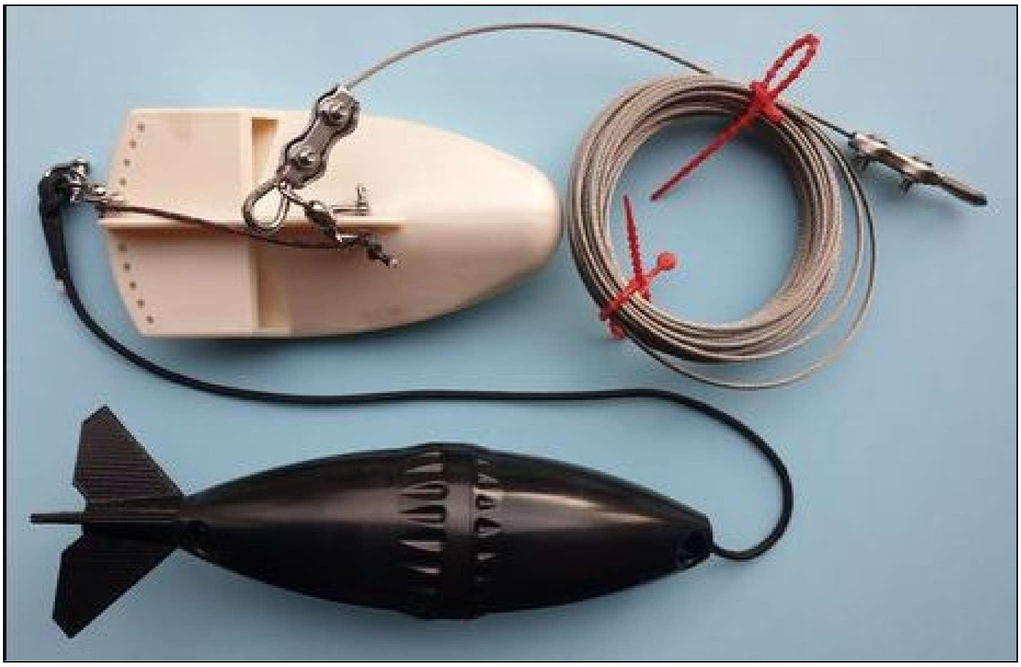
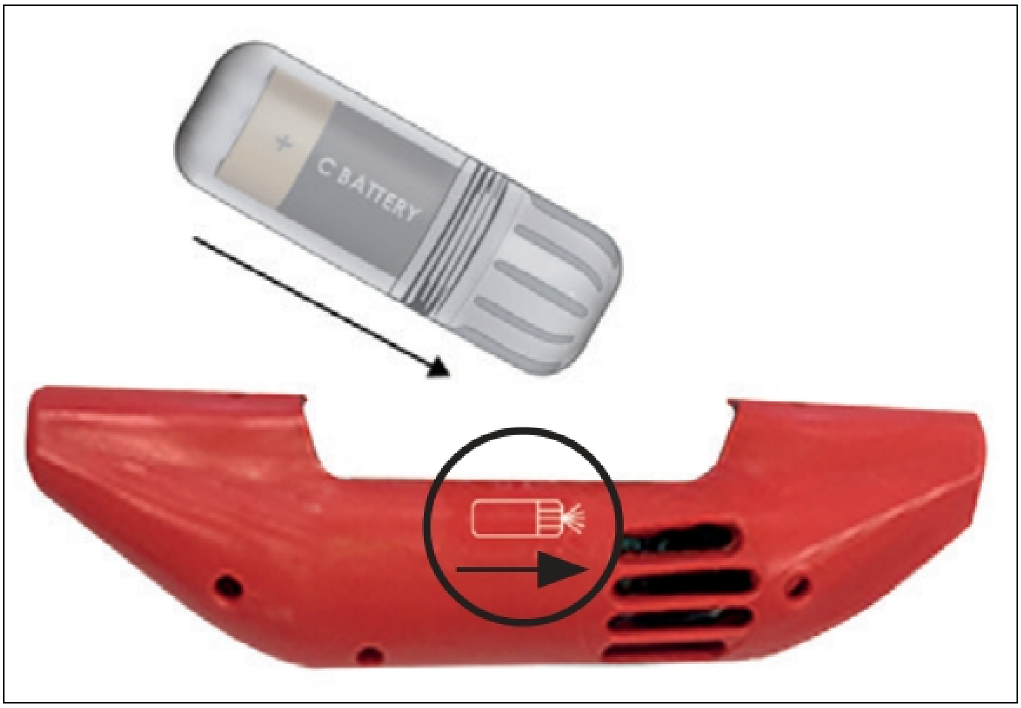
Killer Whale Attacks – Boat Protection

Whale-PAL & Banana pingers comparison
Updated on 17/12/2023





by Pierre Lang

Contents

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The current subject is a living one. Please download the last update of this document. Modified text is marked with its date in superscript that way (2023-11-02).

About the author

I am Pierre Lang, born in Brussels (1951), Polytechnic School (Free University of Brussels), solo sailor, 40 000 miles sailed in Europe between Greenland and Greece (2006-…)

I designed my sailboat Thoè with Gildas Plessis (French naval architect) in 1999-2000. I took a very active part in her construction. As a consultant, I surveyed the construction of one sister ship Tara (2004). Thoè won the first prize of the wooden boat challenge at the La Rochelle boat show (France, 2001).

I took part in humpbacks and blue whale research in Iceland from 2013 to 2018. It is why I own a hydrophone that I used to record possible deterring sounds in this study.

Comments or questions can be sent to plang@irisoft.be – www.thoe.be

Abstract

Pingers are electronic devices which are producing ultrasounds to repel dolphins and orcas. The objective is to avoid animals to be entangled into human gears (fishing nests), to avoid bycatch of fish from the fishing gears and, since 2020, to protect boat rudders to be damaged by orcas along Spanish and Portuguese coasts.

Most studies about orcas interactions are made by biologists, not by sailors. In this project, we are comparing two types of pingers. We consider this study as a semi-scientific one, with a component of vulgarization, as the readers (and the author) have probably not complete knowledge in this matter.

Methodology

Data sources

We used three sources of data. (1) The specifications (brochures) of the products (2) the answers of the manufacturers to our questions and (3) the audio recordings we made ourselves to compare the sound emissions of the devices.

Recording devices

We used a hydrophone H2a-XLR. The recording was made in un-compressed WAV format on flash memory cards using a Tascam HD–P2 recorder (192 kHz sampling rate, 32 bits) and an AudioMoth Dev recording board (384 kHz, 32 bits).

See details in the Annexe 1 "Audio recordings".

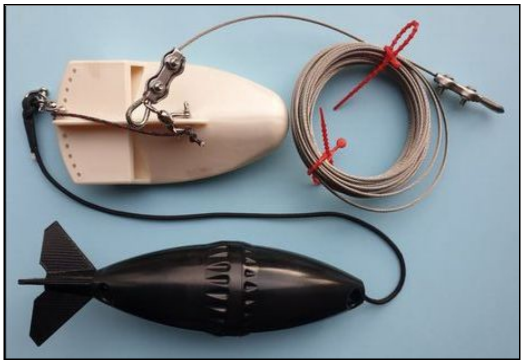
The audio recordings were made in a plastic rectangular vessel (40 × 32 cm) filled with 12 cm clear water. The pinger and the hydrophone were hanging vertically at 25 cm from each other along a diagonal of the vessel. The recordings of the angles of sound emissions around the pingers were not made. We have a project to make these recordings next year at sea.

This is a private initiative made by a single-handed sailor for sailors. It was made without any kind of sponsoring and conflict of interest. The recordings and sound analysis were made by ourselves using our own hardware and open-source software or free versions of commercial audio software.

The Whale-PAL pinger

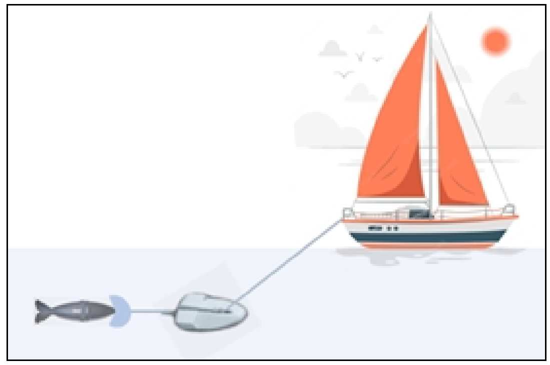
Protecting boats

This pinger and its assembly are designed to specifically protect boats from orcas. The manufacturer programmed it in function of the targeted whale specie.



This pinger has a torpedo shape and a swimming device (paravane) to maintain it at a controlled depth under the surface.

The product includes everything needed to be towed by the boat (line, paravane, etc.)



It is towed at ± 10 m from the boat stern and ± 2 to 3 m depth.

When the boat is stopped, the pinger must hang at the depth of the rudder with its head up (the tail must be loaded by a weight of ± 60 to 100 gr).

It is sending a very wide frequency range sound every ± 4 seconds in a limited angle toward the front. An additional random sound avoids orcas from habituating. Some reports mention that orcas ran away. Other mentions that the orcas seem temporary stuck as paralysed before leaving. The manufacturer claims 90 % successful interactions without damages and in case of damages, that they are limited.

Emission

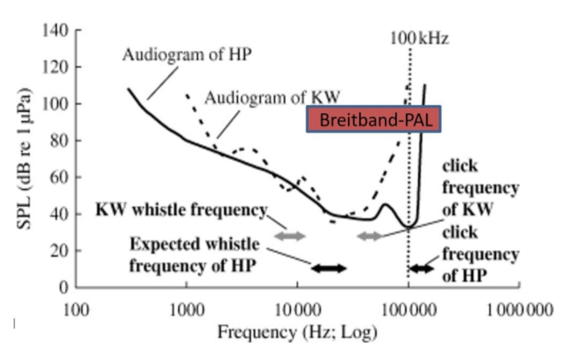
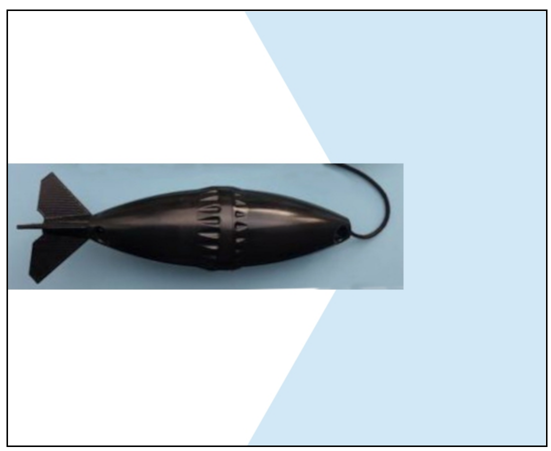


Fig. 7: The hearing curves of killer whales (KW, dashed line) and harbour porpoises (HP, black line) reach their greatest sensitivity at 10 – 100 kHz. This range is completely covered by the broadband signal of the Whale-PAL (own measurements; Szymanski et al., 1999; Kastelein et al., 2002).

The device is emitting two wideband signals in the range 10 kHz to 130 kHz. The centre frequency is at 70 kHz.

The emitted sound is said to mimic the emergency vocalization of the orcas.

The main sound is emitted every ± 4 seconds. A secondary one at 4 – 20 s random intervals is limiting animal habituation.

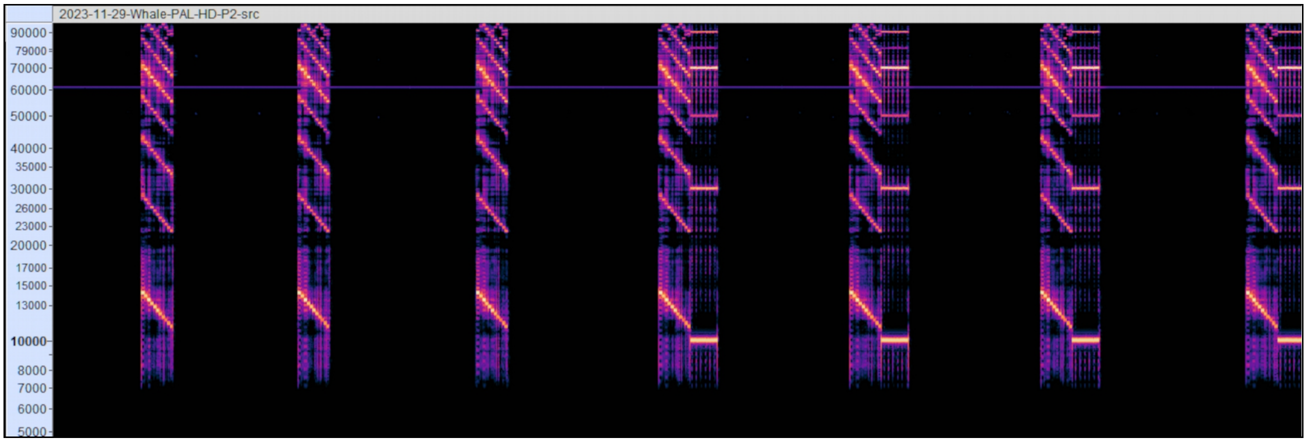


Sound emission sent symmetrically all around, in a 240° angle in forward. It is protecting the rudder in front of it.

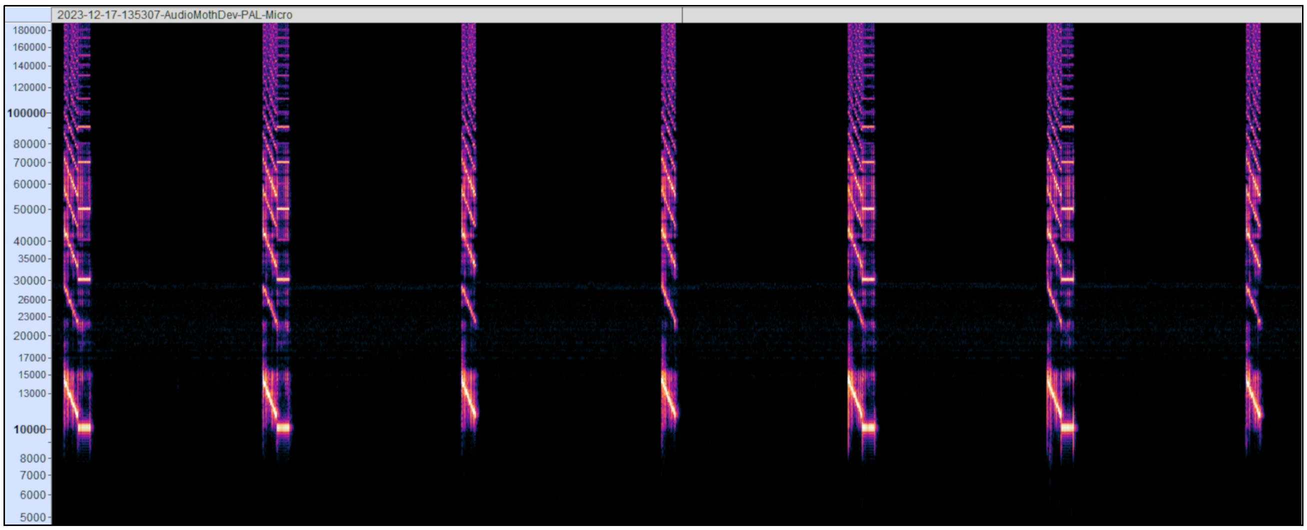
It is mute in the 120° angle backwards.

Note

Should the sample rate be set to 192 kHz, the recorded frequencies would be limited to about 96 kHz. The pinger is said to emit up to 130 kHz which requires at least a 260 kHz sampling (actually 384 kHz).



Recording : underwater, hydrophone H2a-XLR & Tascam HD-P2 recorder (2023/11/29, 192 kHz resolution, 32 bits)



Recording : in the air, AudioMoth Dev used as a microphone (17/12/2023, 384 kHz resolution, 32 bits)

The Whale PL pinger is producing a complex rather long sound (350 to 650 milliseconds) of various frequencies.
Sometimes, it is divided into parts to avoid the orcas to habituate to a non-orca vocalization.
The manufacturer claims that the sound is based on the distress vocalization of orcas.
Listen the Whale-PAL pinger (frequencies divided by 10, silence length shortened)

Links and references

Manufacturer's home page : www.f3mt.net

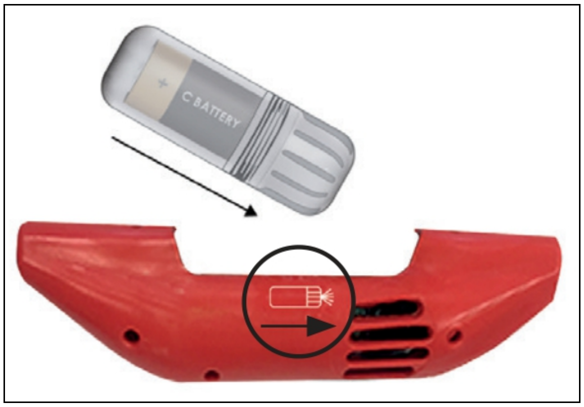
Presentation and references : www.f3mt.net/whale---pal.html

Review by the manufacturer : www.f3mt.net/uploads/1/1/0/9/110974389/orca-attacks.pdf

The Banana pinger

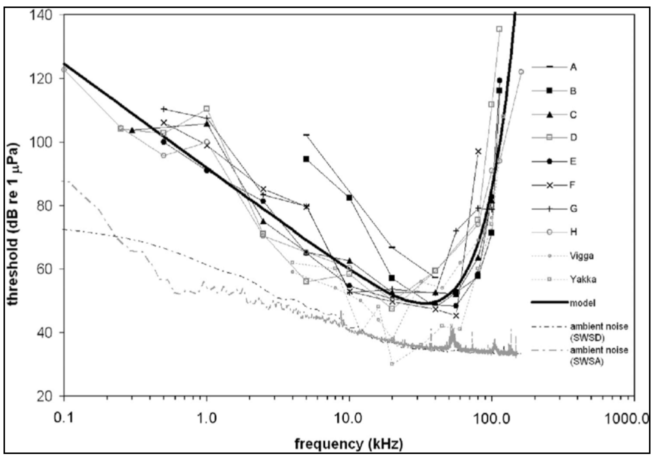
Presentation

Some pingers have the shape of a banana. They are designed to be regularly installed on the border of fishing nets and lines to avoid fish by-catches and dolphins to be entangled in fishing gears.



Transducer and envelop

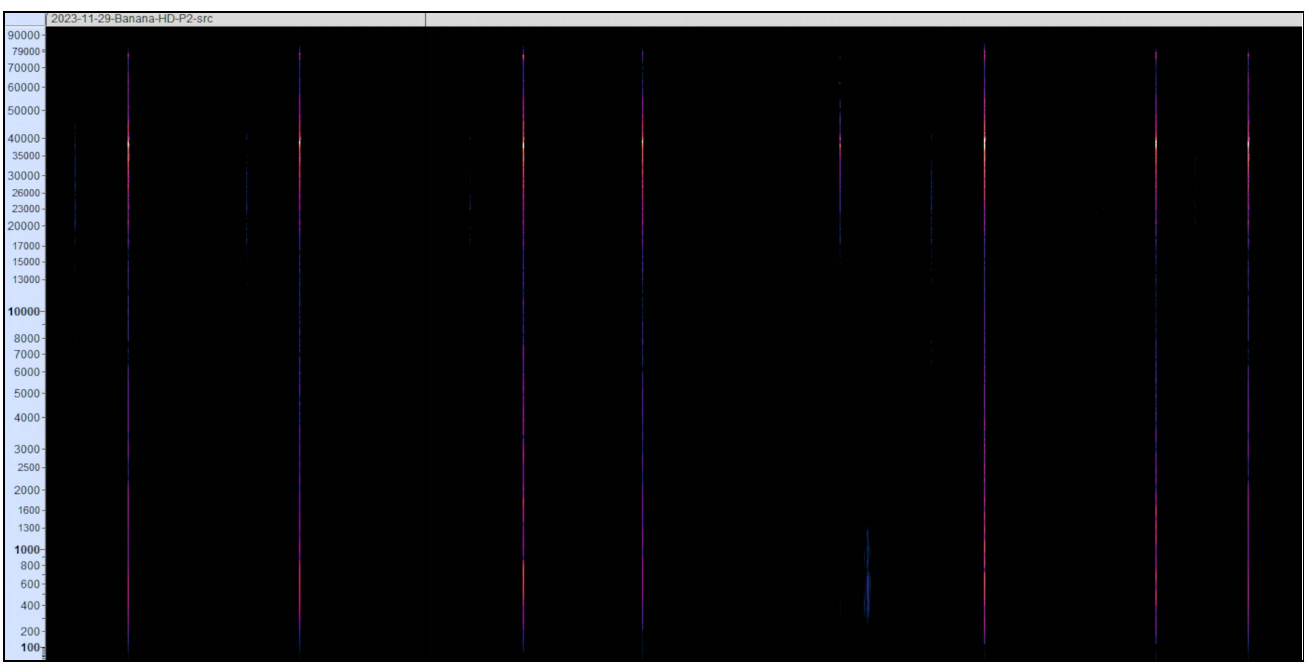
Emission



The audiograms of individual killer whales. Solid black lines represent animals from SWSD and solid gray lines represent animals from SWSA, while dashed lines represent animals from Szymanski et al. (1999). The "model" data is a composite audiogram estimated from the procedure discussed. Average ambient noise values are in dB re 1 lPa 2 /Hz. Ambient noise was measured with a TC4032 low-noise hydrophone coupled to a VP1000 preamplifier.

Source : Fishtek Marine by reference to the following study www.researchgate.net/publication/315803866_Killer_whale_Orcinus_orca_behavioral_audiograms

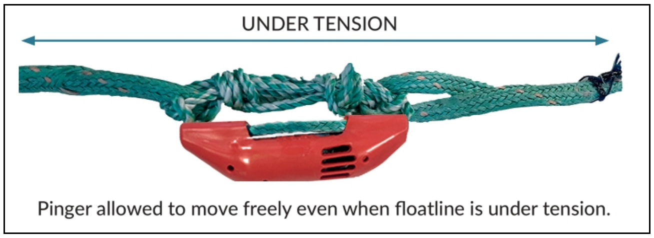
The transducer sound frequency has been adjusted to the orcas audiogram. The pinger is transmitting at 40 kHz which is the greatest sensibility of the orca ear. It is randomized between 4 s and 12 s to avoid habituation.



Recording : underwater, hydrophone H2a-XLR & Tascam HD-P2 recorder (2023/11/29, 192 kHz resolution, 32 bits)

The banana pinger is producing a very short and loud sound (40 kHz, 30 milliseconds).
Listen to the Banana pinger (frequencies divided by 10, long silences shortened)

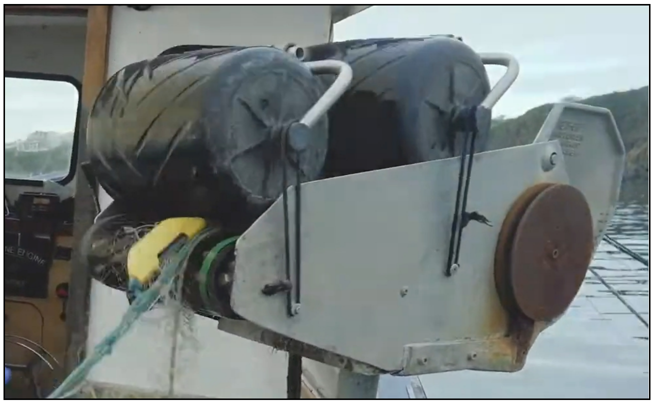
Protecting fishing gears



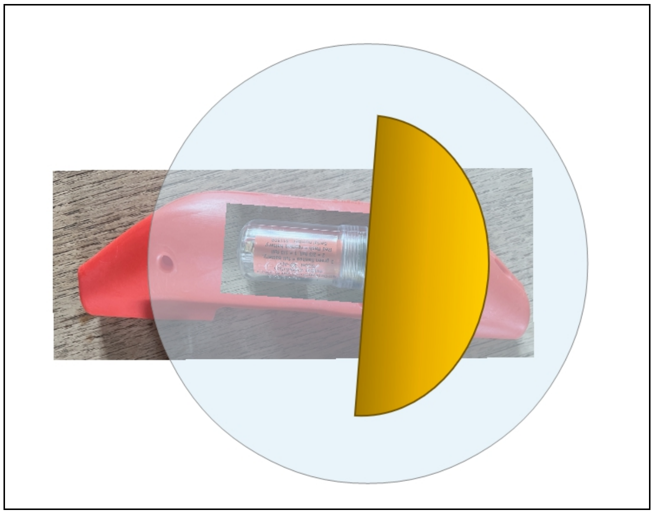
It is specifically designed for fishing gear protection (to avoid by-catches).

It has a banana shape with a horizontal rope channel at the top to be attached inline on a fishing line or net.

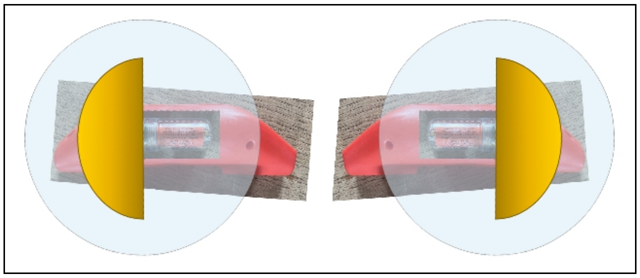
A pinger must be installed every ± 100 m to 200 m.



The rubber envelope is protecting the transducer to easily pass through the lifting systems.



Drawing source : Fishtek Marine



The pinger is supposed to emit sound all around (light blue colour) with a higher intensity in front of the transducer due to the screen of the battery (yellow colour).

Some fishermen experimenting bycatch by bottlenose dolphins are installing two opposite pingers to achieve a symmetric lateral emission (two yellow half circles).

Protecting boats

The manufacturer which is specialized in fishing, changed the frequency of his fishing pinger to match the orca ear sensitivity. He does not warrant any result and does not provide any advice to explain how it should be towed by a pleasure boat. However, the manufacturer is recommending:

- To use the 40 kHz transmitting model which is suitable for "big whales".
- To tow two pingers per boat.
- To maintain it as close as possible to the rudder (2 m) and at 2 to 4 metres depth.
- It is providing a limited or no user support. The product is shipped "as is" for boat protection. There is no boat specific documentation. The set-up is left to the user's responsibility.

The banana shape is **asymmetric** and has **too much drag** when moving at some knots. It is not able to easily dive at a controlled depth when towed by a boat. Some users reported that they tied a 5 kg diving lead to keep it under the surface while sailing ! This is maybe not the right way to use it. At the end of the day, if some are not efficient, an improper conclusion is that *all* pingers are useless, including any other types of pingers !

Our recommendations

As the pinger has a 100 m to 200 m range, it is not necessary to install two of them to protect a small boat. The water drag of the banana is much too large. We suggest making a better shaped DIY low-drag envelope. It is also possible to pull it with no envelope at all, by using a piece of fishing net or light fabric. Use a weight or, better, an adjustable paravane to maintain it under the surface. See www.amazon.com.be/dp/B002AAQ304?psc=1&ref=ppx_yo2ov_dt_b_product_details (maybe too small). It should be towed at some meters from the stern of the boat so that the sound diffusion angle will embrace the rudder(s). It can be towed on one side of a boat with a single rudder and in the middle of a boat with two rudders.

Links and references

Made by Fishtek Marine (UK), sold in France by ISI-FISH.

Manufacturer: www.fishtekmarine.com

French distributor's : www.isifish.fr

Presentation: www.fishtekmarine.com/reduce-cetacean-bycatch

Instructions: www.fishtekmarine.com/wp-content/uploads/2019/07/EN_Deterrent-Pingers-fitting-instructions-1.pdf

References : The Banana Pinger Trial. Investigation into the Fishtek Banana (by Abby Crosby, Nick Tregenza and Ruth Williams, October 2013) www.ascobans.org/sites/default/files/document/NSG4_Inf_4.3_BananaPinger.pdf

Conclusion

Whale-PAL vs Banana pinger

The fact that the manufacturer of the banana pinger is avoiding documenting its use does not plead for it. When looking at the spectrograms of these two devices, it is evident that the Whale-PAL is looking more sophisticated and probably closer to the deterrent objectives. However, the sound intensity of banana the pinger seems to be greater, but is it enough to forecast its efficiency ?

The banana pinger concept looks to deafen the orcas. Animal protection defenders would probably claim that there is a risk to damage the ear of the animal. But does a animal stay in a dangerous area ? On the other side, the Whale-PAL is said to be based on the orca emergency vocalization, which appears to be an attractive concept.

Fishtek Marine is recommending using two pingers. In this case, we would prefer to install one of each model, but certainly not two banana pingers. The second banana pinger would be useless.

Are the pingers attracting orcas ?

Someone, including biologists, says that pingers are attracting orcas. Our opinion is that any sound that orcas learned to be related to boats (engine, pinger, echo sounders, water flow, etc.) can attract these mammals from far away, especially low frequencies spreading further. But when they are close to a pinger, they could be repelled if the intensity of the sound is too high for their ear capability (banana pinger ?) or by the sound profile itself (Whale-PAL pinger ?)

So, in our opinion, the pinger should probably be dropped into the water when a careful visual watch has previously detected that orcas are approaching. Of course, if an attack already in progress, it is never too late to put the pinger(s) into the water.

Are pingers successful ?

No scientific studies have been made to measure the pinger's efficiency. It is very difficult to get lots of observations to compute reliable statistical conclusions. In case of observations made by sailors who experimented interactions with orcas, their reports generally contain emotional or stress bias, missing or inaccurate information, etc. If an orca is stopping its attack, it is practically impossible to know exactly why. The crew probably tried to use several means to repel it. That is, we cannot know what the intention of the animal was. For example, it is said by biologists that an orca is leaving the area if its group or family is far away.

The question will remain unanswered for long. In the meantime, the best is to try them if we can, together with other possibilities protecting our boats...

Annexe 1 – Audio recordings

As this project is a private un-sponsored one, we had to choose low cost but powerful devices. We needed a sampling rate of twice the greatest frequency to be recorded (en.wikipedia.org/wiki/Nyquist_rate). To record up to 130 kHz, we had to use a sampling rate of 384 kHz, which is not easy to find at an affordable price.

Most common recording devices or interfaces are using a ± 48 kHz sampling rate. They have a limited bandwidth because human beings cannot listen more than 20 kHz. So, their eventual possibility to manage ultrasounds is therefore not documented.

The recording process includes two or more parts depending on the type of hardware and the frequency range.

Hydrophone

In either case, we need a **hydrophone**, an underwater microphone having the capability to capture ultrasounds. We used two low-cost Aquarian hydrophones, an H2a and a H2a-XLR, having similar specifications. Their non-linear bandwidth goes to at least 100 kHz with an undocumented sensibility, ± 200 €. www.aquarianaudio.com/h2a-xlr-hydrophone.html.

Recording option 1

The first option is to use a **digital recorder used in the first version of this study**. It is recording the input on a memory card in the uncompressed WAV format (Tascam HD-P2, 24 bits, 192 kHz resolution, documented bandwidth and sensibility up to 80 kHz, discontinued product, ± 80 € as second-hand). www.tascam.eu/en/downloads/hd-p2

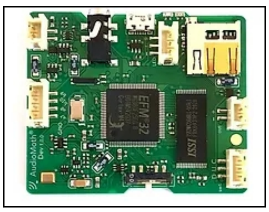
Head speakers can be connected to control the sound real time.

Recording option 2

The second option is to use an **analog to digital interface** connected to a USB port of a computer (Behringer U-Phoria UMC202HD, 24 bits, 192 kHz resolution, ± 90 €). www.behringer.com/product.html?modelCode=P0BJZ. Head speakers can be connected to control the sound real time.

To allow recording ultrasounds, we used the **ASIO4ALL** driver (asio4all.org). Then, many studio software can be used to record the input to the hard disk in the uncompressed WAV format. As an example, we used the free version of Tracktion Waveform. www.tracktion.com/products/waveform-free.

Recording option 3



The third option is to use a dedicated recording board. AudioMoth products are open source, developed by the University of Southampton to record ultrasounds at a sampling rate from 8 kHz to 384 kHz, uncompressed WAV format (board size: 58 × 48 mm). www.openacousticdevices.info/audiomoth

We bought *AudioMoth Dev* from LABmaker/Germany (± 150 €). www.labmaker.org/products/audiomoth-dev

Our choice

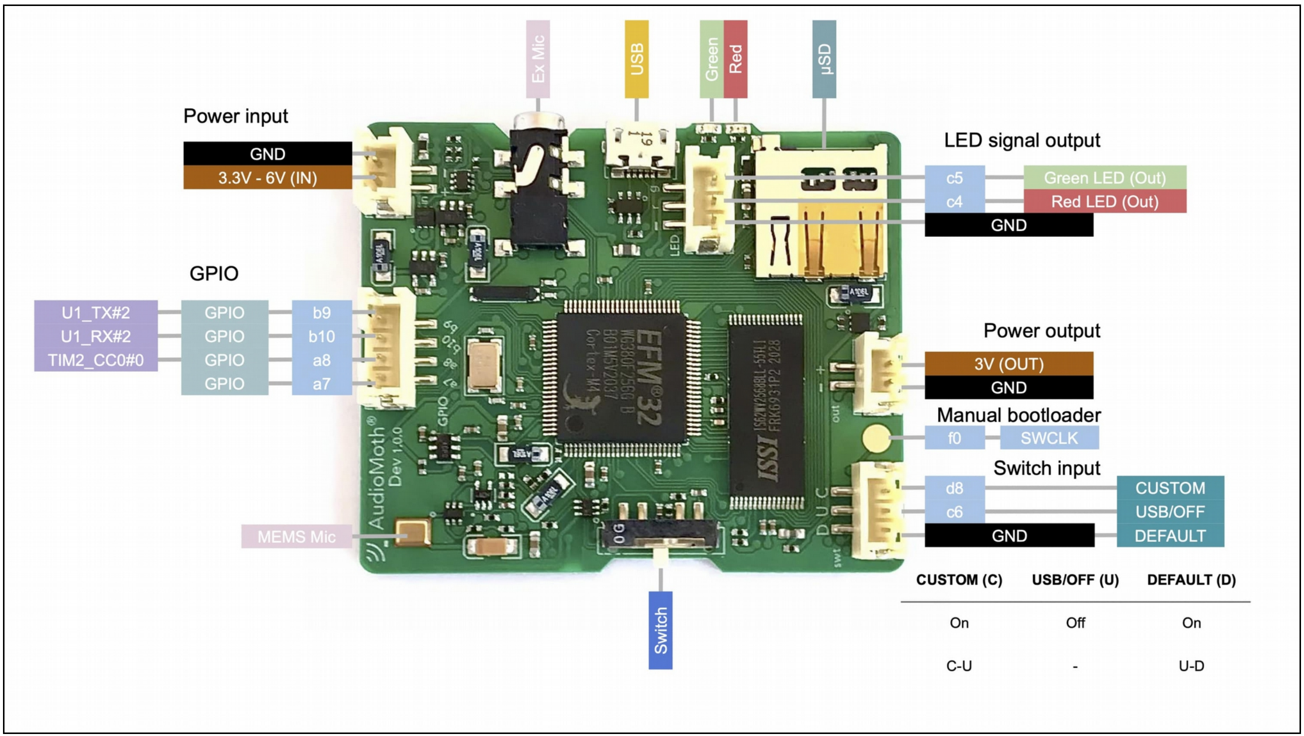
After a testing period, we decided to choose between the following options depending on the recording context.

- The Tascam HD-P2 recorder for recording up to ± 80 kHz connected to the H2a-XLR hydrophone [2023-12-12].
- The AudioMoth Dev used as a recorder connected to the H2a hydrophone.
- The AudioMoth Dev used as an underwater microphone/recorder protected into the AudioMoth/HydroMoth Underwater Case [2023-??-??].

Another recording option

Another possible option is a stand-alone device including a hydrophone and a recorder in a single underwater envelope. This is a very expensive solution. It looks like it is not well adapted to be towed by a pleasure ship.

Using AudioMoth Dev



- Connect the battery to the "Power input" socket. Take **care to the polarity** of the battery which is not standard.
- The device can be used with the internal microphone "MEMS Mic". It can be used underwater if it is protected into the *Underwater Case* as the HydroMoth device. However, the start/stop magnetic switch of the HydroMoth is not available.
- The hydrophone (H2a in our case) can be connected to the "Ex Mic" socket. The device will recognize it automatically.
- The recording can be made on the "µSD" card or by the computer via the USB connection using the *AudioMoth Live App*.
- Set the "Switch" to CUSTOM (C) or DEFAULT (D) after configuration using the *AudioMoth Configuration App*.
- We do not use the following inputs/outputs: "GPIO", "Power output", "Manual bootloader", "Switch input".
- The *AudioMoth Flash App* can be used to update the firmware.

Audio analysis

After recording, we used **Audacity** to analyse the uncompressed WAV format recording (www.audacityteam.org).

Removing the noise

The recorded sound contains a noisy part which includes background sounds (sea, waves, wind, hydrophone movements, etc.) and noises produced by the recording devices themselves (hydrophone, recorder, connections, magnetic interferences, etc.).

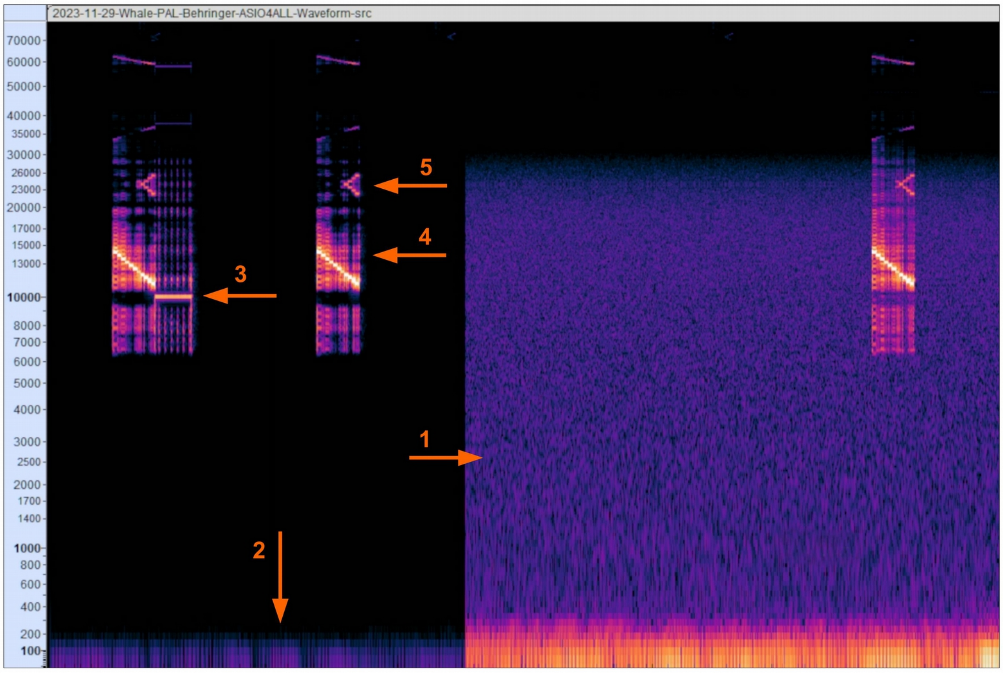
First, we **removed complex noise**. It is a two-step process. First, selecting a part of the recording which contains only noise, without interesting sounds. Audacity will *get the noise profile*. Then, it will remove the same noise from the entire recording.

Then, we **filtered low frequencies**. In this case, pinger frequencies are above 10 kHz. We ignored the lowest frequencies (high-pass filter set to 3 kHz, 24 dB).

Listening to the recordings

Human beings can normally hear from ± 50 Hz to more than 10 kHz (maximum ± 20 kHz) which is much lower than the frequencies used by dolphins, orcas and… pingers. As the recorded sounds are ultrasonic up to ± 130 kHz, the frequencies were **divided by 10** to make them audible. If the source frequency is 60 kHz, the audible sound will be 6 kHz. When looking at the audio analysis charts, we just have to multiply the frequencies by 10 for interpretation.

Understanding audio spectrograms



Whale-PAL pinger, Hydrophone H2a, Behringer UMC202HD, Waveform, Audacity

Horizontal axis: time (seconds) – Vertical axis : frequencies (Hz)
The colour is proportional to the sound intensity at the given frequency. White is the loudest, black is the lowest.

1. *Raw spectrogram.*
2. *Spectrogram after noise removing (noise reduction and high-pass filter).*
3. *Sound of 10 kHz for some seconds (medium intensity)*
4. *Sound decreasing from 15 kHz to 11 kHz (high intensity)*
5. *Two sounds between 22 kHz and 26 kHz (increasing and decreasing, high intensity)*