Reducing sink times to depth in the small vessel manual baiting demersal longline fishery targeting species such as ling and bluenose.

Final report

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Contents

Executive Summary

The introduction of mitigation standards and subsequent changes to regulations require fishers to sink demersal longlines to a depth of five metres within the aerial extent of the tori line. This project involved recording sink profiles for a range of different gear configurations in the manual baiting ling, bluenose, hapuku, and bass demersal longline fishery.

Following review of current fishing practices, and consultation with stakeholders, a range of gear configurations were tested. Weight and float spacing and sequence were altered iteratively to identify various options for fishers to meet the regulations. Overall, 36 different configurations were tested with at least three repeats completed for 34 configurations.

Reducing weight spacing was found to be the easiest and most effective way of reducing sink times to depth. However, in the fisheries under consideration fishers tend to favour large weight spacings and multiple floats between weight to position hooks above the seabed. Increasing weight size was also a simple option but is limited by the amount of weight fishers were prepared to add to the line. Beyond 150 m weight spacing the use of modified floats was necessary to meet regulations. The modified floats had extra buoyancy but were attached to the mainline with a rope with a small weight adjacent to the mainline. These modified floats allowed for the longline to sink rapidly to a depth equivalent to the length of the rope, before the buoyancy of the float reduced the sink rate. Other options identified for reducing sink time to depth included increasing line tension, setting with the current, and using monofilament nylon as opposed to rope backbone.

Time depth recorder (TDR) positions three-quarters of the way after a weight generally sank slower than those midway between weights, unless weight spacing was relatively close. Tori line trials with a series of drag object on a thick rope demonstrated that 70 m aerial extent at 2.3 knots and 100 m at three knots was feasible. Options are presented which allow fishers to fish legally, including with large weight spacings and multiple floats between weights. Further testing is recommended to assess the practicality of the modifications suggested during a commercial fishing trip, and any influence on catch rates.

Background

The introduction of mitigation standards for demersal longliners (MPI, 2019) and subsequent changes to regulation (MPI 2021) have resulted in increased attention on sink times to depth and the depth of hooks at the end of the aerial extent of tori lines. Despite regulations requiring vessels to record sink rates monthly (MPI 2021) and using observers to collect sink rate data in the fishery, there is a lack of data reliably describing sink times to depth across the fleet. There is also a lack of data supporting options and strategies for improving sink times to five metres by the end of the tori line for the ling (hokarari, *Genypterus blacodes*), hapuku (*Polyprion oxygeneios*), bass (moeone, *Polyprion americanus*) and bluenose (mātiri, *Hyperoglyphe antarctica*) manual baiting demersal longline fleet.

Previous work has shown that sink times to depth vary with gear configuration and position on line, as well as with environmental conditions (Goad et al., 2010; Goad, 2011; Pierre et al., 2013). However, for a given gear configuration, times to depth for the slowest sinking part of the line show much less variation within and between sets (Goad, 2021). Goad and Olsen (2022) tested sink times to depth for a range of gear configurations employed by the snapper (tāmure, *Pagrus auratus*) longline fleet using time depth recorders (TDRs). Summarising the results in a two-page flyer provided government liaison officers and fishers with estimates of sink times to depths and how alterations to gear configuration could improve these. In combination with tori line trials recommendations were provided for tori line designs and line configurations that were likely to meet regulations. Following positive feedback from government and fishers this project aimed to expand the approach to cover the rest of the manual 'clip on' demersal longline fleet.

Introduction

The manual baiting demersal longline fishery targeting species such as ling and bluenose deploys hooks on 50 cm long two-millimetre diameter monofilament snoods. Baited hooks are stored either on cards containing (typically) 30 hooks, in fish bins, or on metal rods. Hooks are individually clipped onto the longline during the set, as the line leaves the vessel. Generally, hooks are pre-baited by hand, commonly with squid (wheke, e.g. *Nototodarus spp*.) or barracouta (mangā, *Thyrsites atun*) though some vessels use automatic or random baiters which pull hooks through a pool of pre-cut baits during setting operations (DG pers. obs., JC pers. comm). Mainline or 'backbone' diameter and material vary, with typically three-to-six-millimetre diameter monofilament or seven-to-nine-millimetre rope employed. Hooks are generally separated by regularly spaced stoppers but may be spaced by eye when using rope. The fleet employs a range of gear configurations, which vary with target species. Sets targeting ling are typically over 'clean' ground with skippers aiming to add sufficient floatation to hold hooks just above the seabed to avoid invertebrate bait stealers and lice. Bluenose configurations may be fished over 'foul' features and generally aim to suspend some or all hooks well above the seabed by the addition of several floats between weights. Lines targeting other species tend to employ gear configurations between these two examples, at times also varying with the nature of the seabed.

Gear set-up is flexible and can be changed between and within sets. Hook spacing is dictated to some extent by stopper spacing but vessels can (for example) use lines with one-metre stopper spacing and clip hooks on every two to four stoppers to modify hook spacing. Weight spacing is, in turn, dictated by the number of hooks between weights. The height of the gear above the seabed is controlled by the length of rope between the weights and the longline and the addition of floats in combination with weights and/or directly on the backbone between weights.

Objectives

1. To identify options for increasing the sink rate of hooks in small bottom longline fisheries.
2. To test the performance and efficacy of methods to increase the sink rate of hooks in small bottom longlines.

Methods

Planning

Protected species risk management plans (PSRMPs) for the demersal longline fleet were sourced from the Department of Conservation (DOC) and summarised. A list of gear configurations to be tested was compiled, aiming to cover the range currently used by the fleet. Faster-sinking configurations were added to the list, aiming to reduce sink times to depth.

The work plan was distributed for review to fishers, vessel owners, licensed fish receivers, Fisheries Inshore New Zealand, DOC, and Fisheries New Zealand. Subsequently, the list of gear configurations to be tested was refined and finalised during further meetings and discussions, incorporating feedback from industry representatives and fishers.

A single vessel was chosen for the trials, which targets ling and bluenose on the east coast of the North and South Islands. At 19 m it was typical of larger vessels in the fishery, had two longline drums, and would typically set three or four lines a day. It had a steel hull, aft wheelhouse, a fully-sheltered working deck, and is normally operated with a skipper and two crew.

Prior to sailing, individual one-kilogram lead weights were tied together to make a set of 80 six-kilogram and 40 three-kilogram weights. Twenty-three 'modified' floats were made up which consisted of two 150 mm diameter pressure floats tied together. A 7.2 m (four fathom) long four-millimetre diameter rope was tied to the floats and wound around them. The loose end of the rope had a 1.3 kg weight and 100 mm shark clip attached, resulting in overall buoyancy equivalent to a single float (Figure 1). These floats were designed to reduce sink times to a depth equivalent to the length of the rope, after which the floats get pulled under and the line behaves in a similar manner to adding single float. The vessel's 150 mm diameter pressure floats were also used, with 50 – 150 mm strops and 100 mm shark clips.

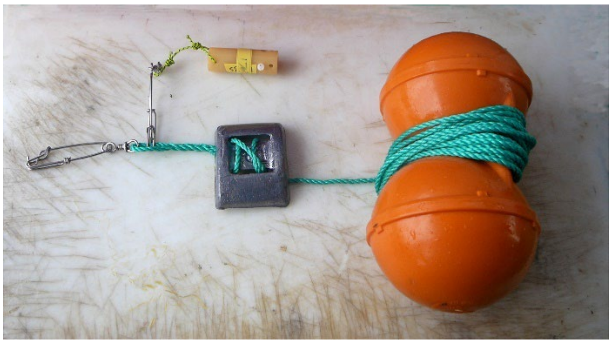

Figure 1. Modified 150 mm diameter floats with TDR housing attached, ready for deployment.

Longline configuration

Lines were deployed starting with A5 and HL3 Polyform buoys attached to 440 m of eight-millimetre diameter rope downline. The first 200 m of rope was set slack and the remaining rope and six-millimetre diameter monofilament nylon backbone was deployed from a free-spooling hydraulic drum. A 30 kg steel grapnel was attached at the junction between the rope downline and the backbone, followed by a float. The gear configurations to be tested were then deployed on the longline, in most cases without hooks. Two sections were deployed before testing started and then three full sections were set with Time Depth Recorders (TDRs). Following attachment of the last TDR the sequence was continued for sufficient time to allow the last TDR to pass beyond 200 m astern. TDRs were attached midway between weights, or three-quarters of the way after a weight. Spacing between weights was determined using a timer, and checked during the haul using a count of regularly-spaced twine stoppers on the backbone. Sets were conducted at 3.0 knots. One set was conducted with eight-millimetre diameter polypropylene rope backbone for comparison, and another set included alternate sections with and without baited hooks. The longline left the vessel 2.6 m above the waterline.

CEFAS G5 TDRs were used in a housing (Figure 1) for all deployments and were stored in a bucket which was filled with seawater several minutes prior to the first deployment. TDRs were programmed and data was downloaded on a set-by-set basis. Between sets TDR clocks were reset to the PC time and this was checked against the clock used on deck to manually record clip-on times.

Gear configurations were classified based on weight size, weight spacing and the number of floats between weights Figure 2). All weights were attached to 3.6 m (two fathoms) of three-millimetre rope, with a 150 mm diameter pressure float at the clip. Floats between weights were clipped directly to the backbone, with 'modified' floats as described above set either on 7.2 m or 3.6 m ropes. One configuration incorporated single floats attached to the backbone with 3.6 m ropes, and another incorporated 'double floats' comprising of two 150 mm diameter pressure floats clipped onto the backbone together.

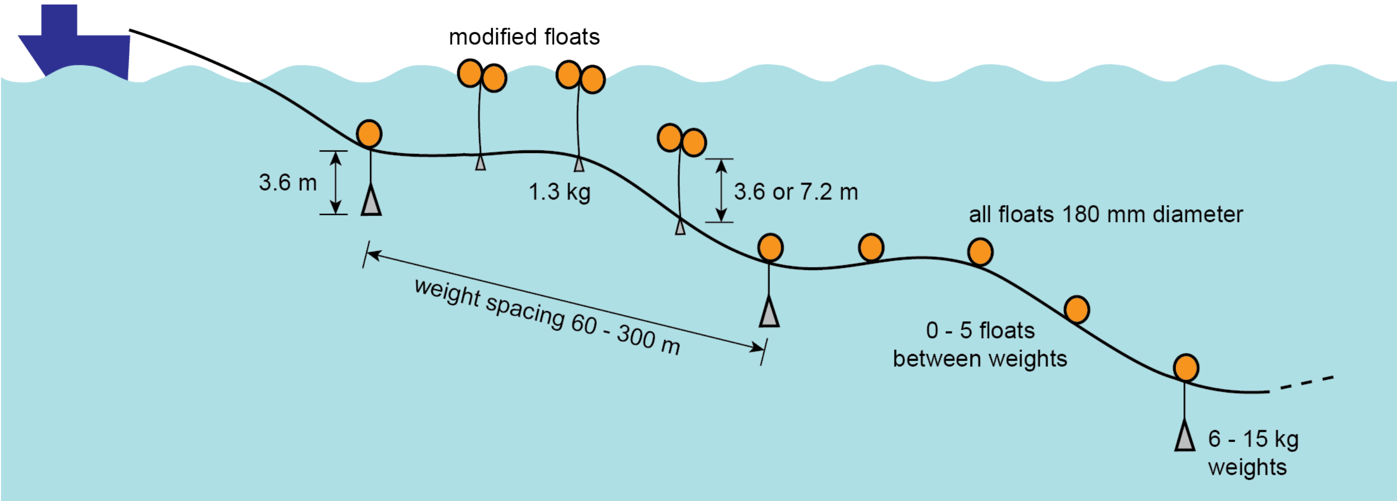

Figure 2. Summary of different line configurations tested.

Line tension was recorded using a purpose-built meter (Figure 3), which was calibrated by hanging a series of weights in six-kilogram increments from a length of monofilament passing through the meter.

Figure 3. Photograph showing tension meter setup.

Sea current measurement

A Marine Instruments pelagic longline GPS beacon was attached to an A4 Polyform buoy. A fish bin and nine-kilogram weight were used as a sea anchor, attached to the float with 200 m of eight-millimetre diameter rope. This setup was deployed and recovered daily, and drift was measured and recorded using the MSC Palangre software supplied with the beacon. Position and drift since last position were displayed and logged at five-minute intervals.

Data processing

TDR depth was adjusted with an offset derived from average readings from one to two minutes prior to deployment. Individual sink profiles and tension records were examined and compared with videos and notes made during the set to verify clip-on times, and to ensure that any records which did not represent typical conditions were removed, for example if the vessel slowed down too soon at the end of a line. In line with previous work (Goad and Olsen 2022), to account for potential inaccuracies in TDR-derived depths and the distance between hook and TDR, maximum times to six metres depth are presented.

Tori line testing

Tori (or bird scaring) line trials were conducted in sheltered sea conditions with no swell with and against approximately 25 knots of wind. A 100 m long three-millimetre diameter aerial section was employed for all trials, with plastic tubing streamers attached every five metres, starting at 15 m. The tori line was attached to the vessel's tori pole at a height of 7.3 m above the sea surface.

Three drag sections were tested (Figure 4) with various lengths and combinations. The drag generated at speeds from 2.3 to 3 knots was measured using a set of spring scales. Aerial extent achieved was then measured at the same speeds, by counting the number of streamers out of the water.

Figure 4. Photograph showing details of the tori line drag sections tested: 52 mm diameter 8 plait rope threaded through a 280 long 150 mm diameter cone (top), 32 mm rope covered in hose with the same cone (middle), and 9 mm trawl braid with a gillnet float (bottom).

Results

Trip summary

The sea time was completed between 27th April and 2nd May 2023, following a few days waiting for a weather window. Conditions were generally good with less than 20 knots of wind and 1.5 m swells, except on the third day where windspeed exceed 25 knots and swells rose to 2+ m. Current varied through the trip and maximum drift coincided with the poorer weather and may have been partly driven by wave and wind action. The vessel proved to be a capable and comfortable work platform and the skipper and crew were unfailingly helpful, keen, proactive, and efficient.

The use of a timer to determine weight spacing worked well, and periodic counts of stoppers confirmed this. Deploying regular weighting required thorough preparation and an experienced crew and skipper. Programming and downloading TDRs was time consuming and limited the amount of gear able to be deployed in a day.

Work flow

Initially a line was deployed using a typical line configuration from PSRMPs, and a total of 23 TDRs were attached throughout the line. Following analysis of TDR profiles, it was determined that those within approximately 300 m of the grapnel sank faster, after which profiles were similar along the line. For subsequent sets, TDRs were only attached at distances greater than 300 m from the grapnel.

Approximate sink profiles were derived between sets, reviewed each night and a plan then made for the following day. As testing progressed the list of configurations was modified to concentrate on testing those which were likely to achieve a sink depth of five metres at approximately the end of the 70 m aerial extent of a tori line, rather than those which would either clearly meet this standard, or likely not come close. Consequently, testing in the latter days focussed on trying to achieve short sink times for gear set with large weight spacings and multiple floats between weights. This was achieved by using heavier weights and/or modified floats.

TDR Data grooming

All sink profiles were checked to ensure that depth offsets corrected TDR depth to zero at the surface, prior to deployment. Notes and video footage taken at the set identified five records for removal due to; late clip-on (1), programming errors (2), and changes to vessel speed and line tension at the end of the set (2). A further two TDRs were lost.

Factors affecting sink time to depth

Examples of how different factors influenced sink times to six metres are presented below. These factors were addressed and taken into consideration during at-sea work, particularly when planning the following days' work. Where possible comparisons are made with all other factors held constant, usually comparing different configurations on the same line. Setting speed remained constant throughout all trials at 3.0 knots.

Hooks

One line set with alternate sections of hooks and no hooks showed sections with hooks sinking marginally faster in the top few metres, but no discernible difference in times to six metres depth (Figure 5).

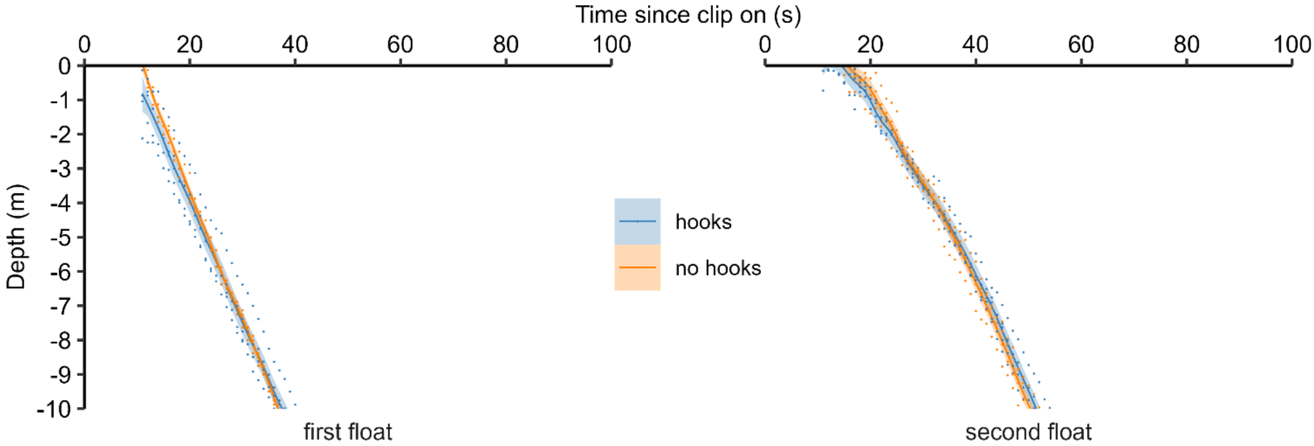

Figure 5. Depth over time for TDRs deployed on sections with and without hooks. Gear configuration was 120 m weight spacing, 15 kg weights and two floats between weights. Separate plots show different TDR positions in the float sequence. Points show individual records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Line tension

The tension meter was used for all sets, although records for some sets were incomplete due to catchups, the line coming out of the meter, and PC logging errors. Line tension was logged for 205 out of a total of 231 TDR deployments and an average value for the 60 seconds post clip-on was assigned to each TDR record. Tension was reasonably consistent within sets and less so between sets. Values ranged between 20 and 30 kg. Increasing line tension from 23-26 kg to 60-66 kg reduced times to depth for a three-float configuration from 59 to 47 seconds. This reduced the required tori line aerial extent from 91 to 72 m (Figure 6).

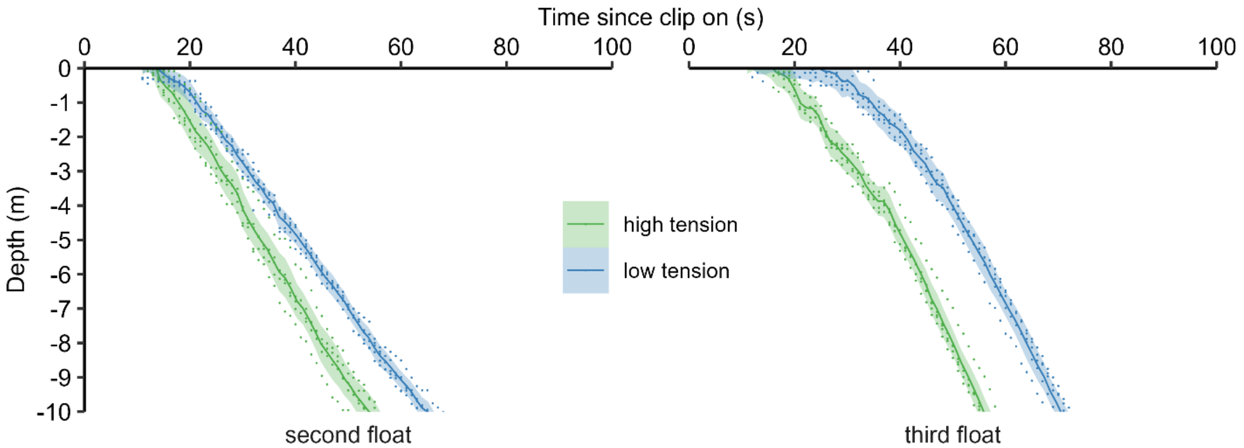

Figure 6. Depth over time for TDRs deployed at 23-26 kg (low) and 60-66 kg (high) line tension. Line configuration was 15 kg weights at 180 m spacing, with three floats between weights. Separate plots show different TDR positions in the float sequence. Points show individual TDR records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Backbone material

Eight-millimetre diameter rope backbone sank slower than six-millimetre diameter monofilament backbone (Figure 7). Maximum sink times to six metres were 41 seconds for monofilament and 44 seconds for rope backbone. Both lines were set with similar tension, in the same direction, and one immediately after the other.

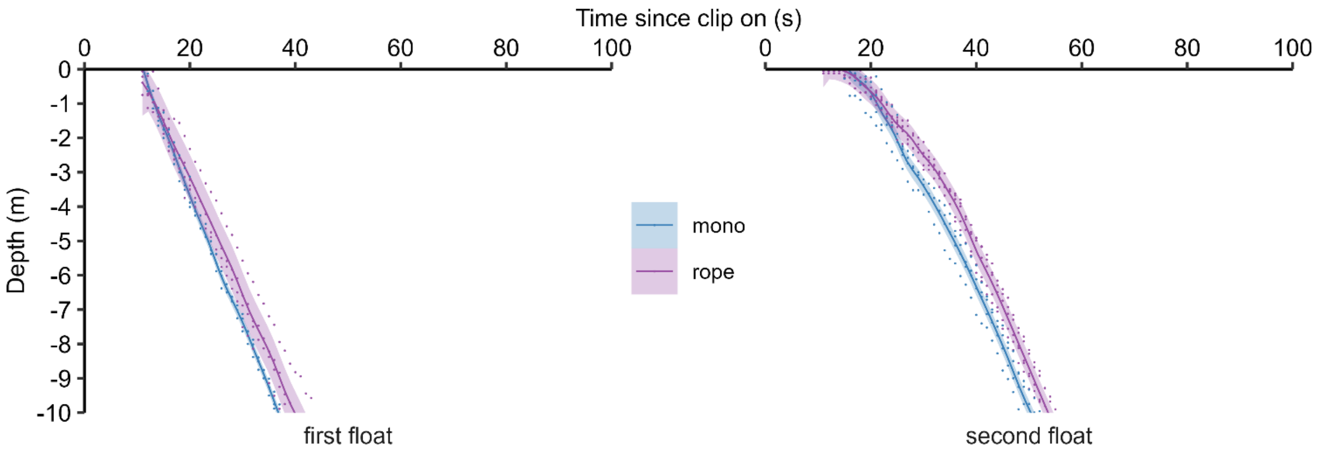

Figure 7. Depth over time for TDRs deployed with rope and monofilament backbone. Gear configuration was 15 kg weights, 120 m weight spacing, and two floats between weights. Separate plots show different float positions. Points show individual TDR records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Sea current

The GPS beacon proved reliable and data was logged for all lines except one, during heavy weather, when it was considered prudent to recover the beacon early. Lines set against the current showed more variation and longer times to six metres than identical lines set with the current. Mean times to six metres were 15, 19 and 20 seconds longer for the different configurations tested (Figure 8).

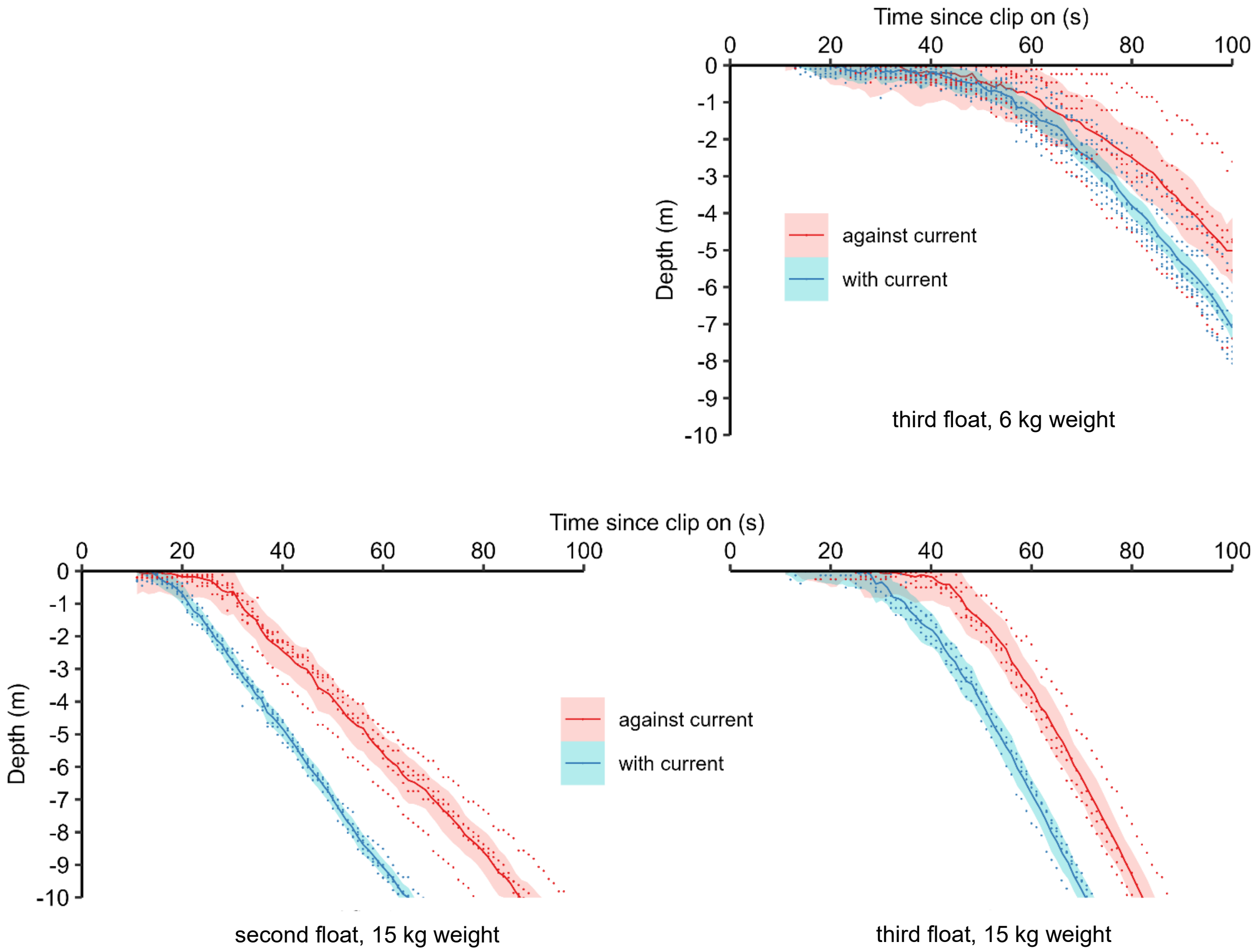

Figure 8. Depth over time for TDRs deployed on lines with and against the current. Both gear configurations had a weight spacing of 180 m and three floats between weights. Points show individual TDR records with lines showing a smoothed mean +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Weight size

Increasing the size of weights reduced time to six metres depth, but returns diminished with increasing weight (Figure 9).

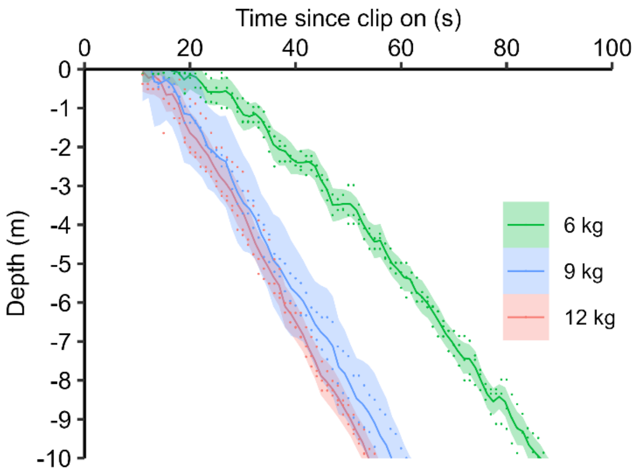

Figure 9. Depth over time for TDRs deployed midway between weights on single float gear configurations, with 120 m weight spacing and varying weight size. Points show individual TDR records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Weight spacing

Decreasing weight spacing decreased time to six metres depth, with more consistent returns than increasing weight size. (Figure 10). Points show individual records with lines plotting smoothed mean depth and shaded areas showing +/- s.d..

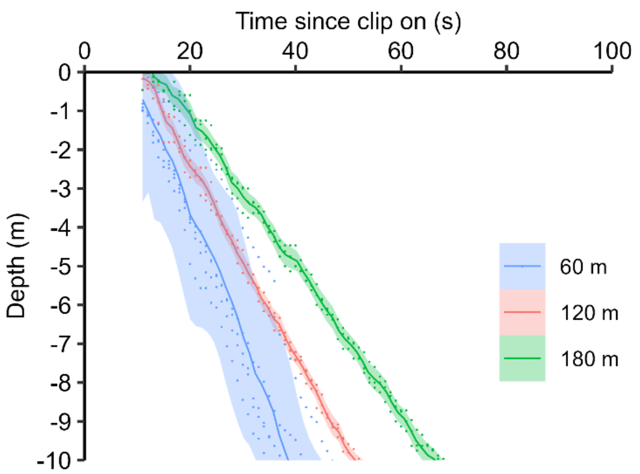

Figure 10. Depth over time for TDRs deployed midway between 6 kg weights with no floats between weights and varying weight spacing. Points show individual TDR records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Number of floats between weights

Increasing the number of floats between weights increased sink time to six metres, with diminishing increases with more floats (Figure 11).

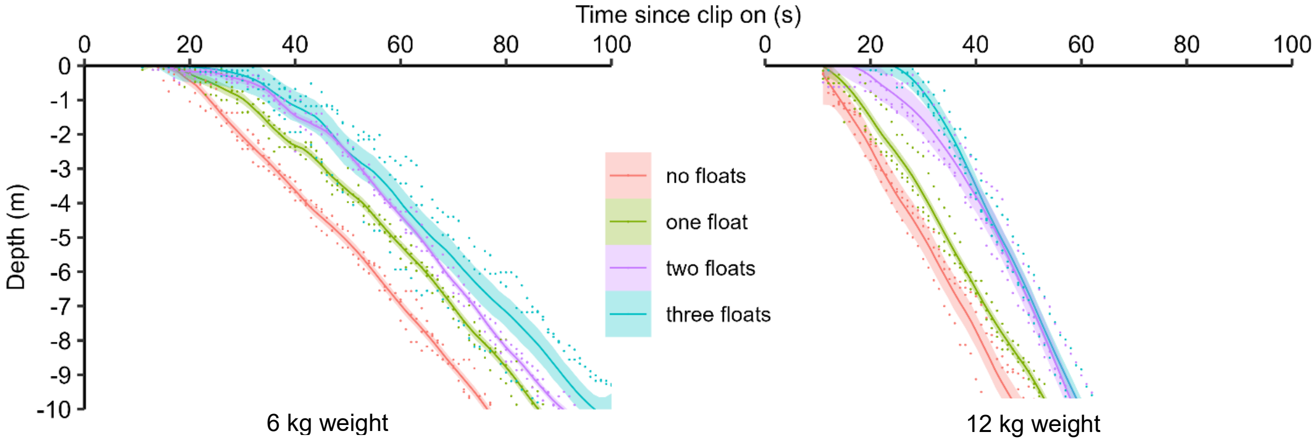

Figure 11. Depth over time for TDRs on line configurations with 0, 1, 2, and 3 floats between weights and a weight spacing of 120 m. TDRs were attached on the last float and separate plots show weight sizes of 6 and 12 kg. Points show individual TDR records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

TDR position within repeated line sequence.

For most configurations TDRs were attached midway between weights and three quarters of the way after a weight. The slowest position to depth varied with weight spacing, weight size, number of floats between weights. Whether time to five or ten metres depth is of interest is also important (Figure 12).

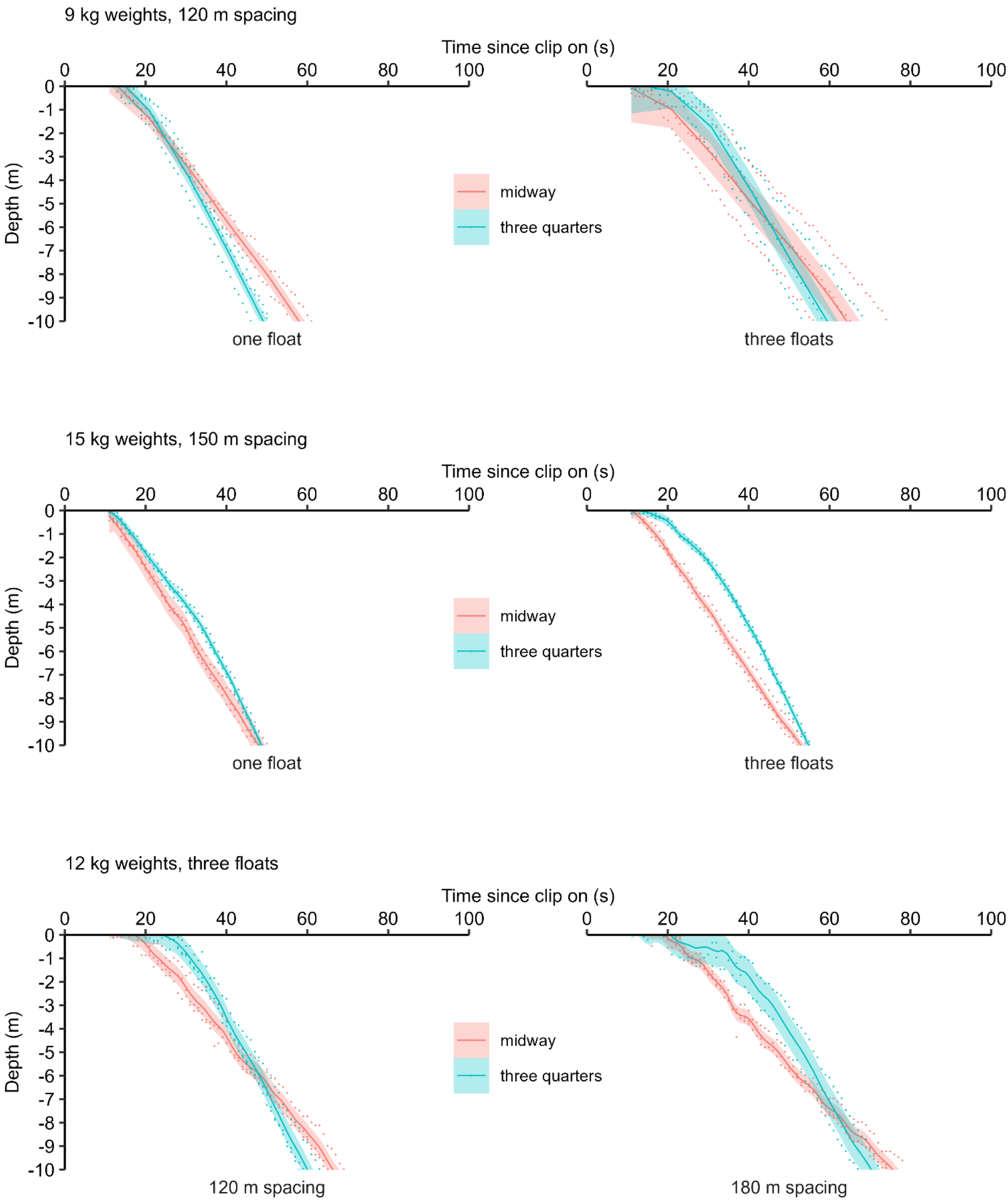

Figure 12. Depth over time for TDRs placed midway between weights and three quarters of the way after a weight for different line configurations. Points show individual TDR records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Modified floats

The use of modified floats with 7.2 m ropes allowed lines with 180 m spacing and three floats between weights to sink to six metres depth within 41 seconds and 65 m astern. Reducing modified float rope length to 3.6 m held no advantage over just a 3.6 m rope on the float to six metre depth, but with 15 kg weights this was sufficient to sink gear to six metres within 47 seconds or 75 m astern (Figure 13).

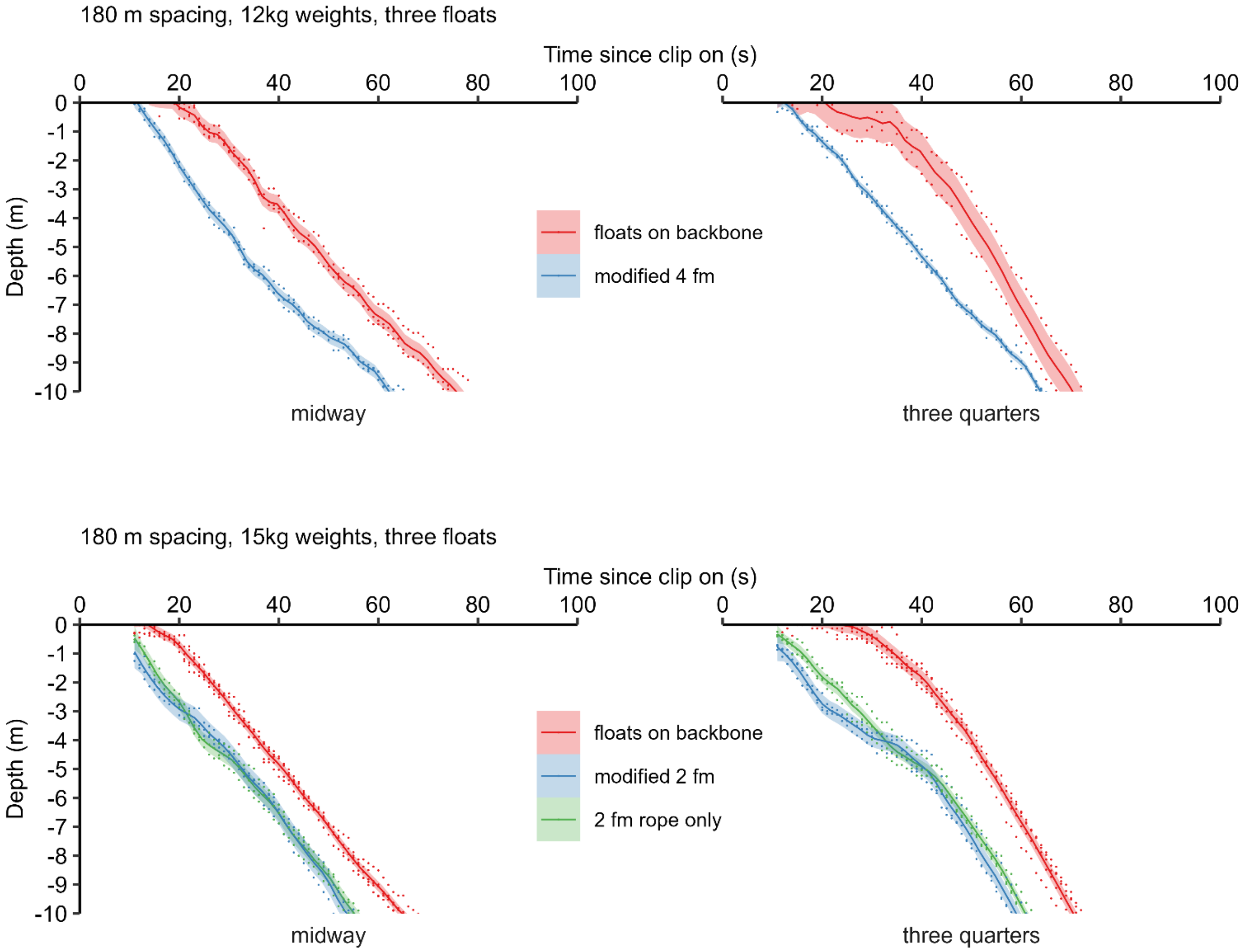

Figure 13. Depth over time for TDRs placed midway between weights and three quarters of the way after a weight for modified float configurations. In the first plot data was all recorded on the same line, whereas the second plot incorporates data from a separate line with floats directly on the backbone. Points show individual TDR records with lines plotting smoothed mean depth and shaded areas showing +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Sink times to depth for different gear configurations

60 m weight spacing

At 60 m weight spacing sink time to six metres depth relates to reasonably achievable tori line aerial extents (49-57 m) using six-kilogram weights. Increasing weight size gives marginal returns (Table 1). With such close weight spacing multiple float configurations are rare in PSRMPs.

Table 1. Summary of maximum sink times to six metres depth, and distances astern this is achieved, for lines set at three knots with 60 m weight spacing.

gear configuration	weight (kg)	weight spacing (m)	tension (kg)	tide (knots)	max time to 6 m (s)	max distance at 6 m (m)
no floats	6	60	20	0.1	32	49
1 float	6	60	21	0.1	37	57
no floats	9	60	19	0.1	37	57
1 float	9	60	22	0.1	30	46

120 m weight spacing

Nine-kilogram weights were necessary to sink gear with 120 m weight spacing to six metres within reasonable distances (54-88 m) astern. Heavier weights and/or modified floats were necessary to sink gear set at three knots within 70 m, for multi-float configurations (Table 2, Figure 14).

Table 2. Summary of maximum sink times to six metres depth, and distances astern this is achieved, for lines set at three knots with 120 m weight spacing.

gear configuration	weight (kg)	weight spacing (m)	tension (kg)	tide (knots)	max time to 6 m (s)	max distance at 6 m (m)
no floats	6	120	39	0.1	57	88
1 float	6	120	39	0.1	66	102
2 floats	6	120	43	0.1	71	109
3 floats	6	120	42	0.1	88	136
no floats	9	120	47	0.1	36	56
1 float	9	120	13	0.4	43	66
2 floats	9	120	16	0.4	50	77
2 floats modified	9	120	15	0.4	37	57
3 floats	9	120	20	0.4	57	88
3 floats modified	9	120	17	0.4	35	54
no floats	12	120	29	0.1	36	56
1 float	12	120	30	0.1	38	59
2 floats	12	120	31	0.1	50	77
3 floats	12	120	31	0.1	52	80
3 floats modified	12	120	29	0.1	41	63
2 floats	15	120	30	0.2	41	63
2 double floats	15	120	36	0.2	42	65

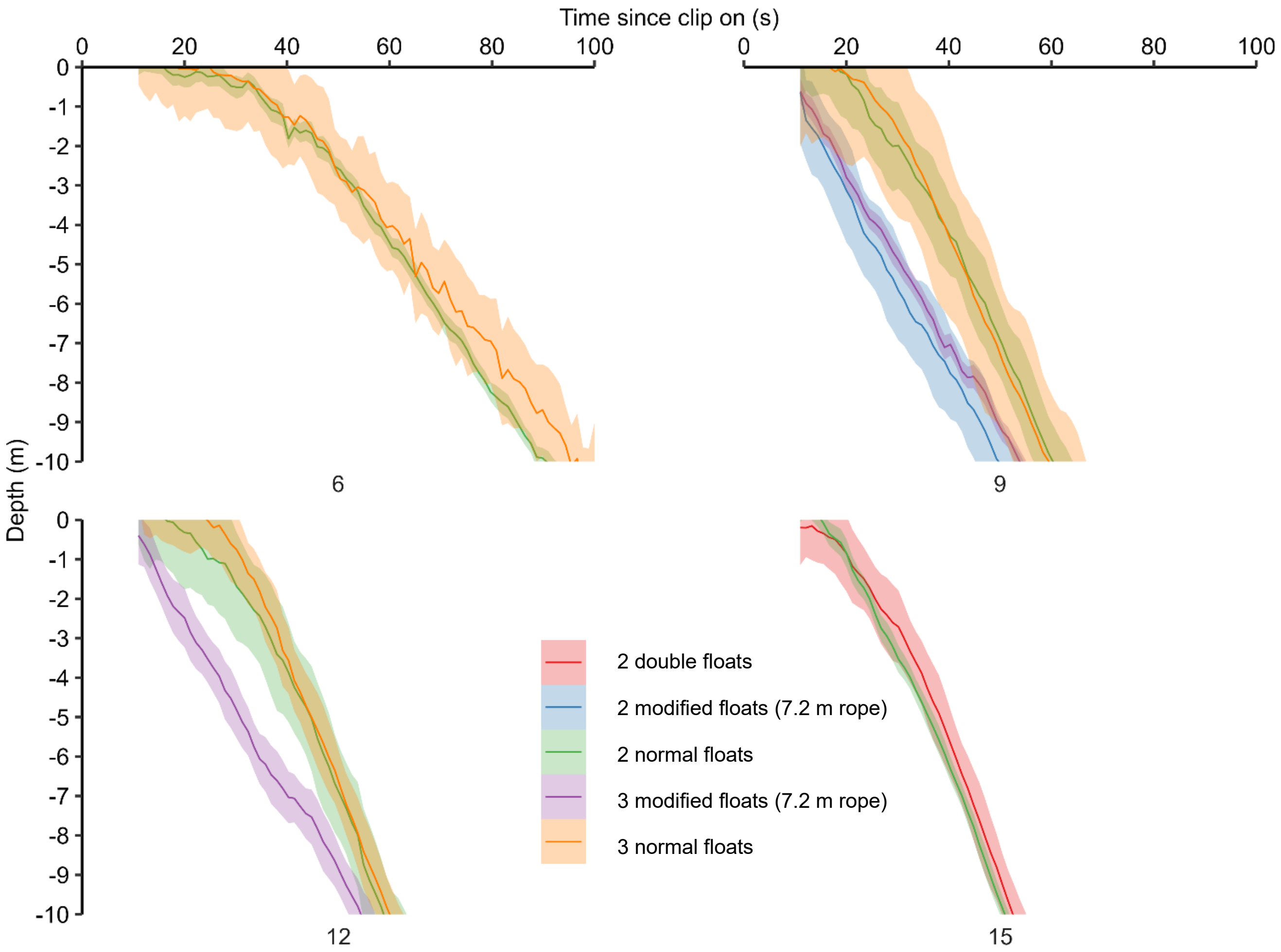

Figure 14. Depth over time for TDRs placed on the last float for a range of gear configurations, all with 120 m weight spacing. Different plots show different weight sizes. Lines show smoothed mean depth and shaded areas +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

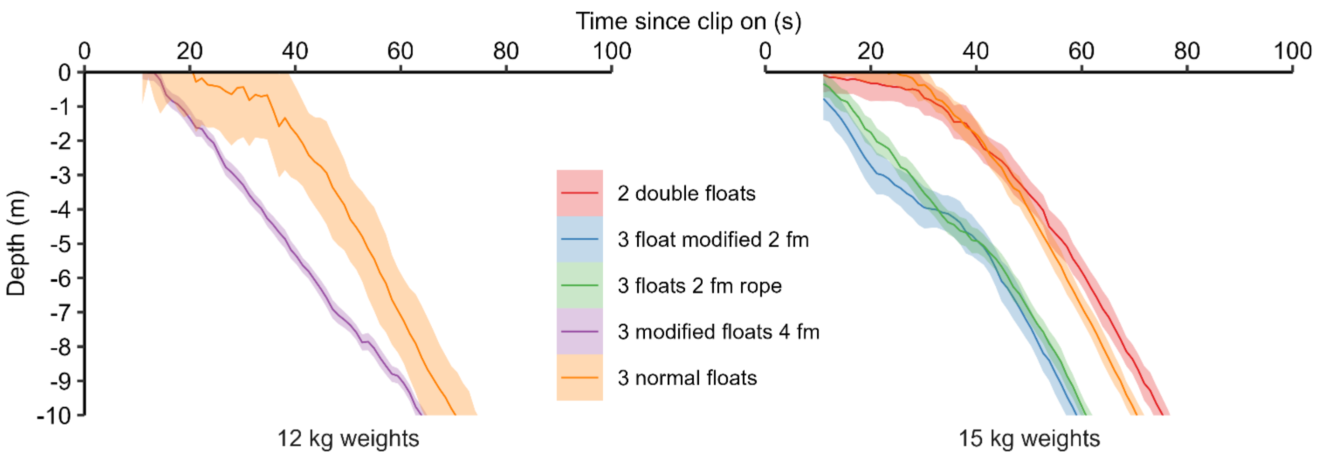

Figure 15. Depth over time for TDRs placed on the last float for a range of gear configurations with 180 m spacing. Different plots show different weight sizes Lines show smoothed mean depth and shaded areas +/- s.d.. A tori line with an aerial extent of 70 m provides protection for 45 seconds at 3 knots.

Larger weight spacing

Several lines were deployed to investigate options for reducing sink times for wider-spaced and multi-float configurations. Modified floats were necessary to sink gear spaced at 180 m within 70 m astern, however 15 kg weights sank gear within 100 m (Table 3, Figure 15). Reducing spacing to 150 m with 15 kg weights sank gear within 70 m without the need for modified floats. By using modified floats larger spacing and four float configurations were achievable, though these were not tested with three repeats (Table 4).

Table 3. Summary of maximum sink times to six metres depth, and distances astern this is achieved, for lines set at three knots with 180 m weight spacing.

gear configuration	weight (kg)	weight spacing (m)	tension (kg)	tide (knots)	max time to 6 m (s)	max distance at 6 m (m)
no floats	6	180	23	0.1	60	93
2 floats	6	180	25	0.4	104	187
no floats	9	180	17	0.1	53	82
one float	12	180	34	0.6	53	82
2 float	12	180	37	0.6	65	100
2 floats modified (7.2 m)	12	180	38	0.6	43	66
3 floats	12	180	33	0.6	54	83
3 floats modified (7.2 m)	12	180	33	0.6	44	68
3 floats	15	180	25	0.4	59	91
2 double floats	15	180	34	0.2	63	97
3 floats modified (3.6 m)	15	180	30	0.1	48	74

Table 4. Summary of maximum sink times to six metres depth, and distances astern this is achieved, for lines set at three knots with 150 m weight spacing and from 2 repeats at 240 m and one repeat at 300 m spacing.

gear configuration	weight (kg)	weight spacing (m)	tension (kg)	tide (knots)	max time to 6 m (s)	max distance at 6 m (m)
1 float	15	150	36	0.2	38	59
3 floats	15	150	34	0.2	45	69
3 floats modified	15	240	26	0.1	39	60
4 floats modified	15	300	28	0.1	46	71

Tori line testing

Seventy metres of aerial extent was achieved with eight kilograms of drag using the vessel's 7.3 m high pole. This required most of the drag sections taken onboard the vessel at 2.3 knots and when towed faster produced aerial extents out to 100+ m (Table 5). The use of a smaller diameter leader with gillnet floats attached to the drag section was useful in that it caused a visible disturbance on the water and was at times in the air, increasing aerial extent. Thicker rope drag sections with small cones threaded onto them seemed to be a good compromise in increasing drag whilst minimising bulk and length. Large road cones with square bases were also trialled but tended to dig in and provide inconsistent drag. The smaller cones on the larger diameter rope produced reasonably consistent drag.

Table 5. Results from tori line tests with an attachment height of 7.3 m above the sea surface

Drag section description	Speed (knots)	Min aerial extent (m)	Max aerial extent (m)	Min drag (kg)	Max drag (kg)
8 m of 32 mm three strand + hose with 4 cones + 10 m 9 mm rope	3.0			5	6
14 m 32 / 52 mm rope with 8 cones +10m 9 mm trawl braid leader	3.0			7	9
18 m 32 / 52 mm rope with 8 cones, 10m 9 mm trawl braid leader	3.0			8	12
18 m 32 / 52 mm rope with 8 cones, 30 m 9 mm + 30 gillnet floats	3.0	95	105	12	15
18 m 32 / 52 mm rope with 8 cones, 30 m 9 mm + 30 gillnet floats	2.5	75	100	10	13
18 m 32 / 52 mm rope with 8 cones, 30 m 9 mm + 30 gillnet floats	2.3	70	75	8	9

Flyer summarising results

A flyer was produced, to summarise results for fishers and liaison officers (Figure 16).

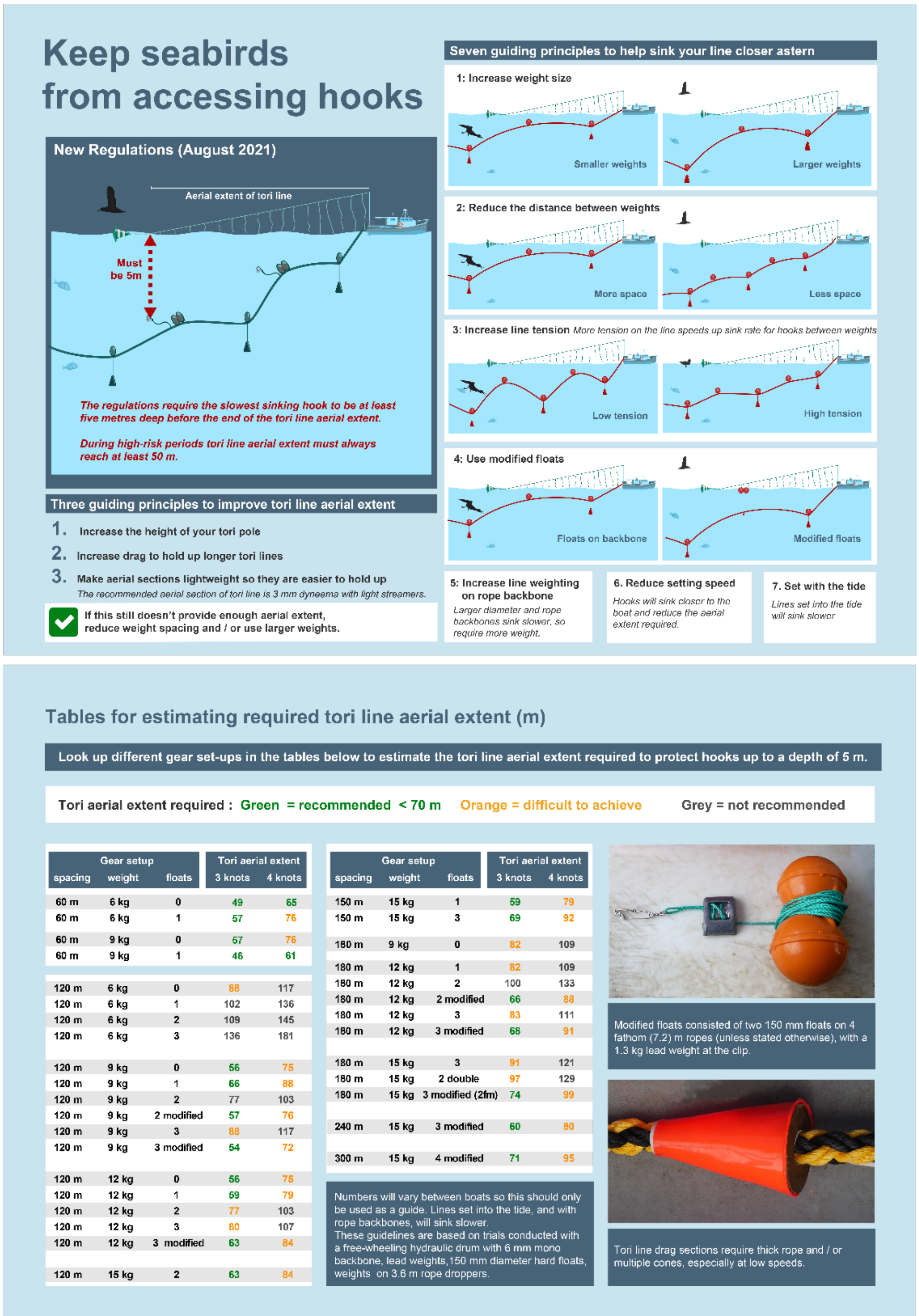

Figure 16. suggested flyer.

Discussion

Setting lines without hooks allowed for much faster turnaround in line setting and thus more configurations to be tested during the sea time available. It was reassuring to confirm that the addition of hooks has little effect on sink time to six metres for configurations sinking gear to this depth within 70 m astern. However, at larger weight spacings and with longer sink times the difference may be more apparent.

Increasing line tension reduced sink times to depth and may be a viable option for larger-spaced multi-float configurations with minimal impact on setting operations. Whether line tension affects catch rates is largely unknown, although as it will alter how the gear sits on the seabed it has the potential to negatively impact catch rates (e.g., Goad et al. 2022).

Rope backbone unsurprising sinks slower as, unlike monofilament nylon, it floats and also has a larger diameter and so more resistance to sinking.

Current flow had a marked effect on sink profiles and, although pretty standard within the fleet (D.G. pers. obs.), setting with the current should be promoted as a mitigation measure.

As found with snapper gear (Goad and Olsen 2022) reducing weight spacing drastically reduces sink time to depth. Spacing is larger in the bluenose fishery and typically correlates with more floats between weights, compounding slower sink times. Consequently, for some fishers, other options for reducing sink times may be more attractive.

Increasing weight size is a relatively straightforward and easy option. However, it is limited by the amount of weight skippers are happy to add to the gear. Larger weights will sink gear with a larger difference between float and weight positions. Consequently, the line will sink in a more pronounced m-shaped profile, resulting in more 'slack' on the seabed. In turn, this will allow the gear to sit higher, providing there is sufficient floatation.

The use of modified floats seems necessary to set with weight spacings greater than 150 m, and provides a large reduction in sink times without altering how the gear fishes. The trade-offs are extra time spent recovering floats, greater cost, more storage space required, and the possibility of floats on the surface tangling with tori line drag objects.

Identifying the slowest sinking position for a given gear configuration requires some thought and testing. Generally speaking, a position three-quarters of the way after a weight or on the last float will be slowest to five metres depth unless a weight is clipped on relatively quickly afterwards. The sink depth of interest is also important. By testing multiple positions per gear configuration, the data summaries presented here provide a reasonable estimate. Confirming the absolute position of the slowest sinking hook per configuration would not have been practical in this project, and is certainly a big ask for fishers.

Tori line trials demonstrated that 70 m aerial extent at 2.3 knots and 100 m at three knots was feasible. This required a series of drag objects in combination with thick rope. In combination with the sink times to depth described here it should be possible to provide any given vessel with a series of options to alter gear configuration to meet regulations and still catch fish. The type and magnitude of the changes made will determine the extent, if any, to which catch rates are affected. When modifying operations to meet the regulations it should be borne in mind that 100 m aerial extents are harder to control. Long aerial sections are harder to keep over baited hooks for their full extent and so are, arguably, less likely to be consistently effective over their full aerial extent than shorter tori lines.

The use of a minimum of three repeats per configuration, generally with a few seconds of each other, provided a reasonable level of comfort around the reliability of these results. However, given the factors that have been shown to influence sink rate, careful consideration should be given to how a given vessel's operation differs from that described here to allow for an assessment of how transferrable results may be, and any adjustments that should be made.

Conclusions

Given the many factors at play and the differences between vessels it is necessary to work with fishers individually to assess and improve, if required, sink times to depth. Different skippers will likely choose different options for improving sink times, based on their vessel, fishing style, and personal preference.

Setting into the tide will require faster sinking configurations and this should be recorded on PSRMPs.

A tori line with sufficient drag to achieve 70 m aerial extent should be achievable for the fleet, and 100 m is achievable above three knots. This is probably the first and easiest thing to change to increase gear depth at the end of the tori line aerial extent, but will require more effective and more expensive drag sections.

Increasing weight size is probably the next-easiest option as skippers can continue with their current gear configurations. However, especially at larger spacings, increasing weight less relative effect and there is a limit as to how much weight skippers are prepared to add to their lines.

Reducing weight spacing is the next option. Where this is not desirable the use of modified floats provides an option for sinking multi-float and larger spaced gear configurations to the length of the rope within reasonable distances astern. Similarly, increasing line tension can also sink gear closer to the boat and may be a viable option for some fishers.

Despite expected variation between sets, and with different current conditions, backbone materials, and line tensions this data set should be broadly applicable across the fleet. However, care should be taken when interpreting the results and they should be considered as indicative of sink time to depth, rather than used in a prescriptive manner.

Recommendations

Consider trials of faster sinking options during a normal fishing trip to see if catch rates are affected, the practicality of meeting the regulations within a fishing context, and any trade-offs necessary to routinely meet the regulations.

Audit PSRMPs to ensure that all gear configurations in use are recorded, with a vessel-derived sink time to five metres.

Collate vessel's sink rate data and assess this against the regulated standard.

Use the information presented here to target support for fishers both generally, for example in port-based workshops, and individually, for example on fishing trips.

Improve tori lines, by increasing drag and aerial extent. Include tori specifications and shooting speeds on PSRMPs so an assessment can be made as to whether they are likely to achieve the required aerial extent.

Train and brief observers to assess the tori line aerial extent, document exact gear setup, and to estimate the slowest sink time to depth for each of the vessel's gear configurations, enabling them to audit PSRMPs and provide feedback to fishers on a set-by-set basis.

Expecting fishers to ascertain the sink time to depth for the slowest hook is probably unreasonable. The regulation could be simplified by specifying TDR position, possibly varying with weight spacing. Whilst this may not prescribe the absolute slowest sinking position it is easier to measure and check compliance, and would produce more repeatable and comparable results. This should be considered in the context that the five-metre target depth is arbitrary.

Distribute the flyer developed as part of outreach to vessel operators to improve their seabird bycatch mitigation.

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