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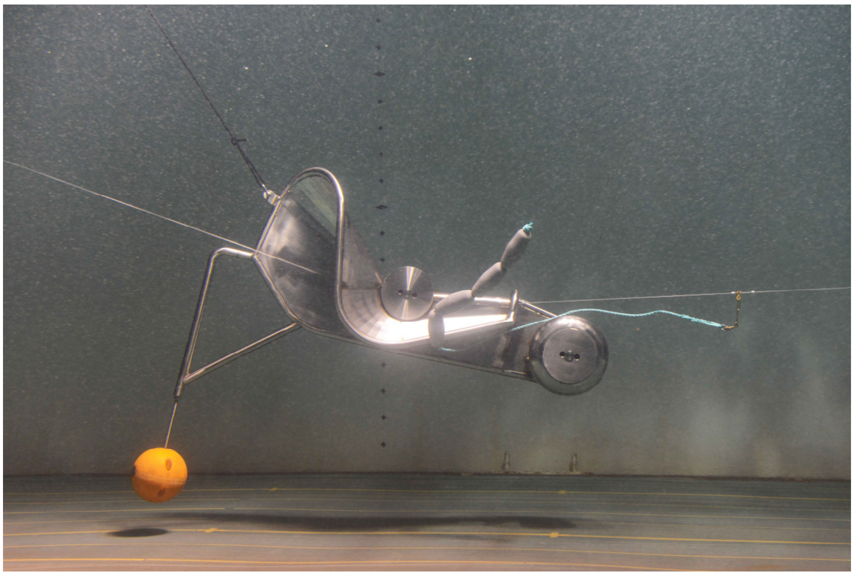
Development of the Kellian Line Setter for Inshore Bottom Longline Fisheries to reduce availability of hooks to seabirds



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1. Introduction

In 2011 quantitative seabird risk assessment work (Richard et al 2011) highlighted the high degree of potential risk that small vessel (inshore) bottom longline fisheries in New Zealand posed to a number of protected species, including the black petrel *Procellaria parkinsoni* and flesh-footed shearwater *Puffinus carneipes*. Although a suite of mitigation measures was mandatory in these fisheries, including the use of streamer lines, line weighting, night setting of longlines and restrictions on offal discharge during setting and hauling, bycatch of protected seabirds still remained a concern (Richard et al 2011). In ongoing experimental work to find solutions Goad et al (2011) reported on the influence of weighting regimes and float placement on sink rates of hooks in these fisheries, as well as describing some initial sea trials to test and develop a novel mitigation device, the Kellian line setter.

The Kellian Line Setter is an underwater setting device developed by Dave Kellian, a fisherman from Leigh, New Zealand. The concept involves running the mainline under a nylon roller towed behind the vessel at depth. The line then runs over second roller, behind and below the first one, to stop weights pulling the backbone off the bottom of the first roller. Snoods, floats and weights pass beside the rollers, rather than over them (Goad 2011; Figures 1 and 2). A 14 kg lead ball on a wire cable holds the device at depth and allows for deployment and recovery with a small winch. Attached to the lead ball a steel tube holds the rollers behind the cable and a paravane on the steel tube assists in maintaining stability during towing. Once deployed, setting depth can be adjusted by increasing or decreasing the cable length.

The initial prototype had been developed through a series of at-sea trials which were conducted during 2011. While these trials had been encouraging, the issue of fouling on the rollers has been identified as needing resolution before further at sea testing should be considered (Goad 2011). In 2012 we obtained funding from the New Zealand Department of Conservation's Conservation Services Programme to refine the existing prototype at the Australian Maritime College (AMC), using the skills and expertise of engineers at the Circulating Water Channel (flume tank) facility of the College. This would permit critical examination of the hydrodynamic characteristics of the device, and re-design to eliminate operational impediments (line fouling) that were inhibiting proof of concept and the potential for uptake of the device by industry.

2. Progress with Development

Review of Prototype 1

New Zealand's Inshore bottom longline fishers use a range of gear types to catch demersal finfish. Goad et al (2011) noted a distinct split of gear types depending on target species. Vessels targeting predominantly snapper (*Pagrus auratus*) fished in shallow water with relatively light gear, long snoods, and small hooks. Other, generally larger vessels, that target bluenose (*Hyperoglyphe antarctica*), ling (*Genypterus blacodes*) and hapuku (*Polyprion oxygenios*) in deeper water used heavier gear, shorter snoods and larger hooks. Vessels employ a diverse range in the mixture of weights and floats attached to the line, which would potentially influence the design of an underwater setting device.

In March 2012 the performance of the initial prototype of the Kellian line setter (KLS) was observed in operation on a small longline vessel operating out of Mt Maunganui. Discussions were also held with Brian Kiddie, a longline fisherman, who had been involved with initial at-sea trials of the device. Matters raised during the discussions and at-sea performance assessment included:

- occupational health and safety issues associated with manual handling of the 14kg lead ball during fishing operations;
- problems with hook-ups on the rollers, and how these have been dealt with;
- the range of gear (floats, line weights) typical used by NZ inshore longline vessels; and
- typical setting speeds for NZ inshore longliners (4-5.5knots).

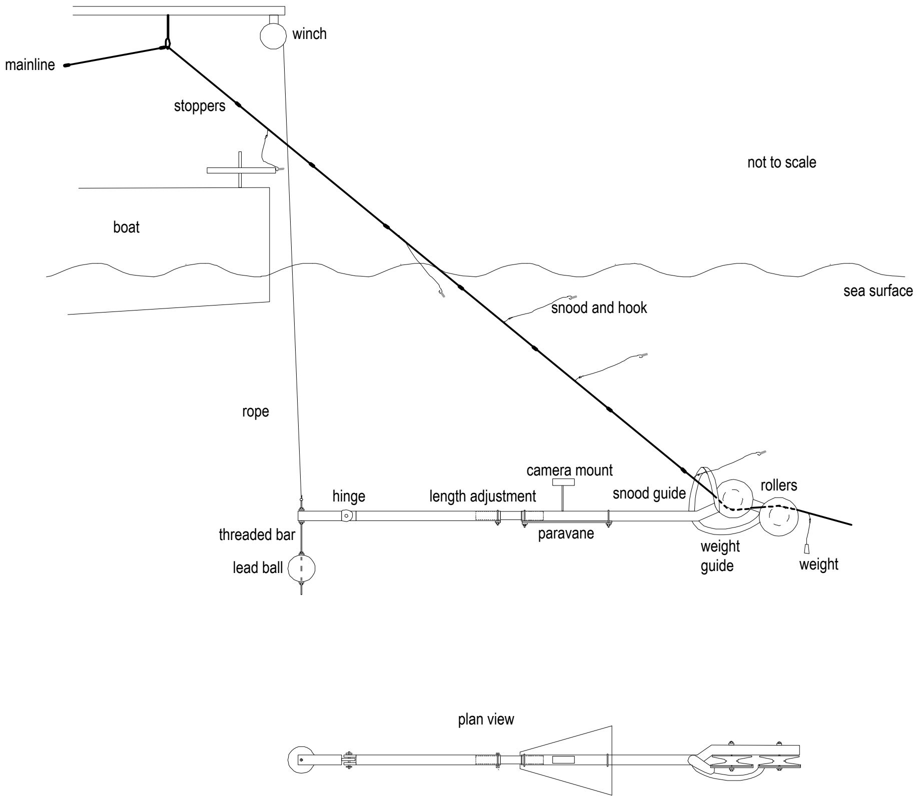
We also assessed video footage collected by David Goad during early work on the KLS prototype. This clearly showed how the initial prototype performed, and permitted a review off how baits were hooking up. Other problems observed were:

- branch lines not passing over the rollers and fouling,
- baited hooks trailing behind the first roller and subsequently hooking up on the backbone; and
- gear tangling around the rollers.

It was also noted that the video footage had been taken when the vessel was setting gear at 3 to 3.5 knots setting speed, and not actual setting speed (5 knots). This was done to accommodate the camera frame rate, which did not permit useful capture of information at higher speeds. Setting at a reduced speed affects the flow regime around the device, which in turn may have affected performance and possibly facilitated foul-ups. This theory was briefly tested on Brian Kiddies' vessel at Mt Manganui, but setting at greater speed showed no noticeable improvement to hook ups.

The at sea trials highlighted that the primary focus of a redesign of the unit should be to minimise hook-ups and refine the design. In particular, the redesign would focus on preventing branch lines stopping at the front roller, removing all potential for hooks to hook-up on the device, and reducing the lead weight or providing grab points for crew to move safely.

Figure 1. Sketch showing Kellian Line Setter Prototype 1 deployed, together with a photograph (from Goad 2011)



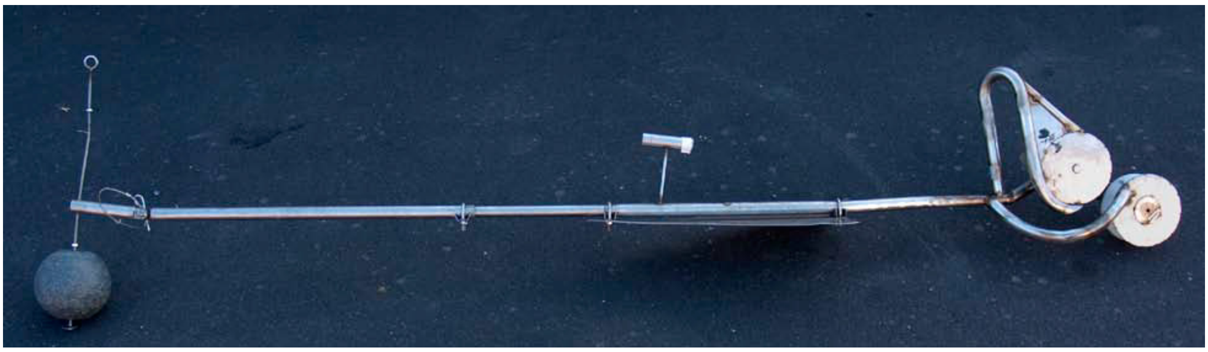
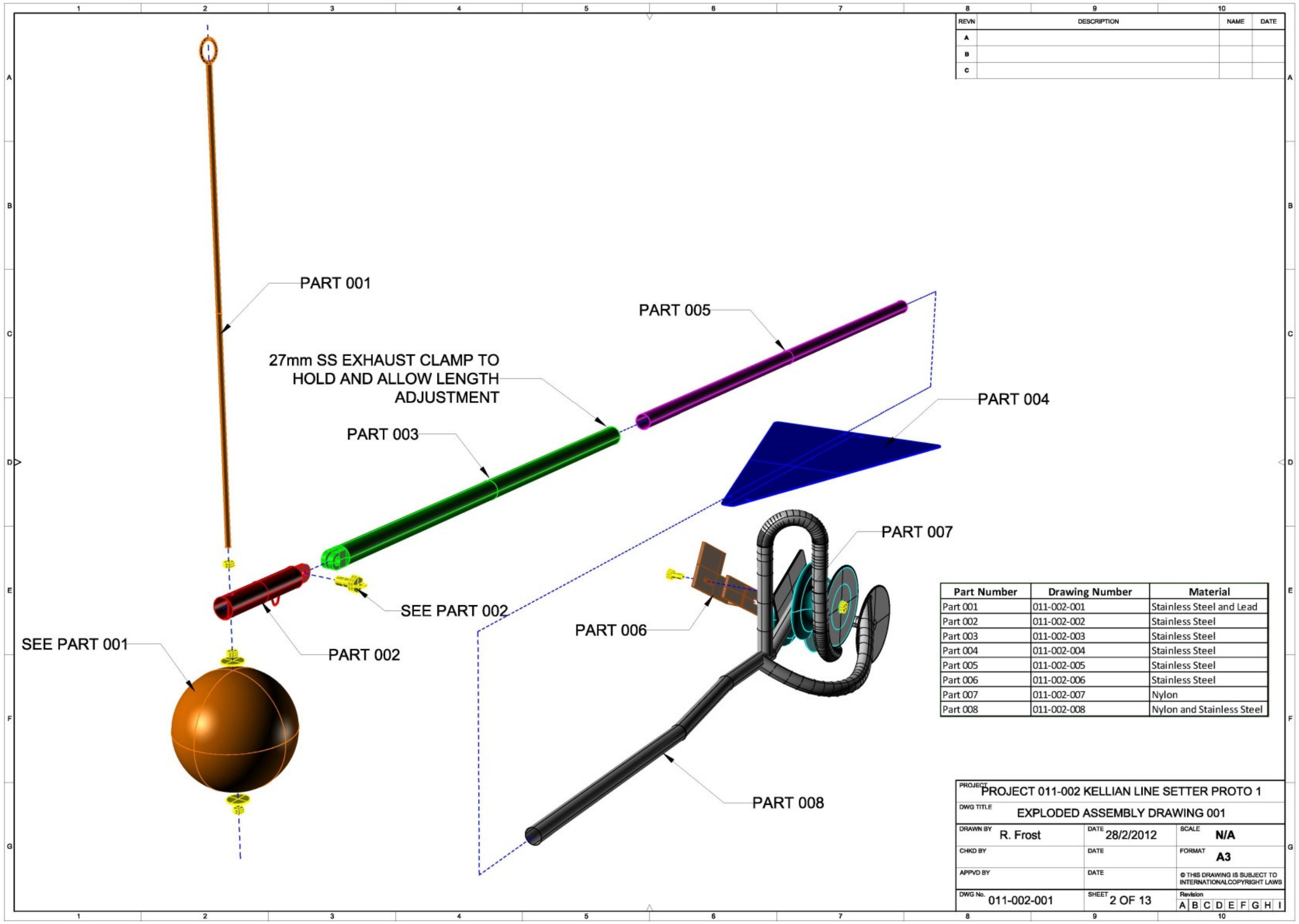


Figure 2. Exploded assembly drawing of Kellian Line Setter Prototype 1



To provide a complete record of the initial prototype, we developed ‘as built’ drawings. The unit was measured, and 2D and 3D drawings of the initial unit produced. The primary dimensions allow for calculations of required weights/forces on key components, particularly the lead weight and paravane.

Development of Prototype 2

On return to Australia concept drawings were prepared for a new prototype (Prototype 2). Prototype concepts were sketched to work out the arrangement and key dimensions, and engineering calculations performed to determine key parameters such as paravane and lead ball dimensions. The resulting design drawings were developed based on professional engineering advice, and are provided separately to this report.

A new prototype (KLS P2) was fabricated and tested at the Australian Maritime College Circulating Water Channel (‘flume tank’) between the 21/1/2013 and the 1/2/2013. The new prototype consists of a stainless steel cowling and funnel arrangement that incorporates two rollers (Figure 3). The device was tested for its towed stability and entanglement issues while setting. As part of this testing a continuous long line setter was developed to allow for visualisation of how hooks, floats and weights interacted with the KLS.

Figure 3. Kellian Line Setter P2 in the flume tank. A string of three small cylindrical floats has just passed through the cowling and funnel and negotiated the two rollers successfully.

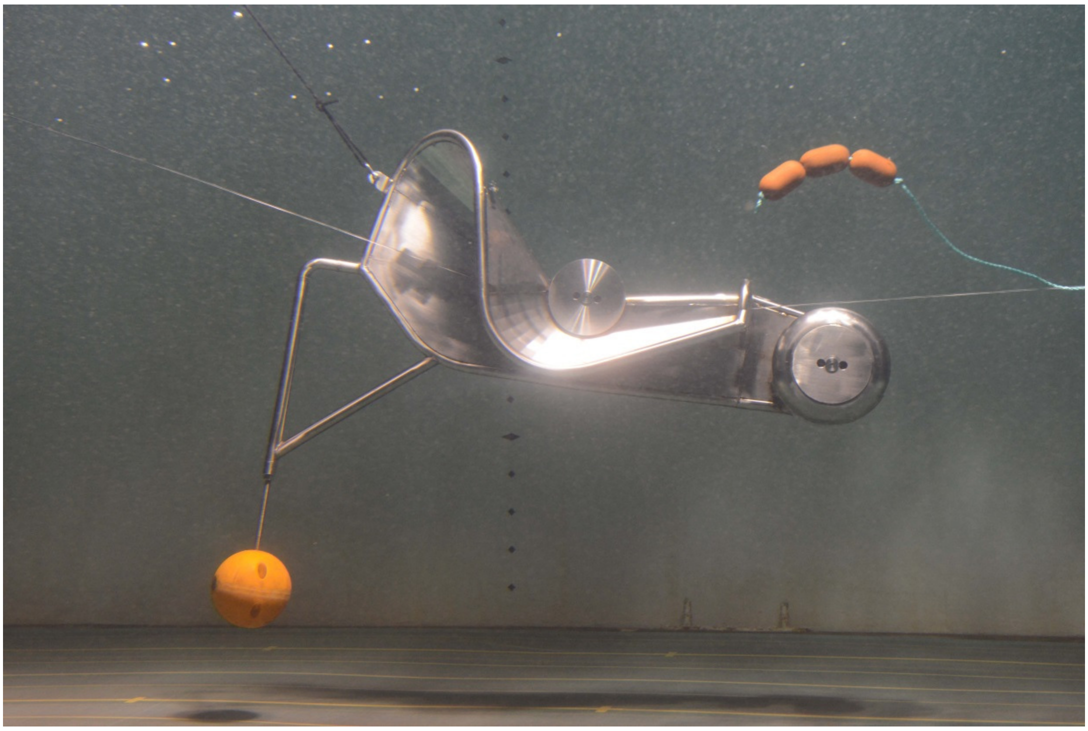
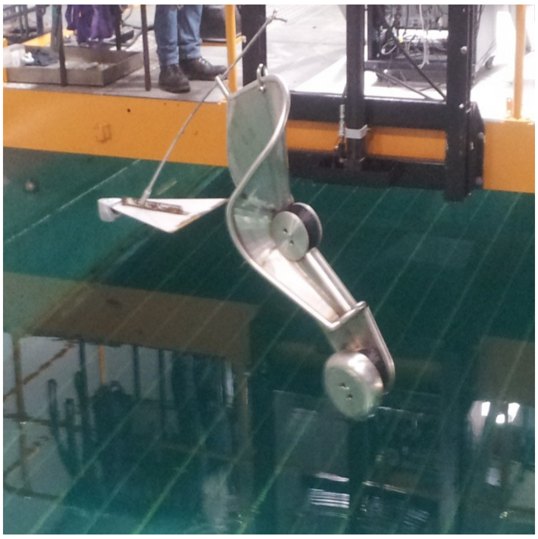


Figure 4. Kellian Line Setter P2 with paravane system attached.



The initial KLS P2 attachment method tested was identical to the Prototype One configuration. Unfortunately it was found that the added hydrodynamic forces generated by the large cowling and funnel arrangement of the P2 could not be reasonably controlled by the paravane system used in P1 (Figure 4). Modifications were made as seen in Figure 5 to increase the unit's towed stability.

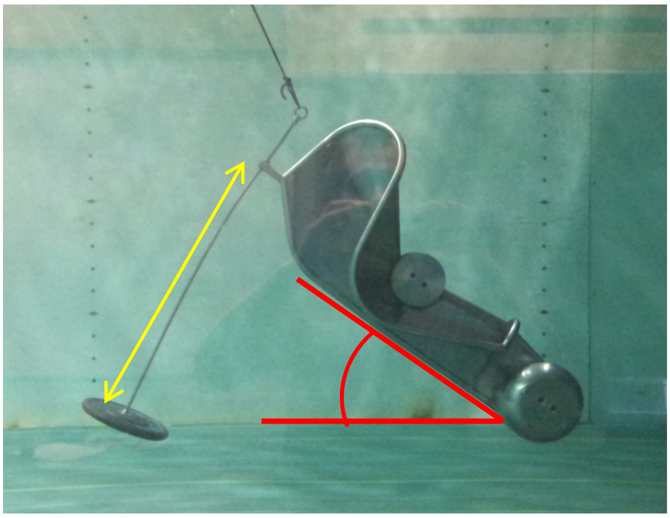


Figure 5: Modified attachment point test, showing angle measured in Table 1

Both hydrodynamic (paravane) and static (weights) were tested to develop the necessary stabilising force on the KLS P2. Weights were selected as the best solution over the paravane as they offer a simpler, safer and more robust solution that is less dependent on setting speed. Furthermore, paravanes can be very dangerous when setting in heavy seas, are prone to weed entanglement, and can have a tendency to wander. The solution was a simple lead weight; unfortunately this will pose a manual handling risk for fishermen with the entire KLS P2 unit weight being around 32kg. This risk will be best mitigated by a specific cradle and winch to raise and lower the bait setter, to avoid manual handling where possible. Some example results are included in Table 1 to show the effect of the variation in attachment position and weight distribution on the setter angle (See Figure 5). From these results a suitable weight and distance was selected to achieve the required moment that produced both a level and stable bait setter. The final weight used will be 14kg at a distance of 500mm; this distance is shown by the yellow dimension on Figure 1. This will have a resultant moment of 68Nm and should ensure sufficient stability for most setting operations.

Table 1: Sample results from varying weight size, location and attachment point height

	Weight (kg)	Weight Height (mm)	Moment (Nm)	Attachment Height (mm)	Angle (Deg)
Run 1	14	750	103	195	24.5
Run 2	14	660	91	285	20
Run 3	14	570	78	375	16
Run 4	0	0	0	375	N/A
Run 5	7	570	39	375	16

The final attachment point utilised is as located in Figure 6. This will allow for a solid padeye (point of attachment) to be fabricated which will reduce the chance of fatigue failure of the attachment point. The attachment height of 200mm lines up closely with the vertical centre of pressure of the setter which minimises the hydrodynamic overturning moment, and increases stability.

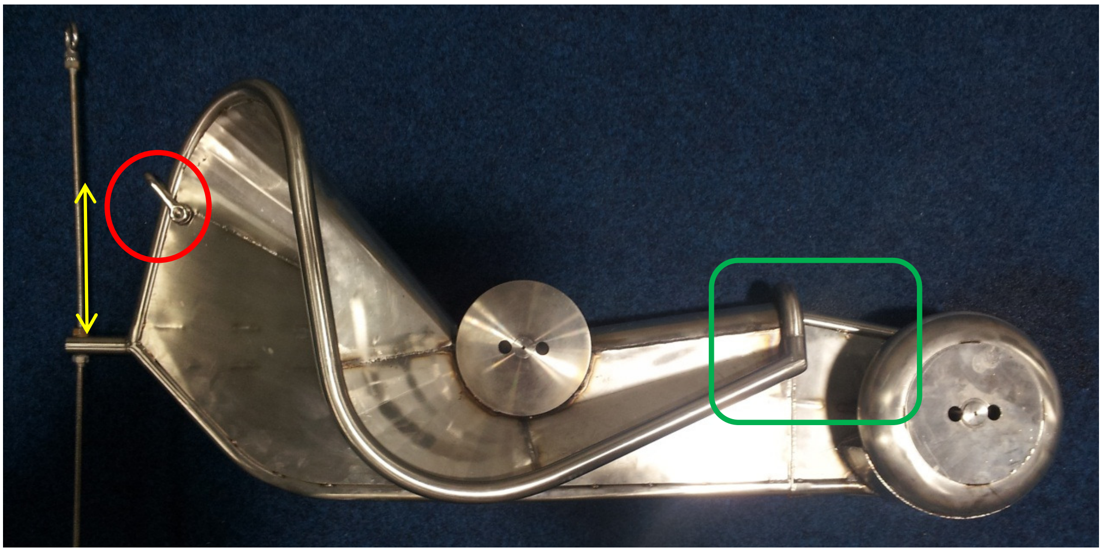


Figure 6: Final attachment point location.

Refinement of Prototype 2

The final component tested was the behaviour of hooks, floats and weights through the setter. Approximately 60 hooks were set through the setter without one incidence of hook up. Unfortunately these hooks need to be potted in resin for safety reasons, however they allow for visualisation of the hook behaviour which would cause hooks ups. No issues were noted. A number of floats and weights were set with generally positive results. The biggest issue encountered was larger diameter floats becoming stuck between the stern rollers and cowling shown in Figure 6, highlighted by the green square. The initial solution tested to resolve this was to use cylindrical floats off drift nets, which easily pass through the setter. It was hypothesised that a longer snood (around 1000mm) would stop the large trawl floats getting sucked through the setter, allowing them to pass by the port side. This hypothesis was tested when the setter underwent final testing after having a permanent weight and attachment point added.

On 5 March 2013 the KLS P2 with modified attachment point was again tested in the flume tank. In order to simulate swell, a crane was used to cause the device to rise and fall in the water column whilst setting hooks, weights and floats. During this process the mainline was lost from the KLS P2 on a number of occasions, and other entanglement issues identified.

The primary issues noted were the continual fouling of large (4 inch) trawl floats. Unfortunately it is unlikely that such floats will be able to be used with the KLS P2. The solution is the use of a string of drift net floats which caused no hook ups. The most concerning issue found with simulated vessel motions is that weights caused the backbone to be pulled out of the device. Weights up to 500g could be set without issue, however above that weight the backbone was dropped.

Unit Cost for KLS P2

Unfortunately at this point not all invoices have been received for the fabrication of the KLS P2, and we are only able to provide a rough estimate for the cost. It is believed that the setter could be manufactured for around $5,000 AUD on a cost recovery basis. If further modifications were made to a Prototype Three it is believed this cost could be reduced somewhat, especially if multiple units were constructed in a batch format.

3. Discussion

The line setter was developed to mitigate the catch of black petrels and shearwaters in NZ's inshore snapper fishery, but could be easily applied in any demersal longline operation, including autolining, once the design has been further refined in at-sea trials.

The most significant problem identified in the flume tank was that of weights causing the backbone to be pulled out of the device. To some extent this may have been exacerbated because the length of the flume tank did not permit the mainline to engage the back roller (evident in Figure 3), which would not be the case when fishing because the weight of the longline would drag the mainline down over the roller. The design purpose of the rear roller is to stop weights pulling the backbone off the bottom of the first roller.

We envisage that when deployed under fishing conditions it will be necessary to specify the size and types of floats that are used. Large (4 inch) trawl floats were regularly caught up between the end of the cowling and the rear roller, and while longer snoods could potentially assist in reducing this problem, they did not reliably resolve the problem in the flume tank trials. We recommend that the use of such floats be avoided, with drift net floats substituted instead.

The weight and dimensions of Prototype 2 exceeded initial design parameters, given our desire to produce a design that is easily deployed. The entire KLS P2 unit weighs around 32kg, which may pose manual handling issues. This risk will be best mitigated by a specific cradle and winch to raise and lower the bait setter, thus avoiding manual handling where possible. We also recommend a safety assessment be undertaken before at sea-trials commence.

Acknowledgements

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The Australian Maritime College provided facilities and support which was essential to developing and refining Prototype 2.

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