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ACN 108 390 01ABN 37 108 390 012

# Kellian Line Setter Sea Trials

# Refinement of design and subsequent developments

Report prepared for

**Department of Conservation**

**Contract 4529**

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May 2014

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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) and Pierre et al (2013) investigated the efficacy of operational practices in use in these fisheries for reducing seabird bycatch risk, reported on the influence of weighting regimes and float placement on sink rates of hooks, 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 initial concept involved running the mainline under a nylon roller towed behind the vessel at depth. The line then ran 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). A lead ball on a wire cable held the device at depth and allowed for deployment and recovery with a small winch. Attached to the lead ball a steel tube held the rollers behind the cable and a paravane on the steel tube assisted in maintaining stability during towing. Once deployed, setting depth could 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 was identified as needing resolution before further testing should be considered (Goad 2011). In 2012 we refined the initial prototype at the Australian Maritime College (AMC), using the engineering expertise of staff at the Circulating Water Channel (flume tank) facility of the College. This permitted 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.

The new prototype (KLS 2 – Figure 1) consisted of a stainless steel cowling and funnel arrangement that incorporated two rollers, and which was towed behind a vessel at depth. The mainline was fed through the cowling, under the first roller and over second roller to stop weights pulling the backbone off the bottom of the first roller. Snoods, floats and weights passed beside the rollers, rather than over them (Baker and Frost, 2013). The hydrodynamic attributes and functionality of the modified prototype were assessed in the controlled environment of a flume tank but further testing and evaluation at sea was required under normal fishing conditions.

**Figure 1: Kellian Line Setter Prototype 2.**

In December 2013 Latitude 42 Environmental Consultants was awarded Contract 4529 to conduct sea trials of the Kellian Line Setter 2. The overall objective of this project was to test the at-sea feasibility, and to the extent possible, the effectiveness, of reducing the availability of hooks to seabirds by using the improved Kellian line setter, in inshore bottom longline fisheries.

In early 2014 we conducted initial performance testing of the KLS 2, near Tauranga, New Zealand (Baker et al. 2014). These trials showed that the linesetter sat reasonably straight at low speeds (< 2 knots), pulling slightly to starboard, but with a longer tow rope and at higher speeds it ran progressively further off to starboard and at a shallower angle, before breaking the surface at about 4 knots. The KLS 2 also appeared to roll over at speed, such that the ball was further out to starboard than the top. The lines setter was systematically modified in an iterative way over a series of sea trips to improve performance (Figure 2). Changes included adding an adjustable paravane beside the funnel, increasing the weight of the ball, increasing the length of the stud above the ball, moving the towing point, and adding a second paravane above the ball to improve stability (Figure 3; Baker et al. 2014). While performance was improved and some gear was set through the line setter, we recommended further development work and additional modifications to the device that would be best achieved through performance assessment under controlled conditions in the flume tank in Australia (Baker et al. 2014). Proposed modifications for consideration included:

- Potentially combining or simplifying the design of the two paravanes used in the iterative approach in the initial testing at sea trials to improve stability of the device. The paravanes were added during the initial performance testing to provide the necessary forces to hold the setter at depth at setting speeds.
- Slight refinement of the funnel shape to prevent the mainline rubbing on the funnel's leading edge and to guide the traces around the outside of the funnel.
- Development of a guide to send weights around the side of the rear roller so that weights on 'dropper' ropes can be deployed. Modifying the rear roller cheek could also help the passage of weights through the setter.

**Port side** **Starboard side**

**Figure 2: Kellian Line Setter with modifications used to improve performance during initial performance testing at sea (Baker et al. 2014).**

It was our intention to confirm in the flume tank that effective performance of the KLS 2 can be achieved at sea behind a vessel at speeds of 5 - 6 knots, before returning the device for further testing at sea in New Zealand. In this report we describe our work to achieve this aim, as well as reporting on the further prototypes we have now developed that may allow bottom longine gear to be efficiently deployed underwater.

## 2. Progress

### Kellian Line Setter 2

The KLS 2 was shipped to Australia and was trialled in the flume tank in December, 2014, following modifications made during the sea trials. Despite adjusting both paravanes through a wide range of settings and experimenting with the cable attachment position, we were unable to produce the necessary forces to replicate the extreme results (i.e. strong movement to starboard and surfacing) seen in the trials at sea. Although the device tracked slightly to starboard it did not do so strongly, and it maintained towing depth. We concluded that this was because we were unable to replicate the conditions encountered at sea in the flume tank (notably speed of water flow, the forces exerted by the longline, and the flow characteristics behind boat) to cause the KLS 2 to misbehave. It was therefore impossible to tune the device as expected and no further modifications were made. Construction of a scaled model may have permitted this but would have exceeded budget and time restrictions.

We reviewed the KLS 2 design and discussed ways of making improvements. We considered the asymmetrical design of the device, originally considered necessary to minimise gear-fouling issues during setting, was likely to continue to generate stability issues under differing sea conditions. We therefore took the opportunity to test simple and more symmetrical designs while we had the flume tank available. We constructed a simple device using a bent rod and weight (Figure 3), and noted that a more symmetrical device could provide a suitable guide for fishing gear and was likely to permit gear setting at depth while tracking truly behind a vessel. Preliminary trials of this simple prototype provided promising results, and led to two new designs, which we have called the KLS 3 and KLS 4.

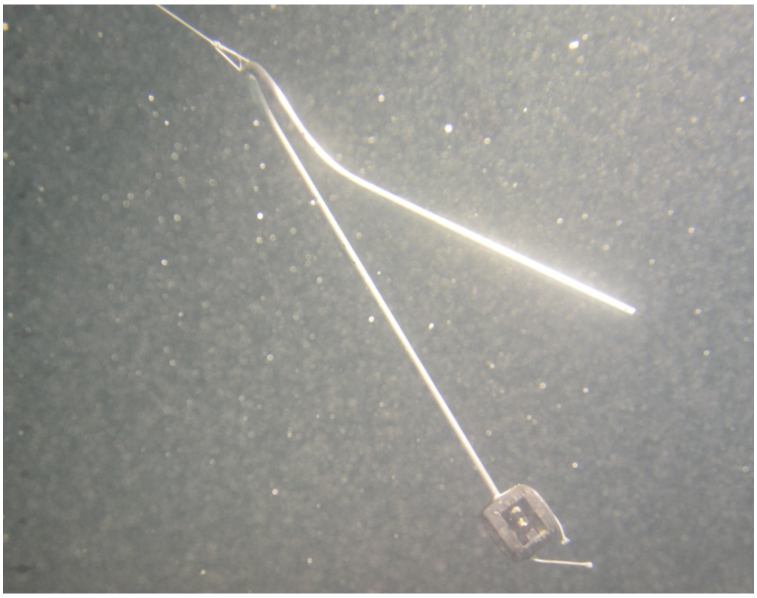

**Figure 3. Bent rod and weight trialled in flume tank. This simple device formed the basis for the design of the KLS 4.**

## Kellian Line Setter 3 (KLS 3)

The KLS 3 is a refined version of the KLS 2, symmetrical in design with a single roller and simple cowling to guide weights, hooks and floats under the roller (Figure 4). There are two paravanes shown on the unit, with the potential for positioning a dorsal fin to improve tracking if required.

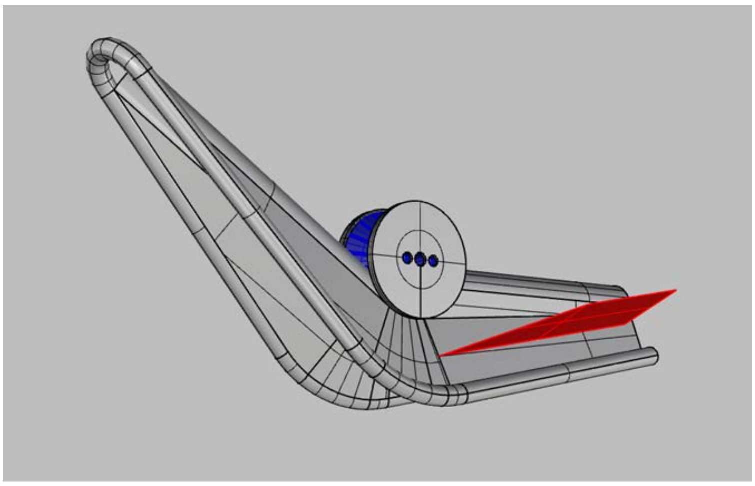

**Figure 4: KLS 3 concept drawing.**

Key features of the design are:

1. Tow point. The device would be towed from the fore most point on the setter, although we gave consideration to the tow point at the roller. This was rejected as the setter would have potentially been unstable in pitch and roll. By moving the attachment point as far forward the unit should track straighter and be more stable. Another advantage of a forward tow point is that the hydrodynamic forces on the funnel will act to raise the tail of the setter, which will increase the angle of attack of the paravanes, and hence increase the force keeping the setter level in pitch.

2. Paravanes. The paravanes will have around 15 degrees of adjustment up and down in their current configuration.

3. Weight. By using stainless steel tube of 31.8mm dia. in the lower half of the setter, 14kg of lead can be located internally in the stainless tube. This has the advantage of providing both lower drag (the lead ball contributed around 10-20% of the drag on the KLS 2), be less susceptible to snagging issues, and easier to handle. However, it may reduce the vertical stability, and the design assumes we can get extra stability out of the paravanes. This assumption would need to be tested through model construction and flume-tank testing.

4. Construction. This has been vastly simplified when compared with the KLS 2. There are only 2 pieces of stainless steel that need multiple bends, with the remainder constructed from flat plate combined with standard tube sizes. This should ensure the device is considerably cheaper and quicker to construct than for the KLS 2. Plate thickness of 1.6mm will make bending and fabrication easier on lighter equipment.

This device was not constructed but remains an option for future work. We would initially recommend the use of 3D printing to construct a model for testing in the flume tank, prior to proceeding further with this option.

## Kellian Line Setter 4 (KLS 4)

This design removed the pulleys, and attempted to minimise drag and simplify the design to the greatest extent possible. It aims to set the longline under a weighted U shaped guide, with swept-back legs to smooth the passage of snoods and weights and to help with tracking. The design was driven from the simple design trialled in the flume tank (Figure 3). A preliminary KLS 4 design is shown in Figure 4. This device was constructed in New Zealand from stainless steel tube of 50 mm diameter, and filled with lead shot to give a total weight of 20kg. It has been field tested and subsequently modified, as necessary, following seven days of sea-time. Reports on these trips and subsequent results are provided below.

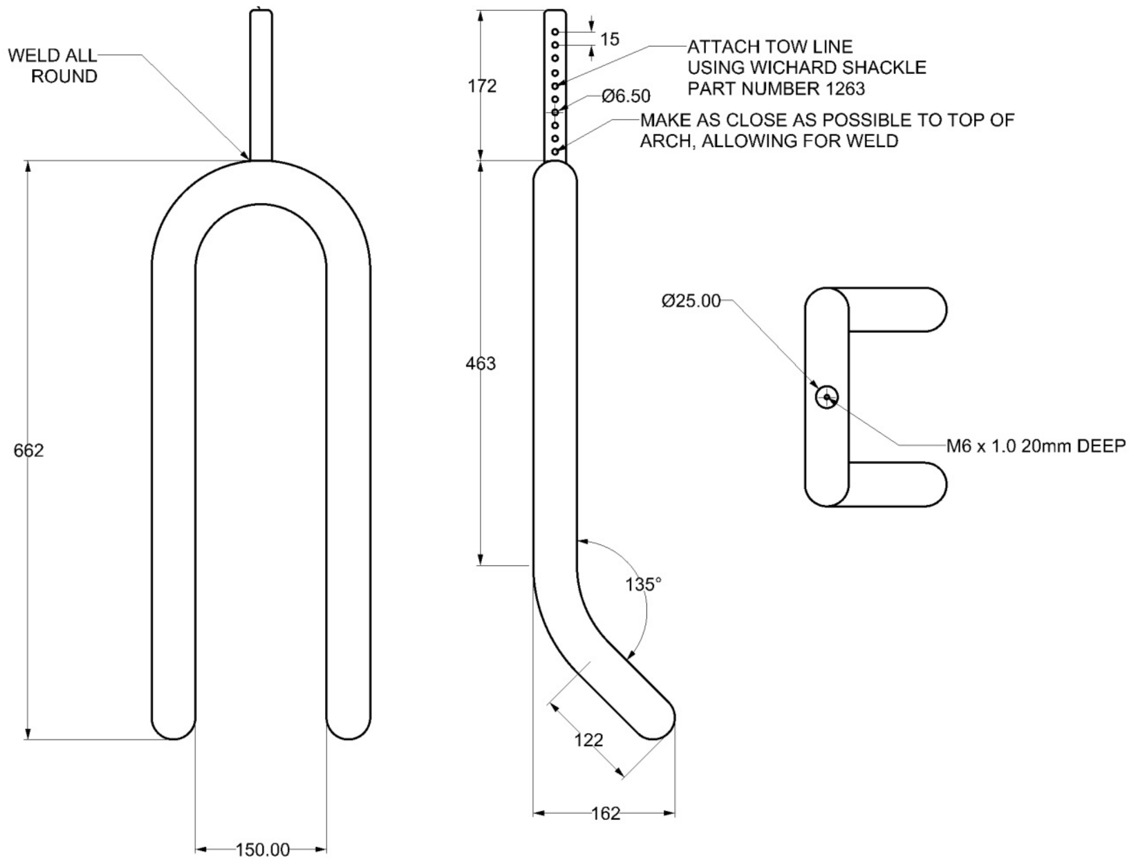


**Figure 5: Schematic drawing of the KLS 4 preliminary design.**

## Trips 1 - 4

The KLS 4 was lowered into the water and as it went under the surface it flipped with 180 degrees of yaw. This was repeated several times with a similar result. When lowered with 5m of cable below the surface the setter sat back behind the vessel at a comfortable angle, indicating that the weight was sufficient to overcome the drag forces and sink it close to the boat.

To solve the flipping problem the bend was cut off the legs (Version KLS 4.1) resulting in a reduction in weight to 15kg (Figure 6).

When lowered into the water the device remained straight behind the boat and seemed stable in the water without the longline deployed. However with the longline in the starboard side of the setter the force exerted by the line caused the setter to twist, and wander in the water, with a yaw angle of 45 to 90 degrees clockwise, and the legs of the U swept back with a pitch of around 30 degrees.

Several hooks were put through the setter indicating that the 50 mm diameter tube was sufficient to guide the longline and gear, providing its position in the water could be controlled. The longline was entering the setter very close to the towline attachment point and this resulted in several foul-ups.

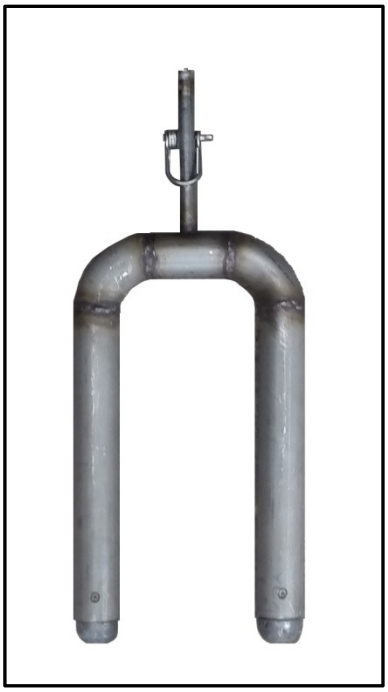

**Figure 6. Photograph of version KLS 4.1**

In an attempt to counter the force exerted by the longline the tow point was moved off centre, in line with one of the legs (version KLS 4.2). This however was not stable and caused similar results to the previous trip but with the longline entering opposite side of the 'U' to the tow cable, with a yaw angle of around 60 to 90 degrees (Figure7).

In order to tow the setter without yawing a version KLS 4.3 was conceived (Figure 8), using similar principles to version 1. This was trialled during a further three trips.

## Trips 5-7

This configuration successfully held the setter stable in the water such that there was no significant roll pitch or yaw with the longline setting through the U. The setter was stable at 5m depth with 10m of cable between the sea surface and the setter. This equated to a measured tow cable downward angle of 29 degrees from horizontal at the back of the boat, at 5 knots. Increasing the cable length to 15 m lowered the setter to 7.5m depth. The setter didn't tow exactly straight behind the boat and was roughly 2 degrees to starboard.

**Figure 7. Version KLS 4.2. Photograph from tow cable mounted camera showing offset tow point and longline passing through setter.**

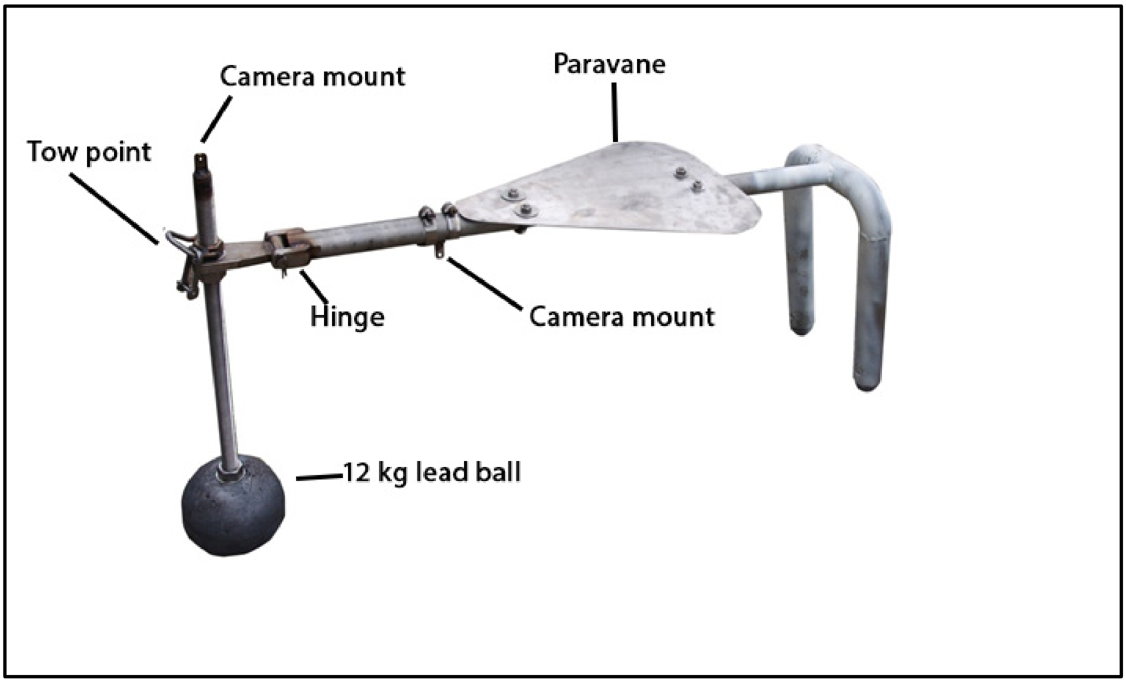


**Figure 8. Version KLS 4.3**

During the second trip (Trip 6) 180 hooks were set at depth with one snood lost. Several weights and floats passed through the U, although these did catch momentarily until enough tension built up in the line to pull them through.

In order to compare the sink rate profile of gear set through the line setter to that of normal gear Starr-Oddi DST centi time depth recorders (TDRs) were clipped onto the longline, in the manufacturer-supplied housing. To estimate the variability in sink rates of gear set normally, TDRs were attached beside weights and midway between weights equally across all normal gear configurations employed. On the line set using the underwater setter TDRs were attached in two groups, one when operating at 5m depth and the second at 7.5m depth, both on an unweighted sections of the line.

The time TDRs left the vessel was labelled as time zero (in Figure 9). TDR data were corrected for pressure offsets (as TDRs did not all read 0 m at the sea surface) and also for surface water temperature (as TDRs took some time to acclimatise to surface water temperature, and use temperature to correct pressure readings).

Sink profiles recorded by TDRs clearly show the longline sinking much closer to the vessel and indicate that there is a huge reduction in the widow of availability of hooks to birds behind the boat when setting gear through the setter (Figure 9).

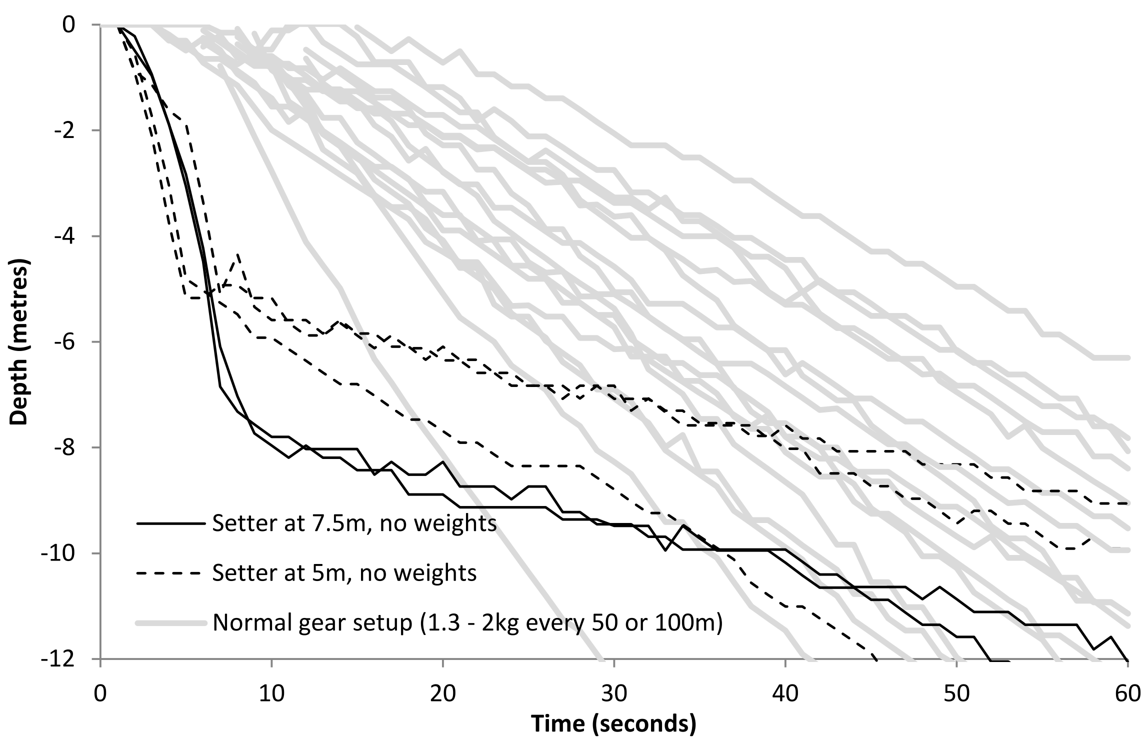


**Figure 9: TDR data from 2 sets with normal gear setup (grey line) and a set using the setter with no weights (solid and dashed black lines).**

The longline entered the setter almost vertically with a catenary in the line between the stern and the setter (Figure 10). Despite a reasonably high line-tension the water flow consistently pushed the longline into a curve before it entered the setter (Figure 10). This resulted in snoods, floats, and weights entering from above or behind the U. It is thought this is due to the setter pulling the line down much closer to the boat than with previous versions.

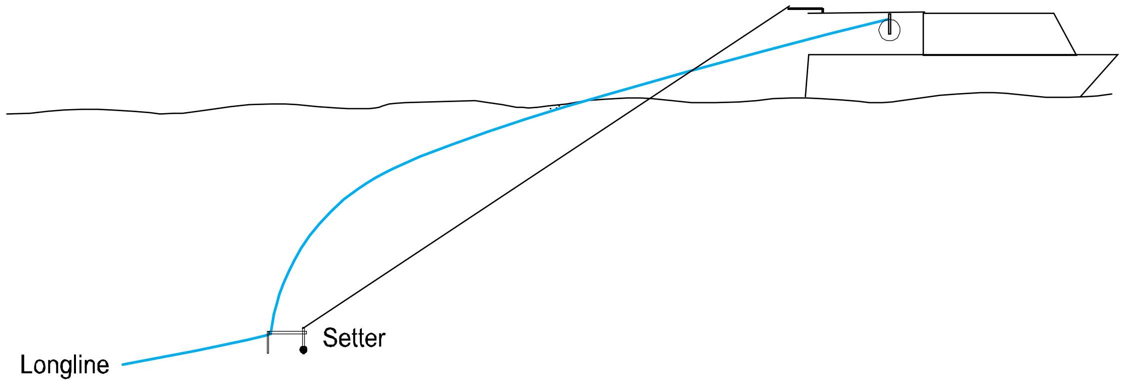


**Figure 10. Diagram showing setter, longline and tow cable relative to the vessel.**

Prior to the third trip (Trip 7) a small rudder was attached above the lead ball as shown in figure 11.

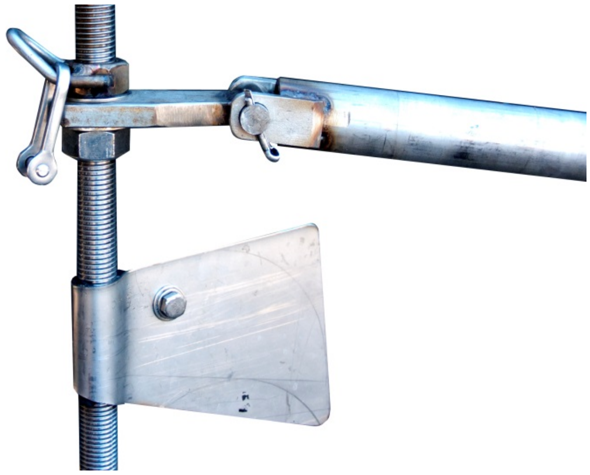

**Figure 11. Rudder attached to setter just above lead ball.**

The rudder allowed the setter to be ‘steered’ behind the boat, with the horizontal deflection angle approximately equal to the angle of the rudder. The addition of the rudder resulted in more drag, reducing the depth of the setter and the downward angle of the setter by 7 degrees. Similarly, halving the weight of the lead ball further reduced this angle by 3 degrees. This indicates that by adjusting the weight of the setter and the angle of the rudder, the position of the setter behind the stern can be controlled both vertically and horizontally.

## 3. Further Development

The next stage of development is to further refine the design, tuning the parameters outlined in Table 1 in an iterative manner.

**Table 1. Design parameters of the setter which can be altered to improve performance.**

| Adjustment | Effect |
|---|---|
| Rudder angle | Steer setter behind boat to alter separation between longline and the setter. |
| Weight of ball / setter | Control downward angle of tow cable, which will in turn alter the degree of curvature in the longline entering the setter. |
| Shape of U | Control where the longline sits in the U, and in turn how snoods / weights / floats pass around and through the U. |
| Vertical attitude and shape of legs | Maximise chances of snoods passing beside the legs rather than through the U, in turn minimising bait loss. |
| Tow cable length | Control depth of setter and distance behind the boat. |
| Geometry and weight distribution of setter | Maximising the chances of the device ‘failing safe’ such that it throws the longline out rather than catching up. |

## 4. DISCUSSION

Overall the development of the setter has been a continual learning exercise and we have been fortunate to have a team with different backgrounds, experience and skills. We have reached the stage now where we have realised that the most efficient way of working on this project is to just build ideas, trial them at sea, and then solve any problems that occur. Whilst flume tank work and mathematical modelling has been useful in calculating expected forces and suitable dimensions, it is hard to factor in all the variables using life-size designs. In future we would recommend the use of scale models, which would permit simulation of greater setting speeds and other fishing parameters in the flume tank. For novel projects such as the Kellian Line Setter, there is little theory to underpin development, unlike that which exists for other structures used in the marine environment. For further refinement of the Kellian Line Setter we believe it will be easier and cheaper to progressively build prototypes to evaluate and learn from each stage. A combination of TDRs, video camera footage, and measurements of tow-cable load and angle has allowed us to critically review each trip and prioritise alterations for further trialling in a systematic manner.

Moving to a simpler design with less drag and no inherent instability has shown promising results in terms of setting gear and made manufacturing and alterations easier and cheaper. It also holds the advantage of being able to run gear through the setter from the port or starboard side

Given the nature of the project we are unable to guarantee the ultimate feasibility and functionality of the Kellian Line Setter, but can see potential solutions to the current problems. At this stage we have several options to explore for fine-tuning version 4.3 that we feel will lead to a device that will permit setting demersal longline gear at depth without impinging fishing efficiency.

## 5. Acknowledgements

Alan Faulkner, Dave Kellian, Graham Robertson, Igor Debski and Kris Ramm provided advice and encouragement during the various phases of the development of this project.

We are also grateful to Janice Molloy and members of the Southern Seabirds Solution Trust Mitigation Mentor Programme's Technical Advisory Group for advice on the initial prototype and how to progress further development of the device.

The Australian Maritime College provided facilities and support which was essential to developing and refining Prototype 2, and subsequently the KLS 3 and 4 solutions.

Funding was provided by New Zealand Department of Conservation's Conservation Services Programme (http://www.doc.govt.nz/csp), principally through a levy on the quota owners of relevant commercial fish stocks.

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