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Setting baited hooks by stealth (underwater) can prevent the incidental mortality of albatrosses and petrels in pelagic longline fisheries

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ABSTRACT

For many decades pelagic longline fisheries have been responsible for the deaths of large numbers of seabirds worldwide. Baited hooks deployed onto the sea surface attract seabirds to fishing vessels leading to attacks on baits, capture and death by drowning. An alternative is to deploy baits underwater where they are less detectable, more difficult to reach and less likely to be taken by seabirds. In 2010 and 2012 proof-of-concept experiments were conducted in the Uruguayan pelagic longline fishery with a newly developed device designed to set baits underwater. The experiments examined the differences between setting baits at the sea surface and setting baits underwater with regard to the abundances of seabirds following the vessel, incidences of attacks on baits and mortality. Underwater setting led to marked reductions in the numbers of seabirds following the fishing vessel and attacks on baits, the behavioural precursors to mortality. Mortality rates of seabirds on baits set to the relatively shallow depth of 4 m were 87% lower than on baits set at the surface. No seabirds were caught on baits released 10 m underwater, a reduction of 100% compared to the surface setting mortality of 11.6 birds/1000 hooks. No differences were detected between the two setting methods in the catch rates of target and non-target fish species. The evidence from the experiments, combined with the known dive depths of the white-chinned petrel (*Procellaria aequinoctialis*), a deep diving, difficult-to-deter species, suggests that baits released 10 m underwater could reduce the incidental mortality of albatrosses and petrels to negligible levels.

1. Introduction

Incidental mortality in commercial longline fisheries threatens the continued existence of seabird populations in many regions of the world and is a key reason why 15 of the 22 species of albatrosses are listed as 'threatened' by the International Union for Conservation of Nature (IUCN, 2017). The commercial longline fisheries with the greatest impact on seabirds are demersal fisheries, which target fish species at or near the seabed, and pelagic fisheries, which target species closer to the surface. In both types of fisheries seabirds die when they attack baited hooks during setting operations, become hooked or ensnared, drawn underwater and drown. The worst affected are the albatrosses and petrels due to their life history strategies (e.g., delayed maturity, low fecundity) which makes them sensitive to high levels of mortality. They are also habitual ship followers, attracted by the availability of baits at or near the sea surface when lines are set. This type of mortality has driven population decreases at some breeding sites over decadal time scales (Anderson et al., 2011). For example, at South Georgia, a probable worst case location in the Southern Ocean, numbers of wandering (*Diomedea exulans*), black-browed (*Thalassarche melanophris*) and grey-headed (*T. chrysostoma*) albatrosses have been decreasing since the mid-1970s and bycatch in fisheries is considered the most likely reason (Croxall et al., 1997; Poncet et al., 2006; Poncet et al., 2017). The decreases continue despite mortality in the local demersal Patagonian toothfish (*Dissosticus eleginoides*) longline fishery falling from high levels in the late 1990s to near zero levels in the early 2000s following the introduction of effective management actions (SC-CCAMLR, 2006; Croxall, 2008). That the negative trends show no signs of abating suggests that pelagic longline (and trawl) fisheries contribute to population decreases. Pelagic longline fisheries target tunas (*Thunnus* spp.) and swordfish (*Xiphias gladius*) in coastal waters and on the high seas and overlap extensively with longline-vulnerable seabirds wherever they range. For many decades pelagic longline fisheries have resulted in the incidental capture and death of large numbers of seabirds

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(e.g., Brothers, 1991; Murray et al., 1993; Baker and Wise, 2005; Jiménez et al., 2010) and effective management responses have proven more difficult to implement than for demersal longline fisheries.

In pelagic longline fisheries baited hooks are set by hand onto the sea surface where they float momentarily before sinking to fishing depths of ~40–200 m depending on species targeted. Setting baits in this manner attracts seabirds to fishing vessels and increases the likelihood they will attack baits as a source of food. This inevitably leads to fatalities and, potentially, reduced fishing efficiency if baits are removed from hooks. Measures to prevent or minimise the number of attacks on baits include the setting of lines at night, use of effective bird scaring streamer lines and adding weights to branch lines to expedite sink rates. Used in concert and in accordance with prescribed performance standards, these measures are effective in deterring seabirds (e.g., Melvin et al., 2014). Together they are considered ‘best practice’ by the Agreement on the Conservation of Albatrosses and Petrels (ACAP). Two recently developed devices that temporarily disarm hooks while sinking in seabird dive depths (see Baker et al., submitted; Sullivan et al., 2017) are also effective in reducing interactions and are also considered best practice mitigation by ACAP (ACAP, 2016).

All measures described above apply to gear set by hand onto the sea surface, the conventional method of setting. However, with the possible exception of setting at night on the new moon when the absence of illumination makes baits difficult to detect, gear set in this manner must contend with potentially large numbers of seabirds seeking to attack baits. A more effective method might be to set baits underwater unseen by seabirds. This method of setting has two potential advantages. First, it could remove the incentive for seabirds to follow fishing vessels. If ship following ceased fewer baits will be attacked and few, if any, seabirds will be hooked and drowned. Second, with any residual ship following the appropriate response would be to set baits to depths that exceed the known dive limits of attendant seabirds, thereby preventing their mortality.

Here we present the results of research on a newly developed underwater bait setting device designed to prevent seabird mortality without negatively affecting fish catch, while allowing fisheries to operate without the use of other seabird deterrent devices and practices (e.g., bird scaring streamer lines, night setting) or concern of temporal or spatial restrictions to protect seabirds. The research was based on proof-of-concept experiments which examined differences between baits set at the sea surface and baits set underwater with regard to: i) seabird abundances behind vessels (ship following); ii) attack rates on baits; iii) seabird mortality, and iv) fish catch. The experiments were complemented by operational trials (conducted following completion of the experiments) to perfect various design aspects of the new technology of fundamental importance to the capacity to deter seabirds while maintaining fish catch rates.

2. Methods

2.1. Underwater setter concept

The idea to develop a system to mechanically deploy baited hooks underwater as a seabird conservation tool originated from the New Zealand pelagic longline fishing industry and was brought to fruition by Amerro Engineering, Queensland, Australia (www.amerro.com.au). The developmental stages of the device, called the underwater bait setting capsule (hereafter the ‘underwater setter’), can be seen at www.underwaterbaitsetter.com.au. The underwater setter is described in detail by Robertson et al. (2015) and shown conceptually in Fig. 1. Briefly, the underwater setter is a computer operated and hydraulically powered machine that deploys baited hooks individually underwater in a capsule. It comprises two hydraulic motors, the ‘pull down’ motor and ‘recovery’ motor, each connected to winches equipped with Spectra® rope. One length of Spectra connects the winch on the pull down motor to a capsule docking unit on a removable track assembly fitted to the vessel's transom. The other length of Spectra connects the recovery motor winch to the capsule. During setting, the pull down motor powers the capsule to the bottom of the track (1.5 m underwater) where it is catapulted to target depth, at which point the recovery motor automatically engages and returns the capsule to the vessel. The baited hook is released from the capsule the moment the capsule recovery process commences. The capsule travels down the track assembly on the vessel at 6 m/s, underwater to target depth at ≥3 m/s, and returns to the vessel at 6 m/s; these speeds ensure cycle times (time from beginning to end of a complete cycle) conform to the time constraints of line setting operations. Baits can be conveniently deployed to a predetermined depth using the systems control unit in the wheelhouse. The decision on setting depth will be influenced by the dive capabilities of seabirds attending vessels on any given day, but generally the 5–10 m range is considered sufficient to prevent most or all interactions while being practical for fishing operations. The underwater setter is operated by a single crew member.

2.2. Operational trials

The underwater setter models used in the proof-of-concept experiments were prototypes and not the finished product. Subsequent to the seabird deterrent experiments described below various design aspects of the underwater setter underwent further research and development with each improvement rigorously field-tested. Of particular concern was the capacity of the capsule to i) retain all baits (no drop-outs) between the surface and target depth, and ii) prevent baits from being drawn up the water column once released from the capsule at target depths. These technical issues were resolved and a remodeled capsule produced, which was trialed operationally in 2014 (Robertson et al., 2015), with further refinements tested in 2016 (G. Robertson, P. Ashworth and S. Candy, unpublished data). As with all trials of new design features of the capsule, bait retention on hooks following the underwater release from the capsule was assessed. The methodologies adopted in 2016 were the same as in previous trials (Robertson et al., 2015). The acceptance standards were 100% bait retention in the capsule during descents, ascents of no > 0.5 m upon release from the capsule and 100% bait retention on hooks following release from the capsule.

2.3. Experiments - seabird deterrence and fish catch

2.3.1. Fishing vessel and gear

The seabird deterrence and fish catch experiments were conducted in the Uruguayan fishing zone in the winter months of 2010 and 2012. Uruguay was the preferred location because of historically high abundances of longline-vulnerable seabirds (Jiménez et al., 2011), most notably black-browed albatrosses and white-chinned petrels (*Procellaria aequinoctialis*). These species are very abundant and among the most difficult to deter; they are two of the commonest species killed in pelagic longline fisheries in the Southern Hemisphere. The experiments were conducted on the F/V *Qian Lian 2*, a 26.5 m long steel longliner rigged to catch swordfish and tunas. The *Qian Lian 2* deployed a 3.5 mm monofilament mainline with 2.0 mm diameter monofilament branch lines attached at 45 m intervals. Branch lines were 14 m long and 20 m long in 2010 and 2012, respectively, and were fitted with 9/0 J-type swordfish hooks and a 75 g lead sinker 4.5 m from the hooks. The mainline was set off the drum over the center line of the vessel in the ‘surface set tight’ configuration (see Robertson et al., 2010); by this configuration the mainline is set fairly tight, entering the water about 30 m astern. In the surface setting part of the experiments baited hooks were set onto the sea surface to the outer edge of the vessel wake zone at 10–12 s intervals. Individually numbered radio beacons were attached to the mainline at 35-min intervals and floats (six in total) on 15 m droppers were spaced evenly between radio beacons. Vessel setting speed was 9 kn (4.6 m/s). Baits were squid (*Illex argentinus*) and