

Deep Caller for Ocean Acoustic Releases

HANS VAN HAREN, MARTIN LAAN, SANDER ASJES, AND BAS DENISSEN

Royal Netherlands Institute for Sea Research (NIOZ), and Utrecht University, Den Burg, Netherlands

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ABSTRACT

We relate about the custom-made modification of a Benthos deep-ocean acoustic release into a “deep caller,” an acoustic transducer for calling and releasing ocean acoustic transponding releases that cannot be reached from a standard deck unit. The self-contained deep caller can be lowered down to 12 km on any nonconducting winch cable. It may prove useful to retrieve subsurface instrumentation like a seafloor lander hidden behind large rocks or in a narrow canyon, or moorings in very deep topographic depressions. We used it to retrieve a 7-km-long mooring from 10910-m depth in the Challenger Deep, Mariana Trench, that a standard deck unit could not reach.

1. Introduction

Ocean researchers who regularly deploy stand-alone subsurface instrumentation in the deep sea may have experienced difficulties in retrieving their precious scientific materials and archived data. Normally, such instrumented lines or landers are equipped with one or two devices to release one or more “anchor” weights acoustically from a deck unit on board a ship. In some occasions when the anchor weight has to be retrieved, a pop-up buoy is released instead of the entire instrumented line.

A standard deck unit is attached to an acoustic transducer via a cable of a few tens of meters in length only. For example, the more commonly used Benthos, IXblue, and Edgetech release systems have deck units with standard cable lengths of 25, 50, and 20 m, respectively, which can be extended to 200 and 100 m, respectively, for the former two. While acoustic transmission is omnidirectional for all of them, the slant ranges vary among 12, 10, and 16 km, respectively, according to the manufacturers’ data sheets. When sufficient buoyancy materials are applied to the mooring the instrumentation will surface after releasing its anchor weight(s).

However, acoustic releases sometimes fail for various environmental reasons other than electronic failure when meticulous maintenance is performed. Environmental reasons include a rocky and/or canyon-like seafloor such that acoustic signals may become reflected leading to loss

from their precise frequency modulation band, a strong bubble or thermocline layer that may divert the acoustic signal, and (too) great distances between the deck-unit transducer and the acoustic releases near the seafloor. In these cases, one could design a custom-made narrow-beam (10° half power point) acoustic release and deck-unit system (Taira et al. 2004). Alternatively, it may be helpful to have the ability to lower a transducer nearer to the deep-sea acoustic releases. This short paper narrates the design, construction and successful use of such a deep acoustic release “caller,” for Teledyne Benthos releases.

2. Design of the deep caller

To release deep or hidden acoustic transponding releases of subsurface ocean moorings and landers, a custom-made self-contained acoustic transducer was designed and built at the Royal Netherlands Institute for Sea Research (NIOZ). Because NIOZ commonly operates two releases in tandem on heavily instrumented mooring lines and landers, the requirement was to have the possibility to call two release codes alternately. Its depth rating should be full ocean depth (>11 km).

a. Remodeling an acoustic release into a deep caller

A secondhand Benthos deep-ocean 865-A was gender changed from being an acoustic release to become a self-contained deep transducer caller, to be lowered into the ocean by a ship’s or helicopter’s winch cable. Its depth rating is 12 km. The entire final stage of electronics was disconnected from the high-voltage transformer.

Corresponding author: Hans van Haren, hans.van.haren@nioz.nl

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The transformer was connected to a newly designed push-pull final stage of electronics. This processor-directed final stage controls in- and out-band frequencies as in a standard deck unit.

More acoustic transmission power was needed. Therefore, the power supply was modified by adding 2×9 chargeable NiMH HR-4/3FAU cells of 4.5 A h. Charging the battery packs takes about 14 h. These extended battery packs last at least 5 h when programmed to ping release codes for 10 s every 120 s. This duty cycle can be modified by the user when programming the unit (see below). Although the transmission power was not measured objectively, it was subjectively louder than the 192 dB (re $1 \mu\text{Pa}$ at 1 m) of a standard deck unit. At a typical cable lowering speed between 0.5 and 1 m s^{-1} , any seafloor can be reached pinging, even in the deepest spot on Earth. The deep caller does not listen back to the return signal from remote acoustic transponding releases, because there is no readout from the deep caller on board a ship. Deep-caller pinging and return signals from remote acoustic releases may be monitored using a standard deck unit on board a ship.

After programming, the deep caller is switched on externally via the screw switch like in Benthos acoustic release activation. The unit will keep pinging at intervals following the preprogrammable cycle, until being switched off by the screw switch or running out of batteries.

b. Software program

A custom-made program allows for calling the release command of two different Benthos acoustic releases, at selectable time intervals. The program demands the main release “in-band” frequency, its narrow modulation bandwidth and its out-band frequency. When two different release codes are programmed, these will be transmitted alternately, with a certain delay in between. Transmission time length and delay time length can be programmed independently. To prevent the caller from overheating, transmission is restricted to less than 20 s per call, and at least 60 s of quiescence (delay) is allowed between transmissions.

3. Using a deep caller at sea

a. Sea test

As a first test, we programmed the deep caller with two release codes, allowing for 10 s of transmission and 120 s of delay between two transmissions. For this test, two Benthos 865-A acoustic releases with different command codes were attached in different positions, not in tandem, to the Rosette-frame of a shipborne

conductivity–temperature–depth (CTD) profiler. The CTD and Rosette were not used for hydrographic sampling during the test. The package was lowered to 2 km below the ship in the open eastern Atlantic Ocean. Using a separate winch, the switched-on deep caller was lowered to 100 m below the ship to be certainly deeper than the diurnal pycnocline.

The 120-s delay of quiescence gave ample time to listen to the releases’ responses via a standard Benthos deck-unit transducer. One release responded immediately upon the very first deep call under water. The second release did not respond after repeated calls, presumably because of signal transmission via the CTD-conducting cable. Although the CTD cable was not used to conduct any release-related signal electronically, the acoustic signal of the deep caller was guided both via the water and the CTD’s steel cable. These two different media, steel and water, have different sound propagation speeds. This will cause differences in proportioning signal to in- and out-band frequency contributions other than fifty-fifty, at certain distances and for particular in- and out-band frequency combinations. An acoustic release only listens to its in-band frequency. When two different media cause smearing of the in-band signal in the out-band signal, the in-band will appear longer active and the modulation around the central frequency is no longer entirely heard.

b. Challenger Deep release

For a study on internal wave turbulence in hadal zones we designed 300 high-resolution temperature sensors rated to 1400 bars that were moored for 3 years between November of 2016 and November of 2019 at about 10 910-m water depth in the Challenger Deep, Mariana Trench, close to the deepest point on Earth (van Haren et al. 2017). The 7-km-long mooring was equipped with top buoys providing 2.9 kN net buoyancy, a 2-km-long 6-mm-diameter Dyneema line, two current meters and a 200-m cable with 100 high-resolution temperature sensors around 6-km depth, a 4-km-long 6-mm-diameter Dyneema line, a 600-m cable with 300 high-resolution temperature sensors around 10.5-km depth, and a pair of Benthos deep-ocean/865-A releases at 6 m above the 5.7-kN anchor weight. The releases could not be reached with a standard Benthos DS8000 deck unit. Steep slopes are observed on the accretionary prism of scraped off rock and sedimentary bedding from the lower tectonic plate piling up vertically for the last 10 km before reaching the deformation front, with water depths increasing from 8300 to 10 925 m. The Challenger Deep is long but very narrow: 120 km wide when measured at 5000-m water depth in the study area, and less than 1 km wide for the lower 25 m above the seafloor.

A deep caller was attached to R/V *Sally Ride*'s steel cable just above a 50-kg weight, holding the caller upside down and using a cable stocking for security. A standard Benthos deck unit with 10 m of transducer cable was used to listen to the releases' response.

After 1.5 h of lowering, the deep caller had reached about 5500-m depth and not a single response was received on the deck unit from the deep releases when the mooring top buoy surfaced, as was noticed via signals from the XEOS XMB 7500 radio beacon and the XEOS Sable Iridium satellite beacon mounted on the top buoy. Reconstructing after the successful mooring recovery, the deep caller had managed to contact the near-bottom releases after about 15 to 20 min of lowering, when it was around 1000-m depth or at a distance of approximately 10 km from the mooring releases. This is calculated from the time for the top buoy to surface from 4 km, which takes about 1 h, whereas the first Iridium beacon position messages arrive about 15 min after surfacing. These 15 min include the time to wake up from standby due to a change in ambient conductivity, acquire GPS data, and start transmission.

During the operation, the R/V *Sally Ride* was held in position via dynamic positioning. In hindsight, acoustic noise due to turbulence generated by the impellers for dynamic positioning may have masked reception of the weak 12-kHz return signal at the deck unit. The sound speed profile in the area was a standard open ocean profile, with a minimum between 1000 and 1500 m with values continuing to increase all the way to the 10.9-km-deep seafloor.

4. Concluding remarks

While we successfully released our mooring from the deepest point on Earth, the self-contained deep caller may prove to be critical, especially for releasing acoustic transponding releases mounted above anchor weights of moorings and in bottom landers that easily hide in rugged terrain such as in canyons. In rugged terrain, deaf conditions may apply after multiple reflections causing

detrimental sound propagation deteriorate the emitted acoustic signal, with the same result as in areas with large ambient noise levels and faraway transponders. In the latter case one could include deep emission as well as horizontally faraway, e.g., by unknown positioning as in lost or towed-away transponders. However, we think the deep caller may be more beneficial for deep emission, whereas ship repositioning may be primarily useful for searching horizontally, with the deep caller perhaps used as a secondary tool. The deep caller may also be helpful under conditions such as when a lander is toppled over, when landed on its side.

An imagined use of the deep caller is from a helicopter or from a free-floating device, when a dipping transducer with short cable is not easily operated from a deck unit. The same may be said for releasing from a ship under strong surface current conditions, when a light-weight deck unit transducer is difficult to direct vertically, as occurred during our first retrieval cruise from the R/V *Sonne* in the Challenger Deep. The deep caller is much easier to direct vertically using a heavy weight and a winch than is a standard transducer.

We described a deep caller for Benthos releases only. Although the electronics are different, the principles are easily portable to other release systems. The acoustic transducer patterns are fully generated via a processor, which can handle any such pattern.

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