Porpoise Alerting Device (PAL): synthetic harbour porpoise (*Phocoena phocoena*) communication signals influence behaviour and reduce by-catch

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In: Progress in marine conservation in Europe 2015. Von NORDHEIM & WOLLNY-GOERKE (eds.) - Proceedings of the symposium, September 2015, Stralsund, Germany. BfN-Skripten 451, p. 150-155, 2016

Introduction

Our research is focussed on using specific acoustic porpoise communication signals to a) mitigate by-catch in fisheries (Fig. 1) and b) increase their detectability.

In a recent study, REEVES et al. (2013) show that over the past 20 years the vast majority of odontocete, mysticete, and pinniped species, as well as sirenians and marine mustelids were recorded as gillnet by-catch. Between 2000 and 2009, the number of harbour porpoise carcasses found annually along the German Baltic Sea coast ranged between 25 to 152 y^{-1} (HERR et al. 2009; KOSCHINSKI and PFANDER 2009), decreasing to around 70 in 2012 (Wehrmeister et al. 2012). In 47% - 86% of the carcasses, by-catch was identified as the mortality cause.

Fig. 1: Porpoises near acoustic buoy during field experiments in Little Belt, Denmark.

To reduce fishery by-catch, currently employed pingers produce aversive noise. CULIK et al. (2001) showed that porpoises maintain a safety distance of several 100 m to pinger-equipped nets. This may lead to exclusion from parts of the habitat. However, the animals simultaneously reduce echolocation intensity (COX et al. 2001, CULIK et al. 2001, CARLSTRÖM et al. 2009, HARDY et al. 2012) and therefore may become entangled between too widely spaced (BERGGREN et al. 2002) or defective pingers (PALKA et al. 2008, CARRETTA & BARLOW 2011).

Because of the large safety distance, it might be possible that porpoises fail to establish a connection between the aversive noise of pingers and the threatening nets. Their sensory capabilities as well as their ability to learn are thus not put to their full use: Monofilament gill-nets become only discernible for their biosonar if the animals are actively echolocating and at very close range (estimates range from 8-25 m, KOSCHINSKI et al. 2006).

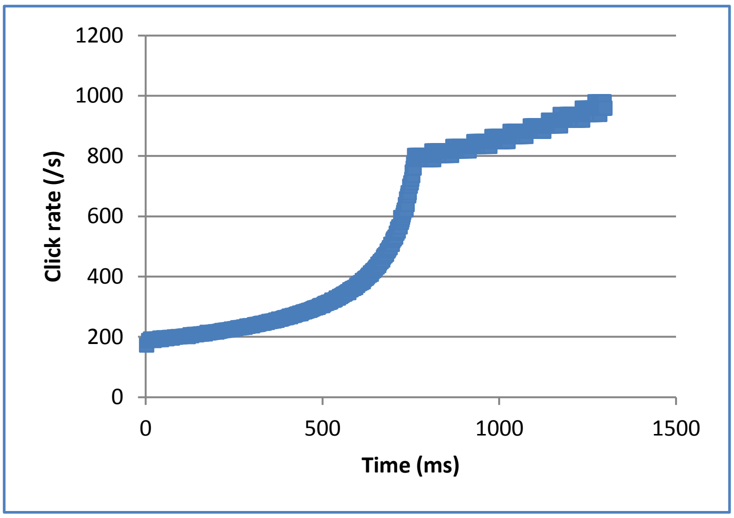

Fig. 2: Synthetic porpoise signal "F3" generated by PALfi

For echolocation as well as for communication, members of the Phocoenidae produce narrow-band, high frequency clicks (NBHF) arranged in specific click trains (CLAUSEN et al. 2010). NBHF clicks have durations of approx. 100 µs, high directionality, centre frequencies around 130 kHz, and source levels of up to 205 dB pp re 1 µPa, 1 m (VILLADSGAARD et al. 2007).

Click trains recorded during aggressive interactions between harbour porpoises observed in captivity (CLAUSEN et al. 2010) served as a template to program and generate de novo life-like communication sounds. We used our new patented, self-contained synthetic porpoise click train generator PAL (Porpoise ALarm; CULIK et al. 2013) to play back these signals in the field during a) behavioural experiments and b) normal operations of commercial gill-net fisheries.

Behavioural experiments

In the Little Belt, Denmark, we employed PAL (SL 158 db ± 1 dB p-p re 1 µPa @ 1 m; centroid frequency 133 kHz ± 8,5kHz) to synthesize three aggressive click train types termed "A", "F3" (Fig. 2) and "M1" to naive, free-living harbour porpoises. Via theodolite tracking (372 h of total visual effort spread over 10 expeditions) we found that depending on signal type, porpoises either avoid or become attracted to PAL (CULIK et al. 2015).

Signal type "A" and "F3" are slight deterrents, porpoises increasing their mean minimum range of 144 m to the PAL by 23 to 32 m, respectively, whereas "M1" attracts porpoises, reducing range by - 29 m. As determined via archival acoustic detectors (AAD), signal "A" led to a significant reduction of echolocation (click rate - 59%) whereas both signals "F3" and "M1" led to an increase (by + 10 and 68 %, respectively).

Detection probability and -radius of PAL/AAD tandems could be improved by emitting signal "M1" (one upsweep chirp, 0.47s duration, 130-911 clicks/s, repeated 3 times per minute) to focus porpoise echolocation signals on the AAD. We calculated that in fair weather, PAL would be heard by porpoises within a radius of 460 m (head on) to 240 m (tail on). The signal may also be useful in luring animals away from hazards. This effect could be helpful for conservation measures prior to the onset of harmful acoustic activities such as pile-driving, seismic exploration or ammunition clearance.

KOSCHINSKI et al. (2006) showed that harbour porpoises could be stimulated to increase echolocation activity by exposing free-living animals to synthesized low-frequency offshore windmill noise. PLESKUNAS & TREGENZA (2005) found an increase in porpoise click activity after the emission of a very brief synthetic click train. CULIK et al. (2015) propose that equipping fishing gear with PAL emitting signal "F3" can potentially reduce porpoise by-catch by increasing a) awareness through enhanced echolocation and b) distance to the nets.

Fig. 3: PALfi attached to gillnet floatline.

Many previous studies (see review by CORAM et al. 2014) report a reduction in responsiveness to acoustic deterrents over time, often referred to as “habituation". However, DAWSON et al. (2013) found that there was no diminution of the response of cetaceans (as measured by bycatch rates) to long-term exposure to pingers. Because PAL produces biologically significant signals, with potential reinforcement occurring during interspecific interactions, we do not expect habituation over time.

PAL deployment in commercial gill-net fisheries

To test the effectiveness of the PAL signal during deployment in commercial gill-net fisheries, we developed a fisheries version of PAL. PALfi (Fig. 3) produces 3 synthetic porpoise-like alerting signals per Minute. Each upsweep chirp corresponds to signal "F3" described above, has a duration of 1.3 s and consists of 700 clicks (SL 151db ± 2dB p-p re 1µPa at 1 m; centre frequency 133 kHz ± 0,5kHz). PALfi are attached to the headrope of gillnets and spaced 200 m apart. Like most pinger types, PALfi are directional and all have to be attached facing the same direction to avoid acoustic "holes".

Between Sept. 10, 2013 and Nov. 6, 2014 we deployed and re-deployed a total of 524 PALfi in German and Danish gillnet fisheries in the Baltic and North Sea. Deployment duration for each batch of 30-50 PALfi was approximately 45 days (corresponding to the safe battery autonomy of the experimental prototype). Fishermen had PALfi attached to gillnets and soaked for approximately 900 Net Kilometer Days.

Simultaneously to deployed nets equipped with PALfi, approx. the same number and net types were set as controls. Details of fishing operations were reported by the fishermen via protocols and for many trips additionally monitored by on-board video-equipment or scientific observers.

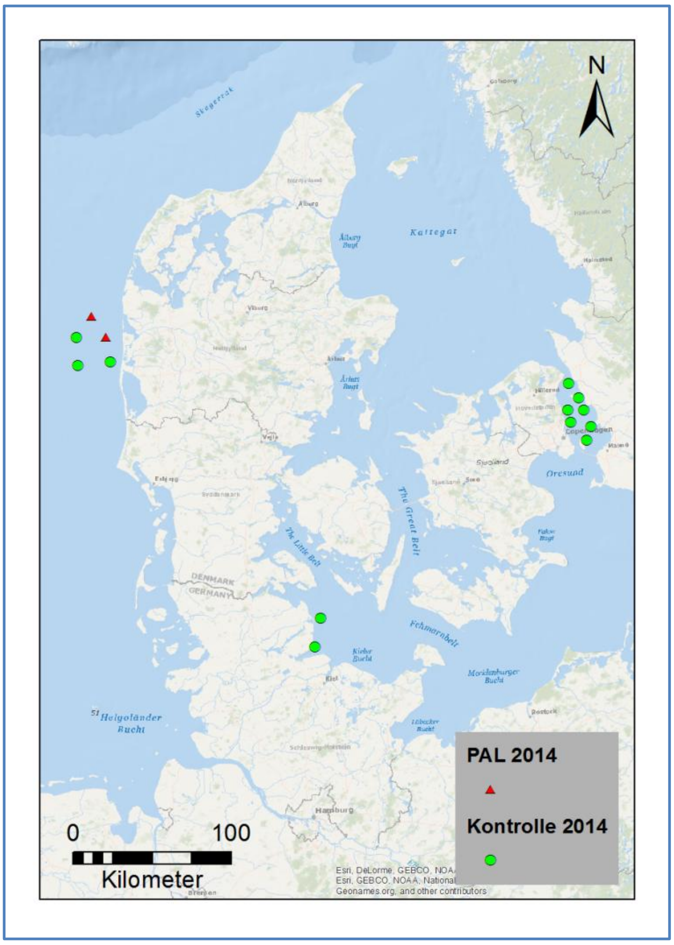

Fig. 4: Porpoise by-catch in 2014 gillnet fisheries. Green: control. Red: PALfi-equipped nets.

A total of 14 porpoises were by-caught during the 14 month field test: 12 in control and 2 in PAL nets (p= 0.006, binomial test). In detail, 3 porpoises were reported in the North Sea from control and 2 from PAL-equipped nets (p=0.5, binomial test). This difference is not significant and needs to be confirmed during ongoing research. It may be that the separate North Sea stock (TIEDEMANN et al. 2015, this issue) uses different communication signals to alert conspecifics. Further research will have to confirm this.

In the western Baltic Sea, however, zero porpoises were reported from PAL-equipped gill nets as opposed to 9 from control nets (p=0.002, binomial test). This difference is significant and needs to be confirmed by applying more rigorous statistics such as e.g. Fisher’s Exact Test. To avoid pseudo-replication, we will analyse all data with respect to bycatch events (as opposed to individuals) and filter it to ensure that the difference of net fleet length between control and PAL nets is within 15%. Results of statistical tests on part of the trials carried out in 2015, where these conditions are fulfilled, look very promising. Therefore, we are looking forward to confirm the preliminary conclusion that PAL seems to be a very effective by-catch mitigation device for harbour porpoises in the western Baltic Sea.

Our research project is ongoing and we are currently improving PAL hard- and software, battery autonomy as well as attachment and monitoring techniques.

Acknowledgements

We are grateful for support by Loro Parque Foundation, Tenerife, Spain. PALfi housings were developed and co-financed by Plastimat, Oranienburg, Germany. Funded by the German Fed. Min. of Food, Agriculture and Consumer Protection (BMELV), Grant Nr. 2819100612 to F³, Boris Culik and Grant Nr. 2819100512 to Thünen Institute, Christian von Dorrien.

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