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Progress report on the development and testing of the underwater bait setter for pelagic longline fisheries

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Graham Robertson and Ian Hay[1]

[1] Australian Antarctic Division, Department of Sustainability, Environment, Water, Population and Communities.

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Graham Robertson and Ian Hay
Australian Antarctic Division, Department of Sustainability, Environment, Water, Population and Communities, Kingston, Tasmania Australia 7050

Abstract
This paper summarises recent research and future improvements relating to the development, construction and testing of a device that sets hooks up to 10 m underwater to avoid detection by seabirds.

The underwater setter is a stern-mounted, hydraulically-driven device. The baited hook is placed into a capsule that is driven down into the water column each time a hook is set; the baited hook is subsequently released from the capsule while underwater. This design provides a more fuel efficient method than devices that remain underwater while setting (e.g., underwater setting chutes). The device can be readily fitted to most tuna fishing vessels, including after their construction.

Background
The underwater setter is a stern-mounted hydraulically-driven device that delivers baited hooks underwater to avoid detection by seabirds. It comprises components that are fixed to the vessel and a bait holding capsule that is driven down into the water column each time a hook is set. This design is the most fuel efficient method of delivering baited hooks at required depths underwater because it minimises the drag associated with devices that remain underwater while setting (e.g. underwater setting chutes). The device is modular and can be readily retro-fitted to most tuna fishing vessels after their construction.

The underwater setter comprises a vertical track on the transom, bait-holding capsule, a box with hydraulics, relays and pulleys and a control box which houses a programmable logical controller (PLC). The PLC runs the system and records data. The capsule is mounted in a docking station and secured to the track by 5 mm spectra rope attached via pulleys to the hydraulic motors. To operate the device the deckhand simply places a baited hook in the bait chamber of the capsule and presses the release button. The pull-down motor propels the capsule down the track at >3 m/s. At the end of the track (which extends ~ 1 m underwater, but is able to be varied to accommodate various sea states) the capsule freefalls to a pre-set depth. Depth attained is a function of capsule descent speed, capsule weight and cycle time. The cycle time is programmed into the PLC. The baited hook is flushed from the capsule on the ascent phases through a spring loaded door at the bottom of the capsule. At the end of the descent phase the PLC engages the recovery motor and the capsule returns to the start position. The cycle is repeated every 8-9 seconds.

Target release depth can be varied from 4 m to 10 m, depending on the diving capabilities of the species of seabirds interacting with gear. As far as is known, it is the only underwater setting device able to set hooks below the maximum dive depth of albatrosses and petrels; all other devices set hooks on or very near the surface. As many seabirds dive in response to a visual 'cue' (Prince, P., *et al* 1999), releasing baited hooks beneath the lower limit of propeller turbulence is expected to be sufficient to deter diving seabird species as the opaque water from the propeller will mask the sinking baits. The leaded swivels (60-75 g) used in most southern hemisphere pelagic longline fisheries will ensure that, once released from the capsule, baited hooks continue to sink at ~ 0.4 m/second.

Recent trials

Following four years research and development, a prototype version of the underwater bait setter (Figure 1) was first trialled in the Uruguayan swordfish fishery in September/October 2010. The trial was a collaboration between Amerro Engineering (Australia) and the Australian Antarctic Division – who have designed, developed and built the underwater setter – and the Direccion Nacional de Recursos Acuaticos (Uruguay) and Golden Star Fisheries S.A (Uruguay). This fishery was chosen because it has a high risk of seabird bycatch, due to the waters off Uruguay being frequented by large numbers of seabirds from South Georgia (Islas Georgia del Sur), the Falkland Islands (Islas Malvinas) and Tristan da Cunha, including more aggressive species such as white-chinned petrels and black-browed albatrosses. In 35 days fishing 15,000 hooks were set by hand and 15,000 hooks set underwater with the bait setter. Seabird catch rates and catch rates of target and non-target fish species were compared head-to-head.

There were no statistical differences between setting methods in catch rates of target and non-target fish. Two birds were caught by underwater setting compared to11 seabirds caught by hand setting. Both birds caught by underwater setting were a consequence of 'secondary' interactions; that is, a bait brought to the surface by a diving bird and which ultimately causes the hooking of another bird at the surface. The prototype version of the machine set hooks only 4-6 m (depended on sea state), which is not deep enough to deter deep diving petrels and shearwaters. However, the experiment accomplished its main aim, which was to give the machine a thorough workout in real fishing operations against difficult-to-deter seabirds. Operationally, the prototype performed well, indicating the design concepts and build quality were up to the standard required for rougher ocean conditions such as occur in the South Atlantic region.

Improvements

The prototype version trialled in Uruguay arrived back in Australia in January 2011. Since then, there has been considerable work to improve its performance based on the lessons learnt in Uruguay, including:

a) to attain setting depths deeper than 6 m while also reducing the cycle time;
b) to modify the capsule holding unit so that it is cushioned from shocks when it reaches the end track during the descent;
c) to eliminate a small number of branch line hook-ups that occurred in the capsule on the descent; and
d) to maximise the sink rate of the capsule.

Following further modifications and sea trials in Australia, the underwater setter is currently capable of setting baited hooks at a depth of 10 m within 15 m of the stern at a setting speed of 9 knots on a cycle time of 9 seconds (c.f. 6 metres/10.5 seconds for the prototype trialed in Uruguay in 2010). This depth is much deeper than the known dive depth of albatrosses (Robertson, G. *et al* 2010) and close to the maximum dive depth of white-chinned petrels (~12 m) (Huin, N. 1994). Given the several seconds it would take for white-chinned petrels to swim down the water column the released baits would have sunk to considerably deeper than 12 m. The improvements mentioned above were achieved by doubling the output from the hydraulic power pack and 'powering out' the spectra rope on the descent phase in order to eliminate drag. It is expected that the cycle time will be further reduced when the final version of the capsule is incorporated into the machine.

The impact of the capsule holding/docking device on the bottom of the track has been solved by fitting a water cushioning piston to the bottom of the track. This robust, virtual maintenance free device is highly effective in absorbing the shock generated at the bottom of the track.

Further modifications were made to prevent branch line/capsule tangles, which were occurring when the sections of the branch line momentarily fouled the bottom of the track when the capsule is launched. These modifications were tested on sea trials held in Australia. Additionally, changes have been made to the capsule design, making it more hydrodynamically efficient, with a much faster descent rate, than the previous version. As well as the improved sink rate, the new design eliminates any possibility that bait can be flushed out the top section of the capsule during the more rapid descent.

The next steps

The modifications mentioned above have resulted in a significantly improved performance that has been demonstrated during sea trials in Australia. At the time of writing (July 2012), further trials were about to begin in Uruguay to complete the proof-of-concept experiment with the improved machine. A scientific paper will be written in late 2012 on the results of the experiment, when it is also hoped that the machine will be commercially mature and ready to enter production.

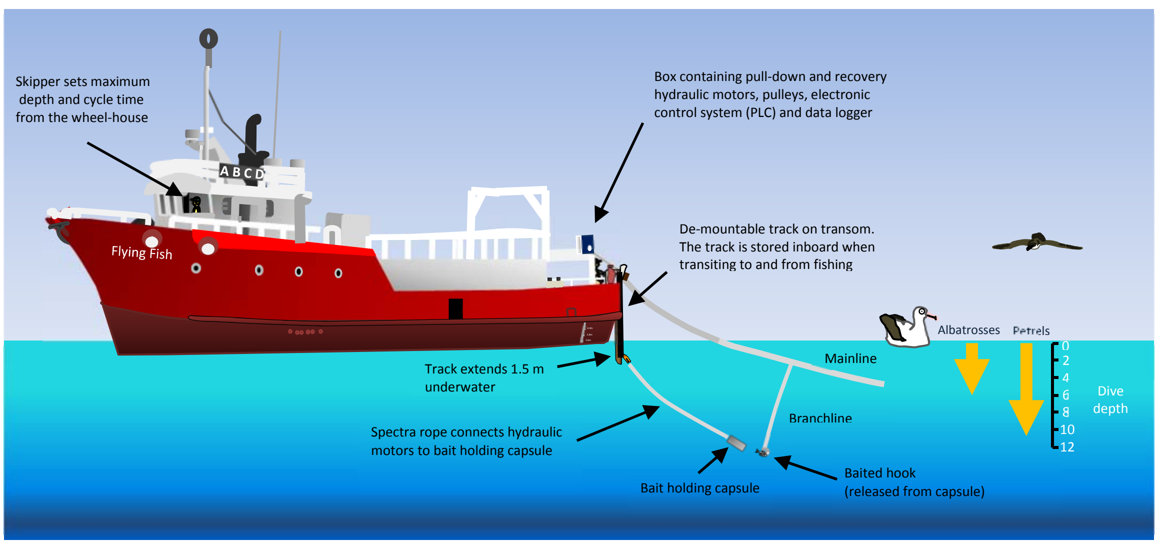

Figure 1. Stylised version of the BS30 underwater bait setter showing the key design features.

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