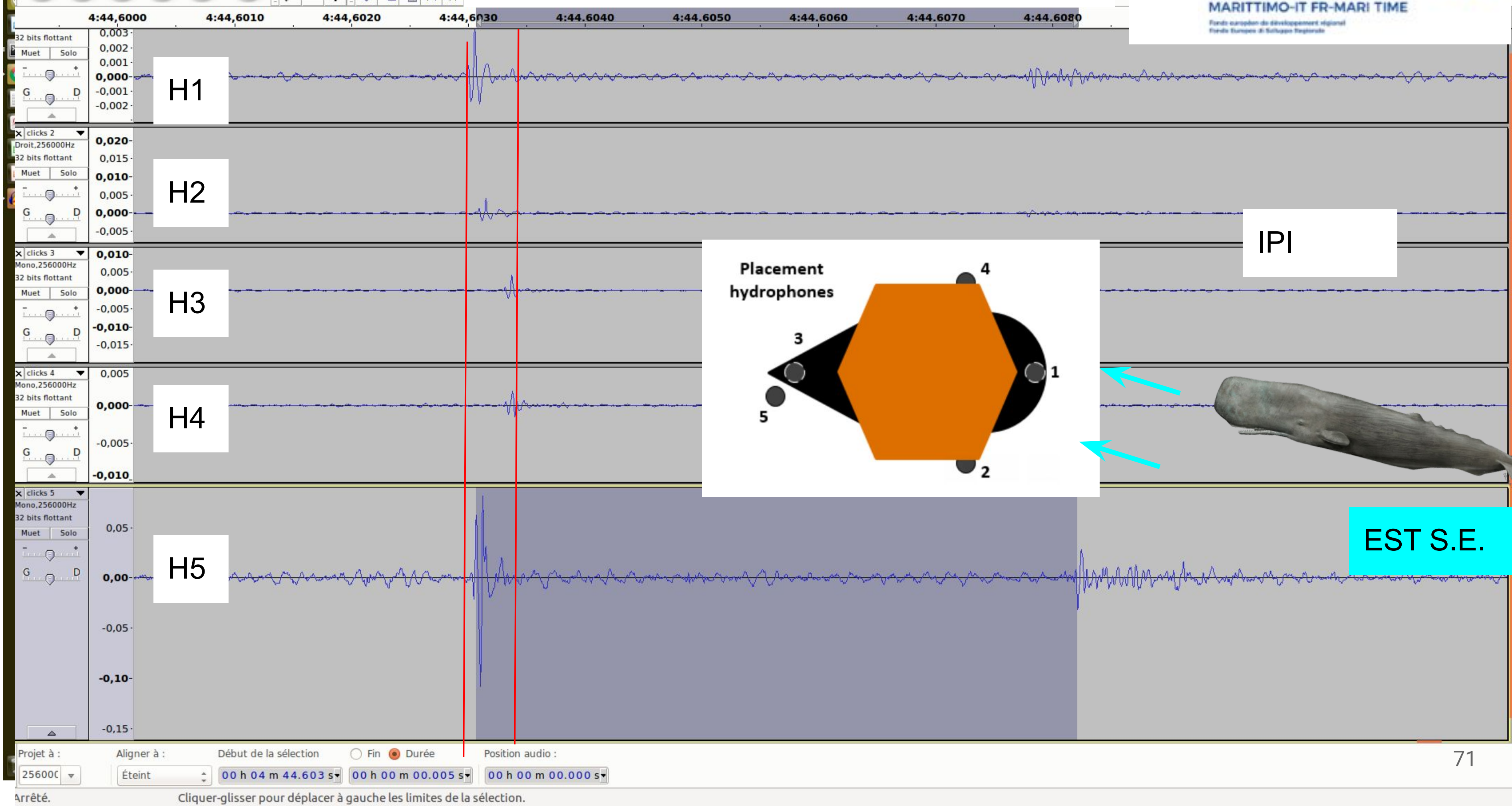
Analyse pour 5 secondes de signal

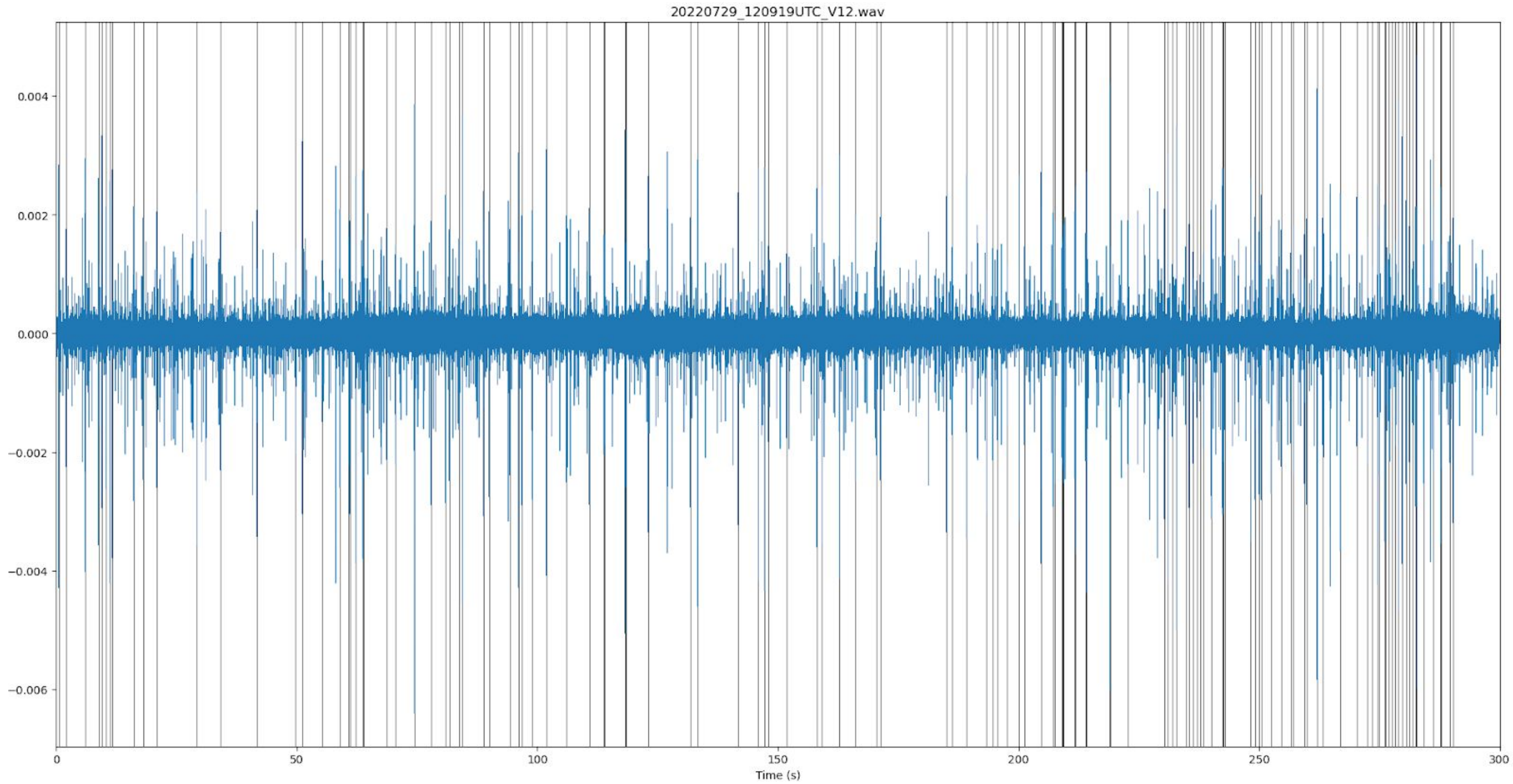
	Fin Whale	Sperm Whale
Sampling rate	200 Hz	50 kHz
Spectrogram size	128 x 46	64 x 974
Spectrogram computation time	0.2 sec	4.5 sec
Forward pass time	0.5 sec	2.1 sec

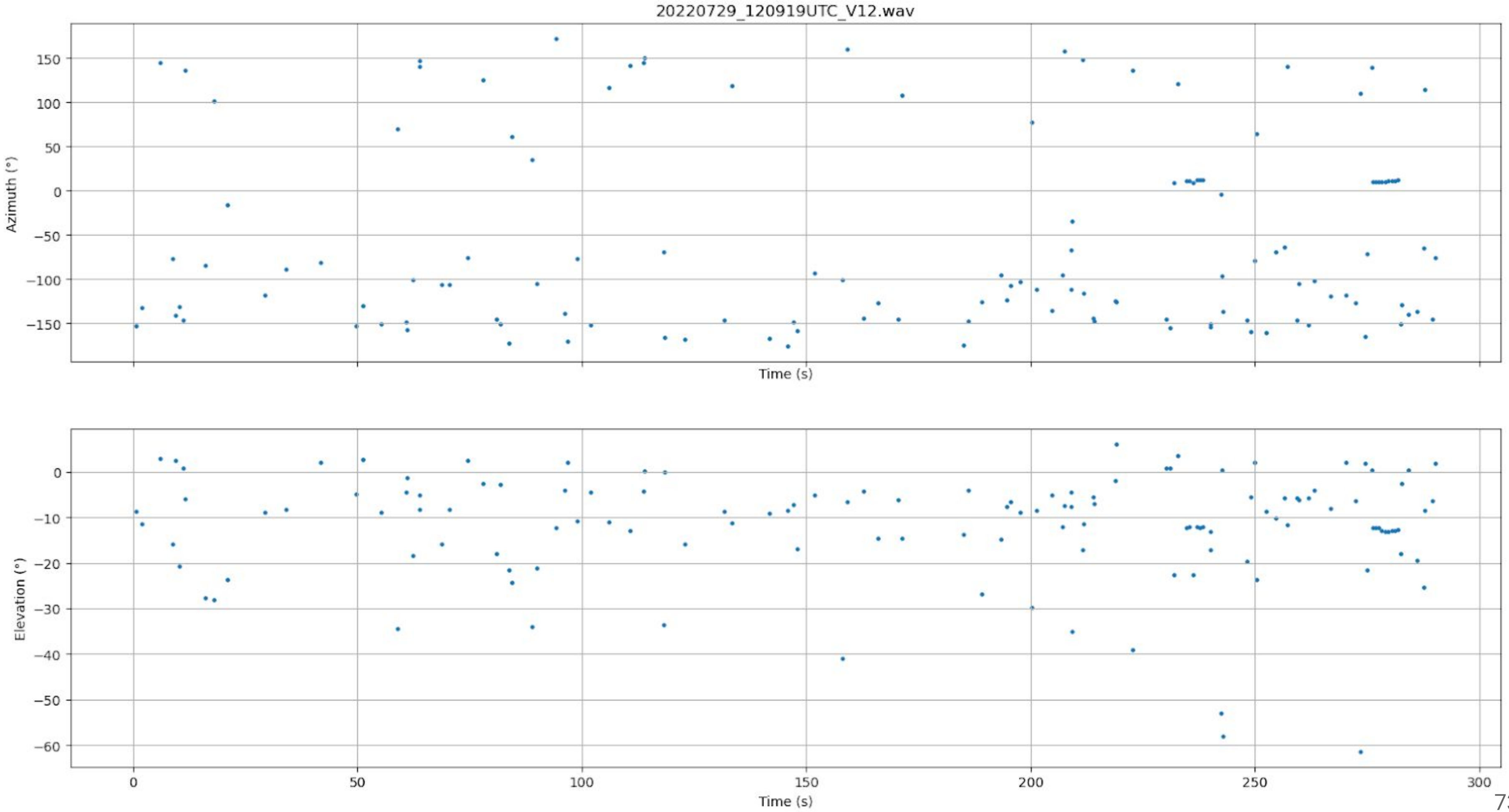
PIC 32MZ by Microchip

Best et al 2020

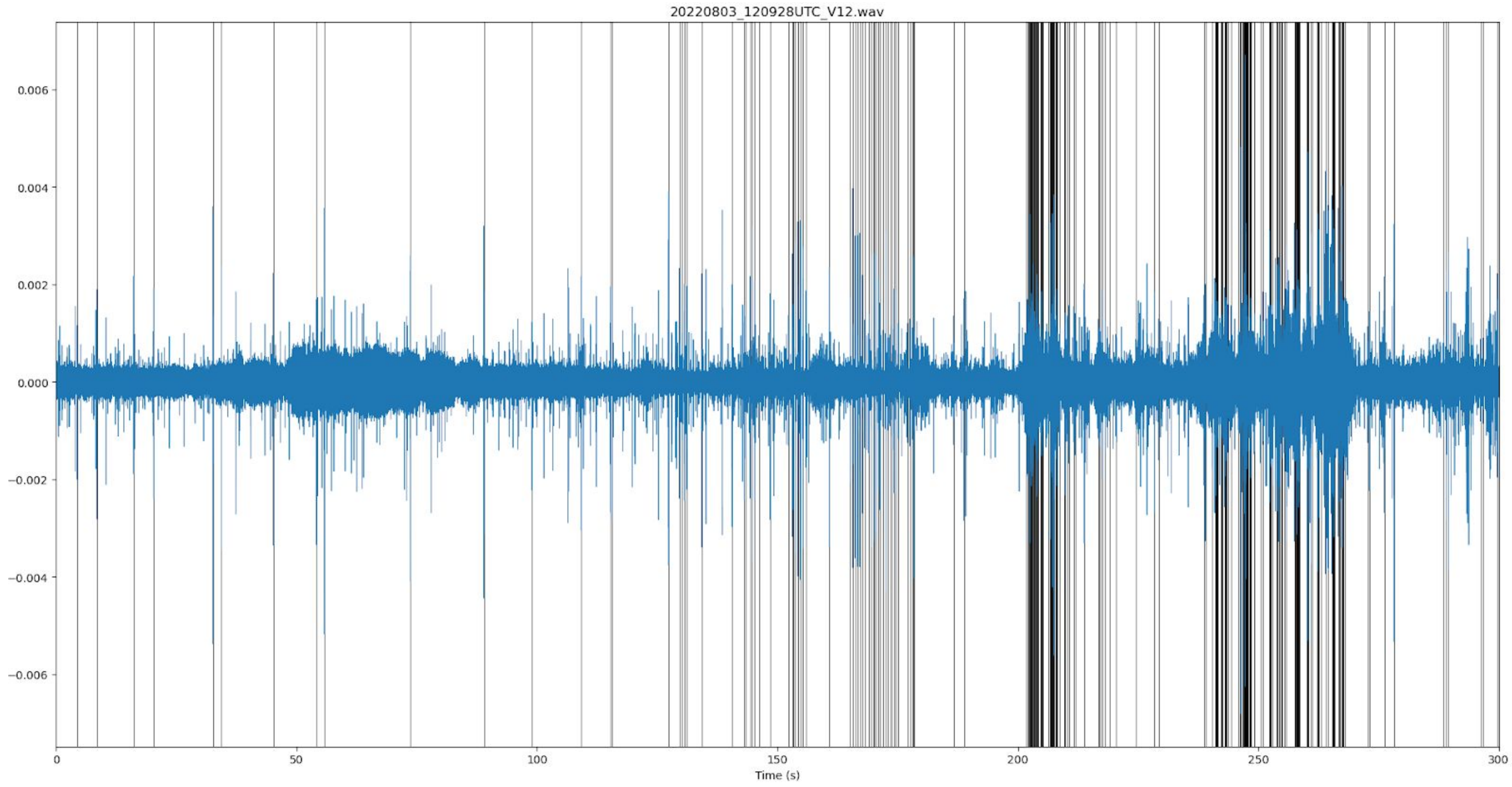
exemple de MESURE TDoA de CACHALOT



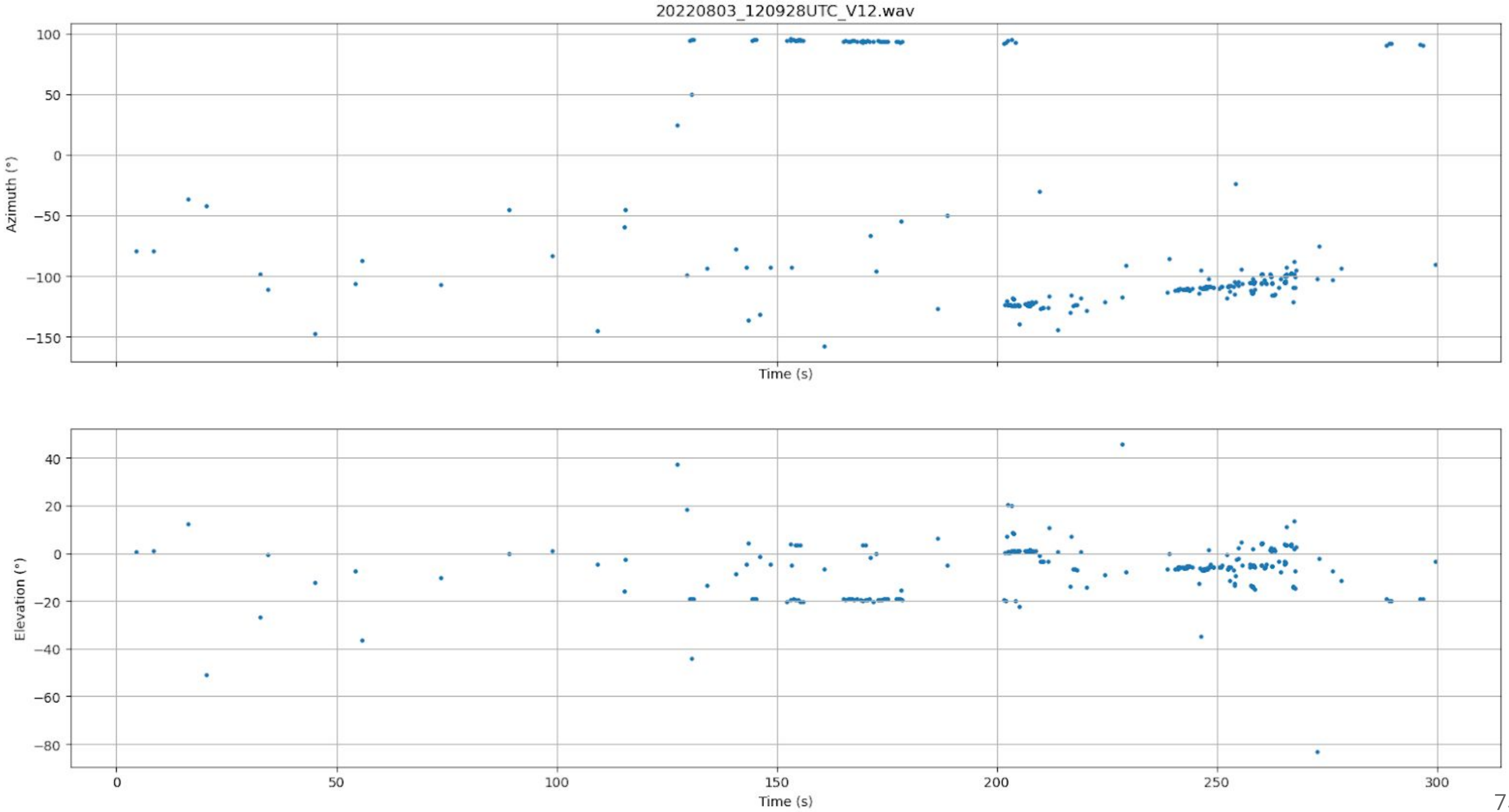

20220729_120919UTC_V12.wav
0.004
0.002
0.000
−0.002
−0.004
−0.006
0
50
100
150
200
250
300
Time (s)



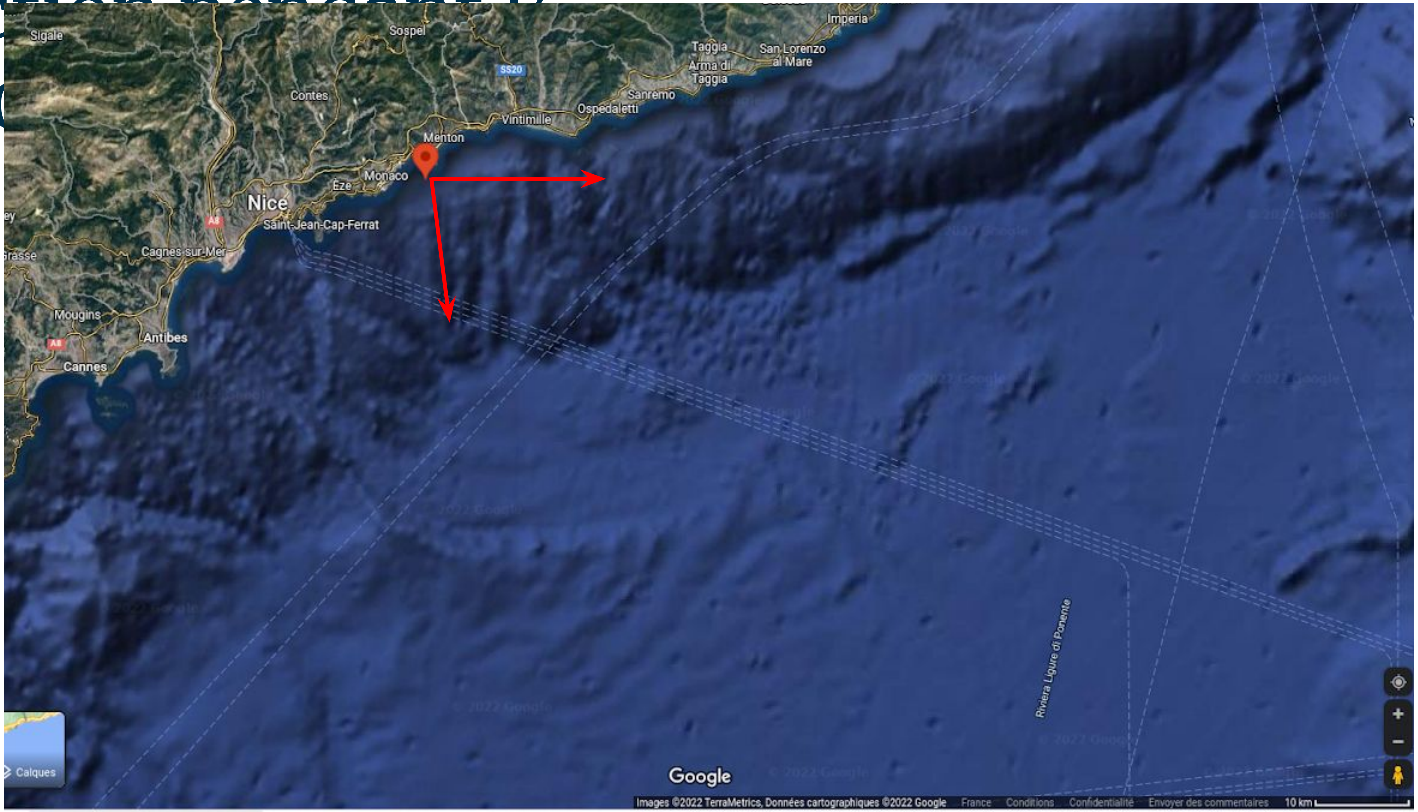
20220729_120919UTC_V12.wav
Azimuth (°)
150
100
50
0
−50
−100
−150
Time (s)
Elevation (°)
0
−10
−20
−30
−40
−50
−60
0
50
100
150
200
250
300
Time (s)



20220803_120928UTC_V12.wav
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
0
50
100
150
200
250
300
Time (s)

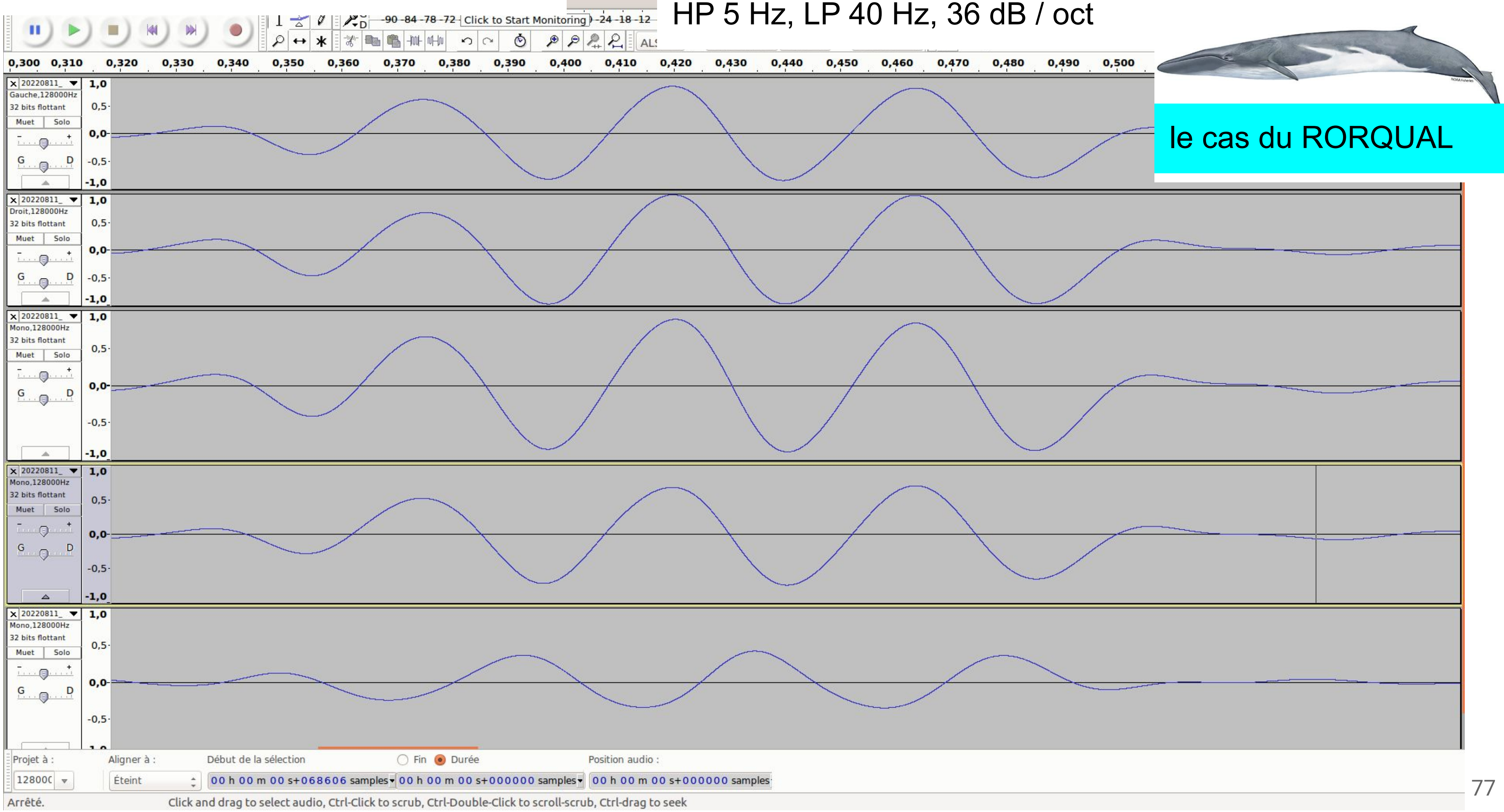

20220803_120928UTC_V12.wav
Azimuth (°)
100
50
0
−50
−100
−150
Time (s)
Elevation (°)
40
20
0
−20
−40
−60
−80
0
50
100
150
200
250
300
Time (s)

Exemples de détection pendant l’ été 20



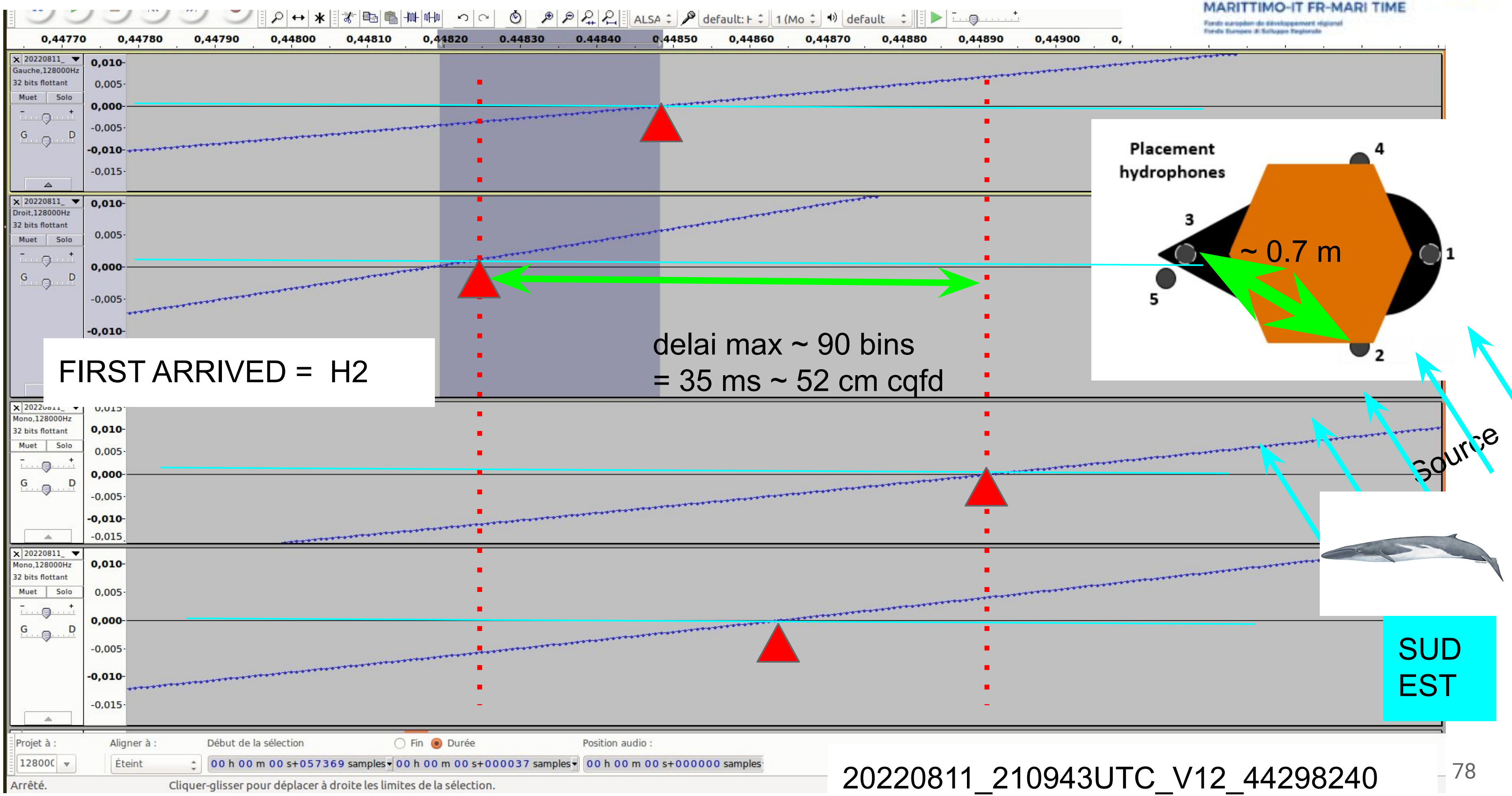
20220811_210943UTC_V12_44298240

HP 5 Hz, LP 40 Hz, 36 dB / oct



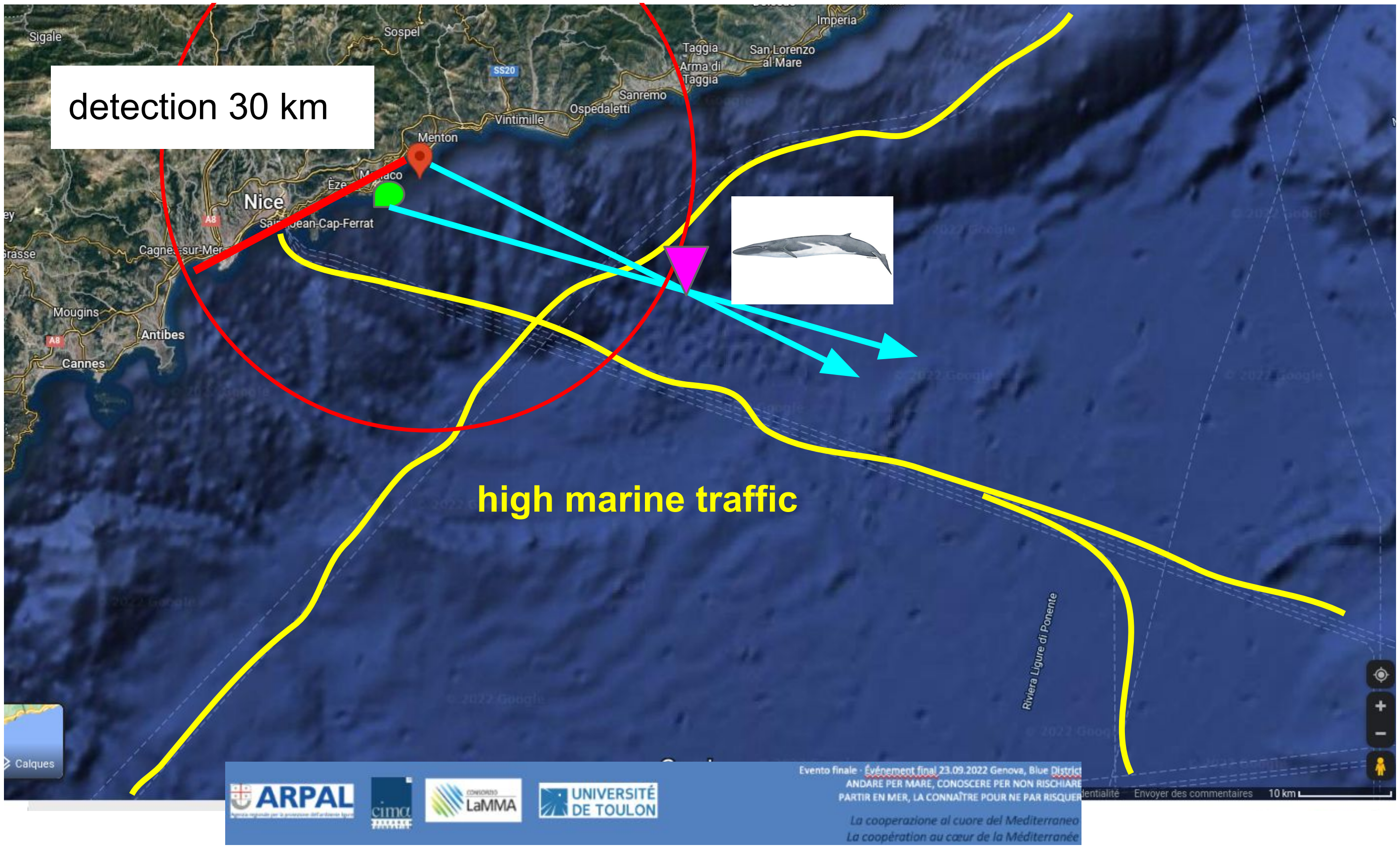
le cas du RORQUAL

20220811_210943UTC_V12_44298240



20220811_210943UTC_V12_44298240

Conclusion : pose de BX22 et BX21 jointes



Interreg MARITTIMO-IT FR-MARITIME

Conclusion

Fonctionnel
Déploiement final BX22 en cours
Envoie des rapports anti-collision temps-réel à MIRACETI REPCET / PREMAR
Mesures anthropophoniques
2023 : Financement de 2 + 4 autres bouées (TMP & UTLN) & Europe BIODIVERSA : ACORES & NORVEGE

RAPPORT : 5 minutes rec, 10 Mo :

Fin/Phy.log
t1 p1
t2 p2
…
tn pn

20220728_000918UTC_V12.wav	155	[illegible]
20220728_000918UTC_V12.wav	160	0.3529639
20220728_000918UTC_V12.wav	165	0.017730286
20220728_000918UTC_V12.wav	170	0.343511
20220728_000918UTC_V12.wav	175	0.03539723
20220728_000918UTC_V12.wav	180	0.08584233
20220728_000918UTC_V12.wav	185	0.917102
20220728_000918UTC_V12.wav	190	0.07624311
20220728_000918UTC_V12.wav	195	0.9999893
20220728_000918UTC_V12.wav	200	0.99990165
20220728_000918UTC_V12.wav	205	0.9406052
20220728_000918UTC_V12.wav	210	0.9485358
20220728_000918UTC_V12.wav	215	0.5486088
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20220728_000918UTC_V12.wav	225	0.054285493
20220728_000918UTC_V12.wav	230	0.15936567
20220728_000918UTC_V12.wav	235	0.6549609
20220728_000918UTC_V12.wav	240	0.07359292
20220728_000918UTC_V12.wav	245	0.08724517

MIRACETI
Place des traceurs de pierres
La Couronne, 13500 Martigues
SIRET : 521 476 267 00039

Mme Hélène LABACH,
Directrice de MIRACETI
hlabach@miraceti.org
06 36 50 03 03

A La Couronne, le 09 mars 2021

Objet : **Manifestation d'intérêt**

Madame, Monsieur,

Par la présente, je souhaite manifester l'intérêt de notre association MIRACETI pour des données scientifiques issues de l'observatoire acoustique Bombyx déployé par le Laboratoire d'Informatique et Systèmes de l'Université de Toulon (Pr. Hervé Glotin).

En effet, dans le cadre de notre programme « Navigation commerciale et cétacés » nous sommes référent scientifique pour le logiciel REPCET (www.repcet.com) qui tend à limiter le risque de collision entre les grands cétacés et les gros navires. Actuellement, le logiciel permet, en temps réel, de signaler et partager entre usagers des positions des cétacés repérés visuellement par les personnels de quart des navires équipés du système (le réseau REPCET comptabilise à ce jour 40 navires de commerce et d'Etat). Pour enrichir le logiciel, nous souhaitons expérimenter l'intégration de nouvelles données issues notamment de détections acoustiques. Ainsi, nous serions intéressés par certaines informations pouvant êtes extraites des algorithmes des bouées de l'observatoire Bombyx :

- L'espèce détectée (cachalot ou rorqual) ;
- La date et l'heure de la détection ;
- La localisation lors de la détection ;
- Le cap et la vitesse des animaux ;
- Un échantillon de signal pour assurer la véracité de la détection ;

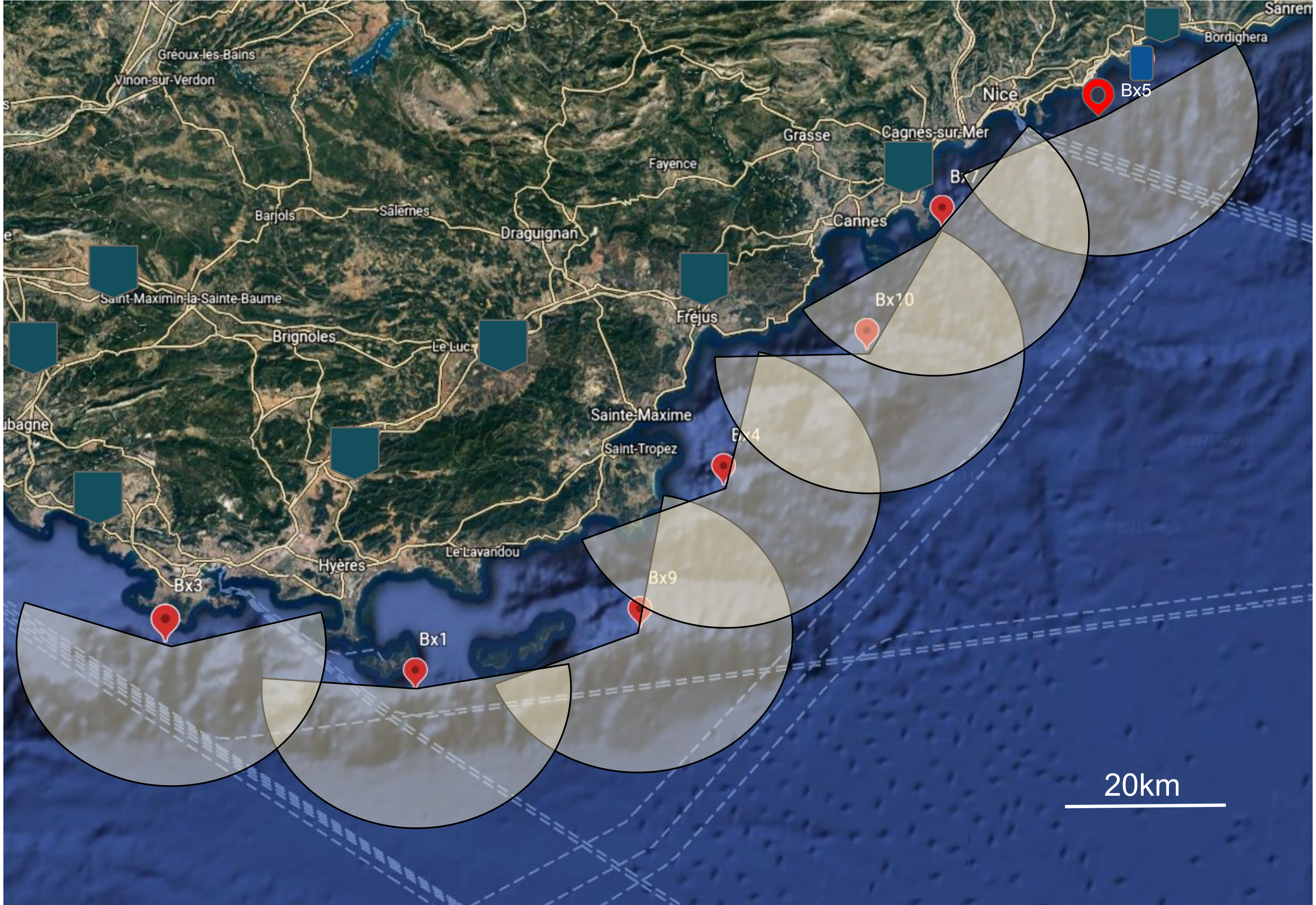
Nous ne doutons pas de la valeur ajoutée que constituent ces données dans un contexte où les espèces sont de plus en plus soumises aux pressions anthropiques.

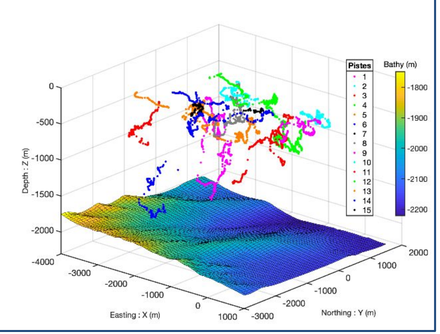
Pour servir ce que de droit,

Hélène LABACH,
Directrice de MIRACETI

BOMBYX

FEDER
GIAS





FONDATION PRINCE ALBERT II DE MONACO

Explorations de Monaco · Monaco Explorations

ACCOBAMS

SEA PROVEN

UNIVERSITÉ DE TOULON

SMIoT

SABIOD.ORG Scaled Acoustic Biodiversity Mastodons Big Data

DYNI

CNRS

Etho-acoustics of Megafauna

from short 4D mobile hydrophone array, and lock down effect

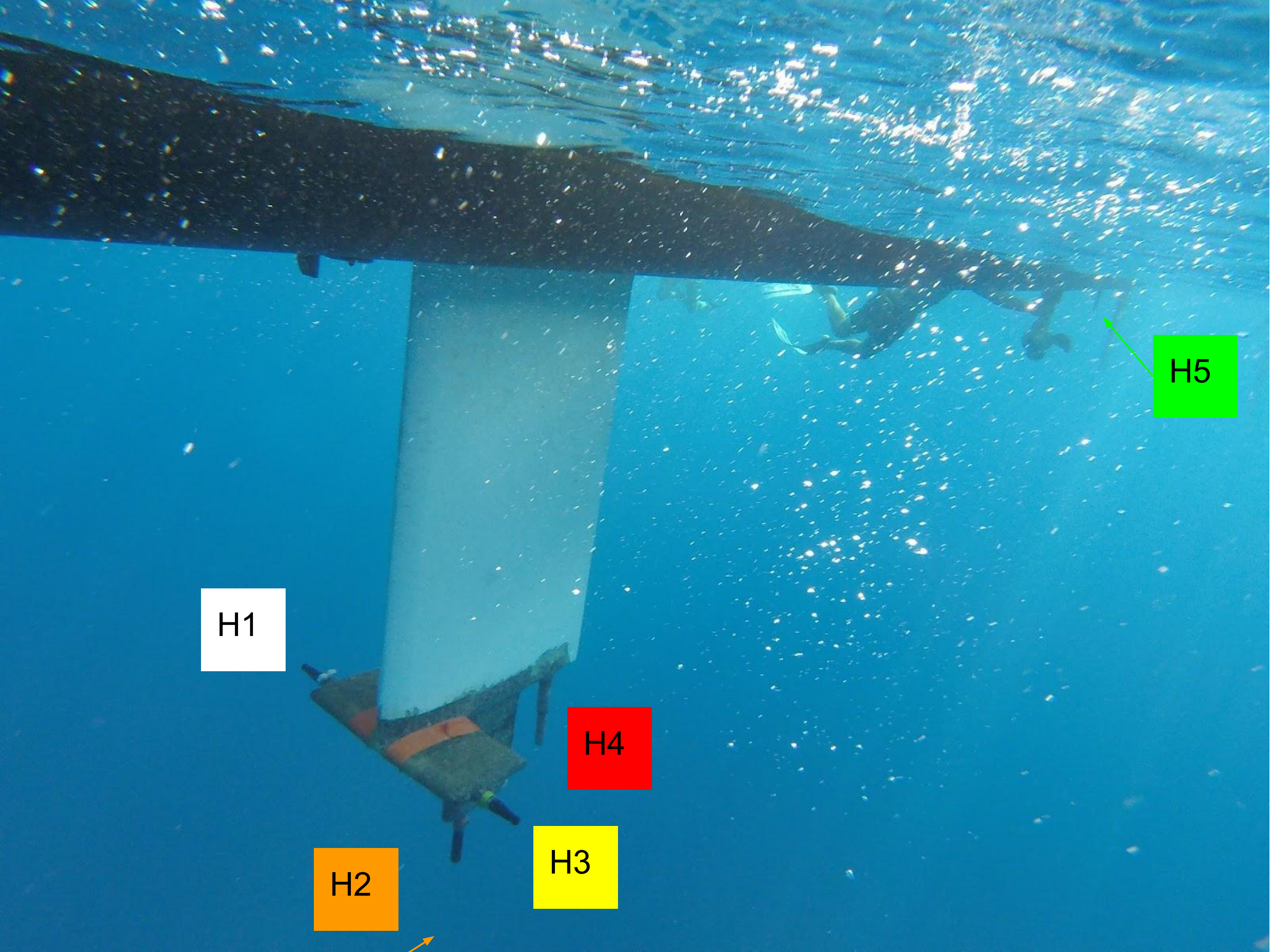
The ASV Sphyrna

ALV Sphyrna (SeaProven)

Polynesian Design, 20 m, Stable

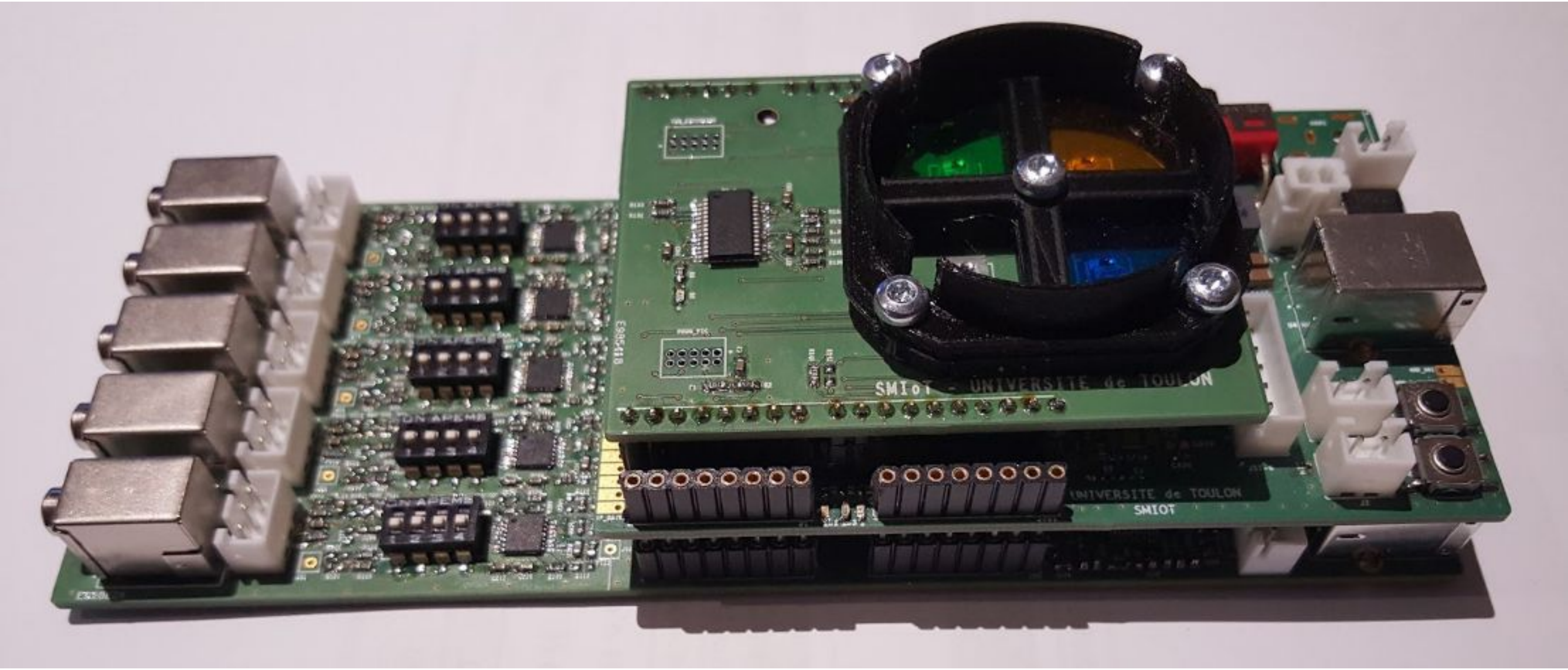
Hydrodynamic, Low acoustic print

1 t. useful charge.



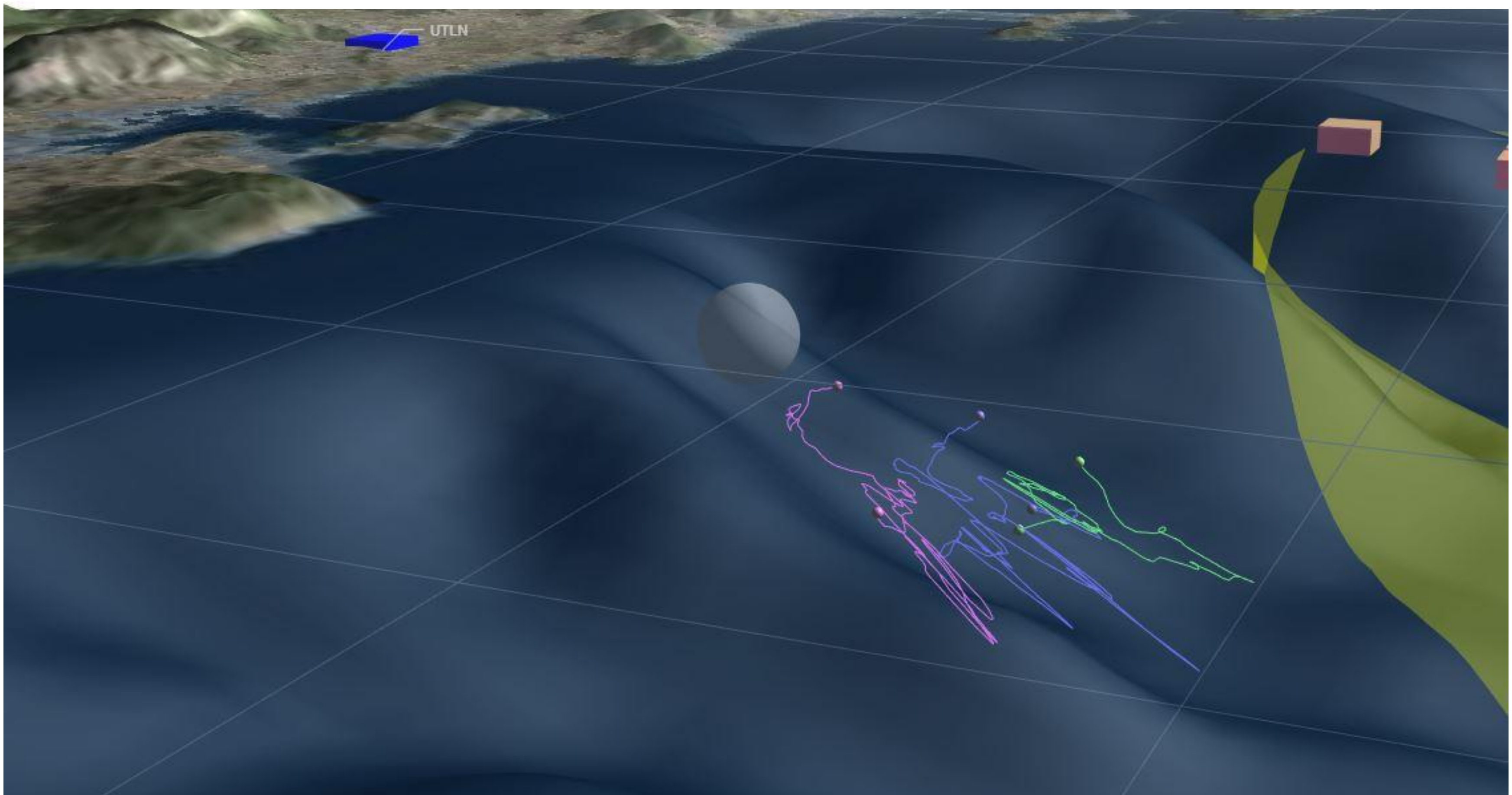
The 5 hydros fixed under the keel of the ASV.

The JASON sound card from univ. Toulon, SMIoT, allowing 5 x 1 mHz Sampling rate + luxmeter, into the drone

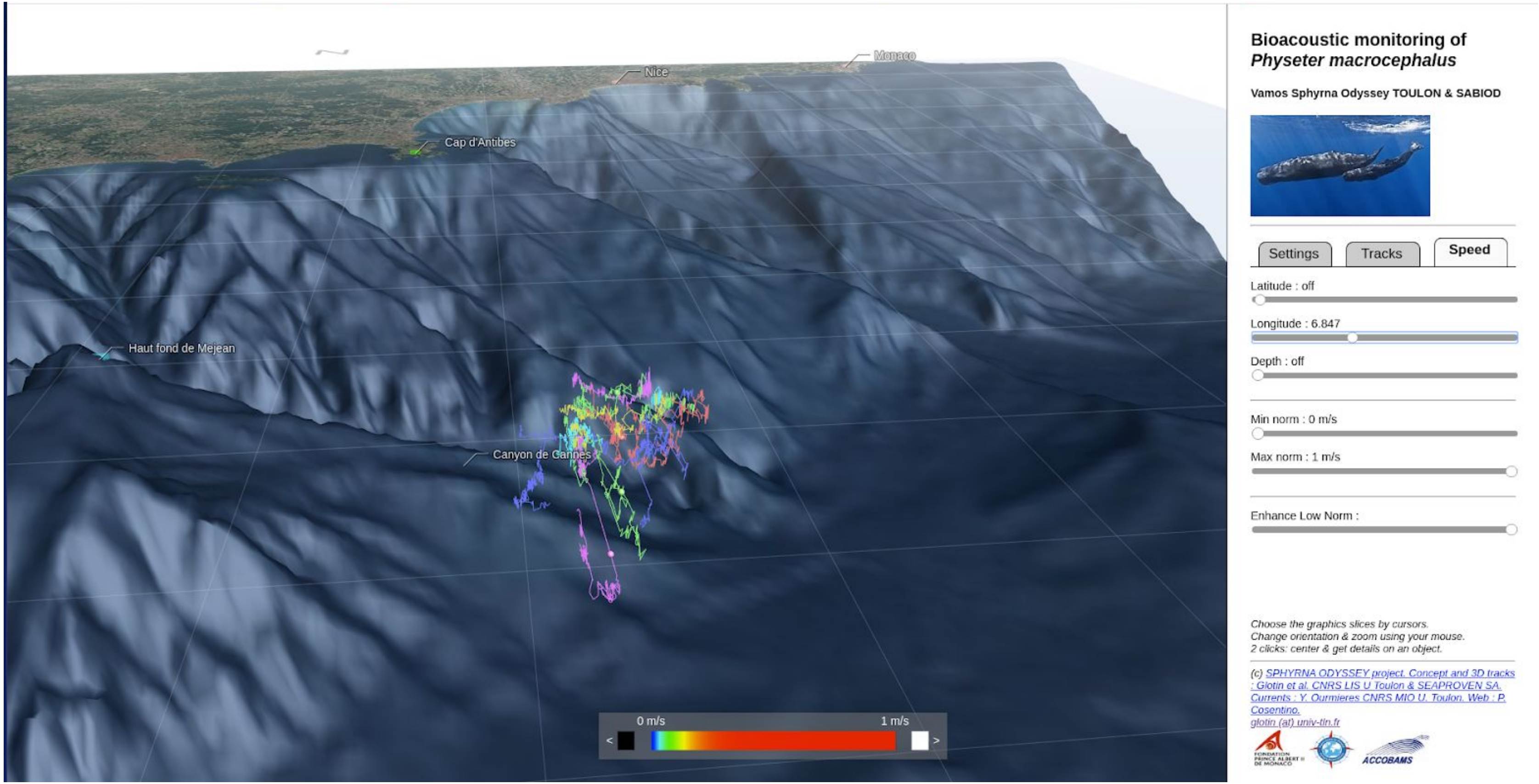


Clear dolphin clicks, TDOA measures, recorded on 5 channels, Chan 1, 4, 5 = gain x 4, Chan 2, 3 = gain 1/2

August 2018, 1 Physeter, 3 tracks, 50 minutes each, down to -1000 m



January 2020, South of Antibes



https://sabiod.lis-lab.fr/pub/SPHYRNA/3D/current_norm/

Matching poursuit & tracking 3D

Missions Sphyrna 2018, 2020, 2021...

Bio-Multistatisme ?

=> corpus & AI

Det Class Loc & Propagation joints

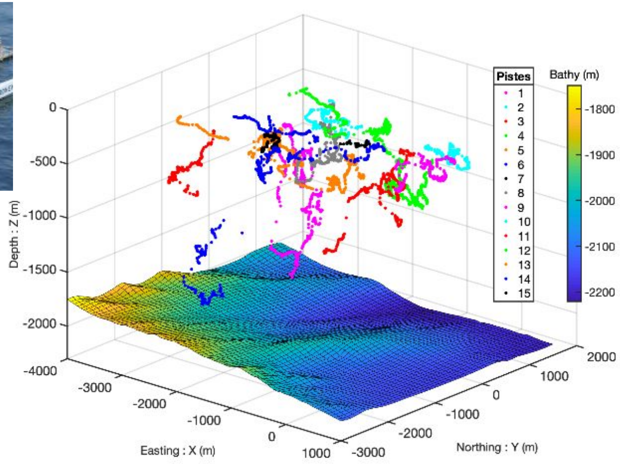
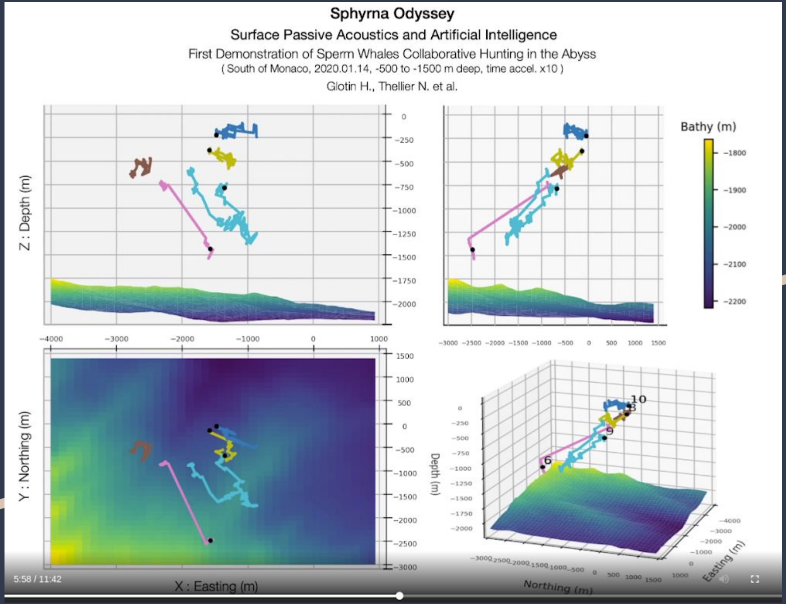
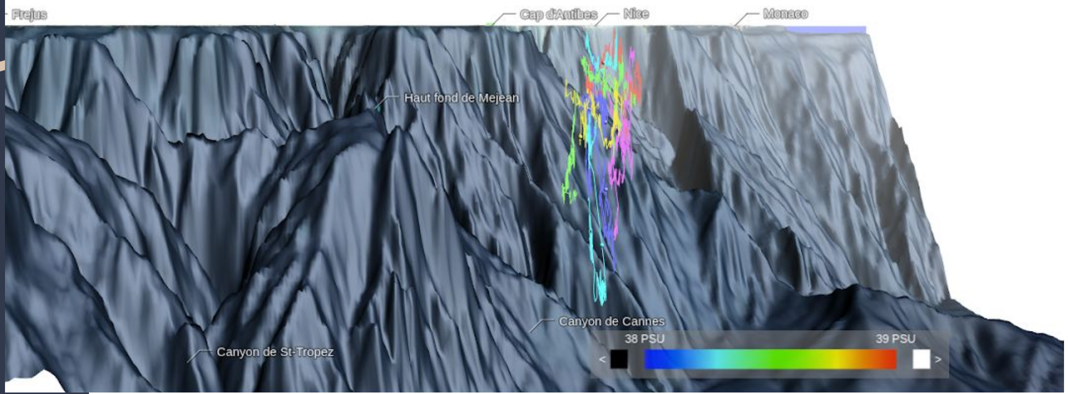


Figure 3.1: Traces 3D des déplacements des 15 pistes (record entier)





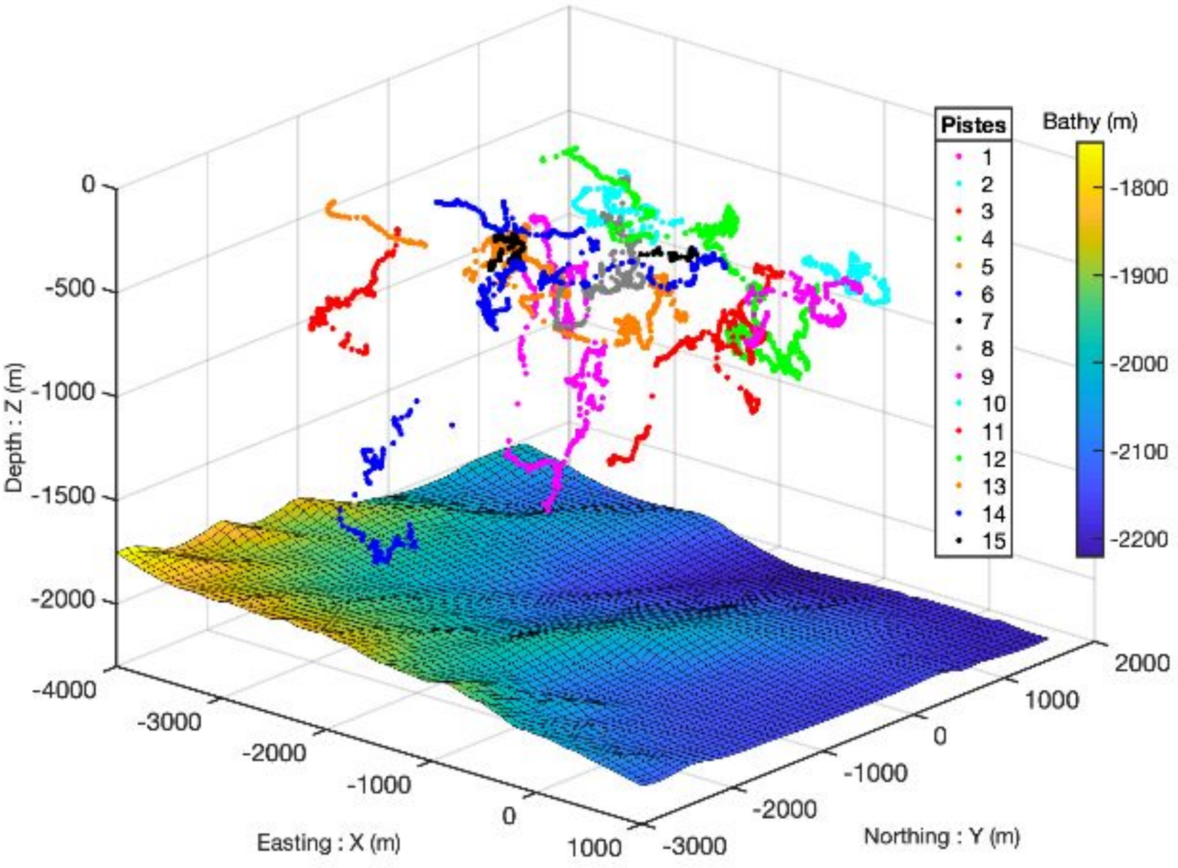
14 january 2020, 6 Physeters : Alliance = coordination up to 500m

http://sabiod.univ-tln.fr/pub/SPHYRNA/Sphyrna_Odyssey_3DAbyssalAlliance20200114Monaco.mp4

Correlation between
the tracks : Alliance

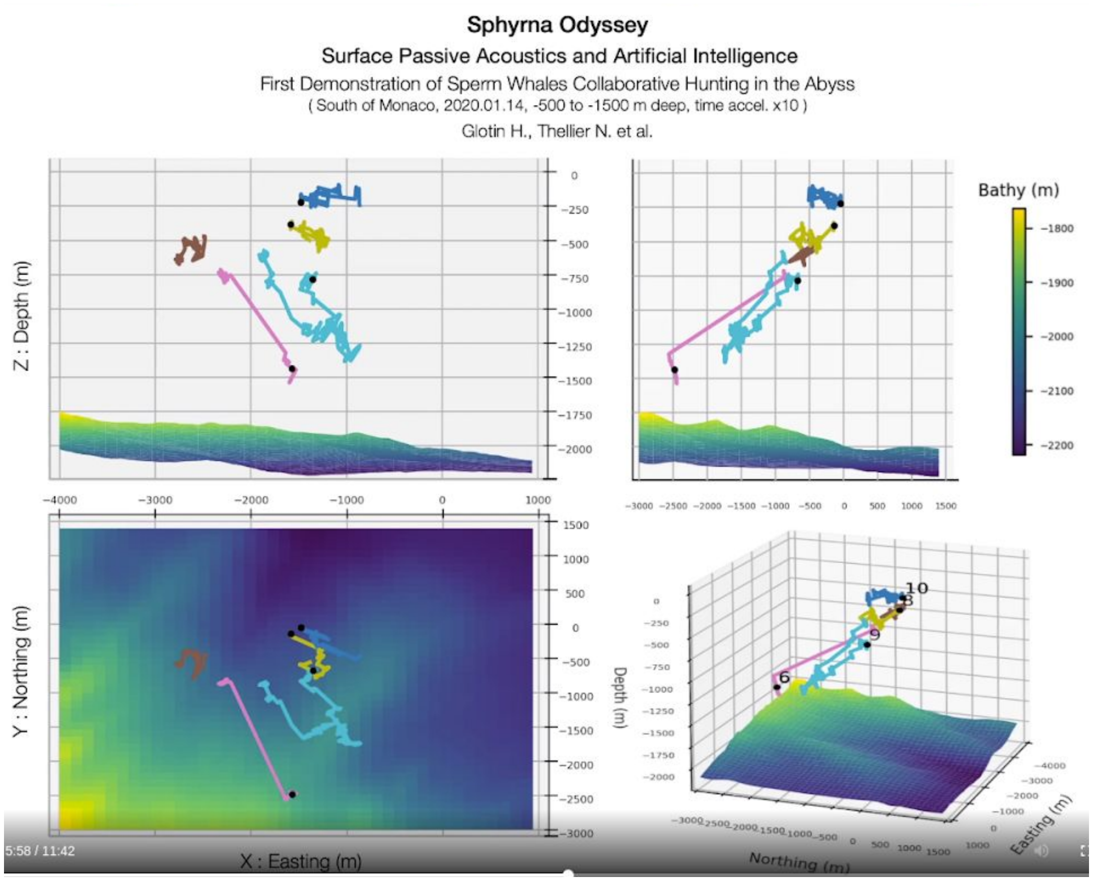
Coincidences of the beams of the biosonars

They Collaborate
May need Silence
to do so.



Dynamic visualisation of the tracks :

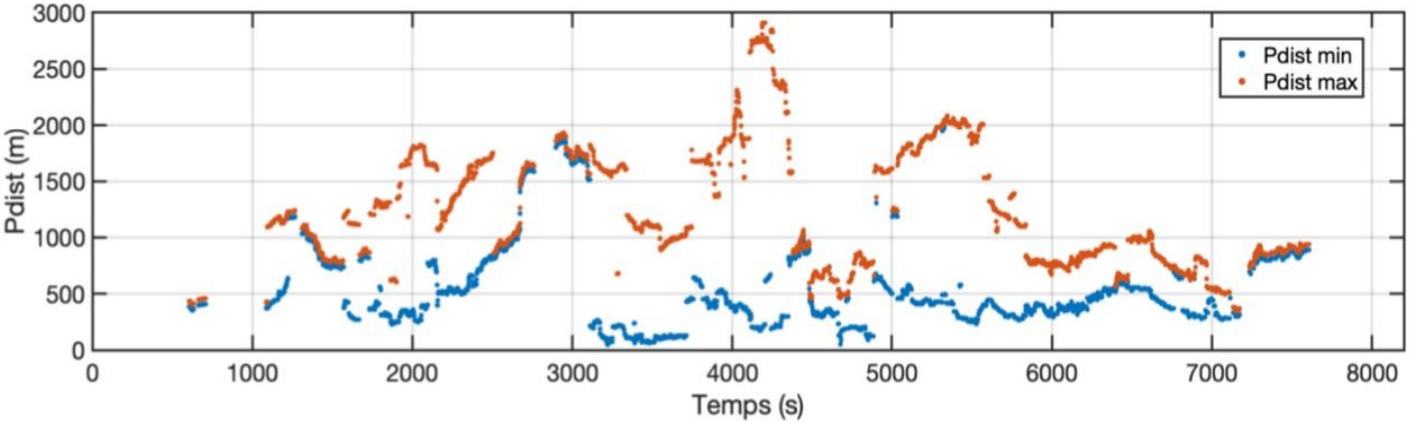
https://sabiod.lis-lab.fr/pub/SPHYRNA/3D/SO_Glotin_Thellier_etal_PhyseterAlliance_Monaco_20200114_3DtracksX_Y_Z.mp4



https://cosphilog.fr/cachalots-musee/

Ethoacoustics : Inter track distances

1 minute time window, computation of distance between each pair of tracks



→Majority Pdist min @ 400-500 m, in agreement with the travel of the click and its echo :

Emission @ 180 dB allow a two way travel of 430m :

Echo Energy Equation $EE = S - 40 \log(R) - 2\alpha(f)R + 20 \log(d)$

New criteria for TSL ?

Conclusion

Evidences of soundscape variation during Covid19.
First 3D tracking of group of Physeters from small mobile surface antenna.
First demonstration of Alliance of cachalots.

Perspectives : Ethoacoustics of the Abyssea, correlation to current, oceanic front, halocline, thermocline, size / age of the individuals, success of predation in group versus alone, interaction in 3D with boat trafic …

Real Time sonobuoy with the same technology (3D) is being deployed in Toulon and Corsica in GIAS MARITTIMO Project for anti-collision

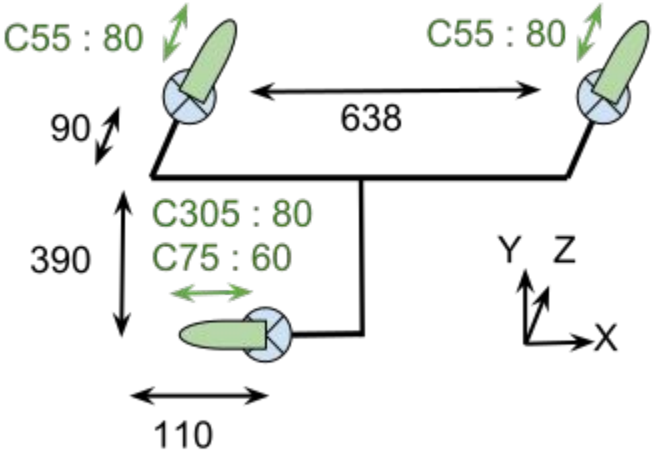
We thank ACCOBAMS, FAP2, EDM for their grants,
SEAPROVEN for its strong effort
and PNPC/Pelagos for logistic support

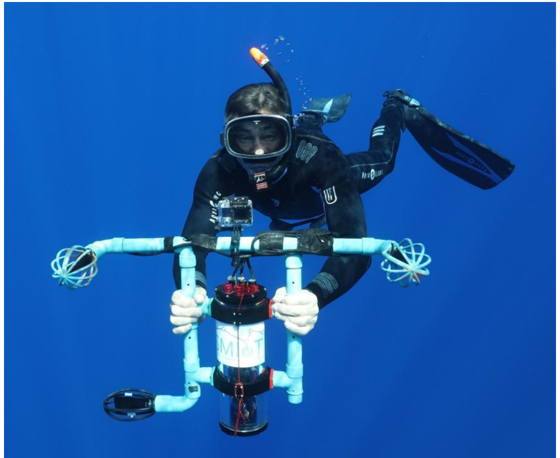
Search of Physeter’s individual acoustic signature and coda / behaviour decoding

Method and Material : Portative Antenna and 3D tracking

M. Ferrari, H. Glotin, R. Marxer, V. Barchasz, V. Sarano, V. Gies, M. Asch, and F. Sarano, “High-frequency near-field physeter macrocephalus monitoring by stereo-autoencoder and 3d model of sonar organ,” in OCEANS 2019-Marseille, IEEE, 2019, pp. 1–4.

Mauritius dataset




Crédit photo : Fabrice Guerin

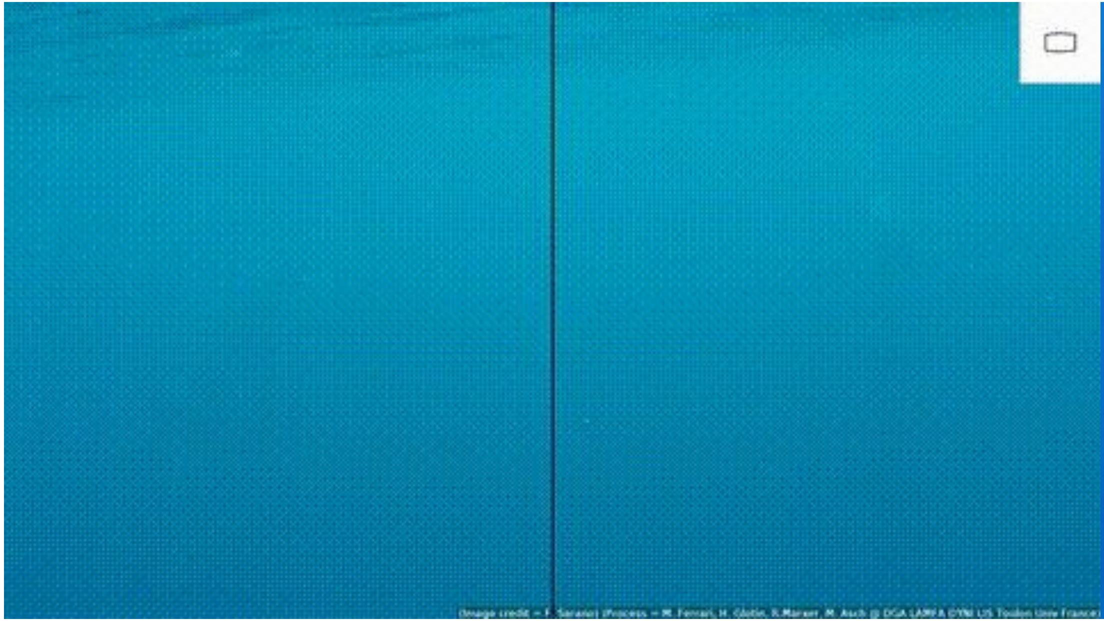
M. Ferrari, H. Glotin, R. Marxer, V. Barchasz, V. Sarano, V. Gies, M. Asch, and F. Sarano, “High-frequency near-field physeter macrocephalus monitoring by stereo-autoencoder and 3d model of sonar organ,” in OCEANS 2019-Marseille, IEEE, 2019, pp. 1–4.

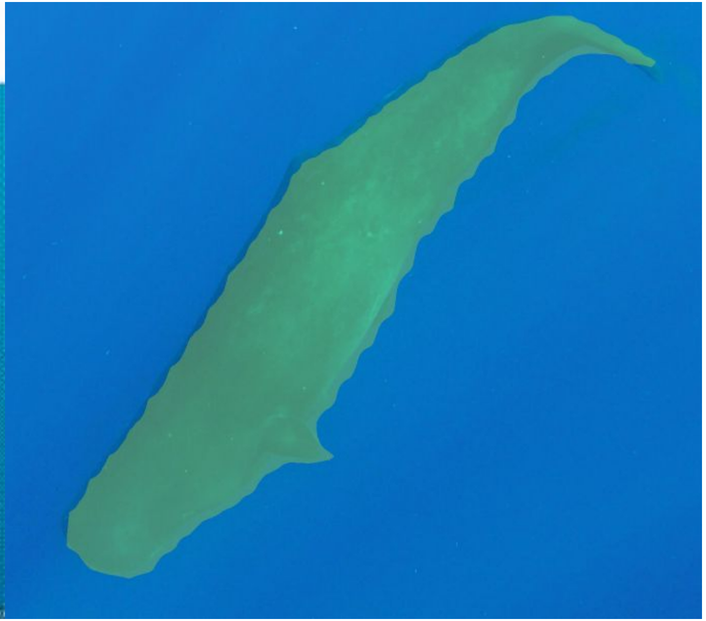
Linking clicks to their emitter

With the TDOA and the antenna shape, we can compute the azimuth and elevation angle by making a far field hypothesis.

We also take into account the fisheye effect of the GoPro.

http://sabiod.univ-tln.fr/workspace/Sarano_2018/ See : https://youtu.be/g3xXM_tycCU





L. Chen, et al., “Encoder-decoder with atrous separable convolution for semantic image segmentation,” CoRR, vol. abs/1802.02611, 2018.


ADAPREDAT expedition
October 31 - November 05
2023

During wintertime,
herrings massively gather together
in the norvegian northern fjords,

Their number greatly varies from year to year depending on hydro-climatics factors (mainly sea temperature).

1945 = 16 millions tons
1960 - 1970 = 45.000 tons
1980 = 10 millions tons

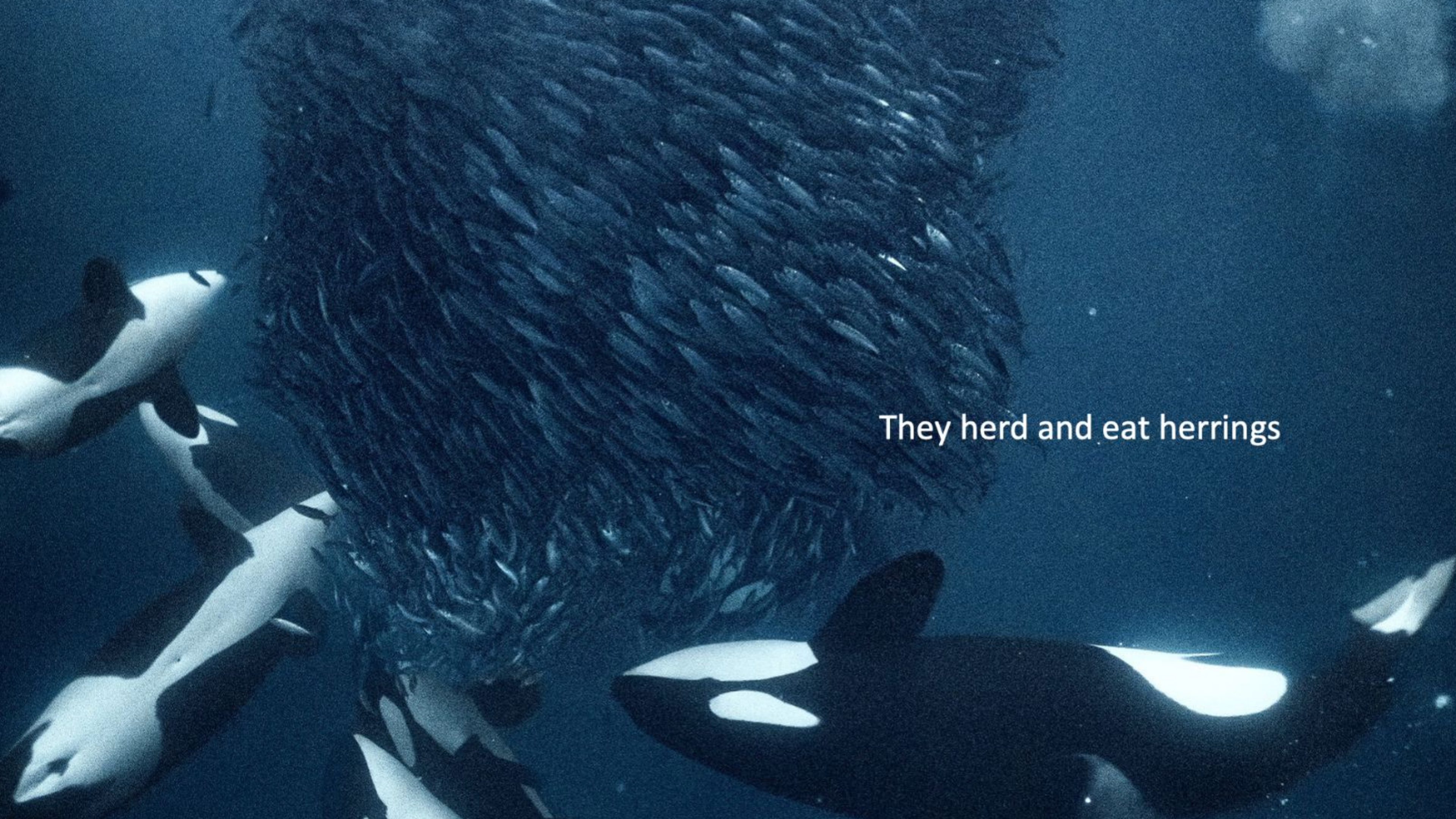
2020 = 11 billions herrings
2021 = 17, 3 billions herrings
2022 = 15 billions herrings

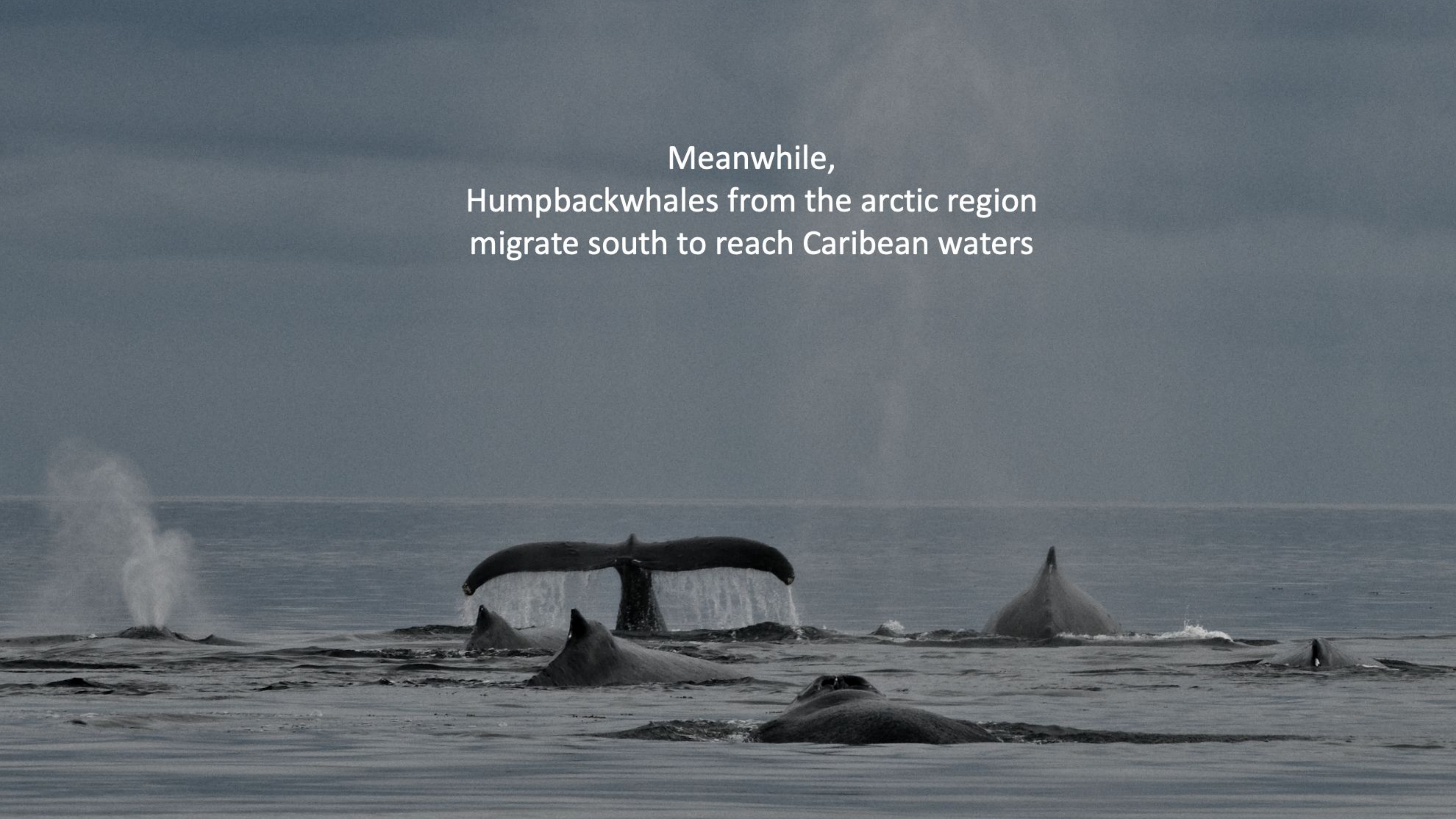
Herrings number depends on 2 factors :

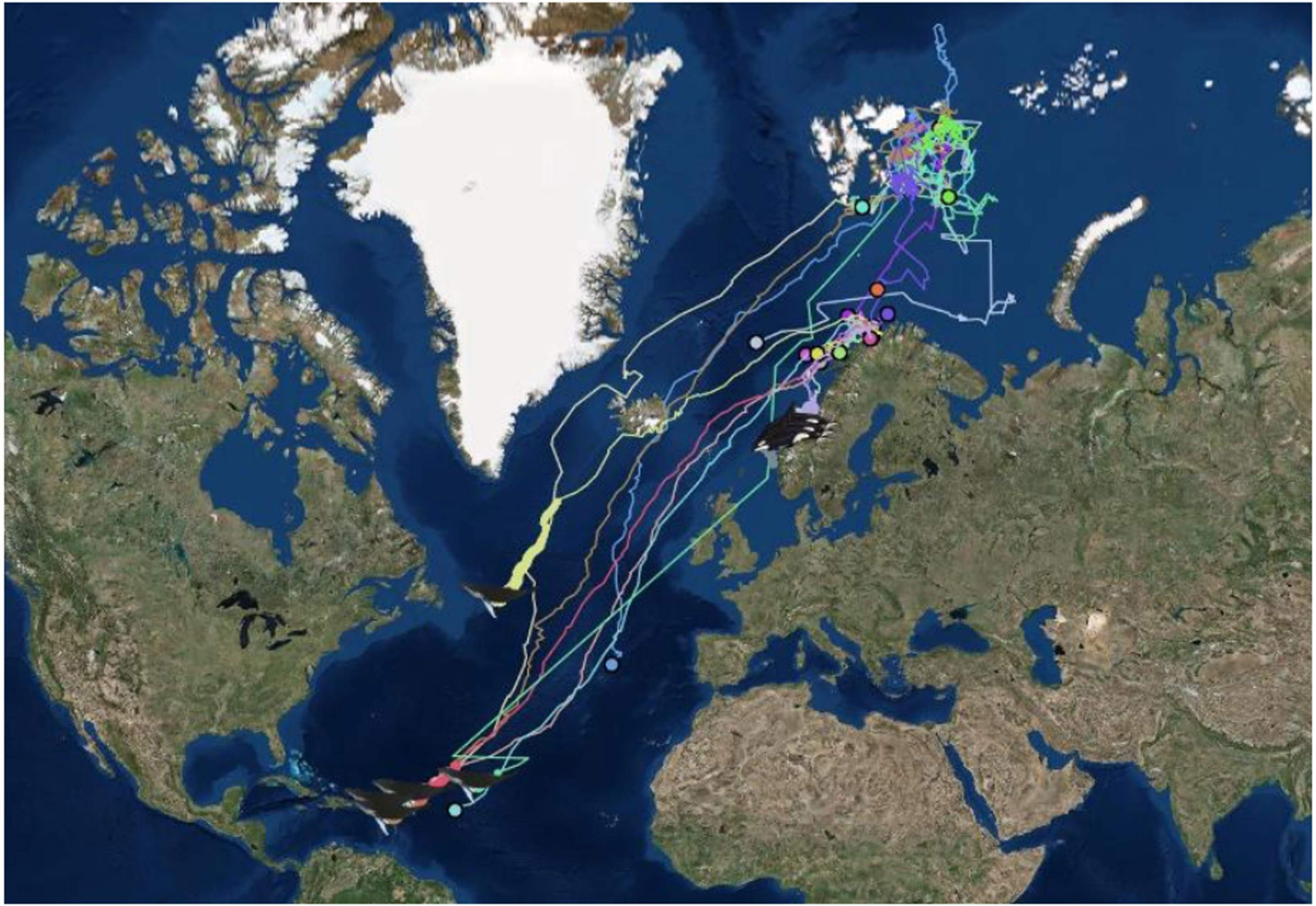
➔ Reproduction success, strictly link to hyrdo-climatics factors, rule the annual recruitment – (a fish larvae is considered as a recruit at 1 year - 10 cm) that could varie from « one to ten » from year to year.

➔ Predation and fishing pressure on recruit who reach their sexual maturity at 3 years and could live until 8 years old.


During wintertime, between november to march,
pods of orcas gather together
in northern norvegian fjords

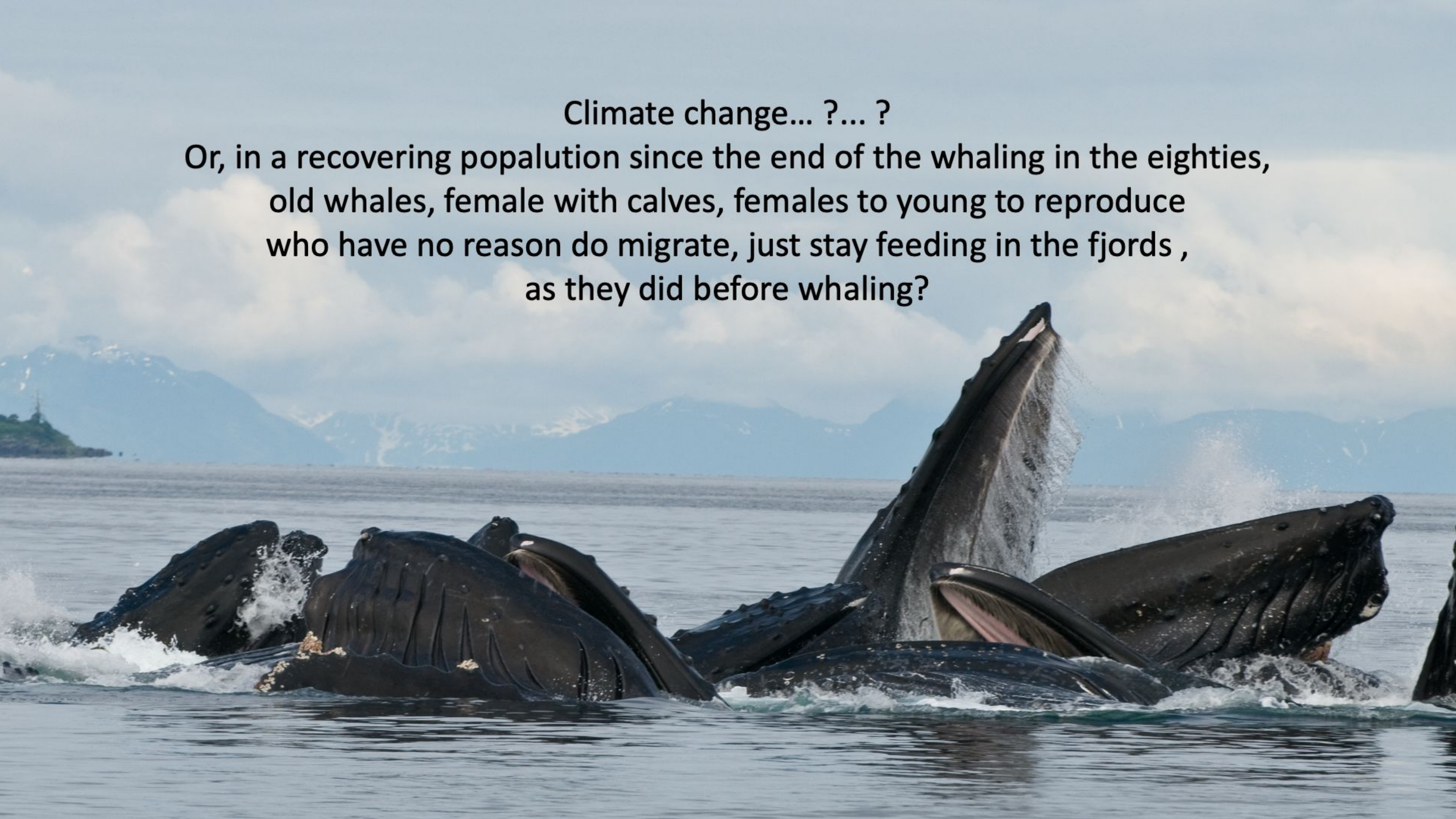

They herd and eat herrings


Meanwhile,
Humpbackwhales from the arctic region
migrate south to reach Caribean waters

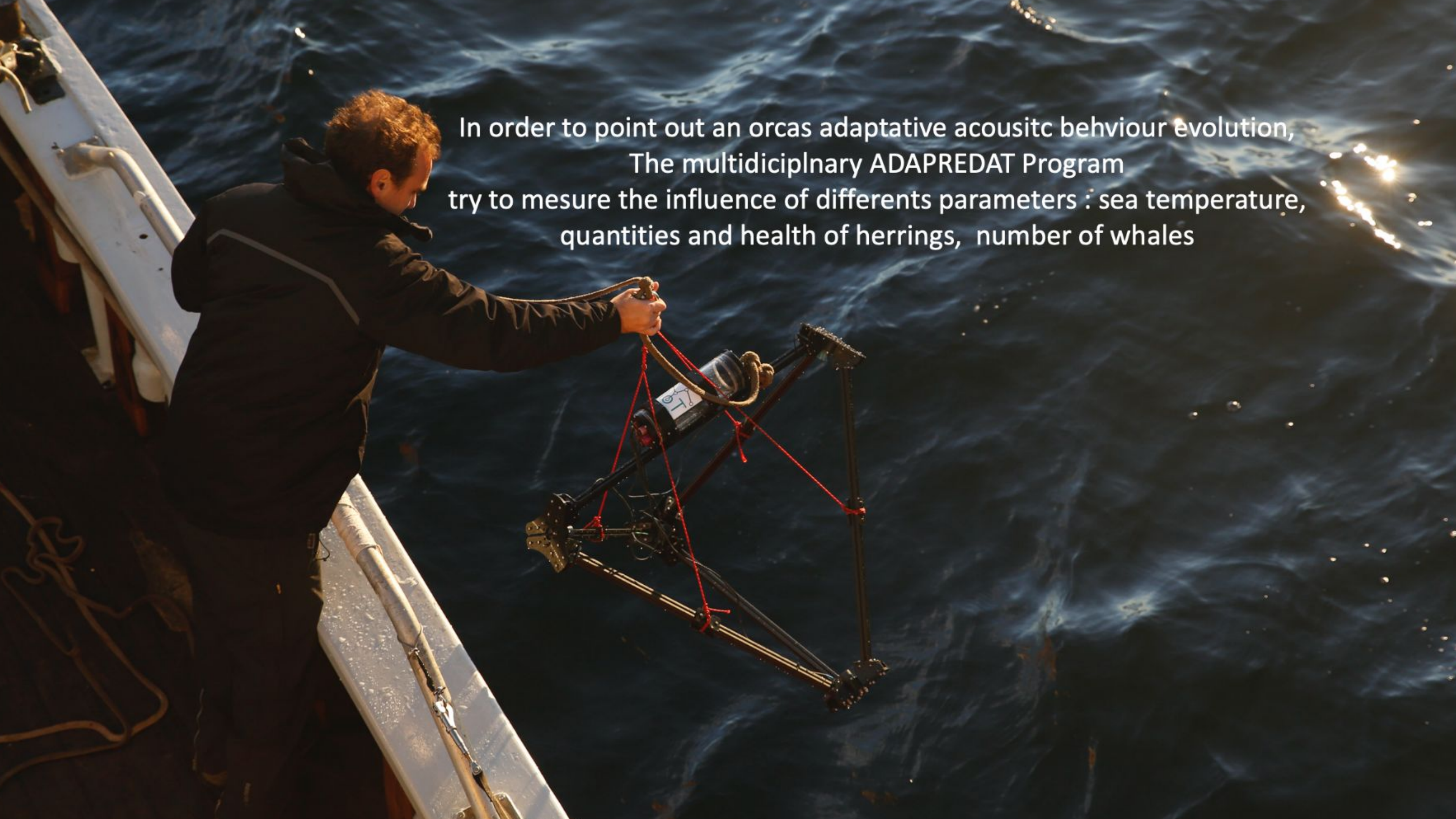


Humpback whales have been satellite tracked from the Arctic to the Caribbean. At the moment they are in the tropical island paradise to find their soul mate. Map: Whale track/UiT The Arctic University of Norway


A whale can eat
2,5 tons of herrings per day,
70 tons during their stay (27 jours)


Climate change… ?... ?
Or, in a recovering popalution since the end of the whaling in the eighties,
old whales, female with calves, females to young to reproduce
who have no reason do migrate, just stay feeding in the fjords ,
as they did before whaling?


What ever the reason of this changes,
whales directly compete
with orcas for food

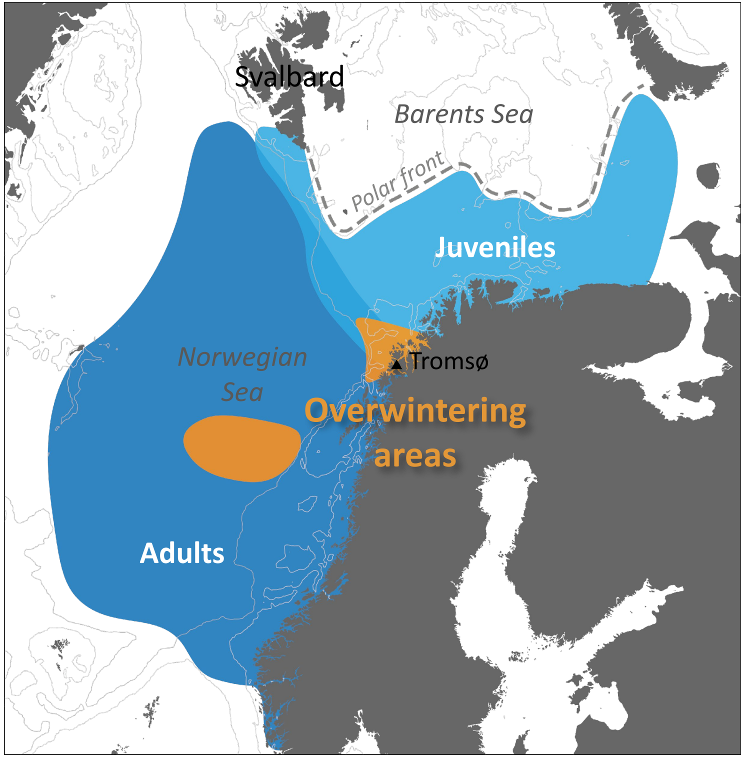

In order to point out an orcas adaptative acousitc behviour evolution,
The multidiciplnary ADAPREDAT Program
try to mesure the influence of differents parameters : sea temperature,
quantities and health of herrings, number of whales

Norwegian spring spawning herring

- Norwegian spring spawning herring (*Clupea harengus*) is the world's largest herring stock
- Historical fishery
- **Seasonal migrations** from feeding to overwintering areas

Herring fishing fleet in Bodø between 1840 - 1880

Herring fisherman ca. 1920

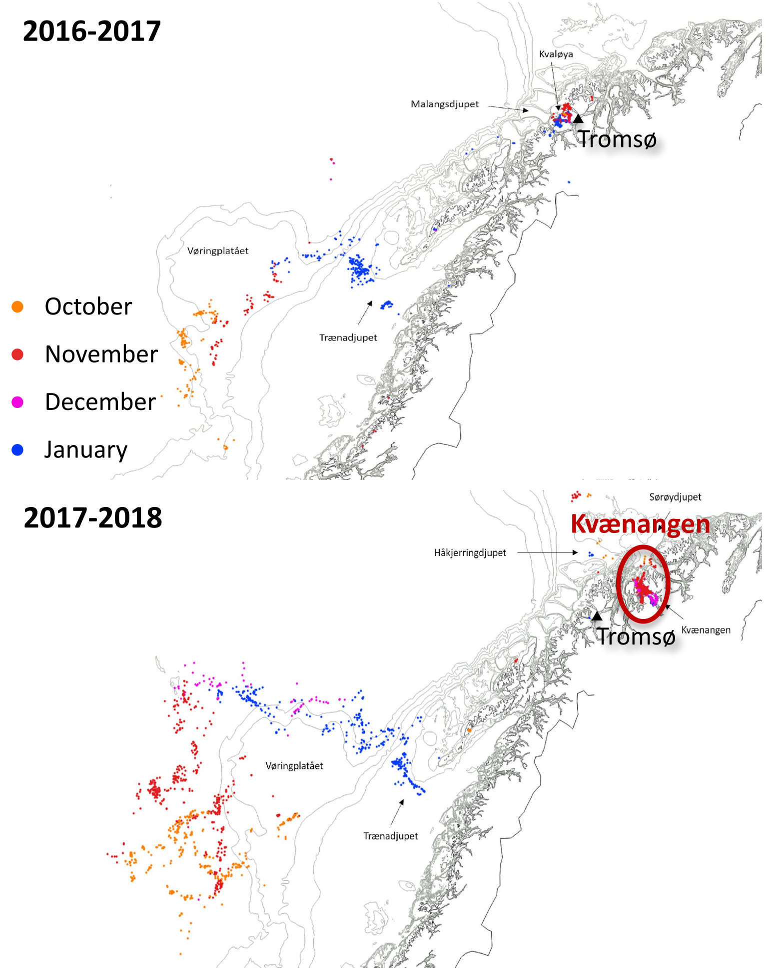


Modified from IMR 2017 & Salthaug et al. 2022

Akvaplan niva

Norwegian spring spawning herring

Herring catches > 10 tons



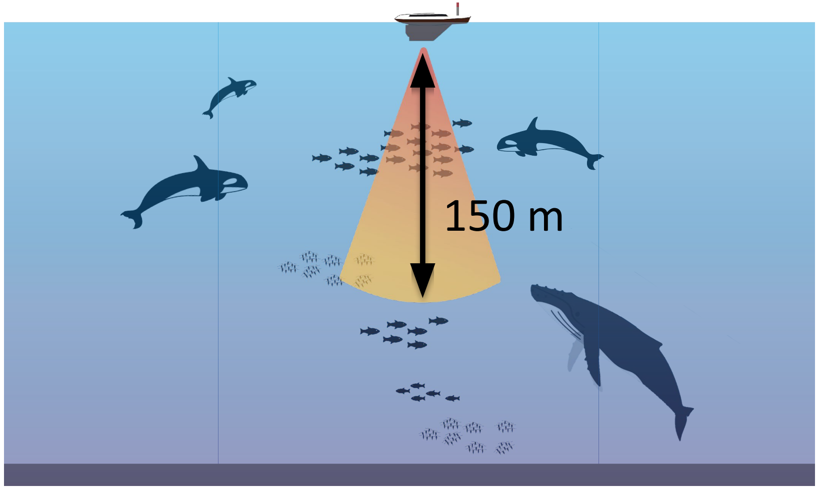
Modified from Salthaug & Stenevik 2020

- Hard to predict recruitment and movements of herring population
- Plasticity in choice of overwintering area
- Norwegian spring spawning herring has been overwintering in Kvænangen near Kjervøy since 2017
- *Theory*: Strong year classes "decide" where to overwinter (Huse et al. 2010)
- Orcas and humpback whales follow the herring to overwintering grounds

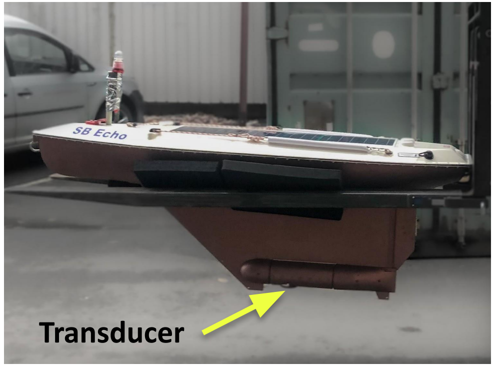
Akvaplan-niva

Instrumentation

- Modified autonomous surface vehicle – Sailbuoy
- Broadband single beam echosounder (Simrad EK80 WBT Mini) recording between 190 – 250 kHz
- Recorded acoustic backscatter of the top 150 m of the water column



Sailbuoy



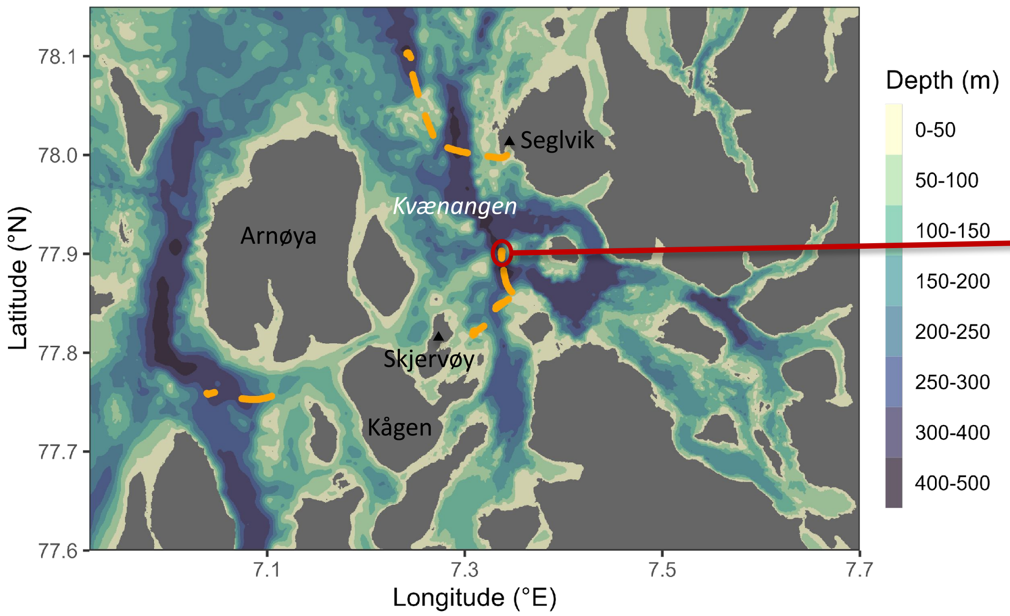
Modified sailbuoy for the 2022 survey

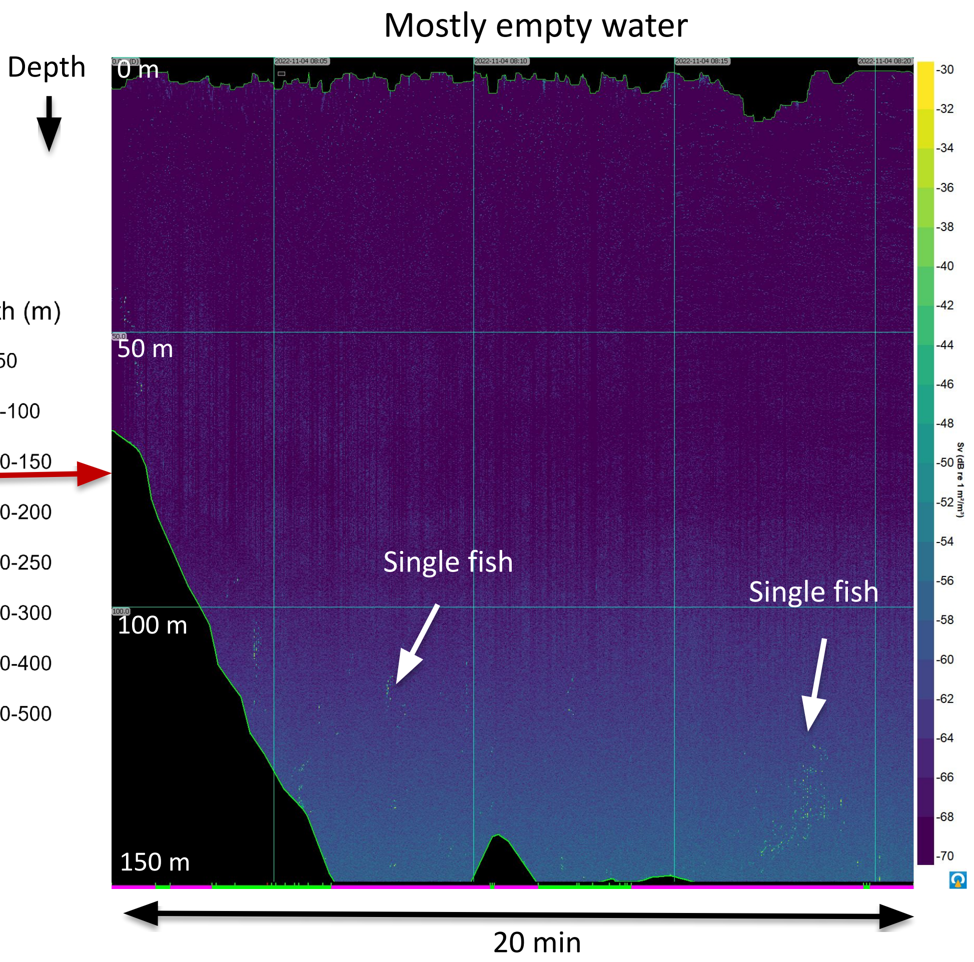
Sailbuoy being towed behind the Isbjørn II

Akvaplan niva

Echograms of Kvænangen 1

Empty water and single fish

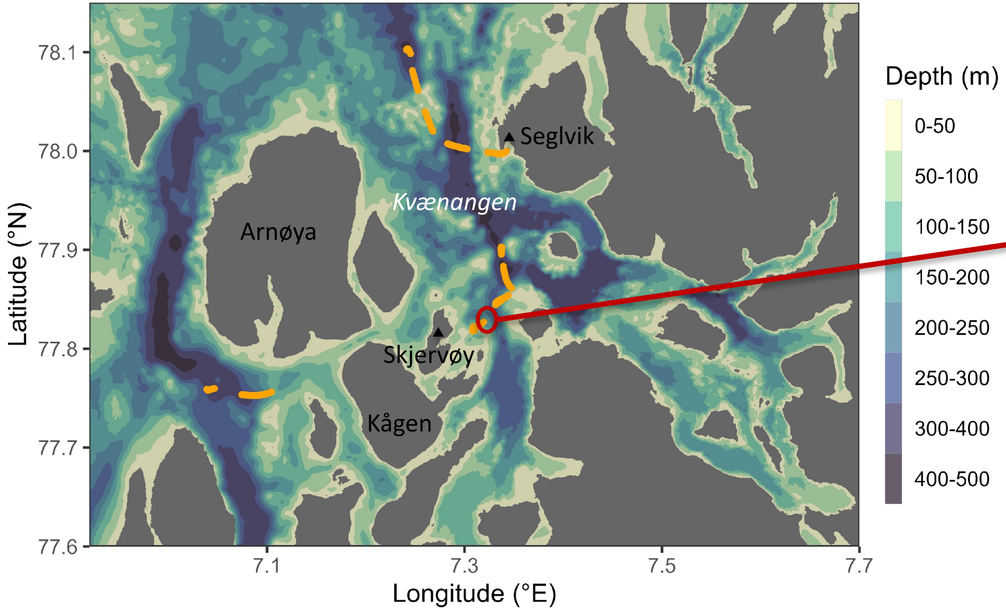




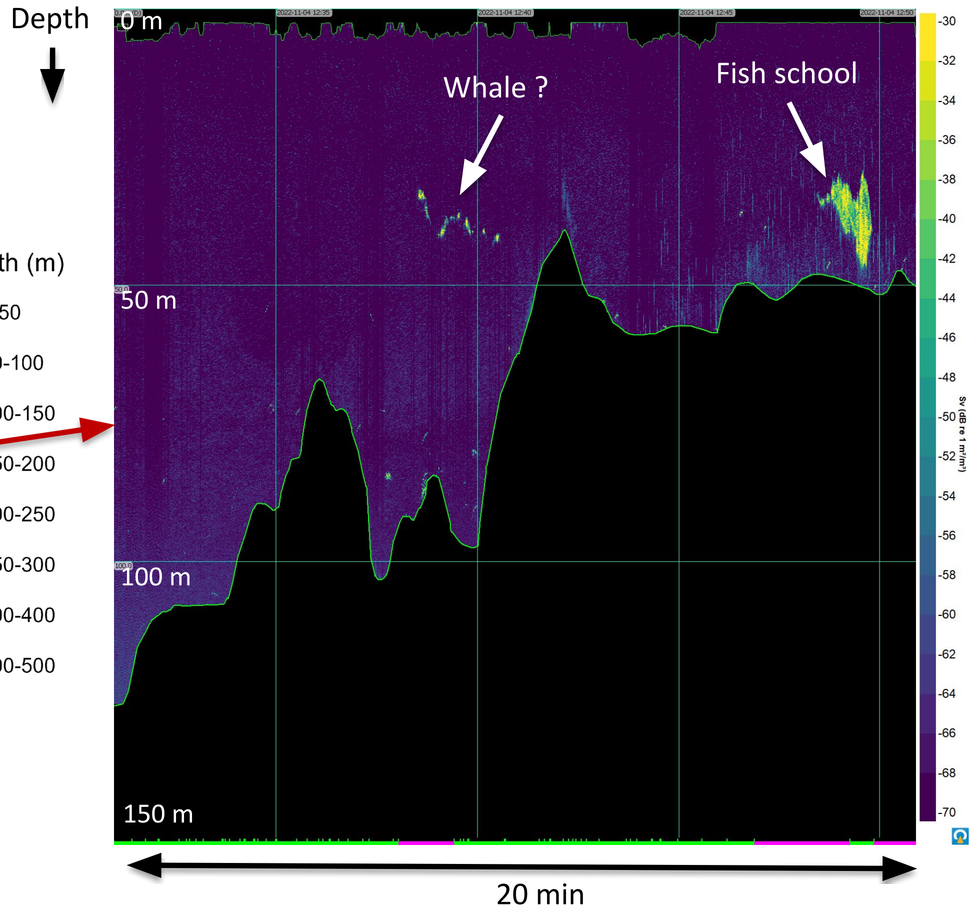
Akvaplan niva

Echograms of Kvænangen 2

Whales and fish schools



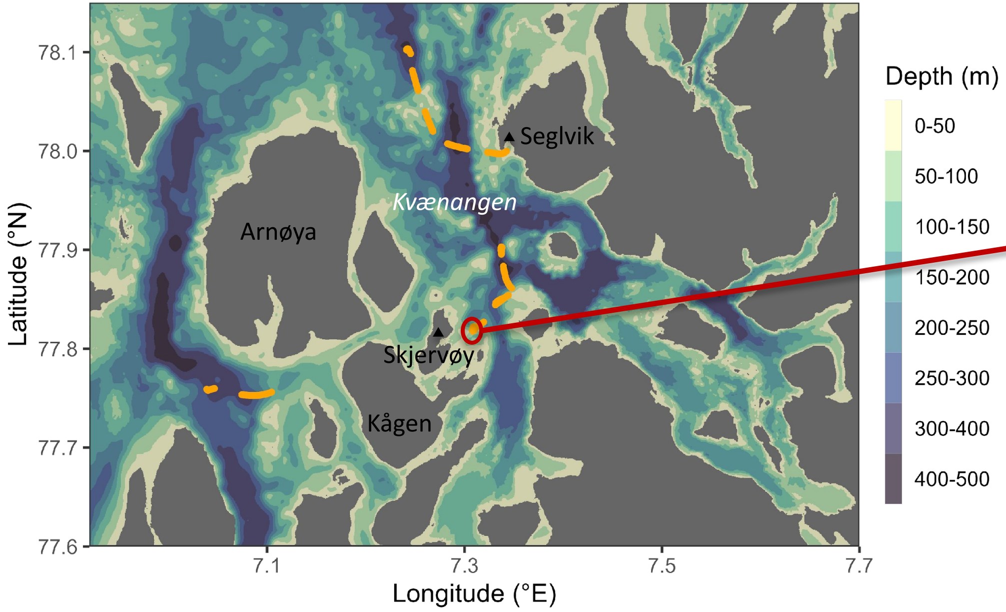
Some schools of fish and possible whale echoes

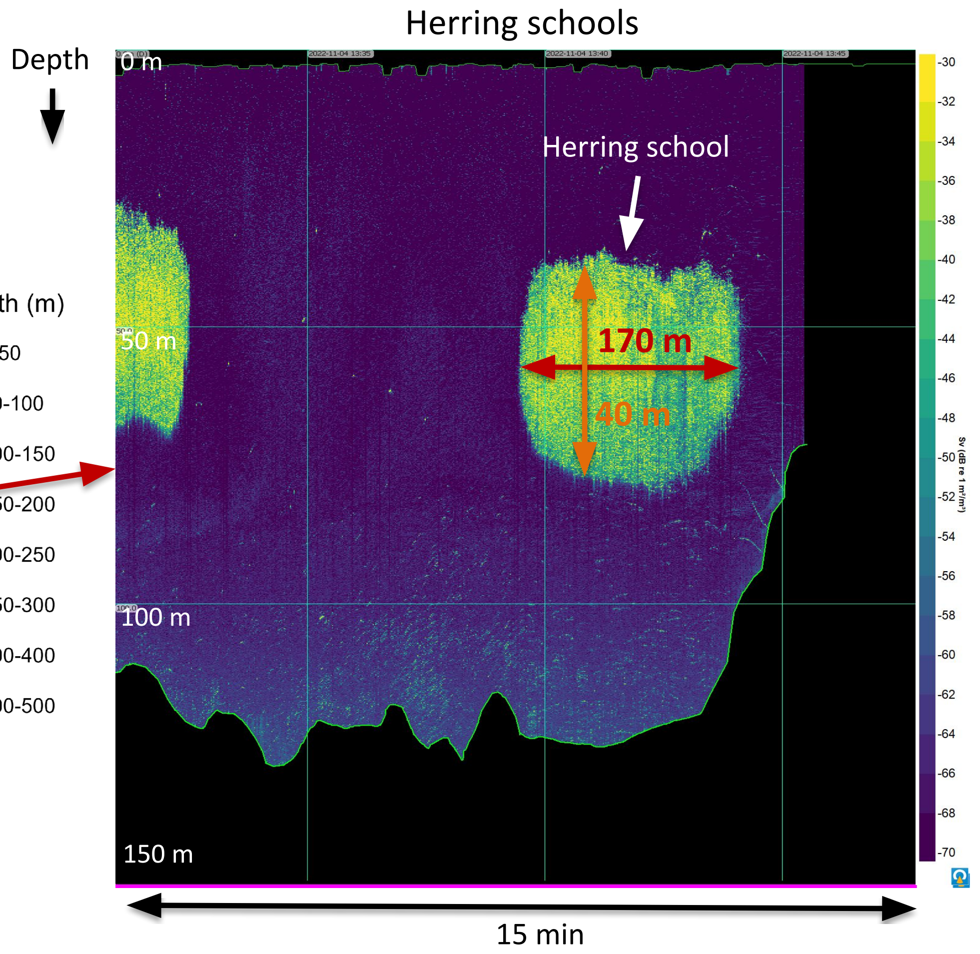


Akvaplan niva

Echograms of Kvænangen 3

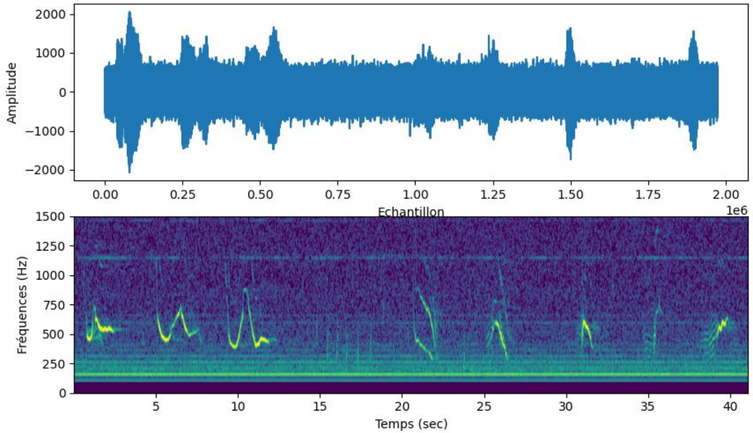
Herring schools

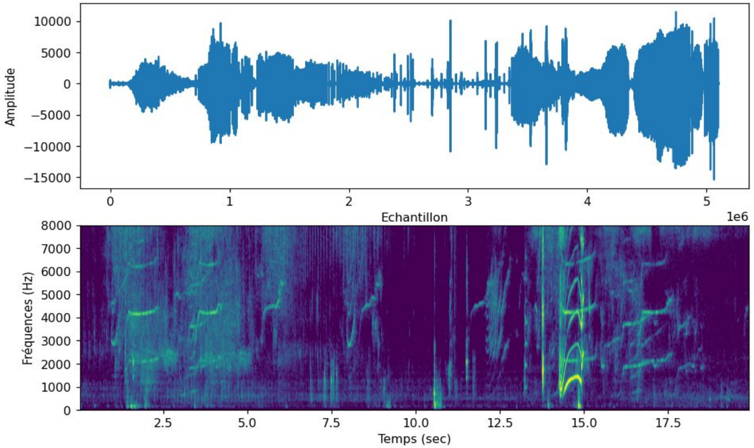




Orca (*Orcinus Orca*) and humpback whales *(Megaptera novaeangliae*)

- Cosmopolite distribution
- Norwegian population
- Hunting strategy : the carousel
- Pods have distinct vocal dialects





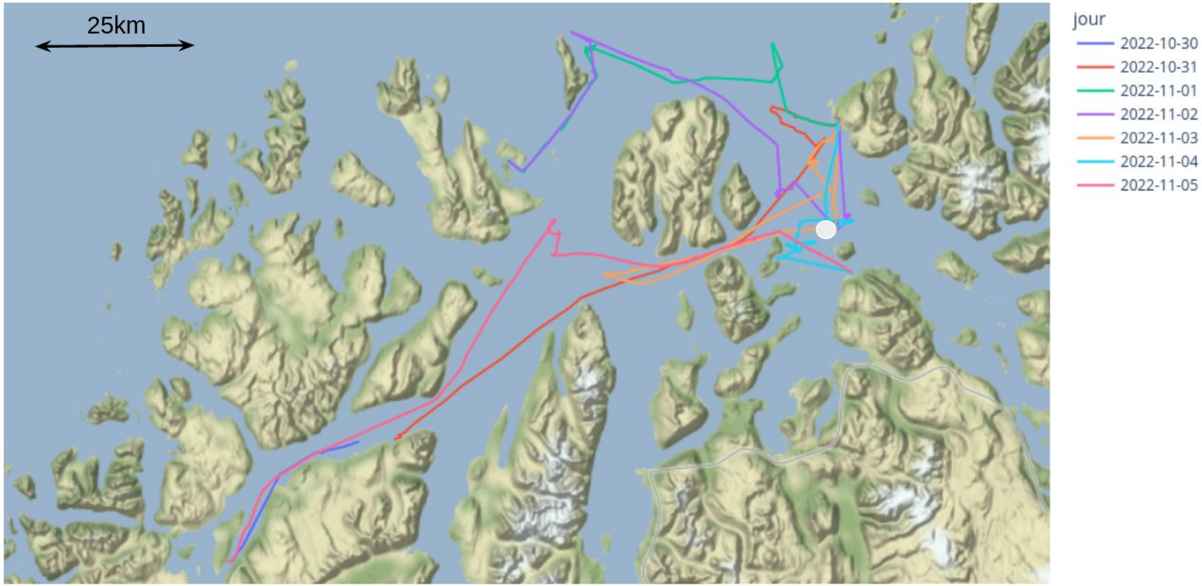
Objective

- Interaction (behaviour and acoustic) between these 2 species
- Evolution of these interactions, both in time and space, coupled with environmental data.

- Characterize the study area (température, pollutants, physics)
- Photo-identification

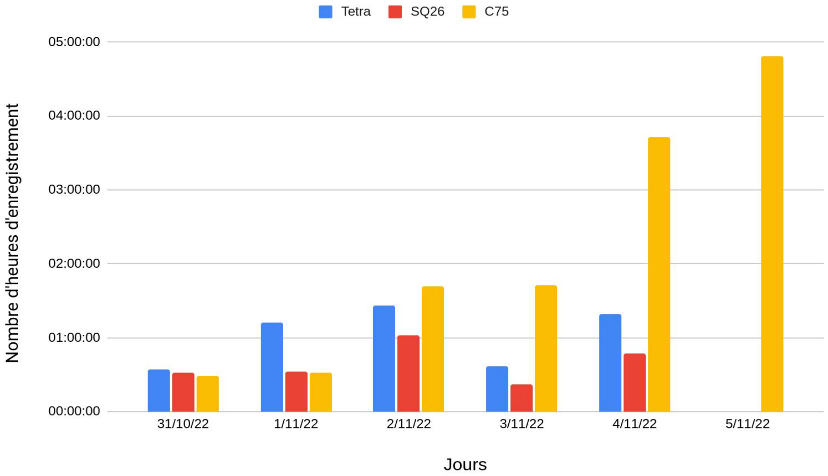
Isbjorn transect

- 31/10 - 06/11 2022
- 7 days of expeditions
- 616 km traveled
- Opportunistic protocole
- Visual protocole
- Help from the whale watchers

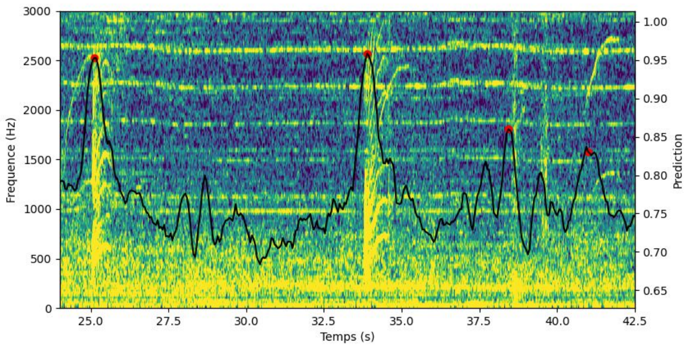


Acoustic data acquisition and automatic detection

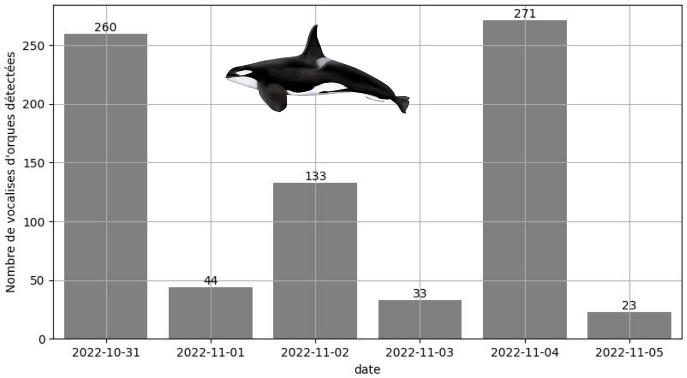
- Tetra = 32 Go
- Mono sq26 = 7 Go
- c75 = 72 Go

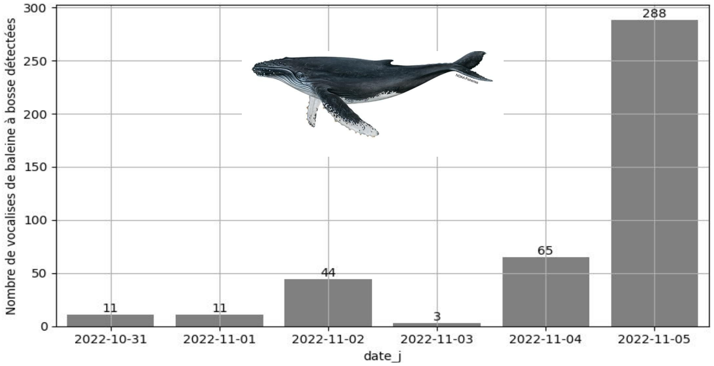


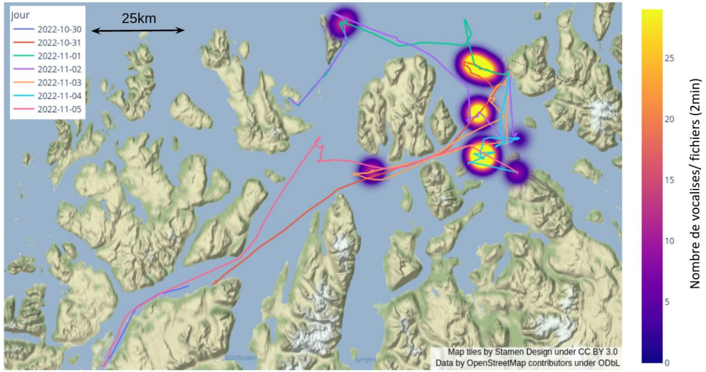
Run CNN to detect humpback whale and orca calls
Probabilities of detection over time

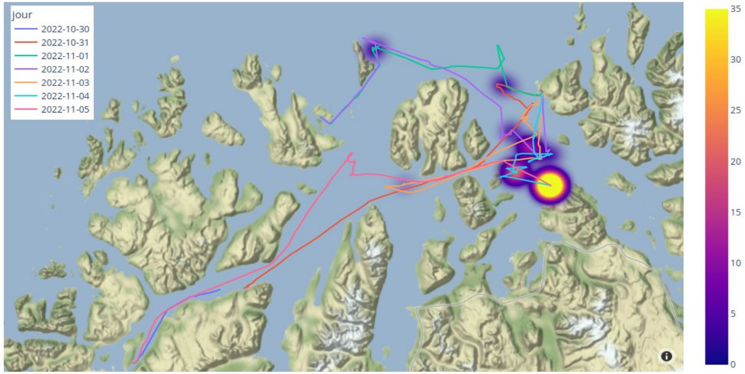


Acoustic presence of orcas and humpbacks



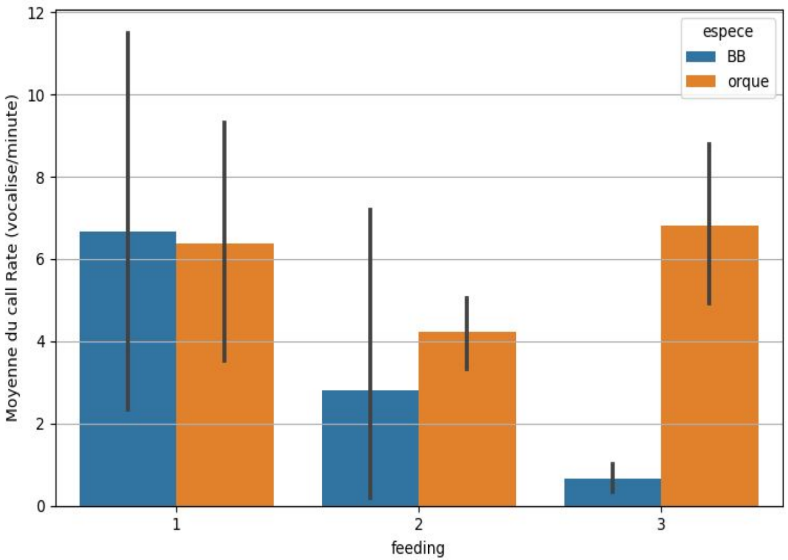


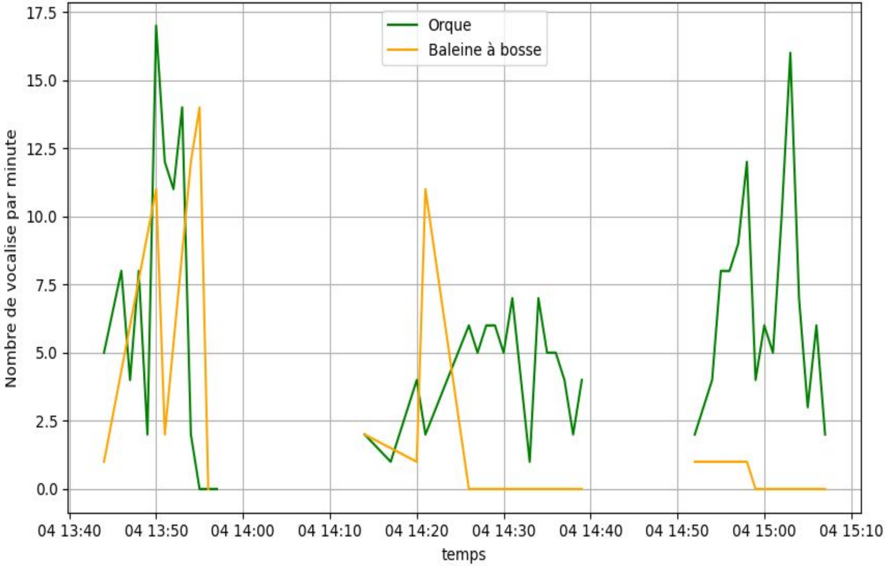




Acoustic analyses during a carousel

November, 4 :group of orcas + 2 humpback whales





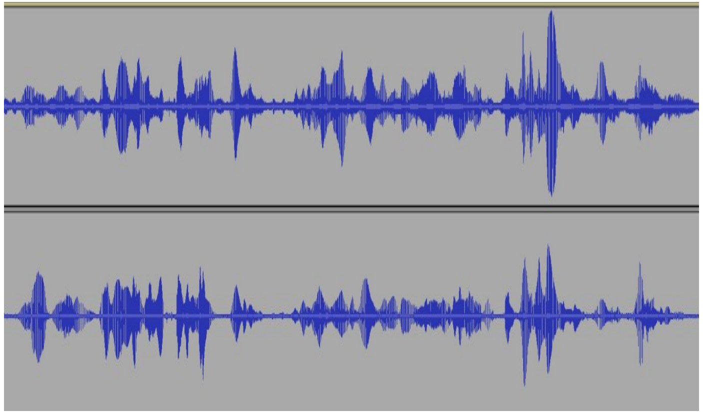
Challenges

Stereo Bird challenge
DOCC10
Biosonar

Learning biosonar DOCC10 challenge

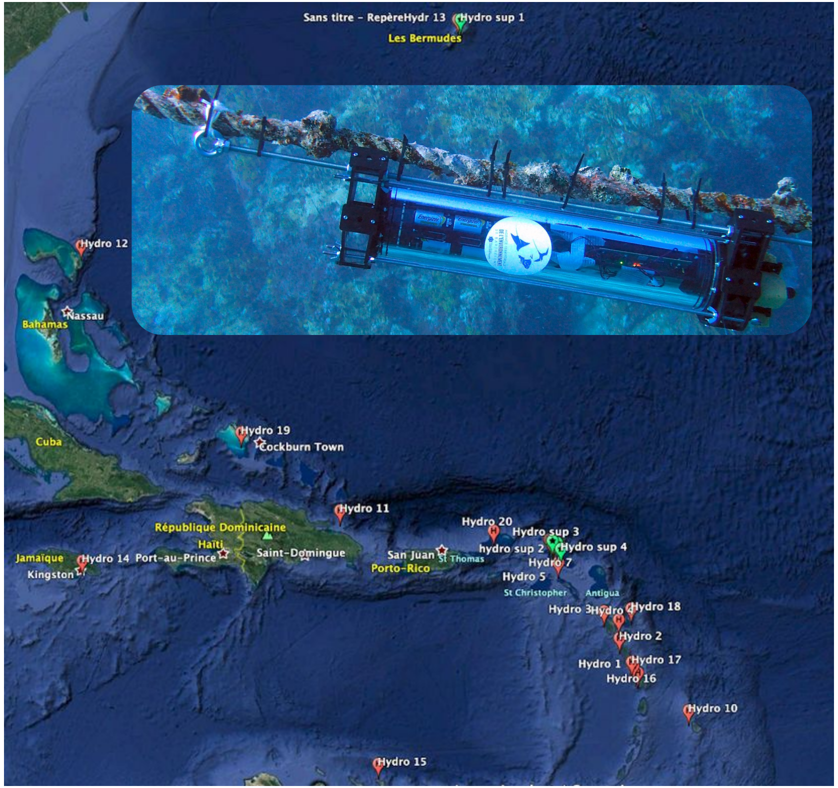
H. Glotin & M. Ferrari

Chair 'AI bioacoustics'
CNRS LIS TOULON univ.
glotin@univ-tln.fr



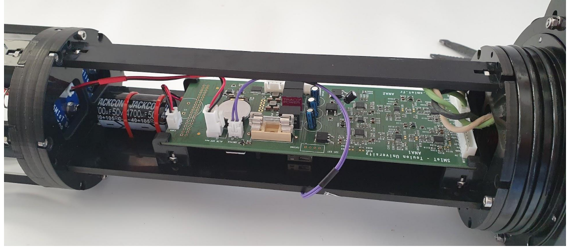
http://sabiod.org/EADM

Needs to sample BIODIVERSITY of the OCEANS / The top predators of the Ocean
ex : 20 species of cetaceans monitored in Antilles (CARIMAM OFB / EU / LIS)
20 x 1 year x 512 kHz sampling rate, 60 To



Famille	Nom vernaculaire	Nom scientifique
Balaenopteridae	Rorqual à bosse	*Megaptera novaeangliae*
	Petit rorqual	*Balaenoptera acutorostrata*
	Rorqual tropical	*Balaenoptera edeni*
	Rorqual boréal	*Balaenoptera borealis*
	Rorqual commun	*Balaenoptera physalus*
Physeteridae	Grand cachalot	*Physeter macrocephalus*
Kogiidae	Cachalot nain	*Kogia sima*
	Cachalot pygmée	*Kogia breviceps*
Ziphiidae	Baleine à bec de Gervais	*Mesoplodon europaeus*
	Baleine à bec de Cuvier	*Ziphius cavirostris*
	Baleine à bec de Blainville	*Mesoplodon densirostris*
	Baleine à bec de True	*Mesoplodon mirus*
Delphininae	Grand dauphin	*Tursiops truncatus*
	Dauphin tacheté pantropical	*Stenella attenuata*
	Dauphin tacheté Atlantique	*Stenella frontalis*
	Sténo rostré	*Steno bredanensis*
	Dauphin de Fraser	*Lagenodelphis hosei*
	Dauphin à long bec de l'Atlantique	*Stenella longirostris*
	Dauphins bleu et blanc	*Stenella coeruleoalba*
	Dauphin de Clymene	*Stenella clymene*
	Dauphin commun	*Delphinus delphis*
Globicephalinae	Péponocéphale	*Peponocephala electra*
	Dauphin de Risso	*Grampus griseus*
	Globicéphale tropical	*Globicephala macrorhynchus*
	Globicéphale noir	*Globicephala melas*
Orcininae (Globicephalinae)	Orque épaulard	*Orcinus orca*
	Orque naine	*Feresa attenuata*
	Pseudorque	*Pseudorca crassidens*

DOCC10 =



JASON, SMIoT UTLN sound cards

Sphyrna Odyssey

(FA2, EdM, Accobams, LIS, Seaproven)

http://sphyrna-odyssey.com

Scripps Inst. & LIS CNRS **+**

3 To http://sabiod.org/dclde

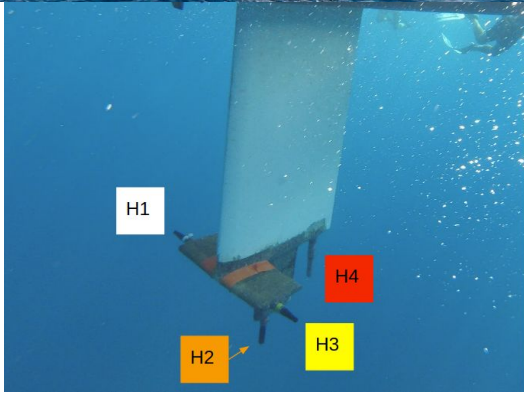
Sampling rate = 200 kHz

Multiple site location per species

Weak label, Relabeled by Ferrari et al.:

Discard samples with multiple labels

Filter on the centroid of the clicks

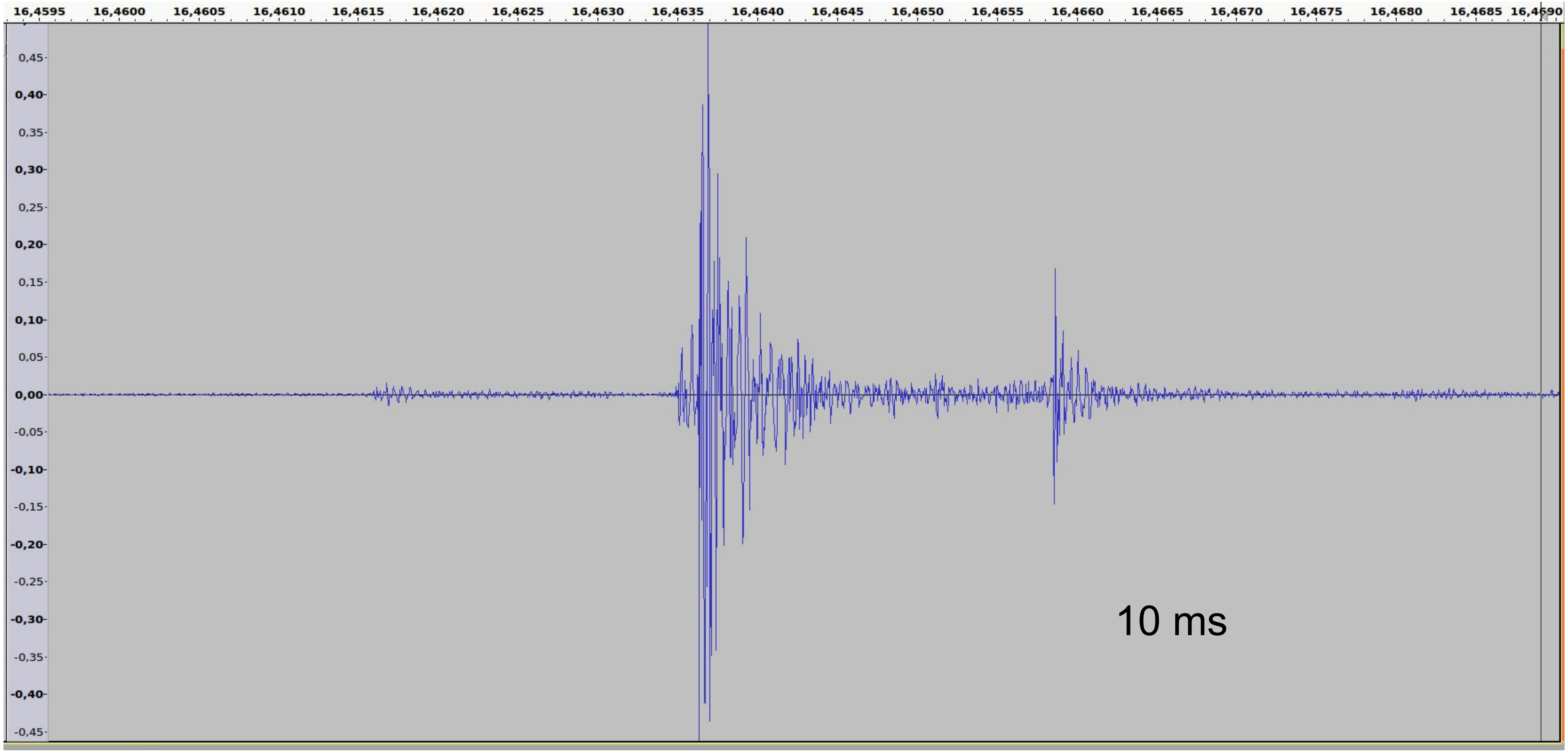


40 To
384 kHz SR
Recording
of Med. Sea

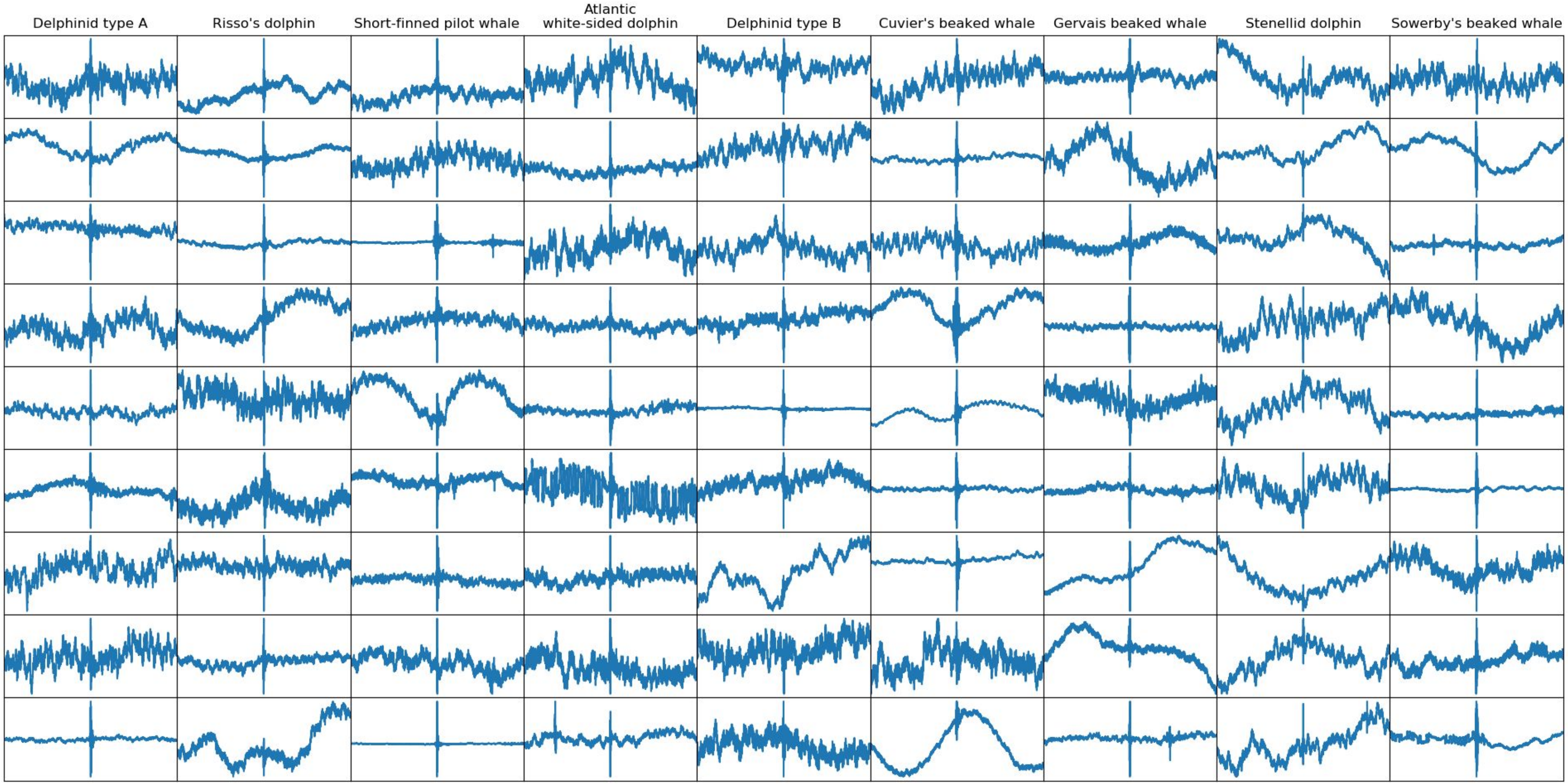
Sperm whales,
dolphins...

High frequency cachalot & globicephala m. sampling from Sphyrna Odyssey

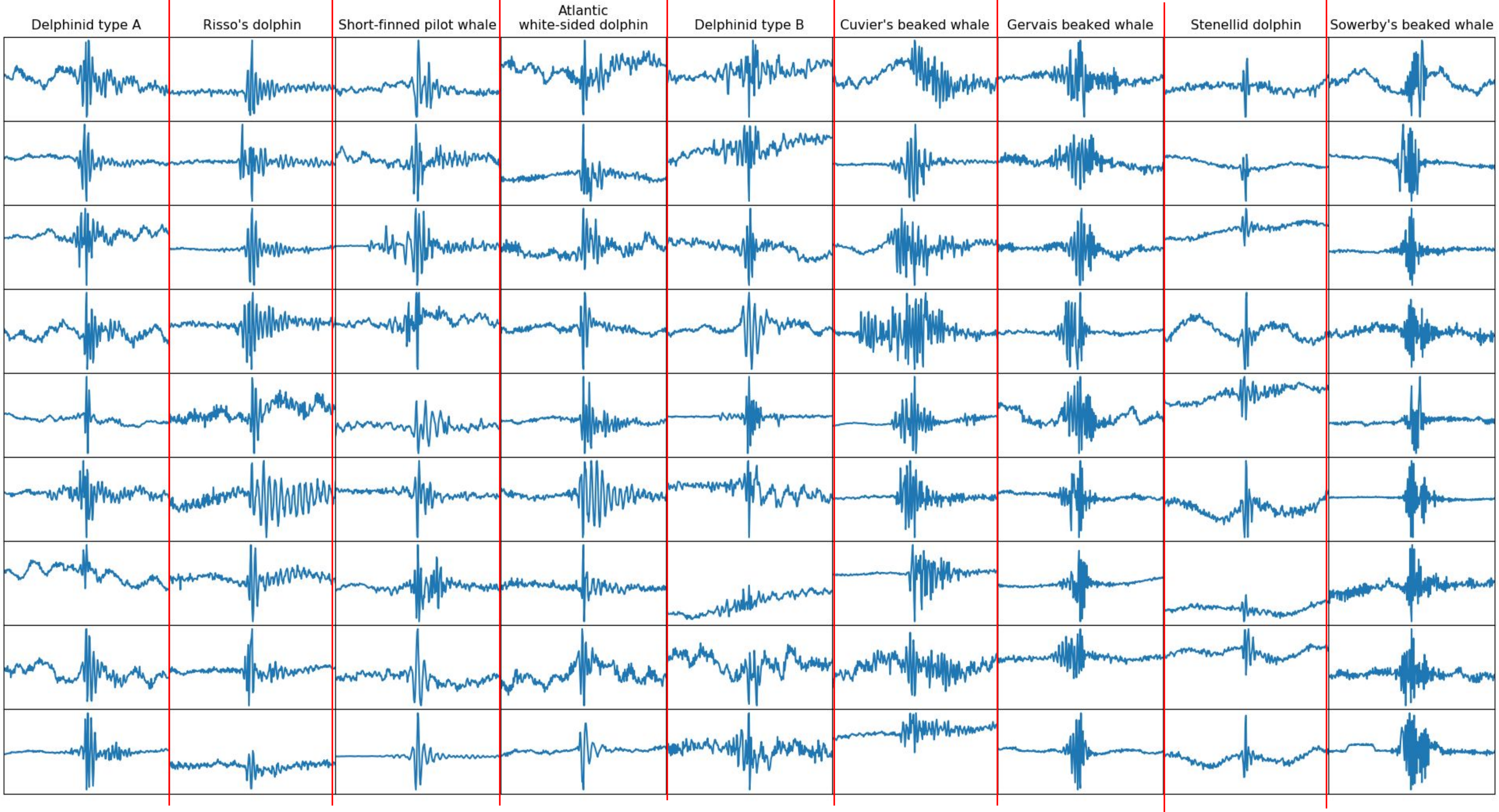
A sample of X for class Yi = Physeter macrocephalus



X samples (clicks) on 9 species



Zoom on the centered clicks



X : Clicks in a window of 8192 samples.

The training set is 113,120 (n) centered clicks balanced in ten classes.
Test set 20,960 (n_t) clicks.
The test set was split into a private test set (90%) and a public test set (10%).

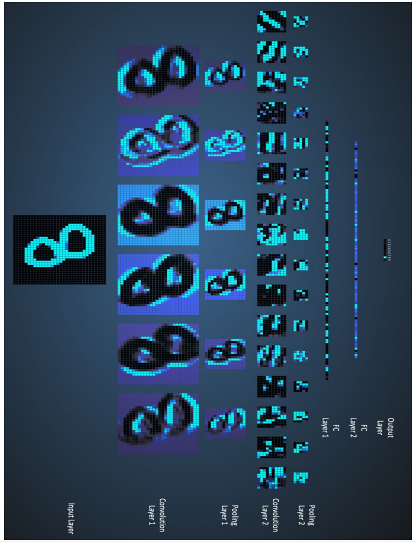
Y :

Label	Scientific name	Common name
Gg	Grampus griseus	Risso's dolphin
Gma	Globicephala macrorhynchus	Short-finned pilot whale
La	Lagenorhynchus acutus	Atlantic white-sided dolphin
Mb	Mesoplodon bidens	Sowerby's beaked whale
Me	Mesoplodon europaeus	Gervais' beaked whale
Pm	Physeter macrocephalus	Sperm whale
Ssp	Stenella sp.	Stenellid dolphins
UDA		Delphinid type A
UDB		Delphinid type B
Zc	Ziphius cavirostris	Cuvier's beaked whale

Metrics, (Risk) = accuray

R = E(argmax(P(Yi | X)) = Yi *)

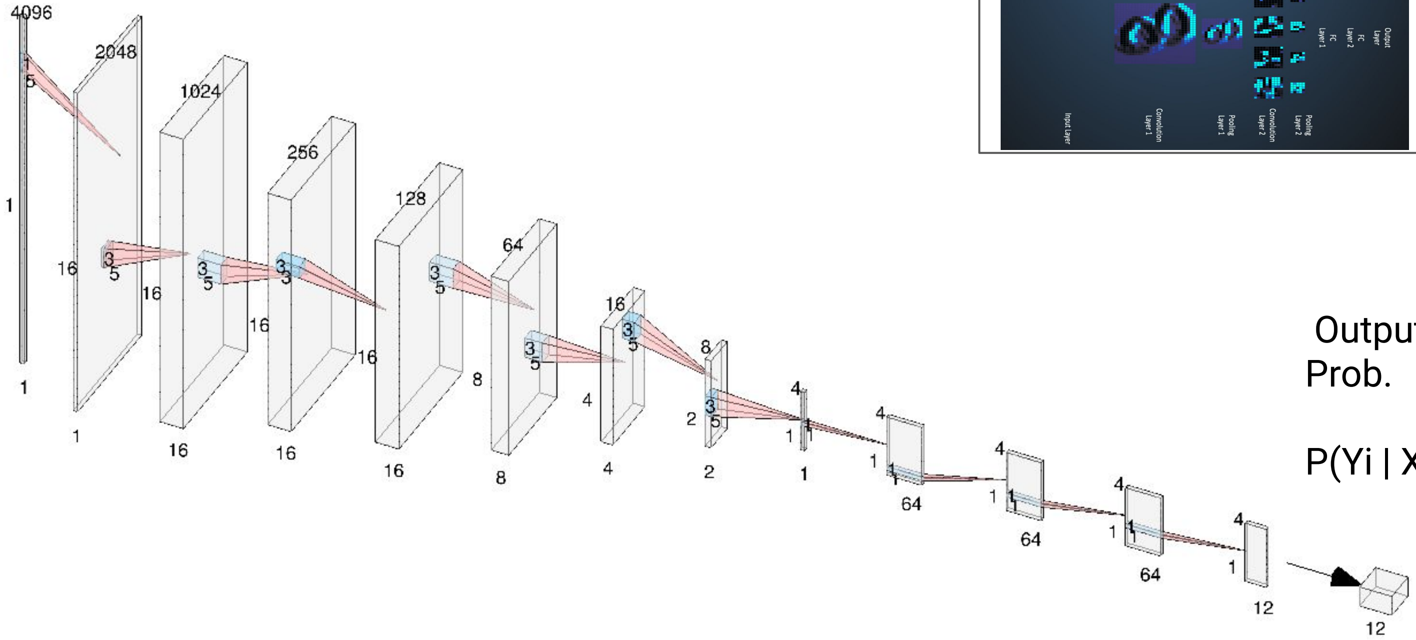
Baseline : Convolutional Deep Learning (Ferrari, Glotin et al. IJCNN 2020)



example of CNN on images

X

RAW WAV Input signal



Output Prob.

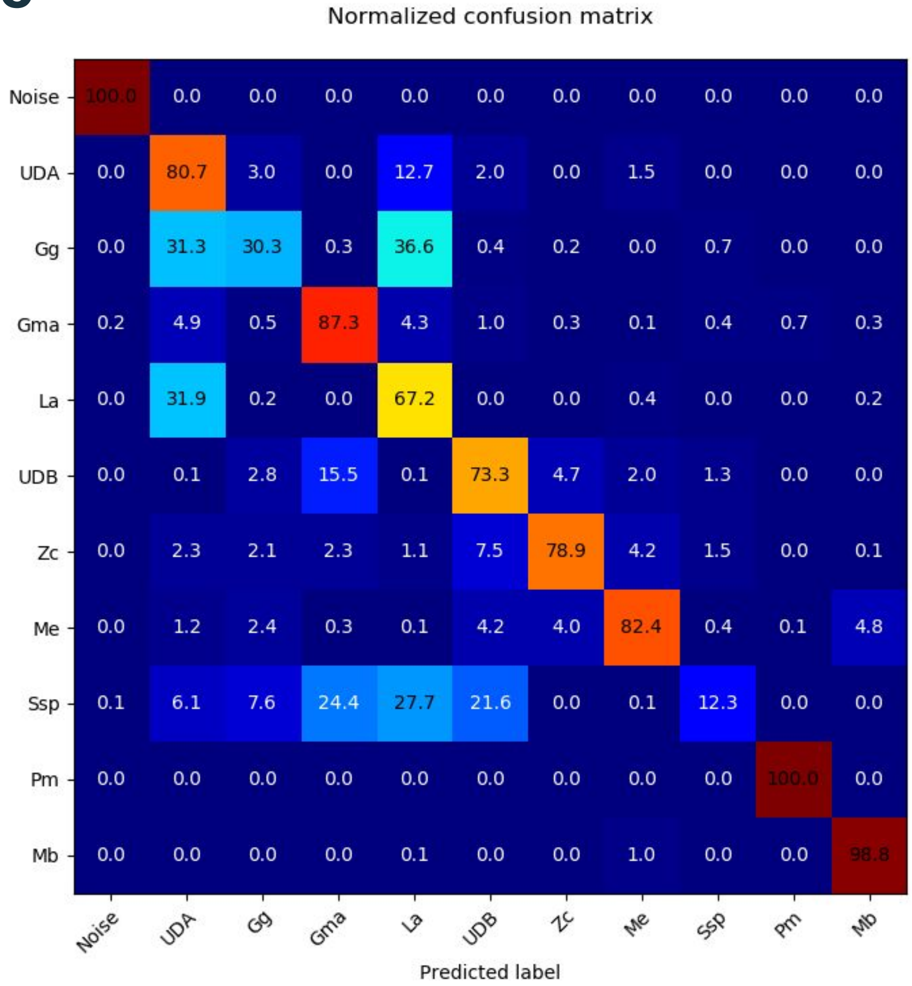
P(Yi | X)

Me	0.03
Zc	0.9
Mb	0.03
La	0.001
Gg	0.01
Gma	0.01
Ssp	0.00
UDA	0.008
UDB	0.01
Pm	0....

Confusion Matrix of the Baseline

accuracy = 71 % on the 10 classes

Abbreviation	Species
Me	*Mesoplodon europaeus*- Gervais beaked whale
Zc	*Ziphius cavirostris*- Cuvier's beaked whale
Mb	*Mesoplodon bidens*- Sowerby's beaked whale
La	*Lagenorhynchus acutus*- Atlantic white-sided dolphin
Gg	*Grampus griseus*- Risso's dolphin
Gma	*Globicephala macrorhynchus*- Short-finned pilot whale
Ssp	*Stenella sp.*Stenellid dolphin
UDA	Delphinid type A
UDB	Delphinid type B
Pm	*Physeter macrocephalus*- Sperm whale



References / LINKS / contact : glotin@univ-tln.fr

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Deep Learning for Ethoacoustics of Orcas on three years pentaphonie continuous recording at Orealab revealing tide, moon and diel effects
M Poupard, P Best, J Schlüter, JM Prévot, H Symonds, P Spong, H Glotin
IEEE OCEANS 1-7, 2019

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M Poupard, B de Montgolfier, H Glotin
IEEE OCEANS, 1-5, 2019

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M Ferrari, M Poupard, P Giraudet, R Marxer, JM Prévot, T Soriano, … H. Glotin
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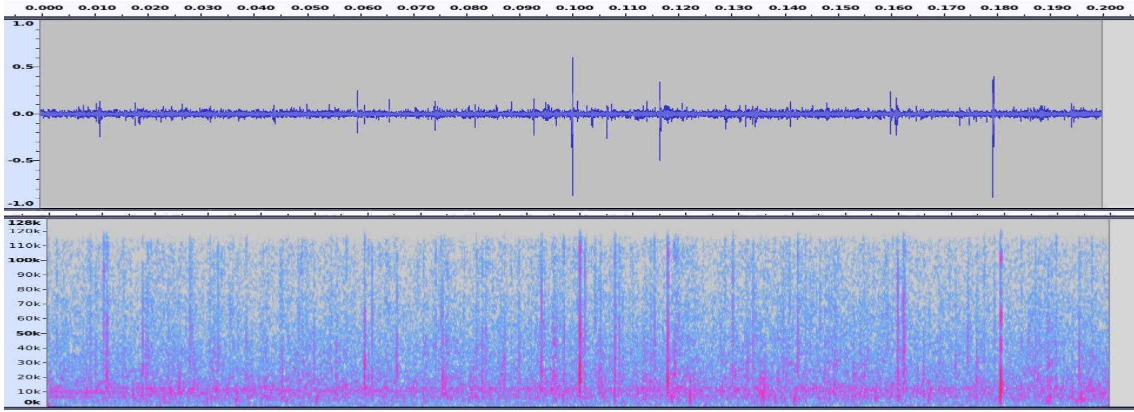
Spline Filters For End-to-End Deep Learning
Randall Balestriero, Romain Cosentino, Herve Glotin, Richard Baraniuk, Proc of the 35th Int Conf.on Machine Learning, 2018

LifeCLEF 2019: Biodiversity Identification and Prediction Challenges
A Joly, H Goëau, C Botella, S Kahl, M Poupard, M Servajean, H Glotin, et al.
European Conference on Information Retrieval, 275-282

Challenge 2
Biosonar ?
click versus reef noise ?

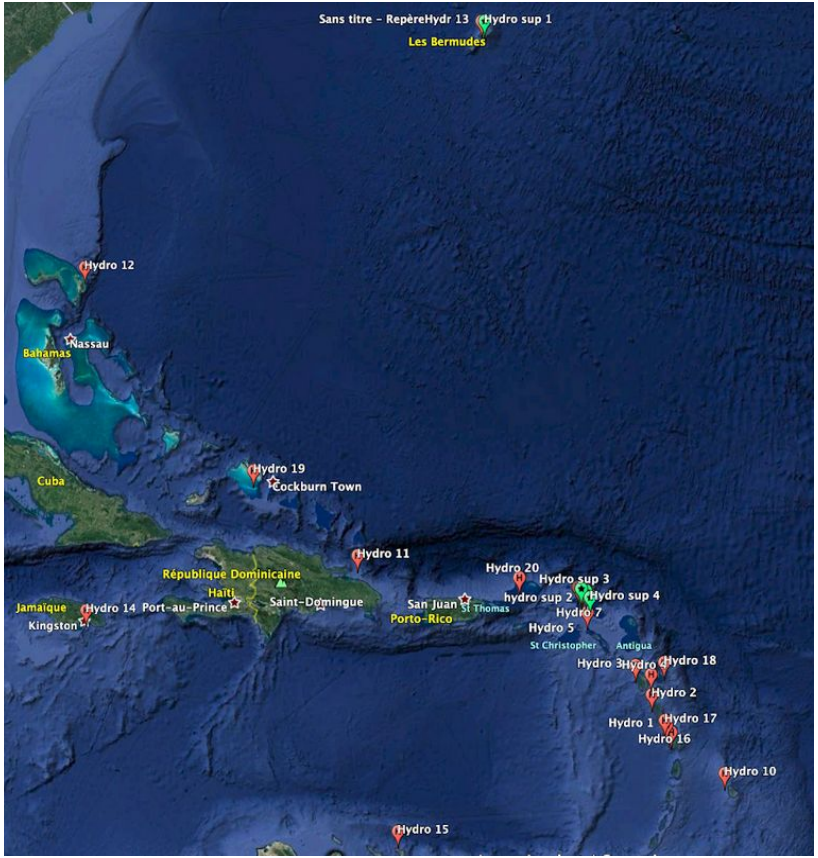
H. Glotin (Professeur) & P. Mahé (Post-doc)
contact : glotin@univ-tln.fr

Chair ‘AI bioacoustics’
CNRS LIS, Toulon université

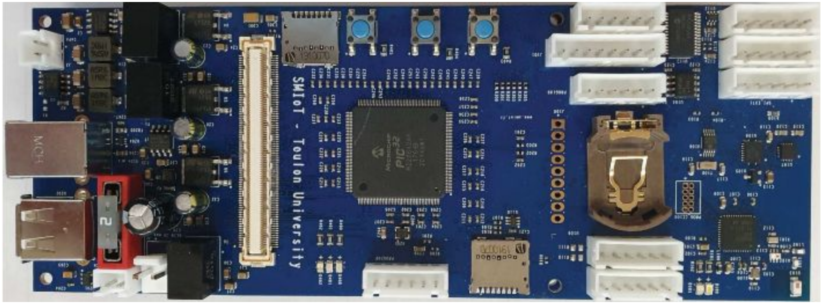


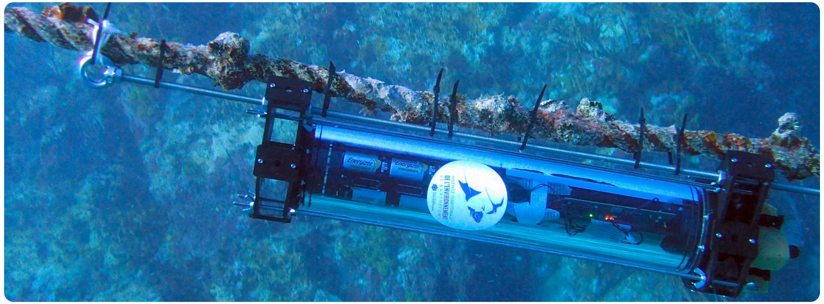
Projet CARI'MAM

Caribbean is a biodiversity hotspot. Thus 20 recorders have been built and installed by LIS DYNI since 2018

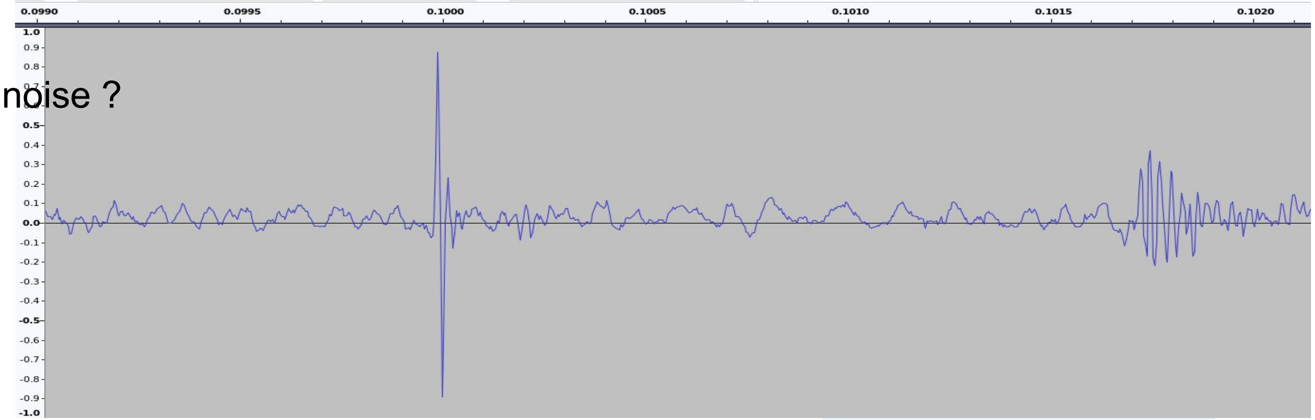


Projet CARI'MAM

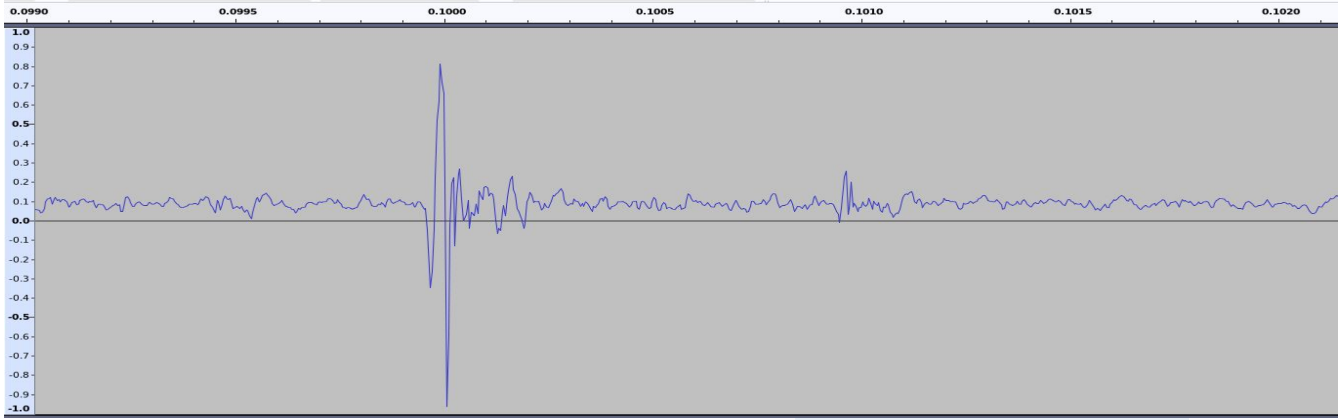




What is a Biosonar vs Reef noise ?



Exemple positif (biosonar)



Exemple négatif (bruit)

- ≈23000 samples
- each of 200 ms
- FS = 256 kHz
- 8 stations :

    "JAM", "BON", "BAHAMAS", "GUA", "ARUBA", "StEUS", "StMARTIN", "BAHAMAS"
- Répartition :

    ≈9500 positives (40%), ≈14000 negatives (60%)

Format du fichier d'annotations Y_train.csv :

[id, pos_label]

1250-JAM, 0

1251-JAM, 1

1252-BON, 1

Bibliography

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CARIMAM REPORT 1, BIOACOUSTIC DATA PROCESSING. Research Report DYNI LIS. 2021. hal-03629286, https://hal.archives-ouvertes.fr/hal-03629286/document

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Automatic classification of humpback whale (Megaptera novaeangliae) vocalization in the Caribbean, 2022. http://sabiod.lis-lab.fr/pub/Chavin_S_MasterThesis2022.pdf

[3] M. Poupard, M. Ferrari, P. Best, H. Glotin (2022);
Passive acoustic monitoring of sperm whales and anthropogenic noise using stereophonic recordings in the Mediterranean Sea, North West Pelagos Sanctuary. In Scientific reports https://doi.org/10.1038/s41598-022-05917-1

[4] M. A. Ziegenhorn, K. E. Frasier, J. A. Hildebrand, E. M. Oleson, R. W. Baird, S. M. Wiggins, S. Baumann-Pickering (2022);
Discriminating and classifying odontocete echolocation clicks in the Hawaiian Islands using machine learning methods. https://doi.org/10.1371/journal.pone.0266424

Our other challenges on
BIRD CLEF 2023

https://www.imageclef.org/BirdCocktailParty2022

data samples :
http://sabiod.lis-lab.fr/pub/HiFi_STEREO_BIRD_COCKTAIL_PARTY_Challenge/SBCP_TESTSET/

Conclusion :

Bioacoustics can today benefit of multichannel observations and joint AI process to:

- Diarize,
- Localize,
- Recognize.

=> study behaviour in anthropophony then assess regulation per habitat

=> Study natural communication systems …

May AI be with you…

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