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Could short duration broadband signals identified in IMS hydrophone recordings be Right Whale vocalizations?

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POSTER

P1.3-273

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ABSTRACT

The six CTBT IMS hydroacoustic hydrophone stations, comprising 11 triplets in total, record continuous data sampled at 250 Hz. Marine mammal vocalizations are frequently identified in these recordings and form an integral part of the HA stations' undersea soundscapes, as reported in numerous scientific publications. During regular IMS hydrophone data quality checks, occasional short duration broadband signals occupying the entire available bandwidth were identified, which differ from the longer duration sweeps and chirps of whale calls reported in prior studies that made use of IMS hydrophone data. When such a sound appears on more than one hydrophone of a triplet, the recordings show amplitude variations across hydrophones that are indicative of a nearby source. Furthermore, the signals do not show signs of dispersion from long-distance propagation. The hypothesis is formulated that these sounds may be the low-frequency portion of short impulsive broadband vocalizations, referred to in the literature as Right Whale "gunshots". Recordings of this endangered species are relatively rare compared to vocalizations from other whales and their study is receiving increased interest from the scientific community.

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INTRODUCTION

- Short, impulsive broadband signals appear from time to time in IMS HA hydrophone recordings.
- Often, such signals are related to seismic air-gun surveys, or explosive underwater volcanic eruptions. However, on other occasions impulsive broadband signals appear which cannot be associated to the above events.
- This poster shows examples of impulsive signals observed in IMS HA data and which sometimes puzzle us. They appear to be of biological origin and may be generated by Right Whales (*Eubalaena Australis*).
- Right Whale vocalizations are a topic of increasing interest in recent years, because their calls are quite different from those of other whales.
- The remote IMS HA hydrophone stations HA01, HA03 and HA04, with their contionuous recordings over very long periods of time, may be convenient “observatories of opportunity” for studying Southern Right Whales.

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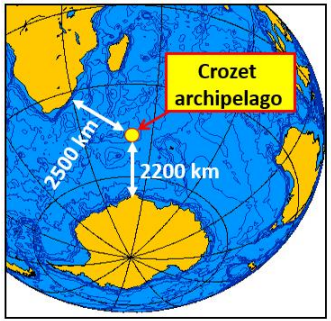
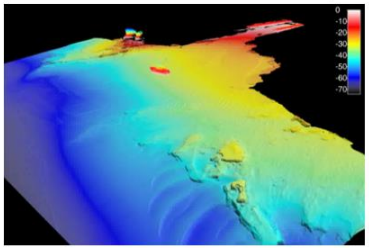
RESULTS

Right Whales do visit Crozet





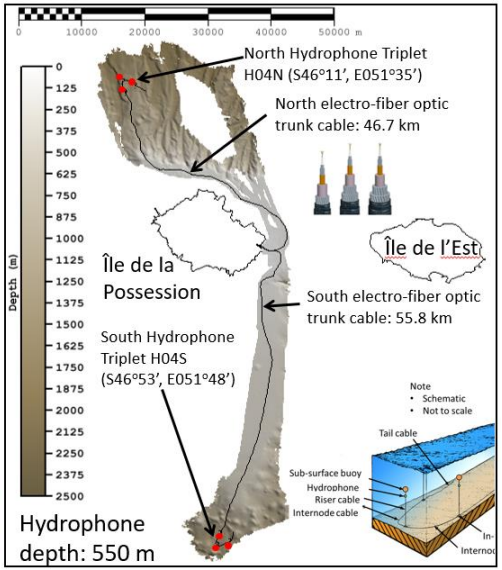


Photo of a Right Whale, taken from Ile de la Possession (Crozet), in February 2017 http://ilescrozet.blogspot.com/2017/02/?m=1

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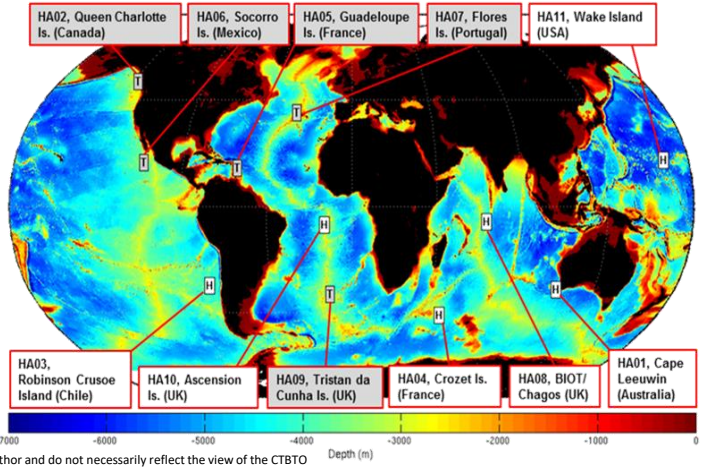
METHODS

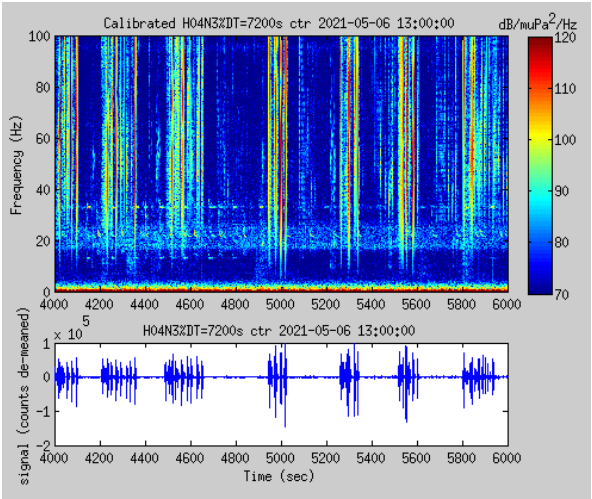
- Impulsive signals observed in time-series and spectrograms of IMS Hydroacoustic (HA) Hydrophone Stations.
- HA01, HA03 and HA04 are at latitudes of known Southern Right Whale habitats ("Southern right whales are distributed throughout the Southern Hemisphere from around 20 degrees South to 65 degrees South." from https://www.fisheries.noaa.gov/species/southern-right-whale)
- The Table and Map below show locations, water depths and hydrophone depths of the IMS HA hydrophone stations:

Hydrophone Station		Water depth (m)	Hydrophone depth (m)
HA01	W	1550	1100
HA03	N	1866	824
	S	2071	830
HA04	N	1310	541
	S	1309	535
HA08	N	2300	1250
	S	1800	1350
HA10	N	2000	850
	S	1700	850
HA11	N	1400	750
	S	1150	750



Disclaimer: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

HA04 Crozet, broadband impulsive calls: Right Whale "gunshot" vocalizations?



See discussions of Right Whale gunshot and other vocalizations recordings in:

- R.N. Ward, "Southern right whale vocalisations, and the "spot" call in Australian waters: characteristics; spatial and temporal patterns; and a potential source - the southern right whale", PhD Thesis, Curtin Univ. (2020) [*presents also data from HA01*]
- J.L. Crance et al., J. Acoust. Soc. Am. 145 (2019)
- S. Parks, P.L. Tyack, J. Acoust. Soc. Am. 117 (2015)

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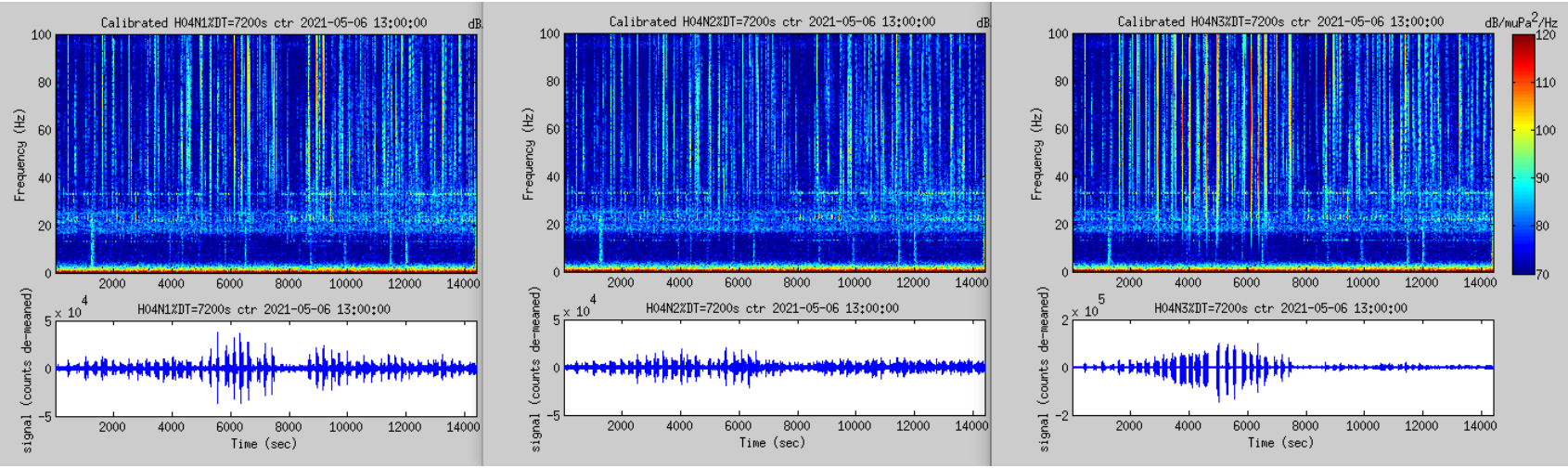
RESULTS

HA04 Crozet North Hydrophone Triplet, 6th May 2021 11:00 – 15:00 UTC



- Signals appear to be low-frequency part of broadband, short impulses.
- Levels are very different between the three hydrophones of the triplet (hydrophone spacing is ~2 km) → source most likely in the near-field of the triplet.
- DTK-GPMCC cross-correlation analysis shows varying back-azimuths → moving sources and/or multiple sources.

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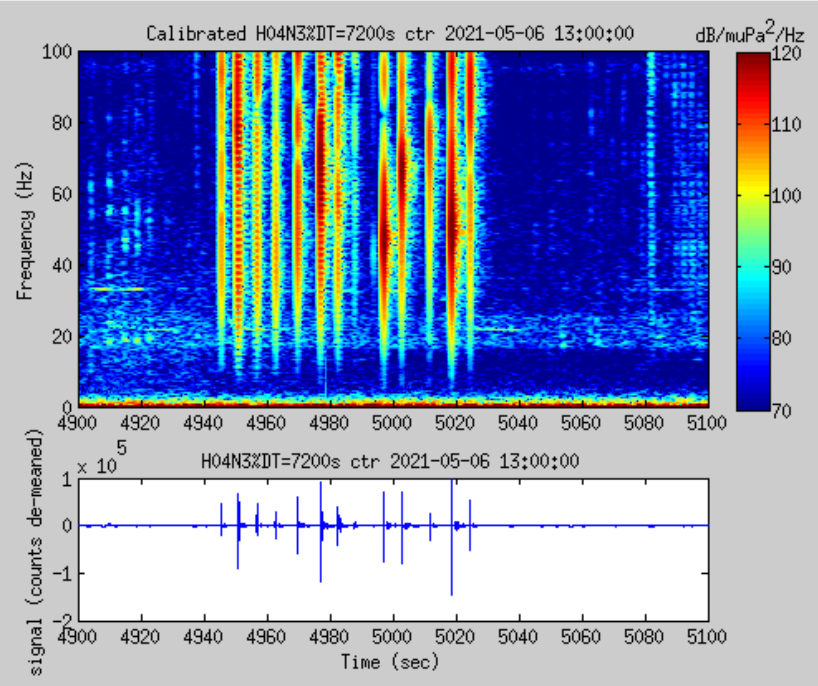
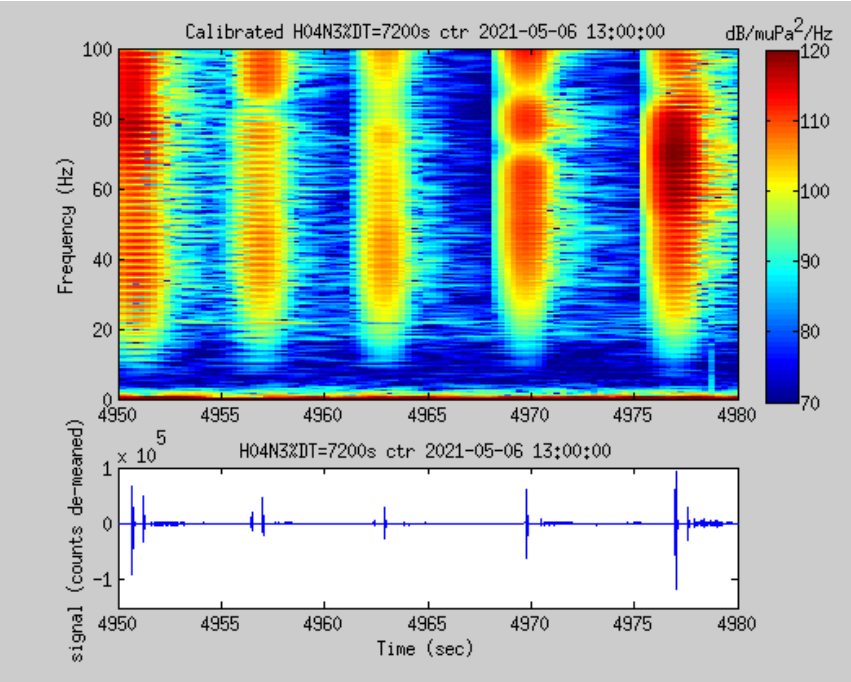
- Progressive zoom on the time-window of the H04N3 signals from the previous slide.
- Short impulses, with frequency scalloping features indicative of interference between closely spaced impulses.





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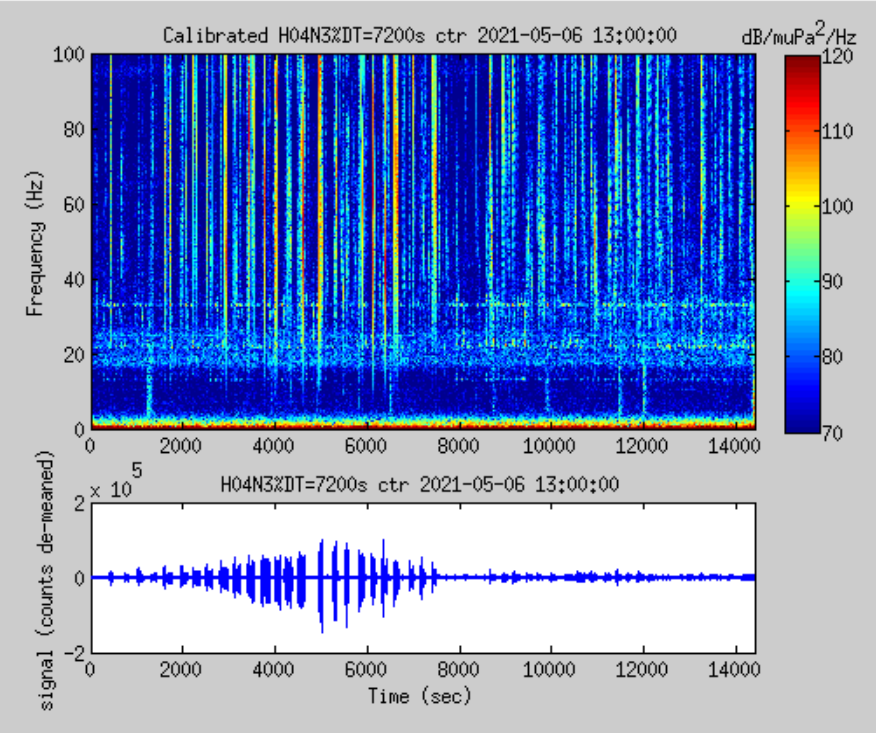
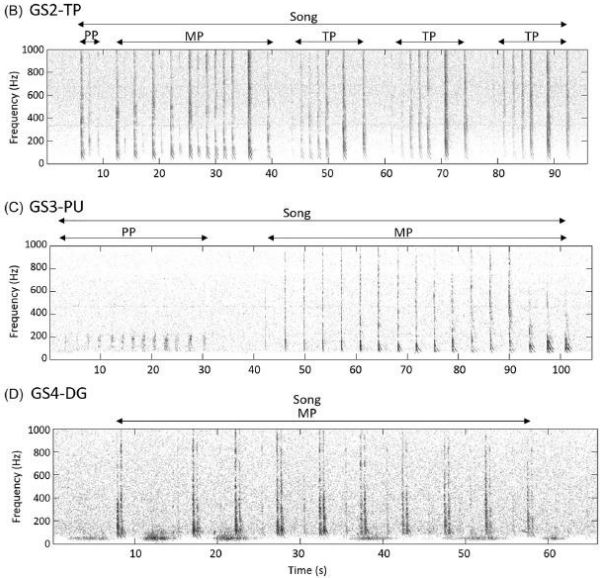


- J.L. Crance et al., J. Acoust. Soc. Am. 145 (2019), from Figure 2: Spectrograms showing North Pacific Right Whale gunshot song types.
- R.N. Ward PhD Thesis (2020) shows also similar signals for Southern Right Whales.
- Note: Frequency bandwidth is 1000 Hz in plots below, vs. 100 Hz for HA Stations.



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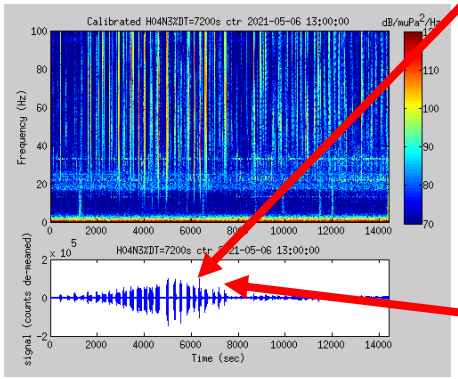
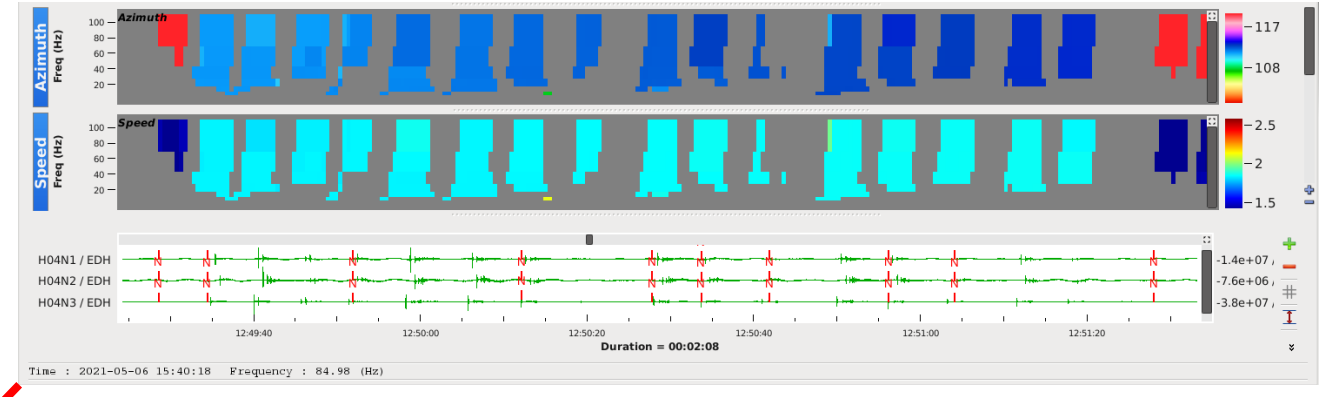
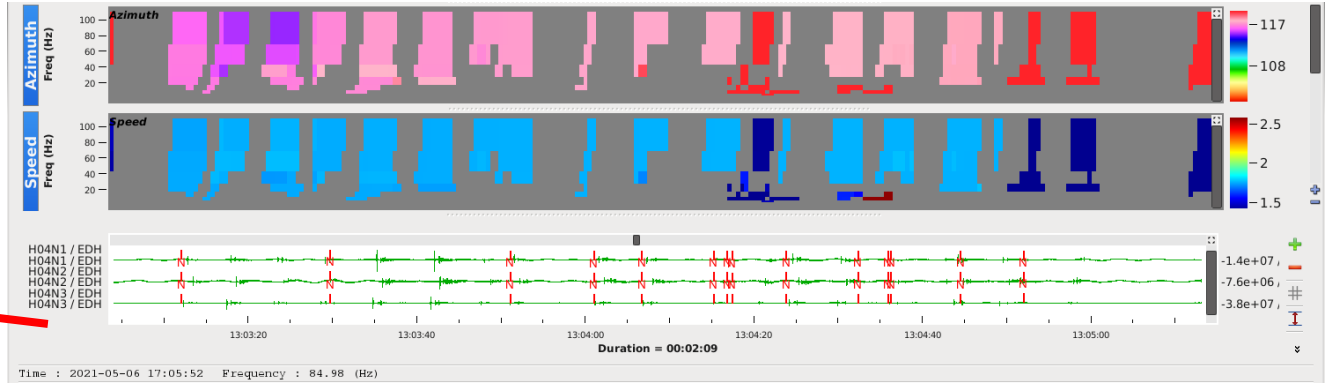
DTK-GPMCC cross-correlation analysis:

- Different apparent wave-speed at the triplet changes for different time snippets.
- Apparent wave-speed near 1.48 km/s → source is distant or at near hydrophone depth.
- High wave-speed → source has a high angle relative to the hydrophones and therefore is not far from the triplet and not near hydrophone depth.







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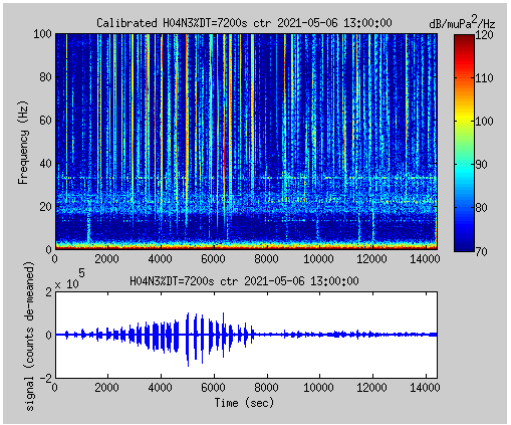
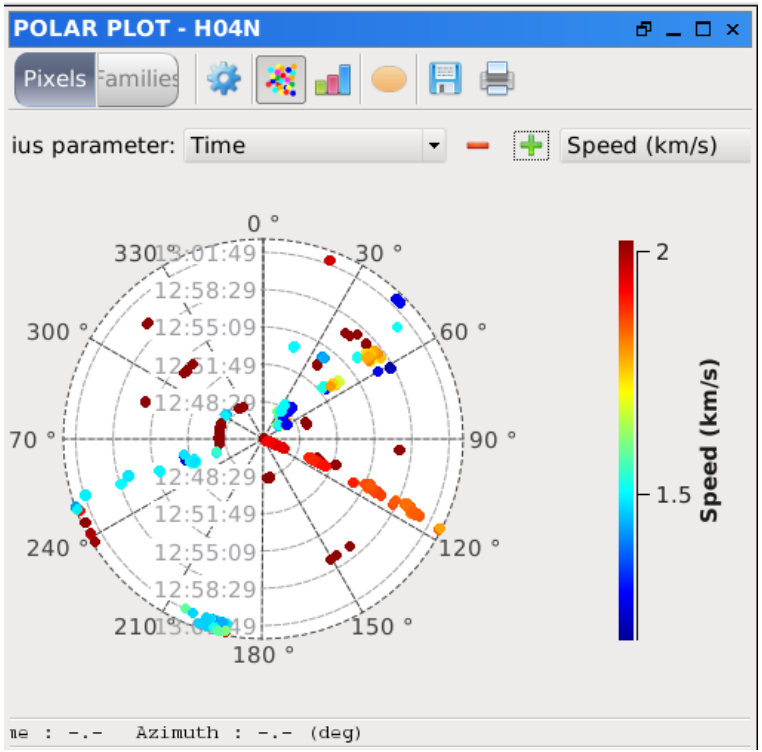
Polar plot showing signals' back-azimuths and detection time:

- One track (orange color) has constant bearing (~120°) and decreasing apparent wave-speed → source moving away from the triplet, or diving deeper, or orienting its beam differently.
- Other dots show varying azimuths → different source in the distance (most likely when wave-speed is low around 1.48 km/s), while others are changing position in the vicinity of the triplet (when wave-speeds are high).
- Therefore, there appear to be possibly more than one source in this dataset.





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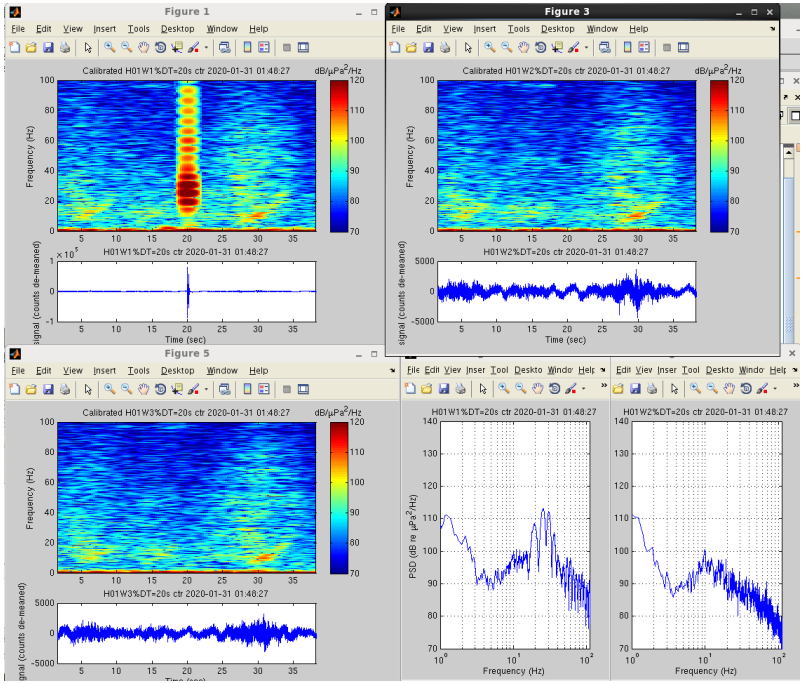
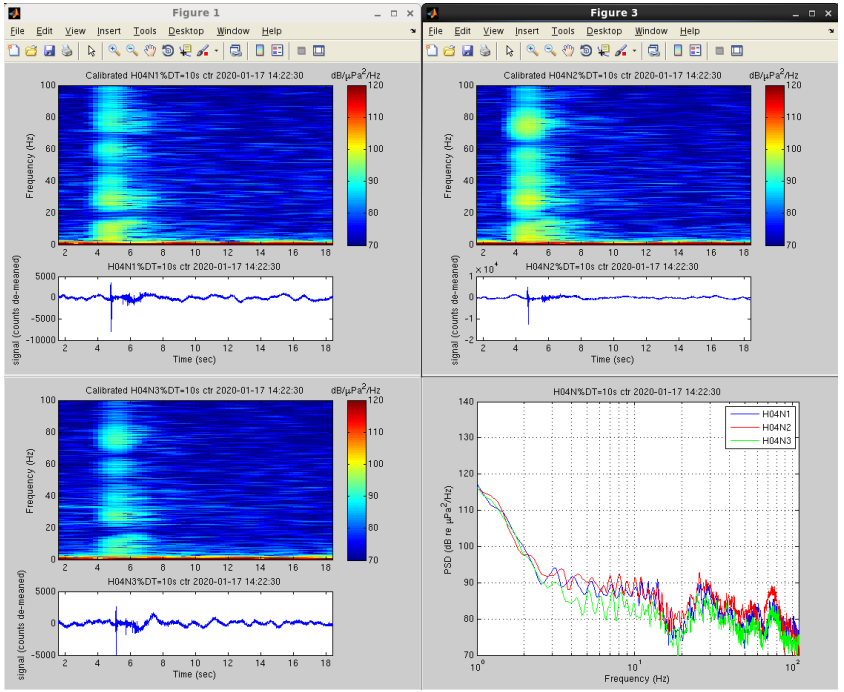
- Sometimes, such impulsive signals appear on single hydrophones → source very near the hydrophone?
- Example from HA01 shown here.



- Sometimes (H04N shown here) low-frequency signals appear on all three hydrophones of the triplet → source is in the water.
- **Is this a Right Whale "Gunshot" or "Pulsive" call ?** (Ward 2020)



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CONCLUSIONS

- This poster presented examples of different short-duration, impulsive signals which are observed at IMS HA hydrophone stations and appear to be of biological origin.
- The signals resemble Right Whale calls published in the literature, multi-frequency cross-correlation analysis suggests multiple sources moving at various distances from the hydrophones.
- The IMS HA hydrophone stations HA01, HA03 and HA04, with their continuous recordings over very long periods of time, may be convenient “observatories of opportunity” for studying calls of Southern Right Whales.
- HA03 and HA04 are in particularly isolated areas, HA04 is very far from any kind of human activity at-sea.
- Researchers interested in the subject and curious to search IMS HA databases for Right Whale calls can request (at no cost) access to the data via the CTBTO’s virtual Data Exploitation Centre (vDEC) https://www.ctbto.org/specials/vdec/