Measuring sink times to depth of a range of line weighting configurations in the snapper longline fishery.

Final report

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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. Previous work has shown that sink times to depth vary with gear setup 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 setup, times to depth for the slowest sinking part of the line show much less variation within and between sets (Goad, 2021).

The snapper-target demersal longline fleet deploy pre-baited hooks typically on 60 cm snoods. Hooks are stored on cards, usually containing 50 or 60 hooks and are clipped onto the longline during the set, separated by twine stoppers which are regularly spaced along a monofilament nylon backbone. The fleet employs a range of gear setups, and many vessels have faster-sinking variations for use at high-risk times. However, most vessels generally have no accurate measure of depth at the end of the tori line for different gear configurations, and limited time to experiment with variations to gear setup and tori line design to improve depths at the end of the aerial extent.

With a shift towards an outcome-based approach to regulating line weighting it is necessary to better understand sink times to depth for different gear configurations, and to communicate to fishers the options available to meet the prescribed depth at the end of the tori line.

Objectives

Measure the sink profiles of a range of snapper longline gear configurations and;

Measure the tori line aerial extents achieved at different setting speeds, for three tori line designs and;

Use summarised results to make recommendations on gear and tori line configurations likely to meet the regulations.

Methods

Protected species risk management plans for the small vessel bottom longline fleet were sourced from the Department of Conservation (DOC) and summarised. A list of gear setups to be tested was compiled, aiming to cover those currently employed by the fleet, and faster-sinking alternatives.

Workshop

A workshop was convened in November 2021 under DOC project MIT2021-03 to discuss options for increasing the sink rate of bottom longline gear. Participants included fishers, vessel owners, licensed fish receivers, Southern Seabirds, Deepwater Group, Fisheries Inshore New Zealand, DOC, and Fisheries New Zealand. During the workshop the proposed methods and a list of gear setups to be tested were tabled and, following feedback, the list was modified and protocols were finalised. Options for presenting results to fishers were discussed and feedback noted.

Vessel

The vessel used for trials fishes in the snapper and 'mixed' target bottom longline fishery on the east coast of the North Island. It was typical of larger vessels in the fishery, had three longline drums, and could set up to 6000 hooks a day. It had a steel hull, aluminium superstructure, and a fully-sheltered working deck. It was powered by a 180 hp diesel engine, had an overall length of 14.5 m, and is normally operated with a skipper and two crew.

Preparation

A set of 350 one-kilogram lead dive weights were sourced and 100 mm shark clips were attached to weights using two-millimetre diameter monofilament and aluminium crimps. Weights were set up singly and in groups to produce a set of one-, two-, and four-kilogram weights. Fifty 3.6 m lengths of four-millimetre diameter rope were prepared with an eye in one end and a 100 mm shark clip on the other end. The vessel's 150 mm diameter hard floats were used during the trials and these were attached to a 100-150 mm long four-millimetre diameter rope with either 80- or 100-mm shark clips at one end, and an eye at the other end of the rope. The vessel's 50 mm x 90 mm 'egg' floats were also used and these were tied in pairs with three-millimetre diameter rope, and were attached to the line with an 80 mm shark clip.

Prior to each set the required weights and floats were arranged to allow the gear setups to be tested to be deployed without delay. Gear setups were classified, using typical terminology in the bottom longline fleet, into three categories. 'Hard down' setups used weights attached directly to the backbone with no floats; 'dropper' setups comprised a float-weight combination with the float attached to the backbone and a weight attached to the float on a 3.6 m long rope. 'Floating' configurations were similar to 'dropper' setups but included 'egg' floats midway between weights (Figure 1). Three CEFAS time depth recorders (TDRs) were deployed on each gear setup, midway between weights.

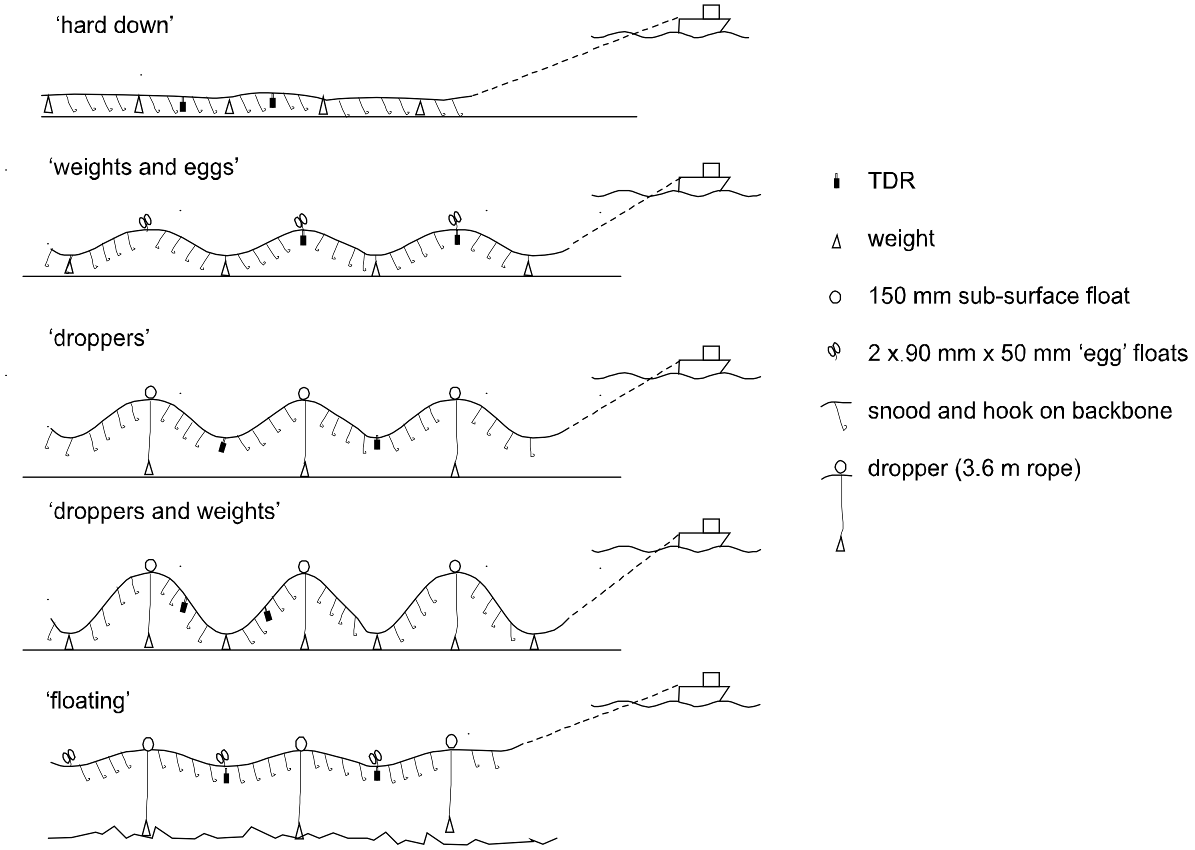


Figure 1. Gear configurations tested.

Deploying longlines during trials

Most sets were without hooks, allowing for multiple configurations to be deployed and recovered in a relatively short time. However, testing was also carried out on part of a commercial fishing longline, on sections with and without baited hooks. Where hooks were not deployed 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 either 4.0 knots or between 6.6 and 6.7 knots. Most setups were tested at both speeds but some only at one speed, if this was the only speed considered practical. For example, short spacings with light weights were not set fast.

A monofilament nylon backbone was used for all sets and most were conducted from a free spooling drum using 2.2 mm diameter backbone. The longline backbone left the vessel approximately two metres above the sea surface. Some sets were conducted with 1.6- and 3.0-mm diameter backbone for comparison. Similarly, some sets were conducted with increased line tension, achieved by adjusting the bypass valve on the hydraulic drum to circulate hydraulic fluid and provide additional friction.

When switching between gear setups at least two full repeated sections were deployed before TDRs were attached, and at least one full section was deployed after the last TDR. At smaller spacings more repeated sections were added to the beginning and end of tests to cover expected sink times to six metres depth. Sets were carried out in water depths of at least 25 m.

TDR deployments

CEFAS G5 TDRs were used for all deployments. At setting speeds of four knots TDRs were stored in a fish bin which was constantly refreshed with seawater, prior to deployment. At higher speeds it was not possible to run the deck hose continuously so TDRs 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 clocks were reset to the PC time and this was checked against the clock used on deck to manually record clip on times.

Zebra-tech TDRs were deployed with CEFAS TDRs in a controlled manner alongside the wharf, with devices held at one, two, three, four, five and six metre depths for approximately 30 seconds. Zebra-tech TDRs were also paired with some CEFAS TDR deployments on longlines, typically two per set, aiming to cover gear setups of particular interest.

Line tension was recorded using a purpose-built meter (Figure 2), which was calibrated by hanging one-to-ten-kilogram weights in one-kilogram increments from a length of monofilament passing through the meter.

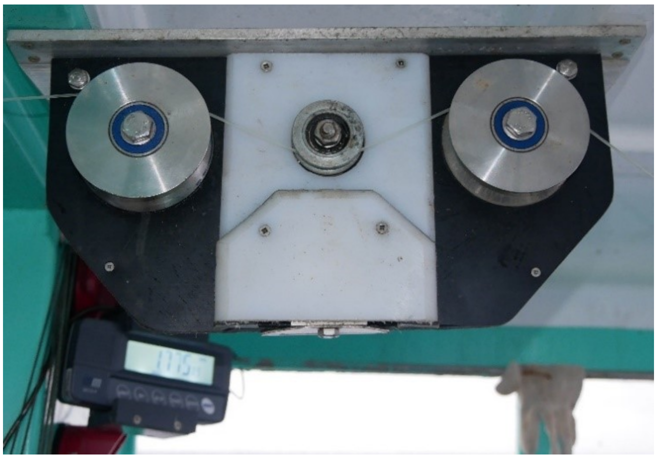


Figure 2. Photograph showing tension meter setup.

Data processing

Depth was adjusted for the CEFAS TDRs, 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.

Zebra-tech data did not require post collection processing, other than aligning times, and depths were used straight from CSV files.

Tori line testing

Tori line trials were conducted on two days, both in conditions of 10 knots of wind and less than a metre of swell. 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 using the vessel's five metre long eight-millimetre diameter rope leader. Six drag sections were tested (Figure 3), initially by measuring the force generated at speeds from four to seven knots using a set of spring scales. Aerial extent achieved was then measured at speeds from four to seven knots, at five and seven metre attachment heights, by counting the number of streamers out of the water.

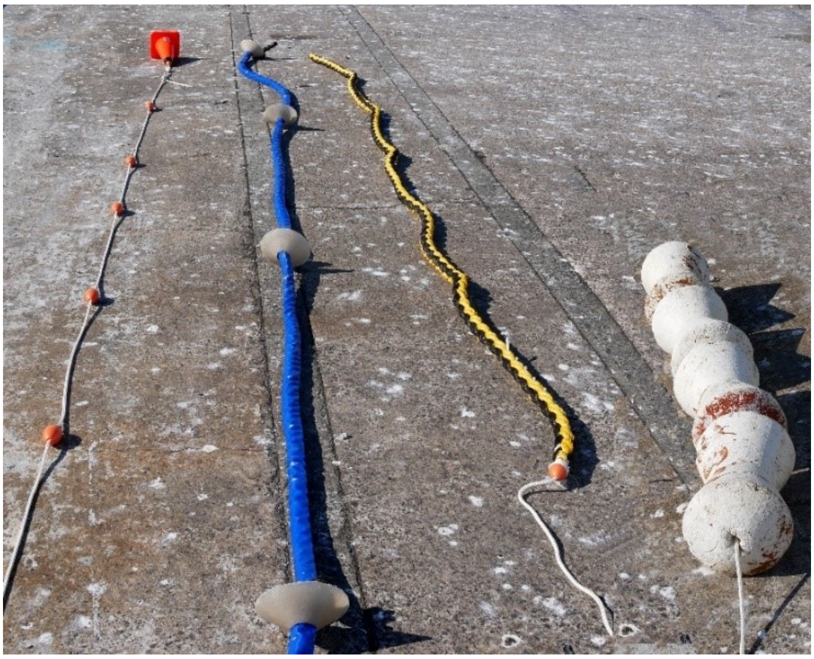


Figure 3. Photograph showing details of some of the tori line drag sections tested, from left to right:
9 mm diameter trawl braid with gillnet floats (80 mm x 45 mm) every metre and a small road cone at the end;
32 mm diameter three strand rope with fire hose and sports cones at 2 m spacing;
52 mm diameter 8 strand polypropylene rope with a 9 mm diameter trawl braid leader;
Intermediate polystyrene floats (750 mm x 250 mm) on 9 mm diameter trawl braid.

Results

Comparison of CEFAS and Zebra-tech devices at the wharf

Controlled drops to pre-set depths produced plots which lined up reasonably well. CEFAS TDRs had a tendency to read too deep, in the order of 0.5 m at 5.0 m depth, whereas Zebra-tech devices were more accurate, reading slightly shallow on occasions but within 0.1m (Figure 4).

The effective weight of the two devices were tested by comparing their weight in water to that of lead sinkers. Attaching a shark clip to the backbone adds approximately 22 g, and a CEFAS TDR with housing added a further 12 g. A Zebra-tech TDR added a further 50 g to the backbone.

CEFAS TDRs in the housing were approximately 300 mm from the end of the clip, and Zebra-tech TDRs approximately 450 mm. Assuming a worst-case scenario that hooks on 600 mm snoods were pulled straight down by the backbone, and TDRs hung directly below the backbone, the CEFAS TDRs were equivalent to adding 34 g of lead and sat 900 mm below hooks, and Zebra-tech TDRs were equivalent to adding 72 g of lead and sat 1050 mm below hooks.

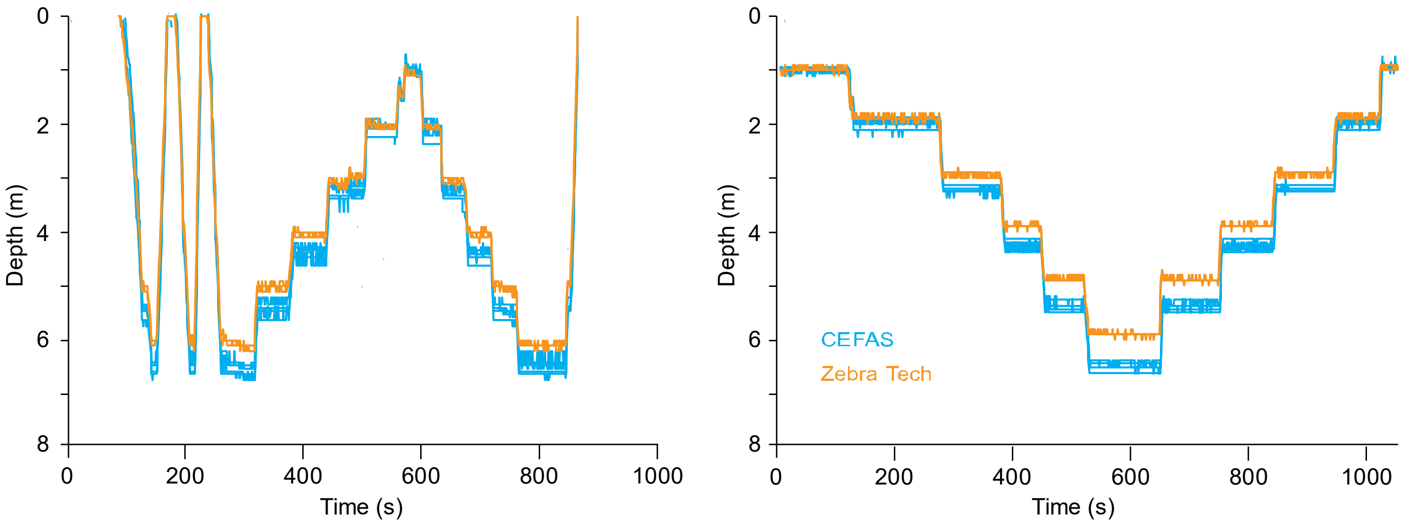


Figure 4. Depth over time for controlled drops of CEFAS and Zebra-tech TDRs.

Trip details

The sea time was split between two trips, separated by a day of higher winds and larger swells. All sets were conducted in less than 15 knots of wind, with the first four sets in 0.2-0.5 m swells. The second trip started with 1.5 m swells however gear was generally set with some protection and the swell dropped off to 0.5 m as the second trip progressed.

The use of a timer to determine weight spacing worked well, and counts of stoppers at the haul were always within four metres of the target spacing. 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. The break mid-trip allowed for data processing and some adjustment of plans for the latter six sets. However, there was insufficient time to process and review data at sea between sets. Consequently, the pre-trip plan was adhered to with only minor adjustments. A total of 11 separate sets were conducted covering a range of gear setups, and individual times to depth are presented in Appendix 1. Slowest times to six metres depth are presented for each setup tested in Tables 1-6.

Data grooming

All sink profiles were checked to ensure that automated depth offsets corrected TDR depth to zero at the surface, prior to deployment. The time period used to calculate offsets was reduced to 30 seconds for four deployments which occurred shortly after TDRs were programmed to turn on.

Notes and video footage taken at the set identified four records for removal due to; a catch up with an end float at the vessel, a tangled dropper, a catch up with the line in the tension meter, and a late clip-on. A further four TDRs failed to download consistently, two of which were not useable for most of the trip. Paired deployments with Zebra-tech TDRs were discarded when considering average sink times to depth. Where line tension records were available tension was averaged per gear configuration and setting speed, typically over 1-3 minutes.

To account for the CEFAS TDRs reading slightly too deep, and the distance between hook and TDR maximum times to six metres depth are presented in the body of the report, and times to both five and six metres depth for each deployment are shown in Appendix 1.

Line tension

The tension meter was used for all sets however, for one set the PC was not recording, and during another set the line came out of the meter. Tension increased immediately after a weight was added, then dropped as the drum sped up, and then increased again after the following weight was added, producing 'spiky' plots (Figure 5).

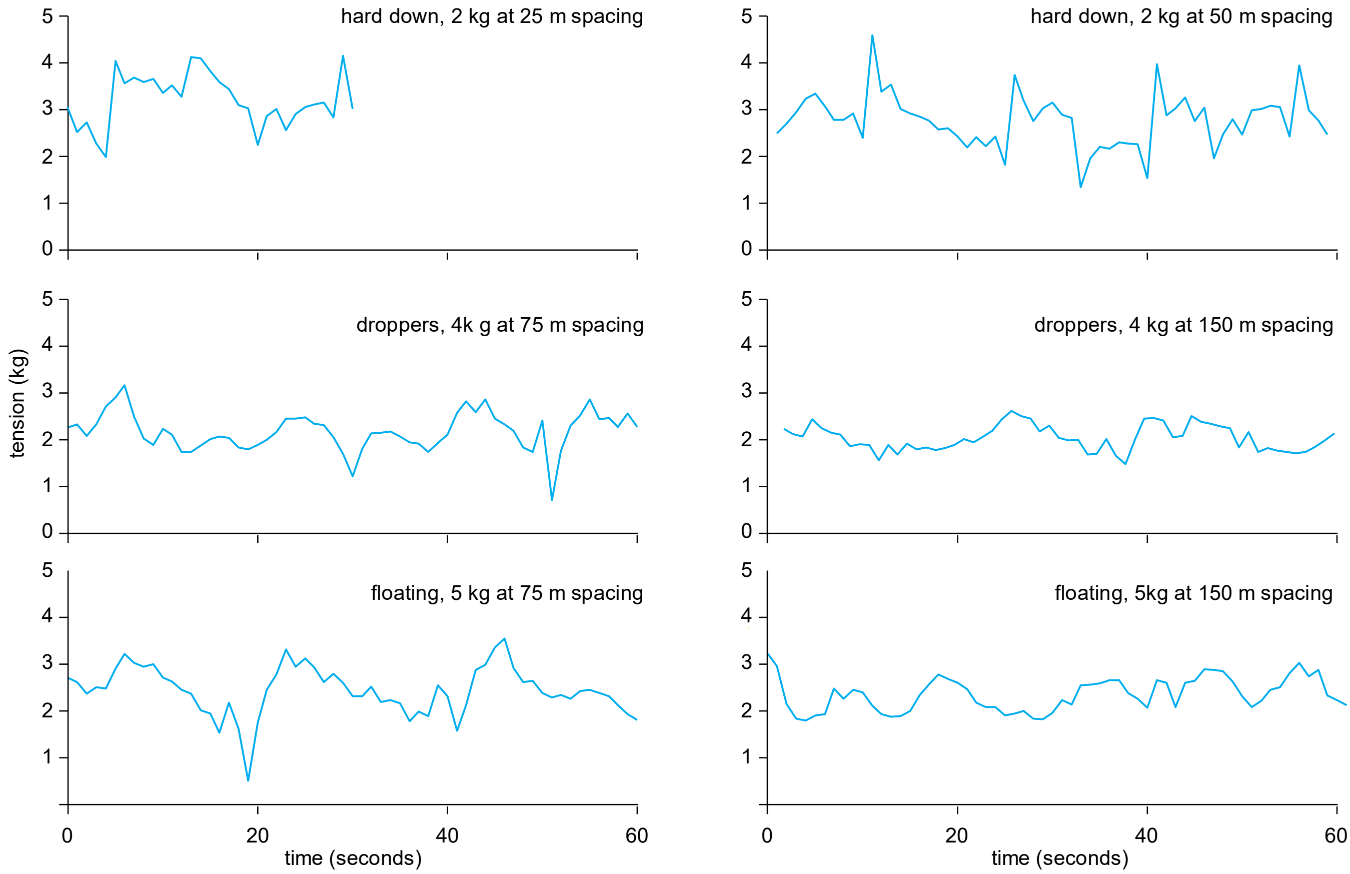


Figure 5. Tension over time for hard down, floating, and dropper configurations set with 2.2 mm backbone, at 6.6 knots.

Higher setting speed resulted in increased average tension, and more weight per metre of line also resulted in higher average tension (Tables 4-6).

Sets directly comparing line tension indicated that, setting gear 'tight' markedly reduced sink times for TDRs placed midway between weights at larger-spaced floating gear, but has less influence at 75 m spacings (Table 1).

Table 1. Sink times to six metres depth for gear set at different tensions and speeds.

gear configuration	weight (kg)	weight spacing (m)	speed (knots)	tension (kg)	backbone diameter (mm)	max time to 6 m (s)
floating	5	75	4.0	6.8	2.2	24
floating	5	75	6.6	2.5	2.2	29
floating	5	75	6.7	12.8	2.2	25
floating	5	150	4.0	1.2	2.2	59
floating	5	150	4.0	6.5	2.2	37
floating	5	150	6.6	2.2	2.2	58
floating	5	150	6.7	12.9	2.2	36
hard down	2	75	4.0	2.4	1.6	29
hard down	2	75	4.0	7.0	1.6	31
hard down	2	75	6.7	2.2	1.6	29
hard down	2	75	6.7	10.4	1.6	28

Backbone diameter

Comparison of sink times of 1.6- and 3.0-mm diameter backbone showed that gear set on thicker backbone sank more slowly (Table 2).

Table 2. Sink times to 6 m depth for gear set at with different backbone diameters at 4 and 6.7 knots.

gear configuration	weight (kg)	weight spacing (m)	speed (knots)	tension (kg)	backbone (mm)	max time to 6 m (s)
hard down	2	75	4.0	2.44	1.6	29
hard down	2	75	4.0	2.06	3	39
hard down	2	75	6.7	2.24	1.6	29
hard down	2	75	6.7	2.26	3	36

With and without hooks

Test conducted on the end of a commercial fishing line indicated that leaving hooks off for the bulk of the trials had little influence on times to six metres depth (Table 3).

Table 3. Sink times to 6 m depth for 2.2 mm diameter backbone gear set with and without baited hooks.

gear configuration	weight (kg)	weight spacing (m)	speed (knots)	tension (kg)	hooks used	max time to 6 m (s)
droppers	4	75	3.3	NA	n	31
droppers	4	75	3.3	NA	y	33
droppers	4	75	6.6	NA	n	33
droppers	4	75	6.6	2.41	y	33

Sink times to six metres, and distance astern

Gear setup was the main driver of sink times to six metres, with heavier weights and shorter weight spacings producing shortest sink times (Tables 4 - 6). Sink times varied little with setting speed. The range of gear setups tested required tori line aerial extents of between 35 m and 197 m to meet the regulations.

Table 4. Sink times to 6 m depth and distances astern TDRs reach 6 m depth for 'hard down' setups tested on 2.2 mm diameter backbone. The 'weight, egg' setup includes two egg floats midway between weights

gear configuration	weight (kg)	weight spacing (m)	speed (knots)	tension (kg)	max time to 6 m (s)	max distance at 6 m (m)
weights	1	12	4.0	1.25	26	53
weights	1	25	4.0	1.27	31	64
weights	1	50	4.0	1.29	33	68
weights	1	75	4.0	1.22	41	84
weights	1	75	4.0	1.38	41	84
weights	2	25	4.0	1.61	17	35
weights	2	25	6.6	3.27	18	61
weights	2	50	4.0	1.13	25	51
weights	2	50	6.6	2.75	26	88
weights	2	75	4.0	1.37	32	66
weights	2	75	6.6	2.24	36	122
weights	4	25	6.6	3.31	15	51
weights	4	50	4.0	1.37	20	41
weights	4	50	6.6	3.18	18	61
weights	4	75	4.0	NA	29	60
weights	4	75	6.6	2.43	27	92
weights	4	100	4.0	NA	34	70
weights	4	150	4.0	NA	54	111
weight, egg	4	150	4.0	1.29	44	91

Table 5. Sink times to 6 m depth and distances astern TDRs reached 6 m depth for 'dropper' setups tested on 2.2 mm diameter backbone. The 'dropper, weight' setup comprises 4 kg droppers alternated with 2 kg weights.

gear configuration	weight (kg)	weight spacing (m)	speed (knots)	tension (kg)	max time to 6 m	max distance at 6 m (m)
droppers	2	25	4.0	NA	31	64
droppers	2	50	4.0	NA	45	93
droppers	2	75	4.0	NA	49	101
droppers	2	100	4.0	NA	62	128
droppers	4	25	4.0	1.64	17	35
droppers	4	50	4.0	1.56	27	56
droppers	4	50	6.6	2.37	25	85
droppers	4	75	4.0	1.17	36	74
droppers	4	75	6.6	2.17	34	115
droppers	4	100	4.0	1.07	44	91
droppers	4	100	6.6	2.19	40	136
droppers	4	150	4.0	NA	56	115
droppers	4	150	6.6	1.96	53	180
droppers	6	50	6.7	NA	20	69
droppers	6	75	4.0	1.62	25	51
droppers	6	75	6.7	NA	24	83
droppers	6	100	4.0	1.6	32	66
droppers	6	100	6.7	NA	29	100
droppers	6	150	4.0	1.59	46	95
droppers	6	150	6.7	NA	39	134
dropper, weight	4	50	4.0	1.31	27	56
dropper, weight	4	75	4.0	1.15	35	72
dropper, weight	4	100	4.0	1.06	44	91

Table 6. Sink times to 6 m depth and distances astern TDRs reached 6 m depth for 'floating' setups tested on 2.2 mm diameter backbone.

gear configuration	weight (kg)	weight spacing (m)	speed (knots)	tension (kg)	max time to 6 m (s)	max distance at 6 m (s)
floating	3	50	4.0	1.52	33	68
floating	3	50	6.6	2.68	31	105
floating	3	75	6.6	2.53	36	122
floating	3	100	4.0	0.97	52	107
floating	3	100	6.6	2.48	52	177
floating	3	150	4.0	1.55	60	123
floating	5	50	4.0	1.53	26	53
floating	5	50	6.6	2.31	22	75
floating	5	75	6.6	2.45	29	98
floating	5	100	4.0	1.09	36	74
floating	5	100	6.6	2.33	35	119
floating	5	150	4.0	1.20	59	121
floating	5	150	6.6	2.19	58	197
floating	7	50	4.0	1.71	20	41
floating	7	75	6.6	2.46	26	88
floating	7	100	4.0	1.3	41	84
floating	7	100	6.6	2.41	36	122
floating	7	150	4.0	1.2	51	105
floating	7	150	6.6	2.29	48	163

Typical sink profiles indicate that, whilst the amount of weight added to the line influences time to depth, reducing weight spacing is key to reducing times to six metres depth. This reduces the time that TDRs midway between weights spend close to the surface (Figure 6).

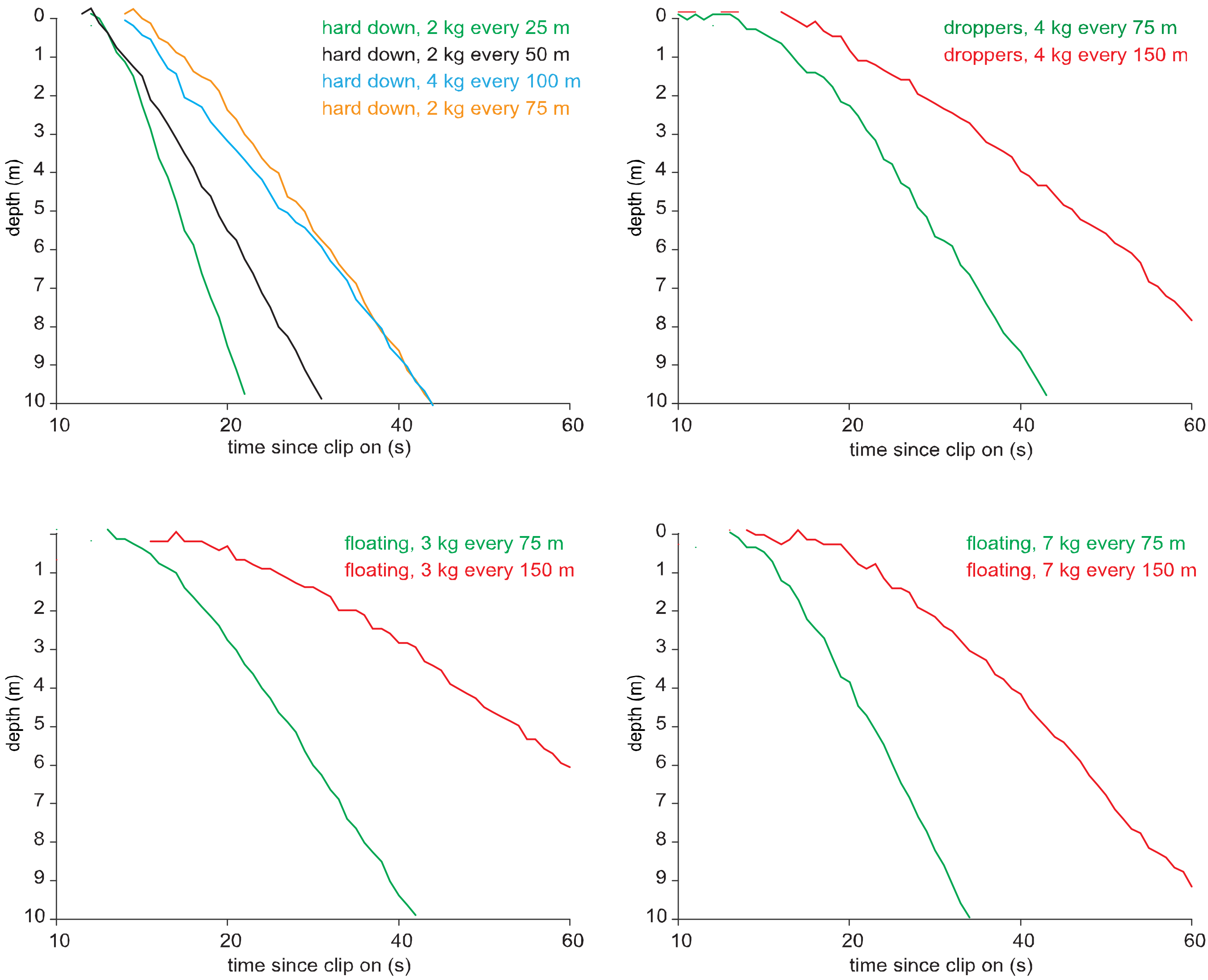


Figure 6. Depth over time after clip-on for different gear configurations.

Paired deployments

Paired deployments of CEFAS and Zebra-tech TDRs during the trials produced similar times to six metres depth, with a maximum of three seconds difference (Table 7). When comparing results to deployments of CEFAS TDRs without Zebra-tech TDRs the added weight of Zebra-tech TDRs produced faster sink times (Table 7). Trials at the wharf showed that Zebra-tech TDRs could be made neutrally buoyant with the addition of a small egg float.

Table 7. Sink times to 5 m depth for paired deployments of CEFAS and Zebra-tech TDRs

gear configuration	weight (kg)	weight spacing (m)	speed (knots)	tension (kg)	Time to 6 m (s)		
					Zebra-tech paired	CEFAS paired	CEFAS only mean
hard down	2	75	4	1.37	29	31	32
hard down	4	50	4	1.37	20	20	20
hard down	4	50	6.6	3.18	20	19	18
hard down	4	75	4	NA	26	26	28
dropper, weight	4, 2	50	4	1.31	24	26	27
floating	3	50	4	1.52	30	33	32
floating	3	150	4	1.55	56	53	59
floating	5	75	6.6	2.45	26	26	28
floating	5	150	4	1.2	48	48	52
floating	7	75	6.6	2.46	26	26	26

Tori line trials

Tori line designs built on current knowledge and provided options for achieving aerial extents of up to 60 m from a five-metre pole at four knots, and 105 m from a seven-metre pole at six knots. Unsurprisingly, series-type towed objects produced more uniform drag than a single road cone, at the expense of visibility and lateral movement of the towed section (Table 8).

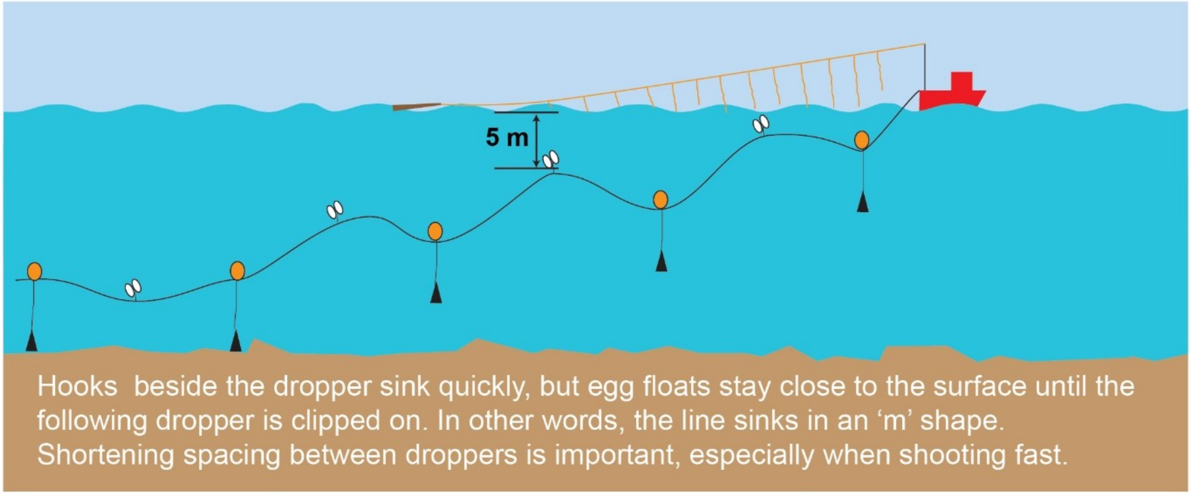
Table 8. Drag force produced and aerial extent achieved by different tori line towed objects at different speeds.

Drag section description	speed (knots)	height (m)	min aerial extent (m)	max aerial extent (m)	min drag (kg)	max drag (kg)
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	4	5	45	45	3	3
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	5	5	55	55	4	4
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	6	5	60	65	6	6
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	7	5	70	75	8	8
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	4	7	55	60	3	3
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	5	7	65	70	4	4
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	6	7	70	75	6	6
6 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	7	7	80	85	8	8
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	4	5	55	60	5	
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	5	5	65	65	6	7
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	6	5	65	70	10	11
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	7	5	75	80	13	14
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	4	7	65	70	5	5
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	5	7	70	75	6	7
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	6	7	85	90	10	11
10 m of 52 mm 8 strand rope on a 10 m of 9 mm braid leader	7	7	105	105	13	14
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	4	5	50	60	7	11
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	5	5	55	70	9	12
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	6	5	70	90	11	16
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	7	5	80	100	12	20
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	4	7	55	80	7	11
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	5	7	60	80	9	12
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	6	7	70	100	11	16
30 m of 9 mm braid with 30 gillnet floats and 1 medium road cone	7	7	95	105	12	20
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	4	5	60	65	5	6
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	5	5	70	75	6	8
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	6	5	80	85	11	12
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	7	5	90	100	10	17
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	4	7	95	100	5	6
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	5	7	95	105	6	8
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	6	7	105	105	11	12
30 m of 9 mm braid with 30 gillnet floats and 2 small road cones	7	7	105	105	10	17
5 polystyrene intermediate floats on 20 m of 9 mm braid	4	5	60	65	3	6
5 polystyrene intermediate floats on 20 m of 9 mm braid	5	5	60	70	4	8
5 polystyrene intermediate floats on 20 m of 9 mm braid	6	5	65	70	5	8
5 polystyrene intermediate floats on 20 m of 9 mm braid	7	5	70	75	6	15
5 polystyrene intermediate floats on 20 m of 9 mm braid	4	7	50	60	3	6
5 polystyrene intermediate floats on 20 m of 9 mm braid	5	7	65	70	4	8
5 polystyrene intermediate floats on 20 m of 9 mm braid	6	7	75	85	5	8
5 polystyrene intermediate floats on 20 m of 9 mm braid	7	7	85	95	6	15
8 m of 32 mm three strand rope in hose with 4 sports cones	4	5	55	75	6	11
8 m of 32 mm three strand rope in hose with 4 sports cones	7	5	70	90	9	14
8 m of 32 mm three strand rope in hose with 4 sports cones	4	7	55	65	9	11
8 m of 32 mm three strand rope in hose with 4 sports cones	5	7	60	75	7	13
8 m of 32 mm three strand rope in hose with 4 sports cones	6	7	65	80	8	12
8 m of 32 mm three strand rope in hose with 4 sports cones	7	7	65	90	9	14

Presenting results to fishers

Following feedback from the workshop a one-page guide for fishers has been drafted for review (Figure 7). This will be refined through feedback from fishers and expert design input prior to dissemination.

Tori line aerial extents required for floating gear



Gear setup		Tori line aerial extent required (m)			
weight (kg)	spacing (m)	4 knots	5 knots	6 knots	7 knots
3	50	70	85	95	115
3	75	80	95	105	120
3	100	110	135	160	190
3	150	124	155	185	215
5	50	50	65	75	90
5	75	60	75	90	105
5	100	75	93	110	130
5	150	125	155	180	215
7	50	40	50	60	75
7	75	55	70	80	95
7	100	80	100	120	140
7	150	105	130	155	180

Aerial extent:
black = hard to achieve
orange = use a 7 m pole
green = use a 5 m pole

Drag sections:
10 m of 52 mm mooring rope
30 m of 9 mm braid, gillnet floats and one or two small road cones
8 m of 32mm rope with 4 sports cones.

Aerial section:
3mm dyneema, light streamers

This table shows the tori line length required to cover egg floats to five metres depth.

It is based on trials conducted using a free-wheeling hydraulic drum with 2.2 mm mono backbone, lead weights,150 mm diameter hard floats on 3.6 m rope droppers, and 2 x egg floats clipped on midway between weights, with TDRs clipped to egg floats. Note that:

These figures are indicative only - gear will sink at different speeds based on things you have some control over like line tension, weight material, and backbone diameter, and things you can't control like sea state.

Larger diameter backbones will sink more slowly

Shallow water (with large spacing) can result in lines sinking more slowly

Shorter tori poles may require more drag, and vice-versa.

Adding tension to the line will reduce the time it takes egg floats to reach five metres as there will be less slack and so the line sinks more evenly, in less of an 'm' shape.

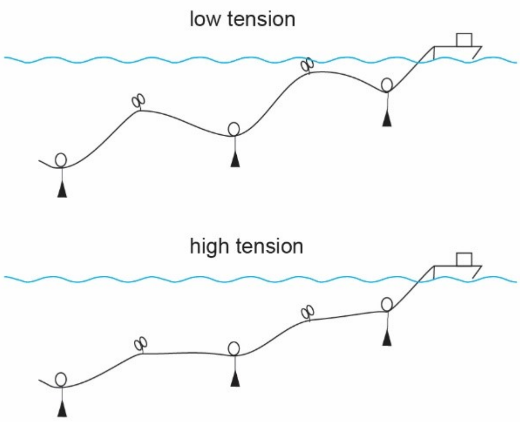


Figure 7. Suggested flyer for fishers.

Discussion

Setting speed and line tension

Tension increases with speed, likely due to greater friction when running the drum at higher revolutions per minute. The increased tension appeared to reduce sink times to depth for gear set with short weight spacing. Conversely, at large weight spacing gear sometimes sank faster, possibly due to the following weight being clipped on sooner at higher speed, and less influence of the vessel as it was further astern. However, with small sample sizes, limited TDR precision, and variability between deployments no firm conclusions can be drawn, other than setting speed does not markedly influence time to six metres.

Purposely increasing line tension will decrease sink times to six metres for larger weight spacings and heavier weights (Table 1), and was noted in post workshop feedback from fishers as a mitigation strategy when larger spacing is desirable, for example when fishing foul ground.

Tori lines

All except one drag design achieved 50 m aerial extent at four knots from a five-metre attachment height, and 60 m was achievable with some designs. At higher speeds and with a seven-metre attachment height the full 105 m aerial extent was achieved by some designs, and aerial extents of 70 m, 80 m and 100 m were reasonably easily achieved at speeds of five, six and seven knots, respectively (Table 8). The drag section of multiple gillnet floats and a road cone supplied to a large portion of the fleet appears to perform well, however it did produce the most variation in drag as the cone skipped across the water, particularly at high speeds. Other options produced more consistent drag, but generally created less splash and were less visible, and so the in-water section may have less of a deterrent effect. Importantly, there are several options available to fishers. Further refinement of a series type drag section could be considered, aiming to produce consistent drag as well as high visibility.

Altering gear setup to meet regulations

When setting gear 'hard down' the weighting regime is less important to fishers as it will not appreciably change hook depth – all hooks will be close to or on the seabed. Two-kilogram weights were adequate for spacings up to 75 m, with one-kilogram weights sufficient at shorter spacings, and four-kilogram weights enabled setting at 75 m spacing at 6.6 knots, albeit with a long tori line. In practice fishers are likely to be able to set a maximum of 50 m spacings, equivalent to four weights per card, without expecting to alter catch rates (Table 4).

Fishers aiming to suspend at least some hooks off the seabed with 'dropper' or 'floating' setups have less flexibility. Results indicate that 75 m spacing (a reasonably common setup of 2 weights per card for 25 hook cards and 1.5 m stoppers) is marginal – it likely requires five-kilogram weights and aerial extents approaching 100 m at six knots (Tables 5 and 6). Reducing weight spacing provides much greater gains than increasing weight size for dropper and floating setups (Figure 5). Another viable alternative is to add a small weight between droppers or floating setups, possibly on a short rope so as not to pull hooks tight to the seabed, as illustrated by the 'dropper, weight' setup in Table 5. Similarly, adding tension to the line can reduce times to six metres for floating and dropper configurations and may be more attractive for some fishers (Table 1).

Variation in time to depth

Only three repeats, reduced to two for several gear configurations, gives a limited insight into variation in sink times to depth, and more repeats and more controlled drops of TDRs would be necessary to fully tease out 'true' variation from 'recorder' variation. However, given that repeats are reasonably consistent, and variation unsurprisingly increases with time to six metres and distance between weights, the data presented here appear to adequately identify the influence that gear configuration has on sink time to six metres. Similarly, the data clearly identify different gear setups and the logical nature of the times to depth (shorter spacing and/or heavier weights show incrementally shorter sink times) further indicate that the level accuracy is useful for the purpose intended. In practice identifying the time TDRs spend close to the surface before sinking is key, and once the following weight has been clipped on and TDRs are sinking relatively quickly, a precise depth is not so important as a half-metre difference in depth typically only represents 2 seconds (Figure 5, Appendix 1).

Assuming birds are able to target slowest-sinking hooks, and noting that the regulations (MPI, 2021) specify that the slowest-sinking part of the line is of interest, it is prudent to concentrate on slowest records to six metres, post grooming.

When calculating distances between weights for protected species risk management plans it is generally assumed that hook spacing between weights and floats is perfect i.e., no stoppers are missed and all weights are clipped on at exact spacings. In practice this is not likely due to card top-ups, missed stoppers, and delays clipping on weights, resulting in variable spacing and number of hooks between weights. Generally, this is likely to result in occasional larger weight spacings and is more likely to happen at higher setting speeds and with less experienced crew.

Absolute hook time to depth.

Comparison between CEFAS and Zebra-tech TDRs was not part of the project objectives, tests were opportunistic, and this could be investigated further. Zebra-tech devices appear to be more accurate and the data is certainly easier to use. However, the additional weight influences sink times, especially at larger weight spacings.

Although potentially not the slowest sinking position on the line (e.g. Goad, 2011) midway between weights was chosen because it is easy to hit accurately when clipping on TDRs and allows direct comparison between different gear setups. Measuring sink times to absolutely assess compliance with regulations would require neutrally buoyant devices and attaching them at the largest spacings on the line and/or between smallest weights.

In order to account for the vertical difference between the hook and TDR, and uncertainty around TDR depth, it is prudent to consider slowest-sinking times to six metres when presenting results to fishers.

Conclusions

Methodically testing many different gear configurations has produced a valuable data set for fishers and liaison officers to use to improve sink rates. It should cut down the need for skippers to spend valuable time trialling different gear configurations. It provides a good indication of how current gear configurations are performing and what, if any, changes are necessary to meet the regulations.

Setting gear without hooks saved a lot of time and allowed for the work to be completed in daylight and without concerns around non-compliance with regulations. It also appeared to have little influence on sink times.

Despite expected variation between sets, and with different weather conditions, backbone diameters, 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

Continue dialogue with fishers, particularly around which of the options presented here are most workable for them, and how best to convey the results.

Further investigate the addition of (for example) two-kilogram weights between droppers, and below egg floats to increase sink rate of these gear configurations with minimal disturbance to current operations.

Consider the usefulness of a similar approach for deeper-water externally weighted bottom longlines, for example those targeting ling, bluenose and bass.

Make Zebra-tech TDRs neutrally buoyant, or possibly very slightly negatively buoyant, by the addition of a small egg float, prior to wider deployment in the fleet, and ensure that observers accurately record and delay between activation time and clip on time.

Continue to foster experimentation with tori line drag objects to produce consistent drag.

Acknowledgements

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Fisheries New Zealand.

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Appendix 1

Sink times to five and six metres depth for all deployments.

Abbreviations include: t_six = time to six metres depth, in seconds; t_five = time to five metres, in seconds; wt_m = weight pacing, in metres; wt_kg = weight size, in kilograms; b-bone = backbone diameter; zebra_5 = time to five metres depth from Zebra-tech TDR.

hard down

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	comments
1_A17041_22-02-2022	26	24	1.25	4.0	12	1	n	2.2	NA
1_A17043_22-02-2022	26	24	1.25	4.0	12	1	n	2.2	NA
1_A17237_22-02-2022	26	24	1.25	4.0	12	1	n	2.2	NA
1_A17049_22-02-2022	28	26	1.27	4.0	25	1	n	2.2	NA
1_A17052_22-02-2022	29	26	1.27	4.0	25	1	n	2.2	NA
1_A17069_22-02-2022	31	28	1.27	4.0	25	1	n	2.2	NA
1_A17048_22-02-2022	33	29	1.29	4.0	50	1	n	2.2	NA
1_A17061_22-02-2022	31	28	1.29	4.0	50	1	n	2.2	NA
1_A17064_22-02-2022	31	28	1.29	4.0	50	1	n	2.2	NA
1_A17050_22-02-2022	41	39	1.22	4.0	75	1	n	2.2	NA
1_A17057_22-02-2022	39	35	1.22	4.0	75	1	n	2.2	NA
3_A17043_23-02-2022	41	36	1.38	4.0	75	1	n	2.2	NA
3_A17072_23-02-2022	40	34	1.38	4.0	75	1	n	2.2	NA
1_A17062_22-02-2022	17	15	1.61	4.0	25	2	n	2.2	NA
1_A17068_22-02-2022	17	16	1.61	4.0	25	2	n	2.2	NA
1_A17072_22-02-2022	16	14	1.61	4.0	25	2	n	2.2	NA
5_A17064_25-02-2022	18	16	3.27	6.6	25	2	n	2.2	NA
5_A17071_25-02-2022	18	16	3.27	6.6	25	2	n	2.2	NA
5_A17237_25-02-2022	17	16	3.27	6.6	25	2	n	2.2	NA
1_A17063_22-02-2022	22	19	1.13	4.0	50	2	n	2.2	NA
1_A17067_22-02-2022	25	22	1.13	4.0	50	2	n	2.2	NA
1_A17235_22-02-2022	25	22	1.13	4.0	50	2	n	2.2	NA
5_A17043_25-02-2022	26	23	2.75	6.6	50	2	n	2.2	NA
5_A17062_25-02-2022	24	22	2.75	6.6	50	2	n	2.2	NA
5_A17072_25-02-2022	24	22	2.75	6.6	50	2	n	2.2	NA
1_A17046_22-02-2022	32	29	1.37	4.0	75	2	n	2.2	NA
1_A17054_22-02-2022	31	27	1.37	4.0	75	2	n	2.2	NA
6_A17046_25-02-2022	32	29	2.24	6.6	75	2	n	2.2	NA
6_A17067_25-02-2022	34	30	2.24	6.6	75	2	n	2.2	NA
6_A17068_25-02-2022	36	32	2.24	6.6	75	2	n	2.2	NA
5_A17042_25-02-2022	13	12	3.31	6.6	25	4	n	2.2	NA
5_A17052_25-02-2022	15	13	3.31	6.6	25	4	n	2.2	NA
5_A17058_25-02-2022	13	12	3.31	6.6	25	4	n	2.2	NA
1_A17056_22-02-2022	20	18	1.37	4.0	50	4	n	2.2	NA
1_A17070_22-02-2022	20	19	1.37	4.0	50	4	n	2.2	NA
5_A17063_25-02-2022	18	16	3.18	6.6	50	4	n	2.2	NA
5_A17073_25-02-2022	18	16	3.18	6.6	50	4	n	2.2	NA
2_A17044_22-02-2022	27	25	NA	4.0	75	4	n	2.2	NA
2_A17056_22-02-2022	29	26	NA	4.0	75	4	n	2.2	NA
6_A17061_25-02-2022	27	24	2.43	6.6	75	4	n	2.2	NA
6_A17065_25-02-2022	26	24	2.43	6.6	75	4	n	2.2	NA
6_A17069_25-02-2022	26	23	2.43	6.6	75	4	n	2.2	NA
2_A17060_22-02-2022	34	32	NA	4.0	100	4	n	2.2	NA
2_A17063_22-02-2022	32	28	NA	4.0	100	4	n	2.2	NA
2_A17048_22-02-2022	54	48	NA	4.0	150	4	n	2.2	NA
2_A17050_22-02-2022	48	44	NA	4.0	150	4	n	2.2	NA
2_A17057_22-02-2022	50	42	NA	4.0	150	4	n	2.2	NA

hard down plus eggs midway between weights

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	comments
4_A17052_23-02-2022	42	37	1.29	4.0	150	4	n	2.2	NA
4_A17237_23-02-2022	44	38	1.29	4.0	150	4	n	2.2	NA
4_A17052_23-02-2022	42	37	1.29	4.0	150	4	n	2.2	NA
4_A17237_23-02-2022	44	38	1.29	4.0	150	4	n	2.2	NA

droppers

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	comments
2_A17058_22-02-2022	31	28	NA	4.0	25	2	n	2.2	NA
2_A17059_22-02-2022	29	26	NA	4.0	25	2	n	2.2	NA
2_A17071_22-02-2022	31	28	NA	4.0	25	2	n	2.2	NA
2_A17043_22-02-2022	45	40	NA	4.0	50	2	n	2.2	NA
2_A17052_22-02-2022	43	38	NA	4.0	50	2	n	2.2	NA
2_A17237_22-02-2022	42	37	NA	4.0	50	2	n	2.2	NA
2_A17046_22-02-2022	49	45	NA	4.0	75	2	n	2.2	NA
2_A17054_22-02-2022	48	44	NA	4.0	75	2	n	2.2	NA
2_A17067_22-02-2022	48	43	NA	4.0	75	2	n	2.2	NA
2_A17062_22-02-2022	57	50	NA	4.0	100	2	n	2.2	NA
2_A17068_22-02-2022	57	51	NA	4.0	100	2	n	2.2	NA
2_A17072_22-02-2022	62	56	NA	4.0	100	2	n	2.2	NA
3_A17052_23-02-2022	17	16	1.64	4.0	25	4	n	2.2	NA
3_A17071_23-02-2022	17	16	1.64	4.0	25	4	n	2.2	NA
3_A17237_23-02-2022	17	15	1.64	4.0	25	4	n	2.2	NA
3_A17042_23-02-2022	23	21	1.56	4.0	50	4	n	2.2	NA
3_A17058_23-02-2022	27	25	1.56	4.0	50	4	n	2.2	NA
3_A17064_23-02-2022	26	23	1.56	4.0	50	4	n	2.2	NA
6_A17044_25-02-2022	24	22	2.37	6.6	50	4	n	2.2	NA
6_A17056_25-02-2022	25	22	2.37	6.6	50	4	n	2.2	NA
6_A17070_25-02-2022	24	21	2.37	6.6	50	4	n	2.2	NA
7_A17043_25-02-2022	31	29	1.17	4.0	75	4	n	2.2	NA
7_A17056_25-02-2022	36	33	1.17	4.0	75	4	n	2.2	NA
7_A17235_25-02-2022	31	28	1.17	4.0	75	4	n	2.2	NA
6_A17043_25-02-2022	32	30	2.17	6.6	75	4	n	2.2	NA
6_A17058_25-02-2022	34	31	2.17	6.6	75	4	n	2.2	NA
6_A17235_25-02-2022	32	29	2.17	6.6	75	4	n	2.2	NA
7_A17042_25-02-2022	36	31	1.07	4.0	100	4	n	2.2	NA
7_A17052_25-02-2022	43	38	1.07	4.0	100	4	n	2.2	NA
7_A17058_25-02-2022	44	38	1.07	4.0	100	4	n	2.2	NA
6_A17042_25-02-2022	40	36	2.19	6.6	100	4	n	2.2	NA
6_A17071_25-02-2022	40	37	2.19	6.6	100	4	n	2.2	NA
2_A17061_22-02-2022	56	52	NA	4.0	150	4	n	2.2	NA
2_A17064_22-02-2022	56	52	NA	4.0	150	4	n	2.2	NA
6_A17064_25-02-2022	53	49	1.96	6.6	150	4	n	2.2	NA
6_A17237_25-02-2022	52	46	1.96	6.6	150	4	n	2.2	NA
8_A17048_26-02-2022	18	16	NA	6.7	50	6	n	2.2	NA
8_A17049_26-02-2022	18	16	NA	6.7	50	6	n	2.2	NA
8_A17065_26-02-2022	20	18	NA	6.7	50	6	n	2.2	NA
3_A17060_23-02-2022	25	22	1.62	4.0	75	6	n	2.2	NA
3_A17062_23-02-2022	24	21	1.62	4.0	75	6	n	2.2	NA
3_A17063_23-02-2022	25	22	1.62	4.0	75	6	n	2.2	NA
8_A17043_26-02-2022	23	21	NA	6.7	75	6	n	2.2	NA
8_A17056_26-02-2022	21	19	NA	6.7	75	6	n	2.2	NA
8_A17235_26-02-2022	24	21	NA	6.7	75	6	n	2.2	NA
3_A17056_23-02-2022	31	26	1.6	4.0	100	6	n	2.2	NA
3_A17070_23-02-2022	32	28	1.6	4.0	100	6	n	2.2	NA
3_A17235_23-02-2022	32	27	1.6	4.0	100	6	n	2.2	NA
8_A17042_26-02-2022	29	26	NA	6.7	100	6	n	2.2	NA
8_A17052_26-02-2022	28	25	NA	6.7	100	6	n	2.2	NA
8_A17058_26-02-2022	28	25	NA	6.7	100	6	n	2.2	NA
3_A17049_23-02-2022	43	37	1.59	4.0	150	6	n	2.2	NA
3_A17061_23-02-2022	46	41	1.59	4.0	150	6	n	2.2	NA
3_A17069_23-02-2022	44	39	1.59	4.0	150	6	n	2.2	NA
8_A17064_26-02-2022	39	35	NA	6.7	150	6	n	2.2	NA
8_A17071_26-02-2022	39	35	NA	6.7	150	6	n	2.2	NA
8_A17237_26-02-2022	37	33	NA	6.7	150	6	n	2.2	NA

floating

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	comments
3_A17057_23-02-2022	30	28	1.52	4.0	50	3	n	2.2	NA
3_A17073_23-02-2022	33	29	1.52	4.0	50	3	n	2.2	NA
5_A17044_25-02-2022	28	25	2.68	6.6	50	3	n	2.2	NA
5_A17054_25-02-2022	31	28	2.68	6.6	50	3	n	2.2	NA
5_A17057_25-02-2022	31	27	2.68	6.6	50	3	n	2.2	NA
5_A17056_25-02-2022	36	33	2.53	6.6	75	3	n	2.2	NA
5_A17235_25-02-2022	34	31	2.53	6.6	75	3	n	2.2	NA
4_A17056_23-02-2022	51	47	0.97	4.0	100	3	n	2.2	NA
4_A17070_23-02-2022	52	46	0.97	4.0	100	3	n	2.2	NA
4_A17235_23-02-2022	50	45	0.97	4.0	100	3	n	2.2	NA
4_A17056_23-02-2022	51	47	0.97	4.0	100	3	n	2.2	NA
4_A17070_23-02-2022	52	46	0.97	4.0	100	3	n	2.2	NA
4_A17235_23-02-2022	50	45	0.97	4.0	100	3	n	2.2	NA
5_A17041_25-02-2022	43	38	2.48	6.6	100	3	n	2.2	NA
5_A17050_25-02-2022	52	47	2.48	6.6	100	3	n	2.2	NA
5_A17059_25-02-2022	44	39	2.48	6.6	100	3	n	2.2	NA
4_A17042_23-02-2022	56	50	1.26	4.0	150	3	n	2.2	NA
4_A17064_23-02-2022	59	54	1.26	4.0	150	3	n	2.2	NA
4_A17071_23-02-2022	60	54	1.26	4.0	150	3	n	2.2	NA
4_A17042_23-02-2022	56	50	1.26	4.0	150	3	n	2.2	NA
4_A17064_23-02-2022	59	54	1.26	4.0	150	3	n	2.2	NA
4_A17071_23-02-2022	60	54	1.26	4.0	150	3	n	2.2	NA
3_A17041_23-02-2022	59	53	1.55	4.0	150	3	n	2.2	NA
3_A17050_23-02-2022	60	56	1.55	4.0	150	3	n	2.2	NA
3_A17044_23-02-2022	26	24	1.53	4.0	50	5	n	2.2	NA
3_A17046_23-02-2022	24	22	1.53	4.0	50	5	n	2.2	NA
3_A17067_23-02-2022	23	21	1.53	4.0	50	5	n	2.2	NA
5_A17048_25-02-2022	20	18	2.31	6.6	50	5	n	2.2	NA
5_A17049_25-02-2022	22	20	2.31	6.6	50	5	n	2.2	NA
10_A17049_26-02-2022	24	21	6.84	4.0	75	5	n	2.2	NA
10_A17056_26-02-2022	22	20	6.84	4.0	75	5	n	2.2	NA
10_A17235_26-02-2022	21	19	6.84	4.0	75	5	n	2.2	NA
5_A17068_25-02-2022	29	26	2.45	6.6	75	5	n	2.2	NA
5_A17069_25-02-2022	27	24	2.45	6.6	75	5	n	2.2	NA
10_A17071_26-02-2022	23	21	12.76	6.7	75	5	n	2.2	NA
10_A17237_26-02-2022	25	22	12.76	6.7	75	5	n	2.2	NA
4_A17044_23-02-2022	35	32	1.09	4.0	100	5	n	2.2	NA
4_A17046_23-02-2022	36	33	1.09	4.0	100	5	n	2.2	NA
4_A17067_23-02-2022	36	33	1.09	4.0	100	5	n	2.2	NA
4_A17044_23-02-2022	35	32	1.09	4.0	100	5	n	2.2	NA
4_A17046_23-02-2022	36	33	1.09	4.0	100	5	n	2.2	NA
4_A17067_23-02-2022	36	33	1.09	4.0	100	5	n	2.2	NA
5_A17046_25-02-2022	35	31	2.33	6.6	100	5	n	2.2	NA
5_A17067_25-02-2022	35	31	2.33	6.6	100	5	n	2.2	NA
4_A17057_23-02-2022	59	53	1.2	4.0	150	5	n	2.2	NA
4_A17073_23-02-2022	45	39	1.2	4.0	150	5	n	2.2	NA
4_A17057_23-02-2022	59	53	1.2	4.0	150	5	n	2.2	NA
4_A17073_23-02-2022	45	39	1.2	4.0	150	5	n	2.2	NA
10_A17042_26-02-2022	37	33	6.48	4.0	150	5	n	2.2	NA
10_A17043_26-02-2022	31	29	6.48	4.0	150	5	n	2.2	NA
10_A17058_26-02-2022	35	32	6.48	4.0	150	5	n	2.2	NA
6_A17054_25-02-2022	52	47	2.19	6.6	150	5	n	2.2	NA
6_A17057_25-02-2022	58	54	2.19	6.6	150	5	n	2.2	NA
6_A17073_25-02-2022	58	53	2.19	6.6	150	5	n	2.2	NA
10_A17046_26-02-2022	35	32	12.88	6.7	150	5	n	2.2	NA
10_A17059_26-02-2022	36	33	12.88	6.7	150	5	n	2.2	NA
10_A17064_26-02-2022	33	30	12.88	6.7	150	5	n	2.2	NA
3_A17048_23-02-2022	18	17	1.71	4.0	50	7	n	2.2	NA
3_A17059_23-02-2022	19	17	1.71	4.0	50	7	n	2.2	NA
3_A17065_23-02-2022	20	18	1.71	4.0	50	7	n	2.2	NA
6_A17048_25-02-2022	26	23	2.46	6.6	75	7	n	2.2	NA
6_A17059_25-02-2022	26	24	2.46	6.6	75	7	n	2.2	NA
4_A17060_23-02-2022	37	32	1.3	4.0	100	7	n	2.2	NA
4_A17062_23-02-2022	41	38	1.3	4.0	100	7	n	2.2	NA
4_A17063_23-02-2022	37	33	1.3	4.0	100	7	n	2.2	NA
4_A17062_23-02-2022	41	38	1.3	4.0	100	7	n	2.2	NA
4_A17063_23-02-2022	37	33	1.3	4.0	100	7	n	2.2	NA
6_A17041_25-02-2022	35	32	2.41	6.6	100	7	n	2.2	NA
6_A17050_25-02-2022	34	32	2.41	6.6	100	7	n	2.2	NA
6_A17072_25-02-2022	36	32	2.41	6.6	100	7	n	2.2	NA
4_A17043_23-02-2022	49	46	1.2	4.0	150	7	n	2.2	NA
4_A17058_23-02-2022	51	47	1.2	4.0	150	7	n	2.2	NA
4_A17072_23-02-2022	51	46	1.2	4.0	150	7	n	2.2	NA
4_A17043_23-02-2022	49	46	1.2	4.0	150	7	n	2.2	NA
4_A17058_23-02-2022	51	47	1.2	4.0	150	7	n	2.2	NA
4_A17072_23-02-2022	51	46	1.2	4.0	150	7	n	2.2	NA
6_A17060_25-02-2022	48	44	2.29	6.6	150	7	n	2.2	NA
6_A17062_25-02-2022	48	45	2.29	6.6	150	7	n	2.2	NA
6_A17063_25-02-2022	48	44	2.29	6.6	150	7	n	2.2	NA

alternate droppers and 2 kg weights

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	comments
4_A17048_23-02-2022	35	32	1.15	4.0	75	4	n	2.2	tdr after weight
4_A17059_23-02-2022	32	29	1.15	4.0	75	4	n	2.2	tdr after weight
4_A17065_23-02-2022	32	29	1.15	4.0	75	4	n	2.2	tdr after dropper
4_A17048_23-02-2022	35	32	1.15	4.0	75	4	n	2.2	tdr after weight
4_A17059_23-02-2022	32	29	1.15	4.0	75	4	n	2.2	tdr after weight
4_A17065_23-02-2022	32	29	1.15	4.0	75	4	n	2.2	tdr after dropper
4_A17049_23-02-2022	40	35	1.06	4.0	100	4	n	2.2	tdr after weight
4_A17061_23-02-2022	44	40	1.06	4.0	100	4	n	2.2	tdr after weight
4_A17069_23-02-2022	36	33	1.06	4.0	100	4	n	2.2	tdr after dropper
4_A17049_23-02-2022	40	35	1.06	4.0	100	4	n	2.2	tdr after weight
4_A17061_23-02-2022	44	40	1.06	4.0	100	4	n	2.2	tdr after weight
4_A17069_23-02-2022	36	33	1.06	4.0	100	4	n	2.2	tdr after dropper
4a_A17041_23-02-2022	27	25	1.31	4.0	50	24	n	2.2	tdr after weight
4a_A17050_23-02-2022	27	25	1.31	4.0	50	24	n	2.2	tdr after weight

hooks / no hooks

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	comments
8_A17041_26-02-2022	32	29	NA	3.3	75	4	y	2.2	NA
8_A17046_26-02-2022	30	27	NA	3.3	75	4	y	2.2	NA
8_A17050_26-02-2022	33	30	NA	3.3	75	4	y	2.2	NA
8_A17059_26-02-2022	31	28	NA	3.3	75	4	y	2.2	NA
8_A17061_26-02-2022	30	26	NA	3.3	75	4	n	2.2	NA
8_A17067_26-02-2022	27	24	NA	3.3	75	4	n	2.2	NA
8_A17068_26-02-2022	31	27	NA	3.3	75	4	n	2.2	NA
8_A17069_26-02-2022	31	27	NA	3.3	75	4	n	2.2	NA
8_A17044_26-02-2022	32	28	2.41	6.6	75	4	y	2.2	NA
8_A17054_26-02-2022	33	29	2.41	6.6	75	4	y	2.2	NA
8_A17057_26-02-2022	30	27	2.41	6.6	75	4	y	2.2	NA
8_A17070_26-02-2022	29	27	2.41	6.6	75	4	y	2.2	NA
8_A17060_26-02-2022	31	28	NA	6.6	75	4	n	2.2	NA
8_A17062_26-02-2022	31	28	NA	6.6	75	4	n	2.2	NA
8_A17063_26-02-2022	33	30	NA	6.6	75	4	n	2.2	NA

backbone diameter

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	comments
9_A17060_26-02-2022	37	34	2.06	4.0	75	2	n	3	NA
9_A17062_26-02-2022	37	34	2.06	4.0	75	2	n	3	NA
9_A17063_26-02-2022	39	36	2.06	4.0	75	2	n	3	NA
9a_A17067_26-02-2022	26	24	2.44	4.0	75	2	n	1.6	NA
9a_A17068_26-02-2022	29	26	2.44	4.0	75	2	n	1.6	NA
9a_A17069_26-02-2022	26	23	2.44	4.0	75	2	n	1.6	NA
9_A17044_26-02-2022	27	24	6.97	4.0	75	2	n	1.6	NA
9_A17054_26-02-2022	31	28	6.97	4.0	75	2	n	1.6	NA
9_A17057_26-02-2022	27	25	6.97	4.0	75	2	n	1.6	NA
9a_A17048_26-02-2022	29	26	2.24	6.7	75	2	n	1.6	NA
9a_A17061_26-02-2022	28	25	2.24	6.7	75	2	n	1.6	NA
9a_A17065_26-02-2022	27	24	2.24	6.7	75	2	n	1.6	NA
9_A17059_26-02-2022	36	32	2.26	6.7	75	2	n	3	NA
9_A17073_26-02-2022	36	32	2.26	6.7	75	2	n	3	NA
9_A17041_26-02-2022	26	23	10.38	6.7	75	2	n	1.6	NA
9_A17070_26-02-2022	28	25	10.38	6.7	75	2	n	1.6	NA

zebra-tech paired deployments

id	t_six	t_five	tension	speed	wt_m	wt_kg	hooks	b-bone	zebra_5	comments
6_A17052_25-02-2022	38	33	2.19	6.6	100	4	n	2.2	NA	not_turned_on
4a_A17068_23-02-2022	25	22	1.31	4.0	50	24	n	2.2	22	tdr after dropper
3_A17054_23-02-2022	33	30	1.52	4.0	50	3	n	2.2	27	NA
3_A17068_23-02-2022	53	46	1.55	4.0	150	3	n	2.2	50	NA
5_A17061_25-02-2022	26	24	2.45	6.6	75	5	n	2.2	24	NA
4_A17054_23-02-2022	48	44	1.2	4.0	150	5	n	2.2	42	NA
4_A17054_23-02-2022	48	44	1.2	4.0	150	5	n	2.2	42	NA
6_A17049_25-02-2022	26	23	2.46	6.6	75	7	n	2.2	24	NA
1_A17060_22-02-2022	31	28	1.37	4.0	75	2	n	2.2	26	NA
1_A17044_22-02-2022	20	18	1.37	4.0	50	4	n	2.2	18	NA
5_A17060_25-02-2022	19	17	3.18	6.6	50	4	n	2.2	18	NA
2_A17070_22-02-2022	26	24	NA	4.0	75	4	n	2.2	29	NA
2_A17235_22-02-2022	32	27	NA	4.0	100	4	n	2.2	NA	not_turned_on