Development of bird baffler designs for offshore trawl vessels

Conservation Services Programme Project MIT2013/05

Final Report

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Abstract

In New Zealand, bird bafflers have been deployed from trawlers for around a decade, including as one of three mandatory seabird scaring devices aimed at reducing seabird interactions with trawl warps. In this project, we report on Conservation Services Programme project MIT2013-05, which involved developing a novel design for a bird baffler for use on deepwater trawlers ≥ 28 m in overall length. Three baffler designs were produced, all based on a combination of booms with droppers hanging to the sea surface and a stern curtain designed to enclose the warp area. The Prototype I design was for a baffler with booms that could be deployed at adjustable angles, to optimise the coverage of trawl warps under different fishing conditions. Booms were stored across the vessel stern when not in use. Challenges with engineering this design to ensure adequate boom strength led to a redesign to strengthen the boom structure. Prototype II therefore retained the concept of rotating the booms out into position and storing them across the vessel stern when not in use. Boom strength was increased by adopting a design analogous to that used for paravane booms, which are regularly deployed from trawl vessels. However, engineers could not identify a mechanism to effectively secure the booms in anything other than mild weather conditions. The final baffler design (Prototype III) comprised a boom tower with a fold-down boom that locks into place at 90° to the tower for deployment. One tower and boom unit is affixed at each stern quarter. A metal plate secures each tower and boom unit to the vessel and the boom extends 8.4 m at a fixed 130° angle to the vessel stern. When not in use, the boom can be stored upright beside its support tower. For testing, boom droppers were constructed using conventional construction materials on one side of the vessel stern (i.e. rope with plastic pipe) and rope inside 45-mm diameter plastic hose droppers on the other side. The performance of the Prototype III baffler was documented during three trips to sea. Government fisheries observers assessing baffler performance at sea considered that the Prototype III baffler was the most effective they had seen on trawlers in New Zealand waters. The hose dropper system worked better than the more conventional rope and pipe dropper construction. However, the area inside the baffler booms and curtain was by no means impervious to seabirds, and both albatross and petrel species were seen to enter. Further, some trawl warp always protruded from the enclosed area. Minor improvements were made to the baffler following at-sea testing to improve its performance. Overall, this baffler cost approximately $40,000 to make and install, and the vessel required strengthening in order to support it. While preliminary testing of the Prototype III baffler showed it performed well at sea, its significant cost is likely to make other mitigation options preferable in the longer term.

Contents

Introduction

Seabirds can be injured or killed on trawl fishing gear due to interactions with trawl warps or nets (Bull 2007, 2009). In New Zealand, bird bafflers have been deployed from trawlers for around a decade, including as one of three mandatory seabird scaring devices aimed at reducing seabird interactions with trawl warps (Bull 2009; Cleal et al. 2013; New Zealand Government 2010). While other bycatch reduction devices, notably streamer lines, are known to be more effective than 4-boom bafflers at reducing seabird strikes on trawl warps (Middleton & Abraham 2007; Bull 2007, 2009), streamer line performance can be compromised in bad weather (when these lines can be blown away from the warps they would otherwise protect). Further, streamer lines can become problematic due to tangling risks, particularly on vessels that reverse frequently. Streamer lines must also be deployed and retrieved for every tow.

In comparison, bafflers have several strengths from an operational perspective:

- they are set-and-forget, being deployed at the start of a fishing trip and requiring little attention throughout,
- they have advantages for crew safety requiring less time spent close to the vessel stern, and,
- they offer relatively consistent performance in variable wind and sea conditions and ease of use for trawlers that back up frequently.

However, a key disadvantage of the baffler approach is the engineering required to develop sufficiently large and strong structures to attach to vessels such that booms extend an effective distance astern and can support the droppers required to protect trawl warps.

Bafflers are one of the two types of devices currently in use on trawl vessels $\geq$ 28 m in overall length that meet regulatory requirements for seabird bycatch reduction measures. The regulated specifications, which permit two and four boom designs, provide flexibility for vessel operators and scope for innovation, while also introducing opportunities for variable efficacy amongst the designs of mitigation devices employed. For example, the relative efficacies of two- and four-boom baffler designs, and two-boom designs and streamer lines, are unknown.

Here, we report on Conservation Services Programme project MIT2013-05, which involved developing a novel design for a bird baffler for use on offshore trawlers. This project was designed to explore bafflers that may be more effective than conventional 4-boom and legally acceptable 2-boom designs (New Zealand Government 2010), in reducing seabird interactions with trawl warps. Developing the design concept in which warps are effectively enclosed in an encircling curtain suspended between booms mounted on each vessel stern quarter was of particular interest (Cleal et al. 2013, and references within).

The specific objectives of the project were (CSP 2013):

1. To design and construct one or more improved bird baffler design(s).

2. To conduct at sea trials of the improved baffler(s) in order to assess efficacy and utility of the design.

3. To produce recommendations on the construction of bird baffler designs in a variety of media in order to maximise uptake in commercial fisheries.

Methods

Workshop

The project team undertook preliminary project scoping, and an exploration of vessels that may be available for the project, at workshop in December 2013. Skippers and senior crew from trawlers operated by Talley's Group Ltd, Sealord Group Ltd and Sanford Ltd attended the workshop. (Together, these companies hold the majority of quota for deepwater species caught by trawling). The workshop group focused on experiences with different baffler designs especially the enclosed design used on the FV San Waitaki (Cleal et al. 2013), and identified features that could be incorporated into a new design developed for this project. The group discussed the Protoype I design as a starting point for this project, identifying potential pros and cons of this design based on collective knowledge and experience.

Design development

Prototype I

The new baffler design concept that served as a starting point for this project is shown in Appendix 1. This design was developed from considering conventional 2- and 4-boom bafflers and the enclosed design (based on the FV San Waitaki), and the characteristics of all three designs that may contribute to efficacy in keeping seabirds away from trawl warps. The initial intent was to minimise the weight of the baffler (i.e. create a two boom design) while picking up a key feature of the enclosed design (the curtain between the booms that enclosed the trawl warps to some degree), thereby making seabird access to the warp zone immediately astern and across the transom more difficult.

The booms were also intended to be adjustable in terms of their angle to the vessel stern. Therefore, a wider area could be covered by moving the booms out (more laterally) and bringing the adjoining curtain in closer to the stern. Conversely, a narrower area that extended further astern could be enclosed by bringing the booms inwards (i.e. closer to 90^o to the stern). The envisioned benefit of adjustable booms was that the dimensions of the area enclosed by the booms and baffler curtain could be managed in accordance with the amount of trawl warp exposed, and therefore optimised for different fishing conditions. For example, where deeper tows make for a steeper warp angle and so less warp is exposed above the sea surface, enclosing a broader area with the boom tips further apart and the curtain closer to the stern may be most effective. In contrast, when mid-water or pelagic trawling occurs, a shallower warp angle and greater exposed warp length means that creating an enclosed warp area extending the maximum possible distance astern would be preferable. (The frequency of turns during trawl tows would be another consideration in the decision-making process regarding boom and curtain positioning. This is because trawl warp exposure changes during turns).

The Prototype I design also provided for booms to be retrieved for stowage across the vessel stern when the baffler was not in use.

Feedback from the workshop group on the Prototype I design included the following.

- It is desirable to keep the stern ramp area clear of baffler materials, and to ensure that the baffler doesn't interfere with the trawl warps.
- Designing droppers such that they link together is recommended as this is considered effective in reducing tangling.
- Ensuring droppers end very close to the water appears important for dissuading birds from swimming under/through the droppers.
- The angled side curtains (i.e., that join the side and stern booms) of the FV San Waitaki's enclosed baffler appear important for blocking birds from landing in the area ahead of the warp, and

subsequently being inside the warp danger zone as the vessel moves forward. The Prototype I design may not offer sufficient protection in these side areas.

- Affixing the baffler booms slightly higher than the railing on the fantail deck will make the retrieval of the dropper system and any required untangling much easier for crew. (They would be able to reach the droppers when the booms are not deployed).
- Fitting a ‘curtain rail’ system under the booms would allow the position of the droppers along the booms to be easily changed if needed.

The Prototype I design concept was discussed with marine engineers with a view to progressing to a final design for construction and installation on the test vessel. The feasibility of different lengths of booms was part of these discussions, with boom lengths of 8 m to 12 m considered. Baffler efficacy, in terms of excluding seabirds from the warp area, was expected to increase with boom length because more trawl warp length would be enclosed by the boom and stern curtains. However, because baffler droppers must be held astern over the trawl warps to protect the warps from seabird interactions, engineering requirements are challenging.

Amongst the fleet of deepwater trawl vessels currently fishing, exposed warp lengths range from approximately 7 – 25 m, depending on vessel size and trawl depth ratio. Weather and swell conditions also affect the length of warp exposed. In the context of an average vessel size (60 m in overall length) and typical fishing depth (500 – 600 m), warps would enter the water approximately 8 – 12 m astern the vessel in calm conditions. Therefore, the final design of the Prototype I baffler featured 12-m long booms designed for deployment at angles from 120^{o} to 140^{o} of the vessel stern.

Prototype I captured many design elements considered desirable from an efficacy point of view. However, challenges with engineering the baffler to ensure adequate boom strength and associated concerns about durability of booms in bad weather led to a redesign to strengthen the boom structure.

Protoype II

To address concerns about the strength and durability of the booms in Prototype I, the boom design proposed for Protoype II emulated the design of paravane booms used on deepwater trawlers (Figure 1). The strength of this design was considered promising in terms of the baffler withstanding the rigours of daily deployment in all sea conditions. The Prototype II design retained the concept of rotating the booms out into position and storing them across the vessel stern when not in use (Figure 2).

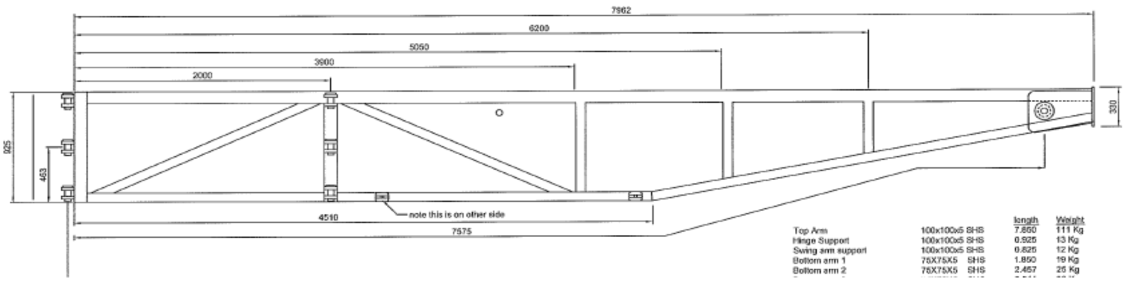


Figure 1. The boom structure proposed for Protoype II of the baffler design considered in this project. (Source: M. Hudson, Tasman Marine Design).

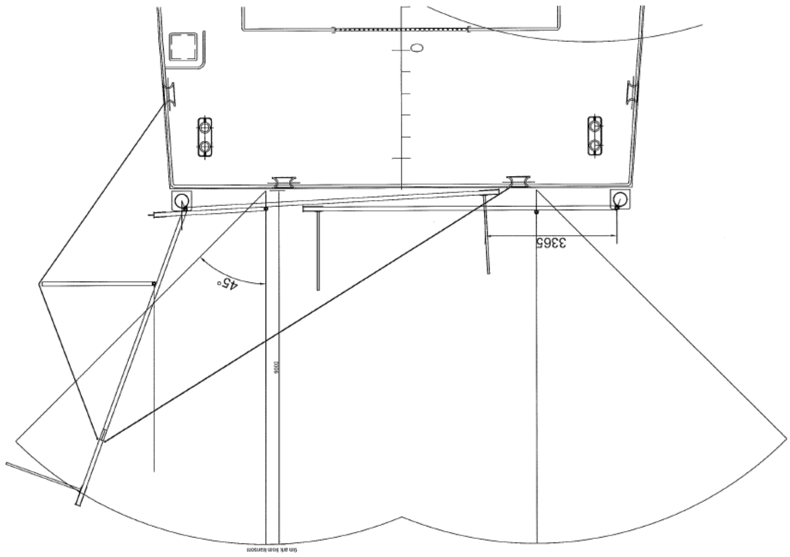


Figure 2. Prototype II booms depicted as they would be deployed from the port and starboard stern quarters, and stored across the stern of the vessel. The stay and support systems required to stabilise the booms at deployment are also shown. (Source: M. Hudson, Tasman Marine Design).

While the boom design appeared more workable in Prototype II providing the additional strength required, engineers could not identify a mechanism to ensure the security of the booms in weather other than mild conditions. For example, they could not design a system of stays (to support the booms) that was not subject to unreasonable loads (M. Hudson, pers. comm.).

Further, engineers' calculations showed that 10-m long booms fitted on each stern quarter of a 60 – 70 m long vessel would be dipped and rolled in the water, as the vessel bow climbed large swells. Engineers also considered that the 10 m booms in the proposed configuration could become a hazard if torn off (e.g. in bad weather). For example, if not cleanly removed from the vessel and its surrounds, booms may entangle with fishing gear or critical components of the vessel structure such as the propeller.

With engineers considering this design could not be made workable, a third boom structure was considered. This involved abandoning the plan to have an adjustable angle where the booms attached to the vessel. The 10-m boom length was also deemed a safety issue, and booms were shortened for the third prototype design.

Prototype III

The final baffler design comprised a boom tower with a fold-down boom that locks into place at 90^{o} to the tower for deployment. One tower and boom unit is affixed on each side of the vessel stern. A metal plate secures each tower and boom unit to the vessel (Figure 3). The boom extends 8.4 m at a fixed 130^{o} angle to the vessel stern. When not in use, the boom can be stored upright beside the supporting tower.

Where the baffler towers and booms were attached, the stern of the vessel was reinforced through the attachment of the 10-mm thick metal plate. This provided the necessary strength to support the baffler tower and boom structure, for example in bad weather when waves may wash across the vessel stern.

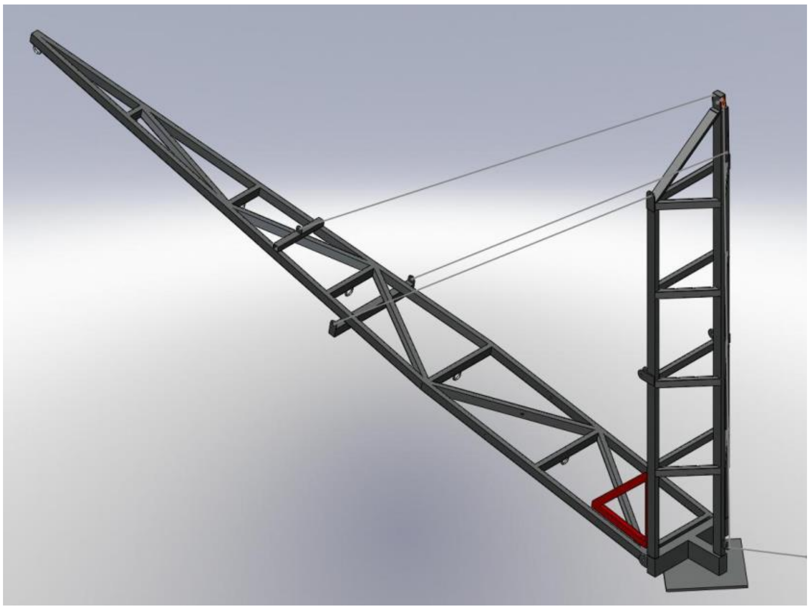


Figure 3. Tower and boom arrangement of baffler Prototype III. The triangle unit shown in red is used to lock the boom in place when it is deployed. Booms are folded back up to the tower for storage when not in use. (Source: P. Wastney).

With the boom structure finalised, the design of the baffler droppers and stern curtain could proceed. This involved determining the suspended load that the booms would need to hold, when the stern curtain was in place from boom tip to boom tip. Load testing was conducted by Hampidjan Ltd in their Nelson net shed. This involved suspending a 28 m length of 24 mm diameter mainline rope between two forklifts. The rope was attached to each forklift at 1.3 m above ground. A load cell measured the pull required to lift the centre of the rope to 72 cm above ground. Two tests were conducted with different amounts of weight attached to the suspended rope. The first test attached 58.4 kg of weight along the rope, comprising 7.3 kg weights at 3-m intervals. The second test used 44.8 kg of weight along the rope, with each weight reduced to 5.6 kg and spaced at 3-m apart as before.

Load testing showed that the load generated by the droppers (i.e. that the booms would need to support) was 666 kg and 502 kg for the first and second test respectively. The dropper system developed following these tests comprised 47 kg deployed from each boom and 79 kg for the stern curtain. The total load generated by this arrangement was calculated as 568 kg (P. Wastney, pers. comm.).

Boom droppers were constructed using conventional construction materials on the port side of the vessel stern (i.e. rope with plastic pipe, Figure 4) and rope inside 45-mm diameter plastic hose droppers on the starboard boom (Figure 5). The goal of this mixed construction was to compare the performance of the two, in terms of operational performance and durability. The stern curtain comprised rope inside plastic hose, with Kraton-like plastic noodle lengths filling in a 6-m mid-section of the curtain aft of the stern ramp. These Kraton-like components were shortened slightly to ensure the trawl net could be shot and hauled without hooking up on the baffler gear.

A weak link was also incorporated in the design of the stern curtain (Figure 6), to ensure that if one boom was damaged or lost, the stern curtain connecting the booms could break in two, thereby saving the second boom from undue stress or damage.

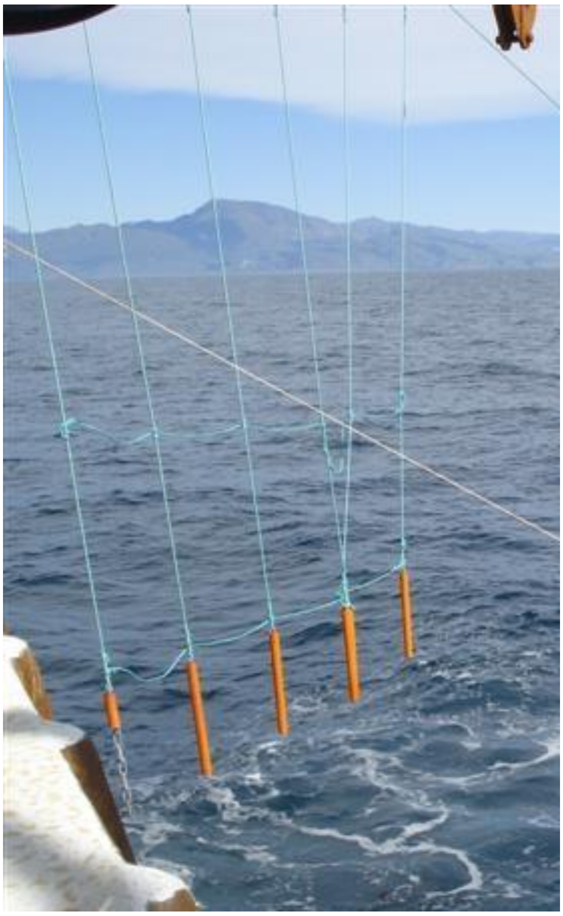


Figure 4. The rope and plastic pipe droppers deployed on the port side of the Prototype III baffler.

Figure 5. Assembly of the baffler dropper system using rope passed through plastic hose, to be deployed on the starboard side of the vessel.

Figure 6. The weak link included in the stern curtain to allow the curtain to break into two parts should one of the booms be damaged or lost into the sea.

At-sea testing

Preliminary testing

The test vessel on which the Prototype III design was mounted is a hoki-fillet processing factory trawler. It is a Sterkoder-class vessel, and one of six vessels of this class fishing in the New Zealand hoki (*Macruronus novaezelandiae*) fishery. The vessel is 60 m in overall length, 3 340 hp and 1 970 GRT. Throughout at-sea testing, the prototype baffler design met legal requirements for bafflers on trawlers $\geq$ 28 m in overall length (New Zealand Government 2010).

A company observer was present on the test vessel for a short transit trip of a single day on 23 November 2015 as the vessel travelled from Nelson to Lyttelton. The baffler was deployed during this trip and the observer conducted a preliminary evaluation of the baffler's performance. The company observer also tested the data collection form intended for deployment with a much longer fishing trip to be conducted by a government fisheries observer. Feedback from the preliminary trip was discussed with the vessel operator and captain, and adjustments to the baffler were made prior to the deployment of the government observer.

During the first fishing trip after the baffler was installed (and prior to government fisheries observers joining the vessel), crew continued the observations that were started by the company observer. This trip targeted hoki on the Chatham Rise. Crew collected information on the baffler performance on nine data collection forms, completed from 23 December 2015 through 13 January 2016. Additional feedback was also provided after the vessel's return to port. This resulted in small modifications being made to the baffler before government fisheries observers were deployed.

Observer data collection

Two government fisheries observers were deployed on the test vessel and conducted observations of the baffler's operation and performance. Observations were recorded from 24 January through 28 February 2016 on the data sheet shown in Appendix 2. The target catch species for the majority of this trip was hoki. Observers were requested to conduct observations on the baffler as their time on other duties allowed, and in as diverse weather conditions as possible (whilst always ensuring their own safety). Observers also took photos and video to illustrate their observations of the baffler's performance.

Results

Preliminary at-sea testing

During preliminary observations, 5 – 6 m of trawl warp was exposed beyond the baffler droppers and stern curtain. The hose droppers performed significantly better than the more conventional rope and pipe droppers. During the transit day when the baffler was deployed, two rope droppers tangled and a third broke.

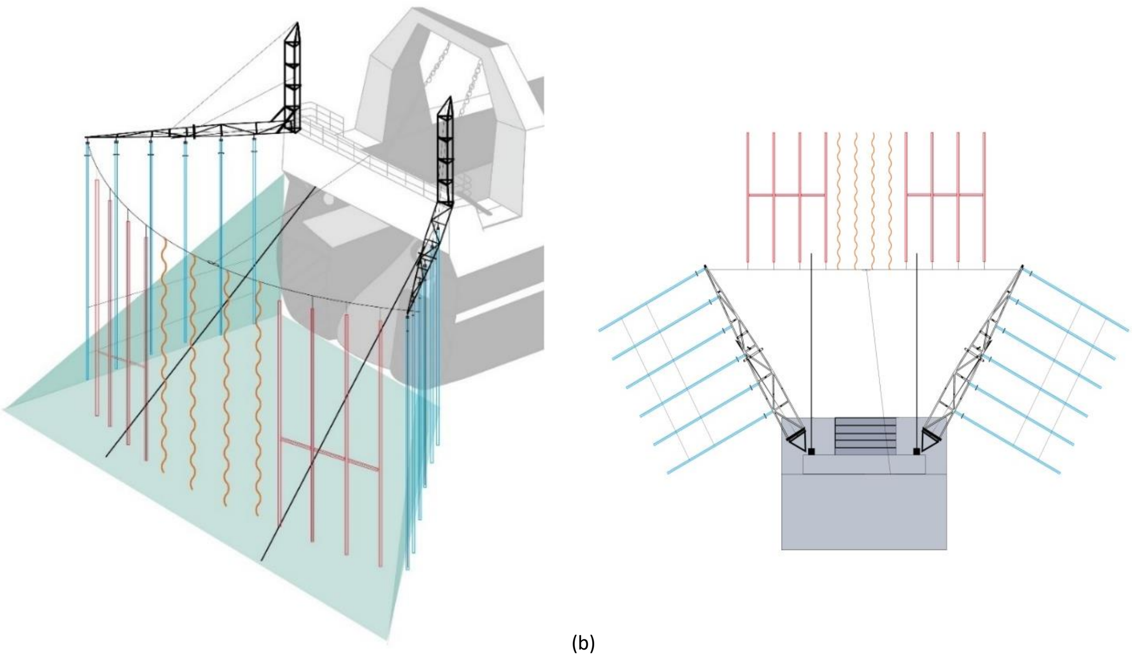
During the first fishing trip after the baffler was installed, crew noted that 5 m or less of the trawl warps extended beyond the baffler's stern curtain. Two orange pipes were broken on the conventional dropper rig within two days of this trip commencing. This resulted from the droppers being caught up during hauling. The conventional droppers of rope and pipe also required untangling four days after the start of the trip. By day 18, all orange pipes had been broken and pieces were being lost. In contrast, the hose droppers were much more durable, lasting throughout the trip. The stern curtain required untangling on days 4 and 18 after the fishing trip commenced.

Preliminary feedback on the design of the baffler from the company observer and vessel crew included the following:

- The pins locking the boom in position on the tower were fiddly and time consuming to operate, as well as placed too high up for the crew's easy reach.
- Another rope guide is necessary for ropes linking back to the baffler tower to keep these inside the boom frames.
- There was a friction point where rope rubbed on one of the pulley housings on the boom where it secures to the tower. Excess metal there should be removed to address friction.
- Rope cleats should be added to allow ropes to be tied off safely.
- A lazy line from the vessel to the inside of droppers would reduce tangling.
- The height of the stern curtain requires shortening to bring it just above the sea surface.
- One more dropper should be added to each corner of the stern curtain to improve the enclosure around the trawl warp area.
- 11-mm diameter plastic Kraton-like tubing should be attached as six vertical droppers, to improve the enclosure of the centre of the stern curtain and reduce seabird access to the trawl warp area.
- The system used to lock the booms into position (i.e. the red triangle shown in Figure 3) may require strengthening. (This was subsequently deemed unnecessary when further sea trials confirmed that the weight of the boom and dropper system was sufficient to stop booms from bouncing up towards the towers).

These recommendations were actioned prior to the trip on which government fisheries observers were deployed.

The final baffler design prototype is shown in Figure 7 and Appendix 3. The Kraton-like lengths covering the area behind the stern ramp were shortened during the observed trip to ensure they did not tangle as the net was shot and hauled.



(a) (b)

Figure 7. Schematics of the Prototype III baffler design developed during this project. (a) The baffler deployed at the vessel stern. (The orange streamers in the centre of the stern curtain were shortened during the observed trip). (b) An aerial view of the baffler system. (Images: Ros Wells).

Observer data collection

The two government fisheries observers completed 47 forms during their deployment. Forms were completed from 06:00 to 20:00 NZST with most observations occurring in the morning. Weather conditions varied considerably during the trip, with Beaufort sea states of 1 – 6 when observations were conducted. Observation periods in which forms were completed ranged in duration from 20 to 35 minutes, with a mean duration of 24 minutes (standard deviation = 4 min 18 s). Vessel speed during tows was 3.9 – 4.2 knots. During observations, the droppers and stern curtain were within 0 – 1.0 m of the sea surface. The droppers on the booms often dipped below the sea surface.

During observations conducted by observers, there was almost always some trawl warp exposed outside the enclosed area formed by the baffler. In calm conditions, this ranged from 0.5 – 2 m. In swell, trawl warps could be intermittently covered such that there was no exposed warp length beyond the baffler curtains. However, between swells, more warp length was exposed. (For example, in sea conditions of 5-m swells, 0 – 4 m of trawl warp was exposed). During vessel turns, trawl warps became more steeply angled to the stern, bringing one warp within the baffler curtain on occasion, while the other did not extend more than 2 m beyond the baffler curtain.

Some wear and tear on the baffler occurred during the observed trip. Wear was documented on one starboard dropper hose where it crossed with a lateral hose and two hose droppers were lost from the starboard boom. A lateral rope also wore on one hose dropper. During an overnight gale of 40 – 45 kn, the curtain broke in one place. This was fixed early in the morning after the gale, and the curtain was soon redeployed as before.

In 12 observation periods, observers recorded that parts of the stern curtain were tangled. Most often the parts tangled were not recorded. However, in one documented case, tangling involved two droppers. Crew retrieved the booms carrying tangles. They removed the tangle quickly and redeployed the baffler in minutes.

In at least three other cases, tangling involved the Kraton-like noodles in the centre of the curtain (Figure 8). The observer noted that some amount of tangling in the noodles was common during the trip. In video taken by one observer, hose droppers were observed to contact the trawl warps, but bounced off and did not tangle.

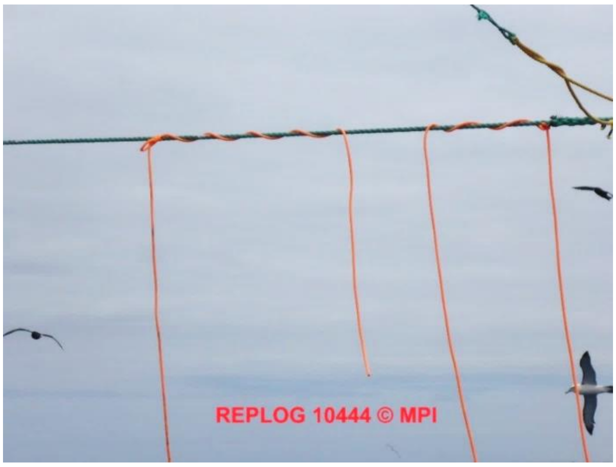


Figure 8. Kraton-like plastic noodle droppers from the stern curtain tangled around the curtain's top rope. (Note that following at-sea testing, these noodles were replaced by hose to prevent future tangling).

During observer observations, the majority of birds remained astern of the baffler's enclosed area (Figure 9). However, the enclosed area was by no means impervious to birds. During 26 observation periods (that all coincided with offal discharge), seabirds were observed to enter the baffler's enclosed area. There were another eight periods of offal discharge during which no birds entered the enclosed area. Finally, there were 13 periods without discharge in which no birds ventured inside the baffler's enclosure.

Figure 9. The Prototype III baffler viewed from the starboard stern quarter. The port warp has crossed the centre of the vessel and is protruding significantly from the protected area covered by the baffler's stern curtain.

Salvin's (*Thalassarche salvini*) and Buller's (*T. bulleri*) albatross, white-chinned (*Procellaria aequinoctialis*), Cape (*Daption capense*) and giant petrels (*Macronectes* spp.), and sooty shearwaters (*Puffinus griseus*) were all observed inside the area enclosed by the baffler curtain during the observed trip. On occasion, a bird sitting on the sea surface would drift back into the enclosed area as the vessel moved forward, passing beneath the droppers apparently unintentionally. However, at other times birds deliberately entered the enclosed area to feed. White-chinned petrels and Cape petrels readily darted between the droppers to grab pieces of discharged offal (Figure 10). While in some of these cases, droppers were seen to contact the birds, the observer recording these contacts considered that they were not injurious. He also considered that the birds were well aware of the droppers. These birds exited the enclosed area rapidly, in some cases retreating from the moving droppers.

Salvin's and Buller's albatross entered the enclosed area both under the plastic noodle curtain and through the hose components of the stern curtain and port and starboard droppers. While noted during observations occurring throughout the trip, their activity was particularly intense during two periods when whole fish discards and fish heads were being discharged. Warp strikes were observed amongst both albatross and white-chinned petrels during these two observation periods of heavy discharge.

On occasion, the lowest rope connecting the port droppers came up under or skimmed over albatrosses and petrels, pushing them around. This was only observed when birds were on the sea surface, not in flight. Birds were mostly observed to bounced away or move off flapping. However on several occasions, Salvin's albatrosses, white-chinned petrels and two unidentified seabirds were observed to become hooked by the wing on this rope. Birds were hooked for not more than a few seconds before escaping.

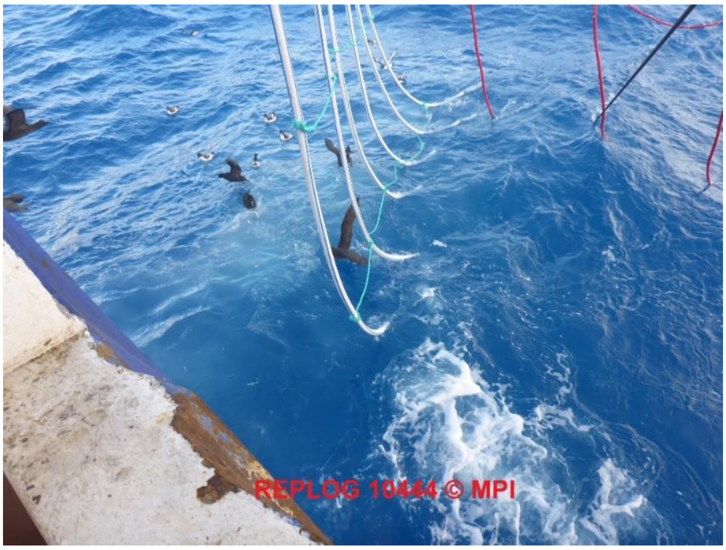


Figure 10. A white-chinned petrel exiting the baffler's enclosed area. (Note that modifications following at-sea testing included moving the cross-ropes higher up to avoid bird contact).

Recommendations to improve baffler durability and performance

Following at-sea testing, observers and crew made the following recommendations to improve the performance or durability of the baffler.

- To avoid birds being tangled and to reduce the likelihood of injuries should that happen, horizontal ropes between droppers should be enclosed in hose and moved higher up the droppers, e.g., 2 m from the sea surface.
- To ameliorate tangling, plastic noodle lengths covering the part of the stern curtain aft of the stern ramp should be replaced with hose lengths. The rigidity of hose should prevent tangling with trawl warps during net shooting and hauling and if hose does get caught up, it will break.
- Friction between the rope at the top end of the droppers on the stern curtain is leading to rope wearing through and the potential for hose dropper loss. This friction point may be eliminated by eliminating the rope and affixing hose directly onto the top rope of the stern curtain.
- Extending the booms using an attachment of lighter-weight pipe 1.5 – 2 m in length, and therefore locating the stern curtain at a greater distance astern should be trialled to increase warp protection provided by the baffler. If heavy seas removed one or both of the boom extensions and the stern curtain, these could be relatively easily and cheaply replaced. The main booms and support towers (the most expensive part of the system) would still be in place.

Discussion

Design challenges encountered with baffler prototypes during this project are exemplary of the issues that must be considered when developing seabird bycatch reduction devices for real-world fishing operations. Hardware attached to vessels must be extremely strong and weather resistant, or readily replaceable. In the latter case, hardware being forcibly removed from vessels in adverse sea conditions must not present an unacceptable risk of damage to other components of the vessel structure, hazard to vessel operations (e.g., by interfering with the propeller), or risk of accident or injury to vessel crew.

The Prototype II design was significantly lower cost than the Prototype III design given its lighter and simpler construction. (No support tower was envisaged in the Prototype II design). However, the design failed at the point where engineers could not devise a solution to secure the booms in place once they were deployed. In contrast, the quality of the design and construction of the Prototype III baffler meant that it was expensive at around $40,000 – twice the cost of a more conventional four-boom baffler, and around five times the cost of a two-boom device. This is because of the size and strength of hardware required to support the 8.4-m long booms. (The booms and support towers were produced at a cost of $23,000). However, longer booms combined with droppers that reach the sea surface astern covering the area where warps enter the water (unlike most baffler droppers in use in the deepwater trawl fleet, Cleal and Pierre 2012) are expected to significantly improve the efficacy of the baffler. Therefore, these higher costs expended in design and construction should be reflected in better at-sea performance, including greater efficacy.

The challenges associated with designing and building the boom system and support structures also caused a one-year delay in completing this project. Designs were developed through the work of two marine architects and a significant amount of time was spent ensuring designs were robust and could withstand weather conditions at sea. When the final prototype design was arrived at, additional time was required to strengthen the vessel such that the fantail deck was able to support the weight of the tower and boom system. This strengthening occurred as part of a major vessel refit, and would not have been required had the lighter Prototype II design been possible.

In the course of targeting hoki, the test vessel generally trawls at depths of 500 – 800 m. For vessels conducting shallower trawls (e.g. at above 500 m depth), significantly longer lengths of warp are expected to be exposed beyond the enclosed area surrounded by the baffler droppers and stern curtain. Clearly, the greater the length of exposed warp, the more risk there is of seabird strikes, and the less effective the baffler can be at reducing those interactions. However, the extreme weather and sea conditions associated with New Zealand oceanic conditions, together with engineering constraints, preclude the construction of a baffler boom that would completely cover trawl warps exposed during all fishing activity.

Overall, the government fisheries observers considered that the baffler was the best-performing they had encountered amongst New Zealand's deepwater trawl fleet. They considered that the angled booms and stern curtain were effective in keeping albatross away from trawl warps. The efficacy of the baffler in terms of reducing seabird strikes on trawl warps has not yet been quantified. However, if efficacy cannot be delivered cost-effectively for this device, other mitigation options (such as streamer lines) are likely to be preferable longer term.

Acknowledgements

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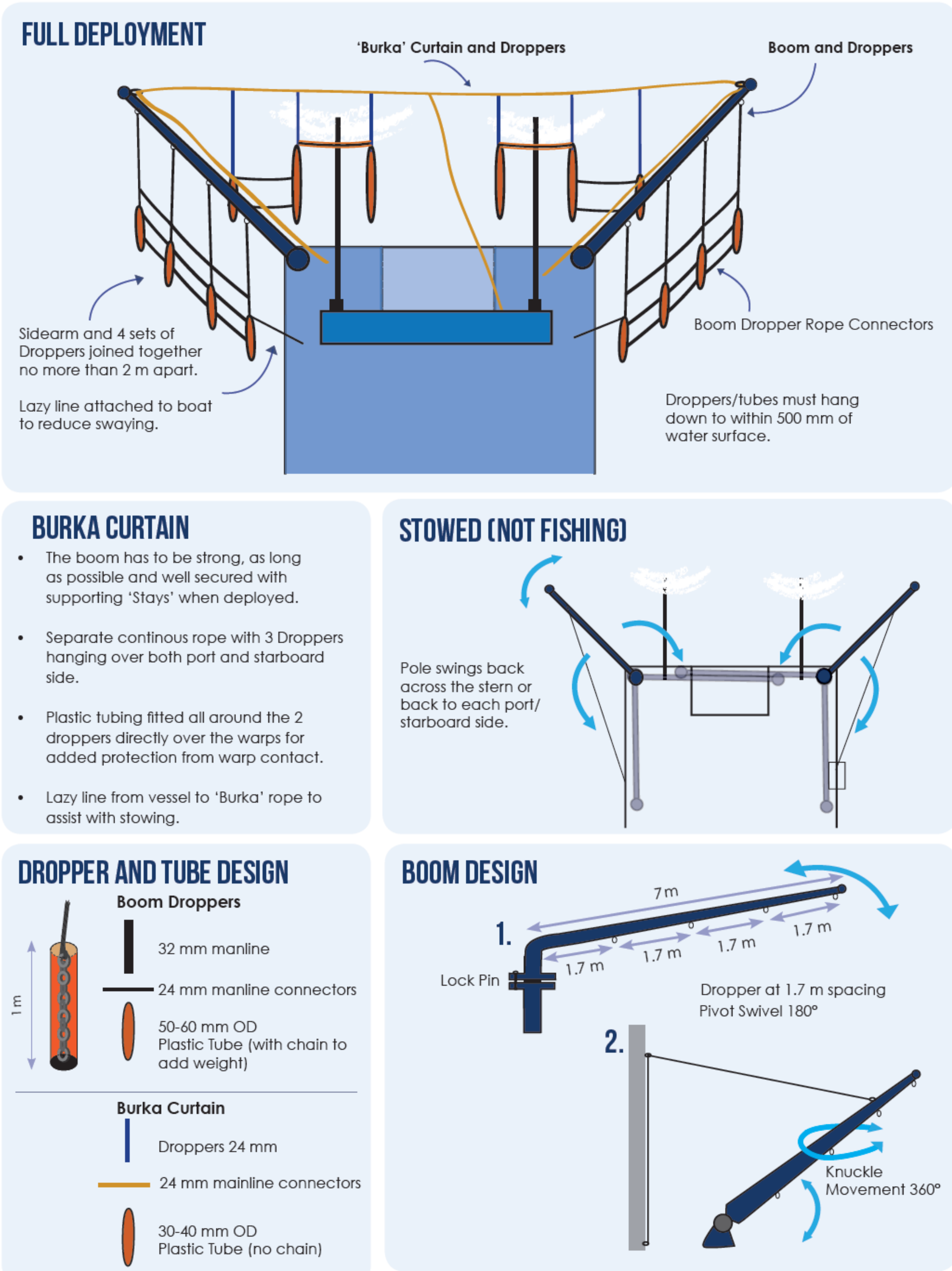
Appendix 1: Prototype I concept design for the baffler to be constructed for this project



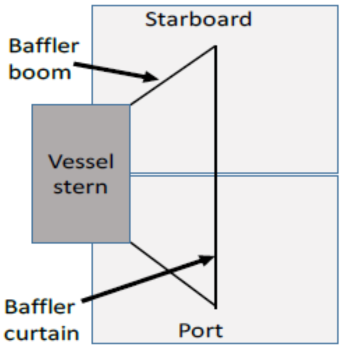
Source: Cleal et al. (2013)

Appendix 2: Data collection form completed by the government fisheries observer monitoring the performance of the Prototype III baffler

B&B Baffler Performance Form

Observer name:

Date:		Vessel towing:	Y / N	Beaufort (0 – 9):		Vessel speed (knots):		Start obs time:	End obs time:



Draw the location of the trawl warp on the diagram.			
Was the warp enclosed inside baffler curtain (circle)?			
Y / N			
How much of the warp extended outside the baffler curtain when the vessel steamed straight ahead (circle):			
0 m 1-2 m 3-4 m 5-6 m 7-8 m 9–10 m > 10 m			
If the vessel turned during your observations, how much of the warp extended outside the baffler box during the turn? (circle):			
0 m 1-2 m 3-4 m 5-6 m 7-8 m 9–10 m > 10 m			
Was offal discharged during this observation period?			Y / N
From the scuppers or sump?	Y / N	From the main offal chute?	Y / N

If the baffler was deployed or retrieved while you observed:
Please describe the deployment of the baffler booms and curtain (was the deployment easy for the crew, were there any tangles or equipment problems, safety issues, etc.):
Please describe the retrieval of the baffler booms and curtain (ease of retrieval, tangles, equipment problems, safety issues, etc.):

During this observation period:					
Were any droppers tangled? (circle)	Y / N	Which ones? (circle)	Port / Starboard / Curtain		
Did the droppers and curtain hang close to the sea surface?	Y / N	Distance to the sea surface (m)	Port	Starb	Curtain
Were any parts of the baffler showing signs of damage? (circle)			Y / N		
Please describe:					

During this observation period, did you notice any seabird interactions with the warps, baffler droppers or booms? Please describe:	
Did birds enter the area enclosed by the baffler booms and curtain?	Y / N
If Yes, where and how did birds enter the enclosed area? (Mark entry point with* on the diagram above and describe bird behaviour).	

Since your last observation period:	
Have any changes been made to the baffler by the crew, e.g. to fix a problem? (circle)	Y / N
Please describe:	

Photos taken during this observation period:		Video clips taken:	Y / N
Baffler curtain area	Y / N	Please take video clips of any events of interest (e.g., bird behaviour, baffler problems, anything out of the ordinary).	
Warp(s) + baffler boom	Y / N		
Boom and dropper arrays	Y / N		
Other	Y / N		

Please record any general observations you have on the performance of the baffler. For example:

- Any improvements to the design that you can think of
- Would the design work on other deepwater trawl vessels?
- Any feedback from the skipper/crew on the baffler and its operational performance

Appendix 3: Dimensions of baffler droppers used in the Prototype III design

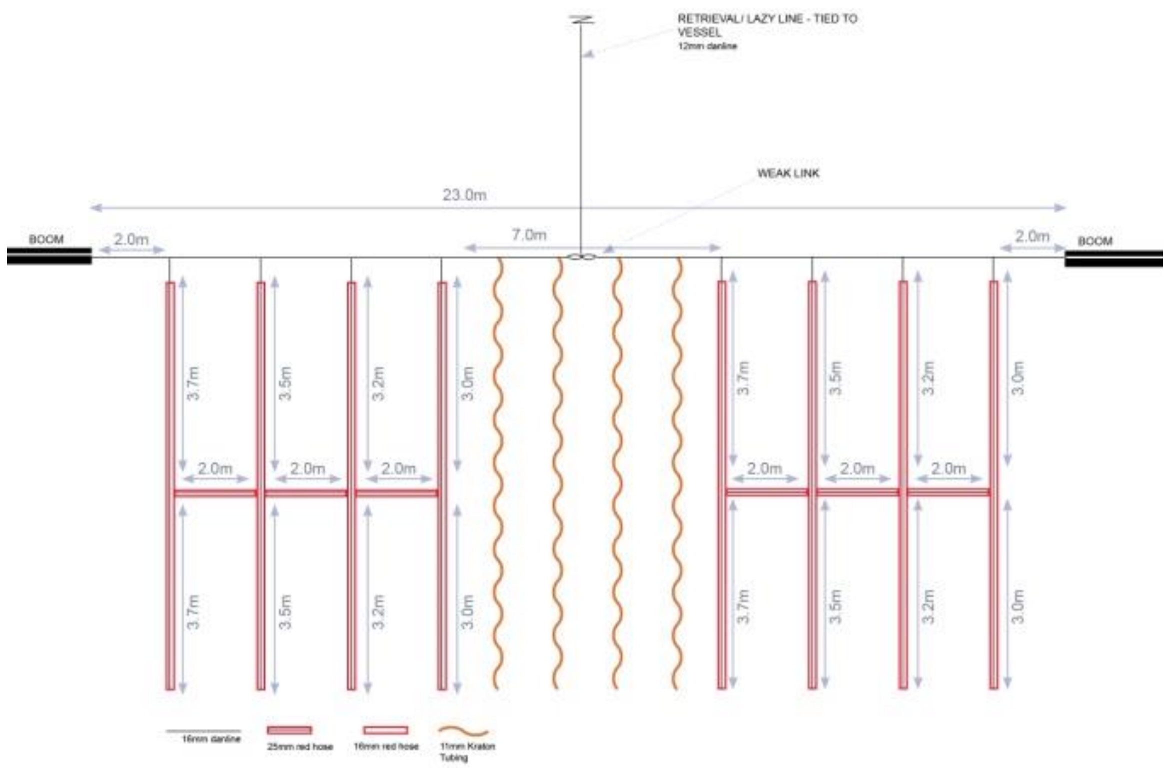


Figure 1. Measurements of droppers comprising the aft baffler curtain. (Image: Ros Wells)

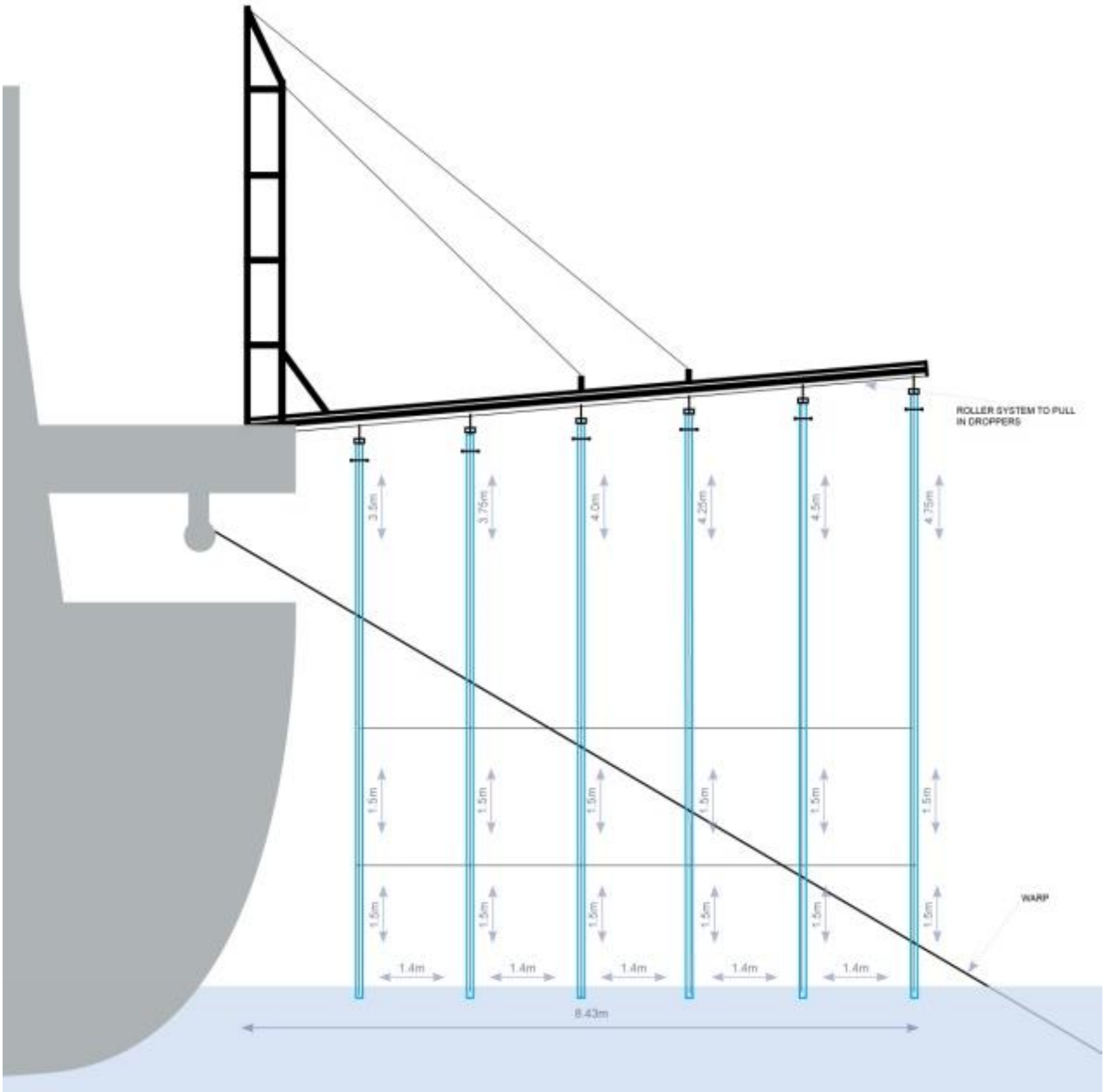


Figure 2. Side view showing measurements of droppers. Droppers are made of 45 mm hose pipe. Bolts are shown as horizontal bold black lines. (Image: Ros Wells)