

Acoustic protection for marine mammals: new warning device PAL

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Summary

Many species of whale become entangled within gillnets, resulting in them drowning. Even with their acoustic sense of direction they are unable to detect these nets in time. The estimated number of animals dying due to this is higher than what is tolerated by international treaties and nature protection regulations.



Figure 1: Harbor porpoise heading for a collision with a net

How to warn whales of danger in their own language? What are other possible applications for synthetically created communication signals?

The newly-developed, programmable warning device PAL (pat.) produces lifelike communication signals of harbor porpoises. Its objective is to alert the animals and to stimulate their echolocation, thus enhancing the acoustic ‘visibility’ of gillnets. In cooperation with German and Danish fishermen at the North and the Baltic Sea, the effectiveness of PAL in the field of gillnet-fishing has been successfully tested.

Harbor porpoise by-catch

Too many maritime mammals become entangled in gillnets (fig. 1, 2) which they can not perceive in time [1]. Subsequently, the animals drown as they are no longer able to surface to breathe. This is due to various reasons. The water is murky and the nets are hard to see. Toothed whales, just as bats, are able to orientate themselves thanks to their bio sonar. They produce clicks, whose echos give them information on prey and obstacles. However, only from close range the nets delicate nylon yarns reflect a weak echo, albeit solely at direct sonication. For harbor porpoises the

sonar beam is very narrow, ranging from 11-13 degrees [2]. This is aggravated by the fact that animals are often distracted by their search for food or by social interactions. Also, they might remain mute as they carry out passive acoustic to not attract the attention of predators or aggressors, like killer whales or dolphins.

The acquisition of data on beached harbor porpoise carcasses at the German Baltic Sea coast shows an increasing tendency: from an average of 30-40 annual findings in the year 2000 to roughly 150 findings in 2017 [3, 4]. Up to 53% of the animals found dead are attributable to gillnet-by-catching [5].

In order not to endanger both the species conservation and its regeneration of the population, the total by-catch rates of harbor porpoises in the Baltic Sea are not supposed to exceed 1.7% of the population size [6]. According to up-to-date estimations however, the rate currently varies between 2.6 and 4.8% which is far beyond this boundary [7].

This is leading to a controversy between the fisheries sector and nature conservation. Demands to expand both protected areas and closed periods for fishing would affect the fisheries sector badly. Moreover, gillnet-fishing is highly selective and sustainable in relation to its target species. Acoustic warning devices could prove to be an important immediate measure to reduce harbor porpoise by-catching.



Figure 2: Drowned small whale as by-catch in a gillnet

At present, acoustic deterrent devices, so-called pingers, are used for this purpose. They emit loud and unpleasant noises to keep maritime mammals at distance. However, these noises also can keep the animals away from their

natural life and feeding grounds. Also, for easily startled harbor porpoises the noises result in an intensity decrease of the animals' sonar beam [8]. The latter is especially counterproductive, as this may lead to an increase in by-catches by neighboring nets or net parts with a defective ping.

Furthermore, harbor porpoises are unable to relate between the pingers and the nets which are dangerous for them, as the devices keep them at a distance which is at any rate greater than 3-6 meters, the very distance at which gillnets are 'visible' for their bio sonar [9]. Pingers used so far also prove to be disadvantageous when used for commercial fishing due to their inconvenient form, heavy weight, low durability, low transmitting power and fast battery drainage.

Newly-developed warning device PAL

Harbor porpoises use clicks and certain click sequences, so-called click-trains, to communicate with each other. In the Fjord&Beltcenter in Kerteminde, DK, Clausen et al. (2010) observed that the animals use and understand certain types of click-trains (upsweep chirps) as warnings [10]. Subsequently, we developed and patented the programmable synthetic click-generator PAL (Porpoise Alert).

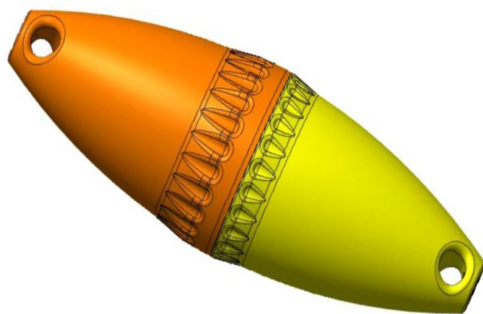


Figure 3: Design drawing of the acoustic warning device "PAL", 2nd generation

Optimized for the usage in fishery, with its current software version the acoustic source PAL (fig. 3) imitates the harbor porpoises specific warning noises. With this, the animals are to be warned of dangers at a frequency of 133 kHz, which is the frequency they use themselves in ultrasonic orientation and communication [11].

In the development of this innovative warning device the expert knowledge of fishermen with pingers from different manufacturers have been optimized further and further concerning design, sound level, durability, weight, buoyant force and battery life.

In contrast to customary pingers, PAL is floatable and internally shock-absorbing, it reaches a very high source level of up to 152 dB and achieves a battery life of up to 1.5 years when continuously operating and of up to 5 years when stored. The battery is replaceable. Moreover, the PAL-Hardware can be reprogrammed at any time to adjust the device for different operating requirements.

The devices are very sturdy and the 2nd generation (fig. 3) easily withstands the rough handling on board unscathed. To that end, the mounting method of the devices to the headline of the nets (fig. 4) has been optimized further and further in cooperation with fishermen. In the course of this, the maximum mutual distance between the devices amounts to 200 meters.



Figure 4: "PAL" v.1 on the headline of a gillnet

PAL in fishery

PAL has been tested by the Thünen Institute for Baltic Sea fishery in professional Danish and German gillnet fishery between 2014 to 2016. As early as in this test phase, the device was conducive to by-catch reduction in the Baltic Sea [12]. For every experiment, two nets of the same length were laid out. One of these nets was equipped with PAL, the other, customary net for comparison (fig. 5).

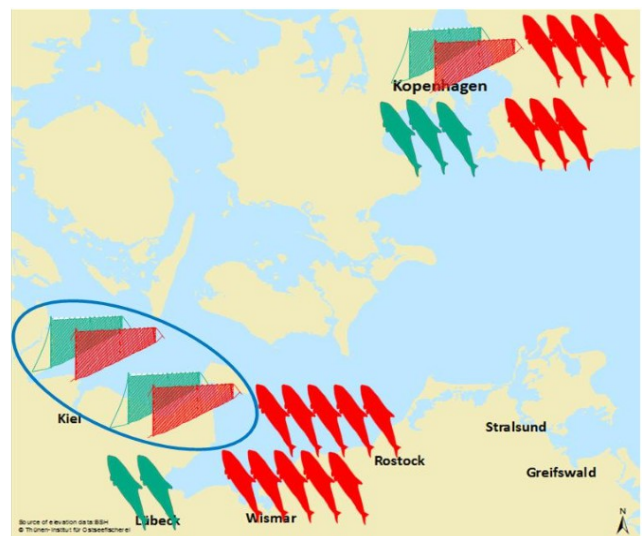


Figure 5: By-catches from fishery experiments in the Western Baltic Sea. Red: standard-nets, Green: PAL-nets.

In about 1.000 experiments, all in all the involved fishing businesses laid out roughly 6.400 km of nets and by-caught 22 harbor porpoises: only 5 of them with PAL-nets but 17 with nets without warning devices. The difference is statistically significant ($p=0.016$). The results show that in the Baltic Sea PAL can be deployed as a means for minimizing harbor porpoise by-catching. Therefore, the newly developed acoustic warning device is an important immediate measure and can reduce harbor porpoise by-catching by over 70%.

At the moment, limitations concerning the usage of PAL persist with regard to the geographic location and the specific harbor porpoise population which reacts to PAL, respectively. Whereas results of testings between Femahn in the east, Eckernförde in the west and Öresund in the north show that PAL effectively protects harbor porpoises from gillnets, the results from testings in the North Sea are yet unsatisfying. More research work concerning more effective forms of signals as well as profound testing of the devices will be necessary here.

Reactions of harbor porpoises to PAL

In outdoor-testings in the Danish Belt Sea we have tested the reactions of harbor porpoises to the noises of PAL by contrast with customary pingers. For this purpose, 5 buoys with a mutual distance of 100 meters have been equipped with acoustic recording devices. The acoustic source to be tested was fixed to the third buoy in each case. The harbor porpoises' behaviour was recorded visually by means of a theodolite from a cliff.

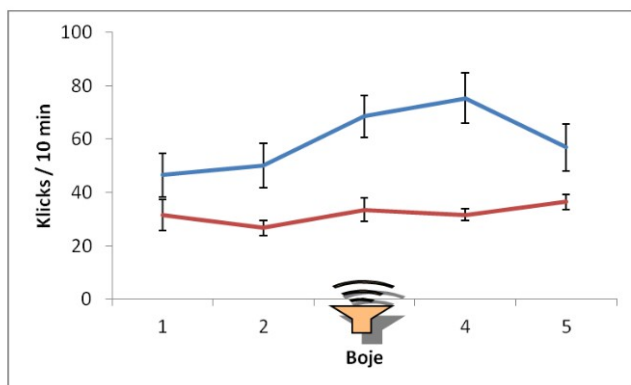


Figure 6: Sonar beam activity of wildlife harbor porpoises. The acoustic source was mounted to buoy 3. Red: customary pinger. Blue: PAL.

The results show that harbor porpoises react to PAL most notably by increasing their sonar beam activity in the surroundings of the acoustic source, albeit they are not decoyed by the artificial communication signal. In contrast with the pinger model “Aquamark 100” (Aquatec, UK), with PAL the animals have shown click activities twice as high at buoy 3 and its surroundings (fig. 6).

The reduction of by-catching which was observed in the fishing-tests is due to the increased sonar beam activity of the animals especially. Presumably, the result of PAL is that the animals acoustically sense the net, which is lethal for them.

Other parameters, which would reduce the risk of collision in the vicinity of the acoustic source, for example a decrease in their duration of stay, increased distance or a change of their swimming speed do not seem to make a difference for the usage of PAL [7].

Practical relevance

With the aid of PAL as a warning device, a new path in avoiding by-catching in fishery will be pursued. The device can contribute significantly to by-catching avoidance, as we have shown in extensive fishery tests in the Western Baltic Sea.



Figure 7: Typical fishing cutter in Schleswig-Holstein

The Baltic Sea info-center in Eckernförde is currently planning to use 1.500 PAL within the scope of a validation and proving study together with fishery businesses in Schleswig-Holstein. An according application was put before the Ministry of Kiel for Energy Revolution, Agriculture, Environment and Rural Area. Further east, in Mecklenburg-Vorpommern as well as at the Danish and Swedish Baltic Sea coast, the usage of PAL would already be reasonable as well. Moreover, the PAL-Hardware is suited to conquer further market segments. The fishing fleets of the German federal states, of the EU and many more are targeted markets. According to previous experiences, a demand for 20 – 60 devices can be expected per fishing vessel.

In the region of the Baltic Sea of Schleswig-Holstein, 220 fishermen who carry out gillnet fishing have joined a voluntary agreement (fig. 7). Altogether, roughly 1.435 cutters and (uncovered) open boats were part of the Kleine Hochsee- and Küstenfischerei (Small Deep Sea and Coastal Fishery) of the Republic of Germany in 2015 [13]. The fishing fleet of the EU comprises roughly 85.154 fishing vessels [14]. Most of them ships – 72.301 ships – are smaller than 12 metres.

Further application possibilities

In the future, we would like to characterize, generate and test further communication signals to warn other populations and species with PAL. Our target species are other harbor porpoise populations, the Mexican vaquita as well as other species which stand out through mass strandings like sperm whales or pilot whales.

Further areas of application could be to decoy other specific whale species and to focalize their echolocation for scientific research, respectively. For instance, in preliminary tests it was shown that according signals decoy harbor porpoises and pool their attention towards one single detector. This can contribute to the improvement of their acoustic acquisition.

Furthermore, PAL can be used as a calibration device for acoustic recording and detection devices. The latter generally operate as a “black box”. This is where PAL can be useful to provide users with a comparison on the spot before and during their tests with a comprehensible test pattern of their synthetically and controlled generated acoustic signals of their targeted species.



Figure 8: Harbour construction-site in Kiel-Schilksee

Finally, it is conceivable to program the PAL-Hardware to use the device as a general deterrent. This is reasonable in situations in which maritime mammals are to be protected from sound or explosive injuries. This concerns seismic studies of the ocean floor in the range of offshore oil and gas, for military exercises with very intense sonar devices, for construction work at offshore wind power plants, for waterways and harbor installations (fig. 8) or for munition blasts.

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Flensburg

“Environment protection and gillnet fishing are not a contradiction!”, emphasized the first chairman of the Fischereischutzverband (fishery protection union) Schleswig-Holstein and thanked

Minister Habeck for the support in relation with purchase, introduction and handover of the electronic warning device **PAL (Porpoise Alert)** for further minimization of possible by-catching of harbor porpoises within the gillnet fishing of the **Flensburger Fischereiverein** (fishing association)



The devices will be provided free of charge for gillnet fishers and can be picked up at the Ostsee Info Center in Eckerförde, Jungfernstieg 110 after telephone inquiry.

The enclosed paper informs about the mechanism with the kind permission of Mr. Boris Culik.