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RESEARCH

Development of an adaptive management tool for line setting

**DRAFT Final report for MIT2018-03 prepared by Pisces Research Ltd and Fisheries
Inshore NZ for the Department of Conservation, Conservation Services Programme**

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To be cited as:

Middleton, D. A. J.; King, B., and Wilson, O. L. (2020). Development of an adaptive management tool for line setting. DRAFT Final report for MIT2018-03 prepared by Pisces Research Ltd and Fisheries Inshore NZ for the Department of Conservation, Conservation Services Programme. 26 p.

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EXECUTIVE SUMMARY

1. INTRODUCTION

Foraging seabirds are attracted to many of the baits used in longline fishing, and also to the fish caught. However, depredation of longline baits and catch items puts seabirds at risk of becoming caught on hooks or entangled in lines. Seabird captures during line setting are particularly problematic because, unless the bird is able to free itself, it will be pulled underwater by the sinking line and drowned.

Croxall et al. (2012) suggest that the issue of seabird bycatch in fisheries has only been apparent for about two decades. However, there is evidence that the issue was recognised prior to this (see, for example, Murray et al. 1992), and that captures in longline fisheries were anticipated to become more pervasive with the cessation of large-scale high seas drift netting in the 1990s (Manville 2005).

A range of technical and operational measures to mitigate seabird captures in longline fisheries were documented in the IPOA-Seabirds (FAO 1999), some of which had been proven to be effective whilst others were potential approaches of unknown effectiveness. Current measures to reduce captures during line setting remain primarily focussed on restricting seabird access to baited hooks during the period that these are within the diving range of birds.

Bentley et al. (2021) used time-depth recorders to study the diving behaviour of three albatross species breeding at Bird Island, South Georgia, noting that a number of studies had indicated that albatross diving depths reported from early studies using capillary depth gauges were likely overestimated and that more meaningful ecological conclusions could be drawn from devices that recorded complete depth profiles rather than just the single deepest dive during a deployment.

On the basis of their results and other recent studies, Bentley et al. (2021) concluded that:

- all three genera of small albatrosses (*Phoebetria*, *Thalassarche* and *Phoebastria*) undertake infrequent, short and shallow dives, reaching <1.5 m on average;
- many shearwaters are far more proficient divers, attaining mean maximum depths of 10–20 m, although the *Calonectris* shearwaters only dive to mean depths of 1–2 m;
- the *Procellaria* petrels are also proficient divers; with mean diving depths of around 3 m and maximum depths of 15–25 m.

In New Zealand, black petrels (*Procellaria parkinsoni*) are the species assessed to be at greatest risk from captures in commercial fisheries (Richard & Abraham 2020). Bell (2016) used time-depth recorders to collect dive data from 22 black petrels breeding on Great Barrier Island. While the deepest dive recorded was 34.3 m, the majority of dives were less than 5 m and dives to greater than 10 m were rare. Most dives were during the day and only males were recorded as diving at night.

Bell (2016) noted that Wanless and Waugh (2010) had indicated that if a vessel set lines

at a speed of 6 knots, with a line sink rate of 0.3 m s^{-1} , then 97% of hooks would reach depths of 10 m under a streamer line with an aerial extent of 100 m. While this result is indeed stated by Wanless and Waugh (2010), their Table 1 indicates that this result is only achieved if the setting speed is reduced to 3 knots, with only 49% of hooks expected to reach 10 m within a 100 m streamer line extent when setting at 6 knots.

Under the NPOA-Seabirds 2020, seabird bycatch mitigation in New Zealand fisheries combines regulatory and non-regulatory measures, applied on a vessel-specific basis (Fisheries New Zealand 2020). For bottom longlining, the regulated measures are currently defined by the Fisheries (Seabird Mitigation Measures–Bottom Longlines) Circular 2020¹ while regulated measures for surface longline fisheries are included in the Fisheries (Seabird Mitigation Measures–Surface Longlines) Circular 2019².

The Department of Conservation and Fisheries New Zealand have also documented ‘Mitigation Standards’ for bottom³ (BLL) and surface⁴ longlining (SLL) that aim to outline current best practice to reducing seabird interactions. These describe a series of standard practices (Mitigation Standards) necessary to achieve a number of desired outcomes, which are common across the two longline methods:

1. The discharge of fish waste from the vessel is managed so as not to attract seabirds to risk areas.
2. Seabirds are not able to access baited hooks during setting.
3. Seabird access to hooks during hauling is minimised.
4. The risk of deck landings or impacts against the vessel is minimised.

Line weighting and the use of streamer lines are included as mandatory measures for both BLL and SLL fishing. The mandatory measures take the form of input controls, detailing streamer line designs and the line weighting regime required. In contrast, the Mitigation Standards for bottom longlining take an outcome based approach to line sink rates, specifying that hooks set should be protected by the aerial extent of the streamer line until hooks have reached a depth of 5 m (outside of high-risk periods) or 10 m (during high risk periods).

In the Mitigation Standards for surface longlining a hook depth is only specified for vessels using hook shielding devices, which are required to remain in place until the hook reaches a depth of 10 m. For vessels that are not using hook shielding devices, vessels are directed to undertake line weighting.

In large vessel bottom longlining, line sink rates are frequently tested using bottle tests (Fenaughty & Smith 2001). The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)’s Conservation Measure 24-02⁵ requires that longlines sink

¹<https://gazette.govt.nz/notice/id/2020-go2290>

²<https://gazette.govt.nz/notice/id/2019-go5782>

³<https://www.mpi.govt.nz/dmsdocument/38009/direct>

⁴<https://www.mpi.govt.nz/dmsdocument/38018/direct>

⁵<https://www.ccamlr.org/en/measure-24-02-2014>

at a rate of at least 0.3 m s^{-1} , verified using either time-depth recorders (TDRs) or bottle tests. Wienecke and Robertson (2004, Table 2) list pros and cons of bottle tests and TDRs, ultimately expressing a preference for TDRs which they suggest provide more reliable and consistent data, and an electronic copy of the data from the test.

1.1 Objectives

The overall objective of project MIT2018-03 was to mitigate seabird bycatch by providing fishers with information on realised sink rates, promoting adaptive management through optimisation of mitigation practices during individual trips. The specific objectives were to:

1. deploy time-depth recorders routinely on surface and bottom longline sets to automate the collection of data on sink rates and soak depths;
2. develop a system to provide fishers with information summaries that allow the interpretation of these data in the context of seabird exposure to hooks;
3. assess variation in sink rates achieved across the fleet, the extent of between and within vessel variation and the association with fishing practices (such as the species targeted); and
4. assess the extent to which fishers make use of real-time information on sink rates to adapt their fishing practices when necessary.

The project began in 2019, with initial at-sea testing carried out in September 2019. Fleetwide deployment of the TDRs was impacted by the COVID-19 response in 2020, which prevented the shipping of devices to fishers and limited engagement with participants. Initial deployment and data collection timelines were extended to the end of 2020.

This final report details the technology deployed, summarises the data collected, and assesses the utility of the information for fishers and fisheries managers.

2. METHODS

2.1 Time-depth recorders

Many studies of longline sink rates, both internationally (for example, Wienecke & Robertson 2004) and in New Zealand (for example, Goad et al. 2010), have used time-depth recorders originally developed for deployment on marine mammals and diving birds. These are miniaturised devices that must be connected by cable to a computer to set up recording and to download data. While suitable for research projects supervised by a technician, these devices are generally unsuitable for routine deployment on fishing gear.

This project opted to use Zebra-Tech Wet Tags⁶, which are robust, low-cost depth and temperature loggers, designed specifically for deployment on fishing gear, and which operate automatically to record and offload data. Wet Tags have a battery life of 5–10 years, and the batteries can be replaced by the manufacturer. The accuracy of depth data is stated as +/- 1% of the full depth range or better, with temperature accuracy +/- 0.1°C. For this project, the Wet Tags used were rated to 150 m.

Standard Wet Tags record average depth and temperature at a fixed interval, typically two minutes. For this project, a new version of the Wet Tag firmware (WetTag BLE - Line Speed Version 1.xx) was developed to log these parameters at a 5 s interval (the depth sensor sampling interval) whenever the tag was at depths shallower than 20 m.

Data logging by the Wet Tags is triggered by immersion; the tags begin recording automatically after immersion to a trigger depth of 1.2 m for a period of 30 s. The use of a trigger depth and delay is designed to prevent the tags from being activated at the surface by changes in atmospheric pressure.

The tags remain active for 2.5 minutes after the end of a dive event, during which time a bluetooth connection can be made to download the data. If the data is not downloaded immediately after retrieval, the tags must be reactivated by immersion to the trigger depth.

An initial batch of ten Wet Tags was supplied for testing; these tags were configured with an attachment plate (Figure 1). The main batch of ninety tags supplied to fishing vessels for operational use had a revised format with an attachment eye as part of the moulded sensor housing (Figure 1).

The original Wet Tag firmware was also updated after initial testing to improve memory use, following a problem where some tags became unable to communicate with the data download app.

⁶<https://www.zebra-tech.co.nz/wet-tag-data-collection-fisheries/>



Figure 1: The original (left) and revised (right) Wet Tags, with a one dollar coin for scale.

2.2 Deployment schedule

The project aimed to recruit nine bottom longline and nine surface longline vessels. For each fishing method, six vessels were supplied with three tags each and three vessels with nine tags. Vessels were asked to deploy all available sensors on each line set, with the expectation that the sets with nine sensors would provide additional information on within-set variation in sink rates.

2.3 Wet Tag data retrieval and submission

Fishers were asked to download data from the Wet Tags after retrieval using the Zebra-Tech BLE⁷ app. This is currently available for both Android⁸ and iOS⁹ smartphones and tablets.

During the initial testing phase of the project it was necessary to manually scan for devices ready for data offload by pressing a button in the app (Figure 2a). However, a revision to the app was available for the main deployment of Wet Tags to the fleet; this provided an 'auto-offload' mode (Figure 2b) that continually checked for newly retrieved Wet Tags and downloaded these automatically when they were discovered.

Each download of a Wet Tag resulted in a CSV data file on the device (Figure 3a). Files were initially submitted to the project using the 'share' function of the Zebra-Tech BLE app (Figure 3b) to send the files by email (Figure 3c).

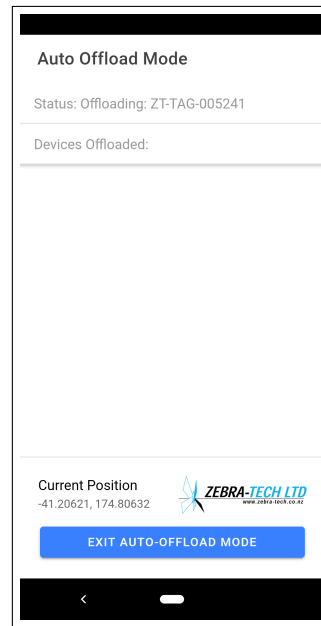
⁷Bluetooth Low Energy

⁸<https://play.google.com/store/apps/details?id=com.zebratech.zebratechble>

⁹<https://apps.apple.com/nz/app/zebra-tech-ble/id1338544188>



(a) Alternative download modes



(b) Automatic Wet Tag download

Figure 2: The Zebra-Tech BLE app provided the ability to manually scan for Wet Tags, or to enter an auto-offload mode that continually scanned for devices.

In the latter part of the project a separate app, Demitto, was introduced to assist with data transfer. The app automatically discovers Wet Tag data files that have been downloaded using the Zebra-Tech BLE app (Figure 4a) and submits these to the project server (Figure 4b). In addition, the Demitto app allows data to be submitted from multiple vessels (Figure 5) and provides access to the processed data summaries (Figure 6).

2.3.1 Data download via Deck Units

During the course of the project, Zebra-Tech developed a new temperature and depth profiling sensor for the Moana Project¹⁰, which is focused on using fishing vessels as vessels of opportunity for the collection of oceanographic data.

On a number of vessels, the Moana TD sensors¹¹ are automatically downloaded by a deck unit which then transmits the data autonomously to the project servers. In collaboration with the Moana Project, the deck units were configured to additionally download and forward data from Wet Tags.

One vessel participated in both the Wet Tag based sink-rate project and the Moana Project and tested this mechanism of data download and submission.

¹⁰<https://www.moanaproject.org/>

¹¹<https://www.zebra-tech.co.nz/moana/>

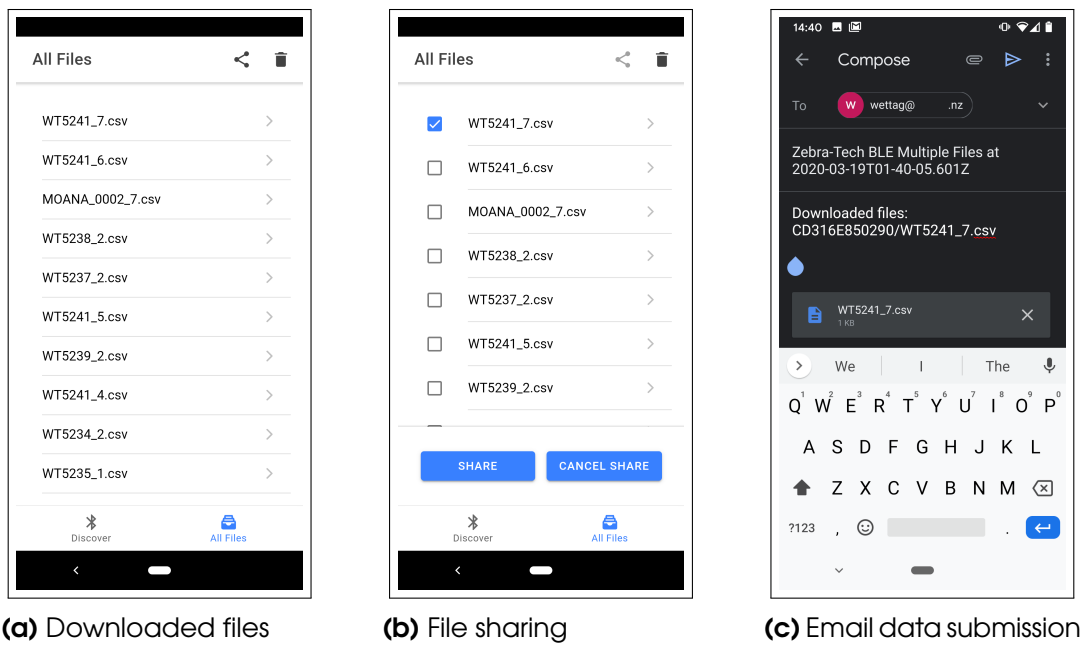


Figure 3: Submitting data by email from the Zebra-Tech BLE app.

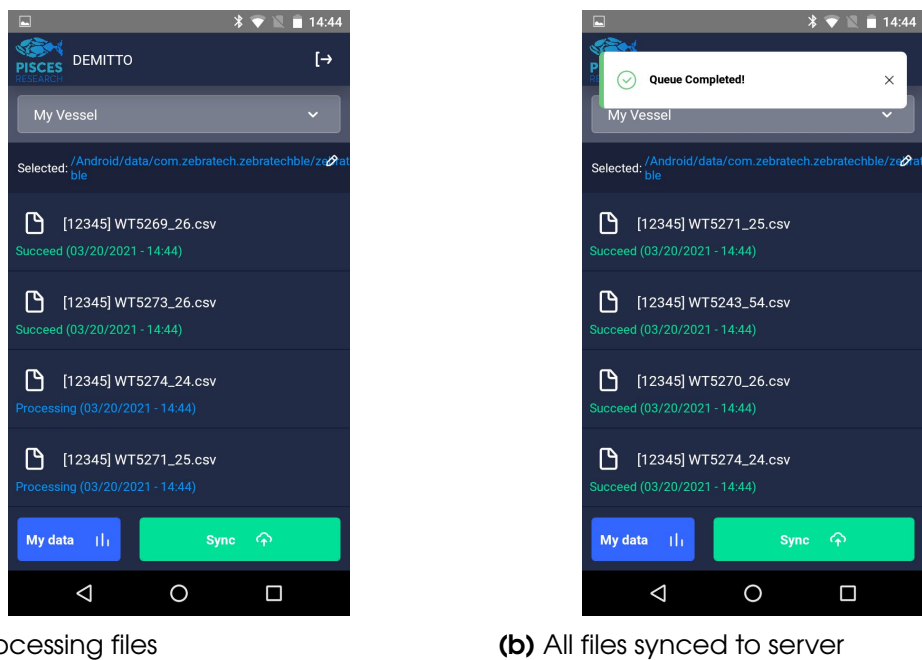


Figure 4: The Demitto app automatically discovers Wet Tag data files and submits these to the project server.

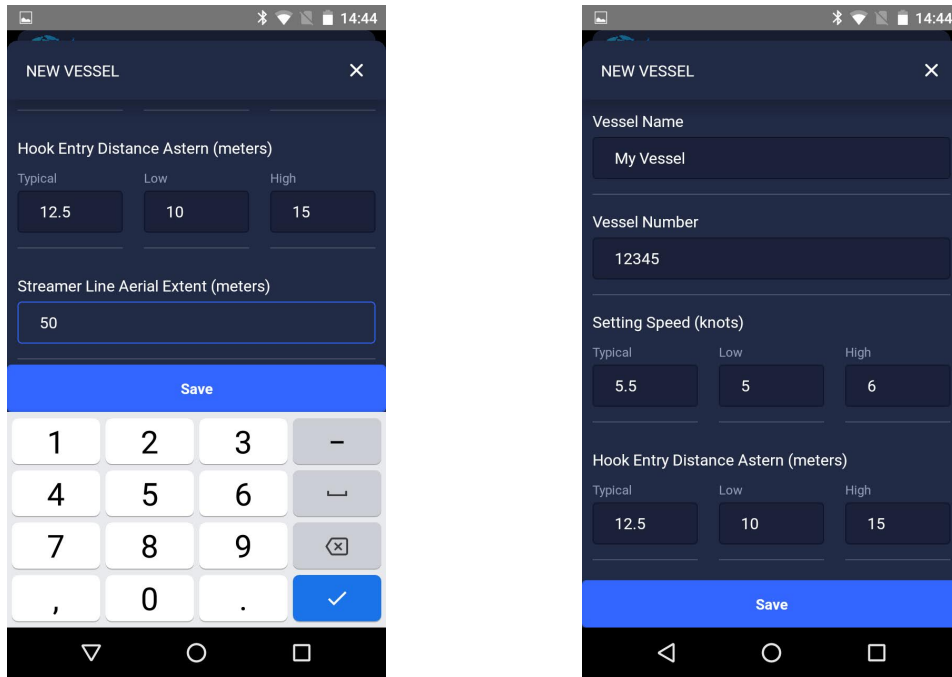


Figure 5: Setting up vessel information in the Demitto app.

Vessel	Set ID	Start	End	Sensors
	141	14 Sep 2020, 07:00	14 Sep 2020, 12:20	3
	143	15 Sep 2020, 07:23	15 Sep 2020, 12:03	2
	146	16 Sep 2020, 07:41	16 Sep 2020, 12:53	3
	159	22 Sep 2020, 07:31	22 Sep 2020, 09:57	3
	163	29 Sep 2020, 06:28	29 Sep 2020, 11:15	3
	175	13 Oct 2020,	13 Oct 2020,	3

Figure 6: The 'My data' button in the Demitto app provided access to set-by-set summaries of the Wet Tag data.

2.4 Wet Tag data processing

Wet Tag data received from vessels by email, the Demitto app, or the Moana deck units was automatically on receipt. This involved a series of steps:

1. The individual CSV files were read and the header and data blocks contained within each file were separated. The header block contained metadata about the tag, its deployment history, and the download event, whilst the data block consisted of time-stamped depth and temperature readings accumulated since the preceding download.
2. The sensor data were associated with a particular vessel, based on the email address from which the data were submitted or metadata available from Demitto app submissions.
3. The data from each sensor were processed to identify tag deployments. Deployments were identified by temporal breaks in the sequence of data from a sensor, representing periods where the Wet Tag stopped logging after retrieval. Deployments less than 800 s or which did not exceed a depth of 5 m were dropped, as these typically represented instances where the tag was briefly submerged to facilitate data download, or other testing.
4. Deployments of sensors from a vessel were grouped based on overlapping deployment time ranges, in order to identify groups of sensors that were deployed on the same longline set.
5. Wet Tag deployment groups were matched to the statutory catch-effort data in order to gain information on the fish species targeted during a set.

2.4.1 Initial sink rate

For each Wet Tag deployment, the initial setting phase was identified. This was defined as the period at the start of the deployment during which depth and time were logged at 5 s intervals (i.e., until the tags reached a depth of 20 m). The mean sink rate was then calculated over all records in the initial setting phase where depths were less than or equal to 10 m.

2.4.2 Estimating hook depth at end of streamer line coverage

An estimate of the depth of baited hooks as these pass beyond the area protected by the streamer line is potentially the most useful metric to provide to fishers to assist them in adapting their line setup and setting processes.

For a streamer line with an aerial extent of 50 m, and a setting speed of 5 kn (2.57 m s^{-1}), an object deployed from the stern of the vessel will be within the aerial extent of the streamer line for 19.4 s. Hooks deployed on longlines will be in the air for a short distance behind the vessel; if this distance was 5 m then, for the same parameters as the previous

example, the hooks would be in the water for 17.5 s while within the aerial extent of the longline.

In mathematical form, the covered sink period c (in seconds) is given by:

$$c = \frac{e - o}{v} \quad (1)$$

where e is the aerial extent of the streamer line, o is the distance behind the vessel where hooks enter the water, and v is the setting speed of the vessel in metres per second. The depth reached by hooks by the time they reach the limits of the streamer line coverage is

$$d = cs \quad (2)$$

for depth, d , in metres and a mean sink rate of s metres per second.

On each vessel deploying Wet Tags, the skipper (or vessel operator) provided an estimate of:

- typical setting speed, v , and the minimum, v^- , and maximum, v^+ , settings speeds likely to arise in their normal fishing (estimates were given in knots);
- the typical distance astern of the vessel where the hooks entered the water, o , and the minimum, o^- , and maximum, o^+ , distances likely to arise; and
- the aerial extent, e^v , achieved with their streamer line.

The minimum aerial extent for streamer lines as specified in any relevant regulations, e^r , was also considered.

The ‘best estimate’ of hook depths at the end of streamer line coverage, was calculated by using the vessel estimates of v , o , and e^v in equations 1 and 2, while minimum and maximum depths were estimated by substituting v^+ and o^+ , and v^- and o^- respectively. Likewise the depth achieved at the minimum statutory extent of the streamer line was estimated by substituting e^r for e^v .

2.5 Standard graphics provided to fishers

Data from Wet Tags were compiled into standard graphics for distribution back to fishers. For each set, a four panel data display was provided that summarised information from all sensors deployed on the set (Figure 7).

The plot elements, as numbered in Figure 7, were:

1. A title identifying the vessel, the date of the set, and the time range for which sensor data were available.

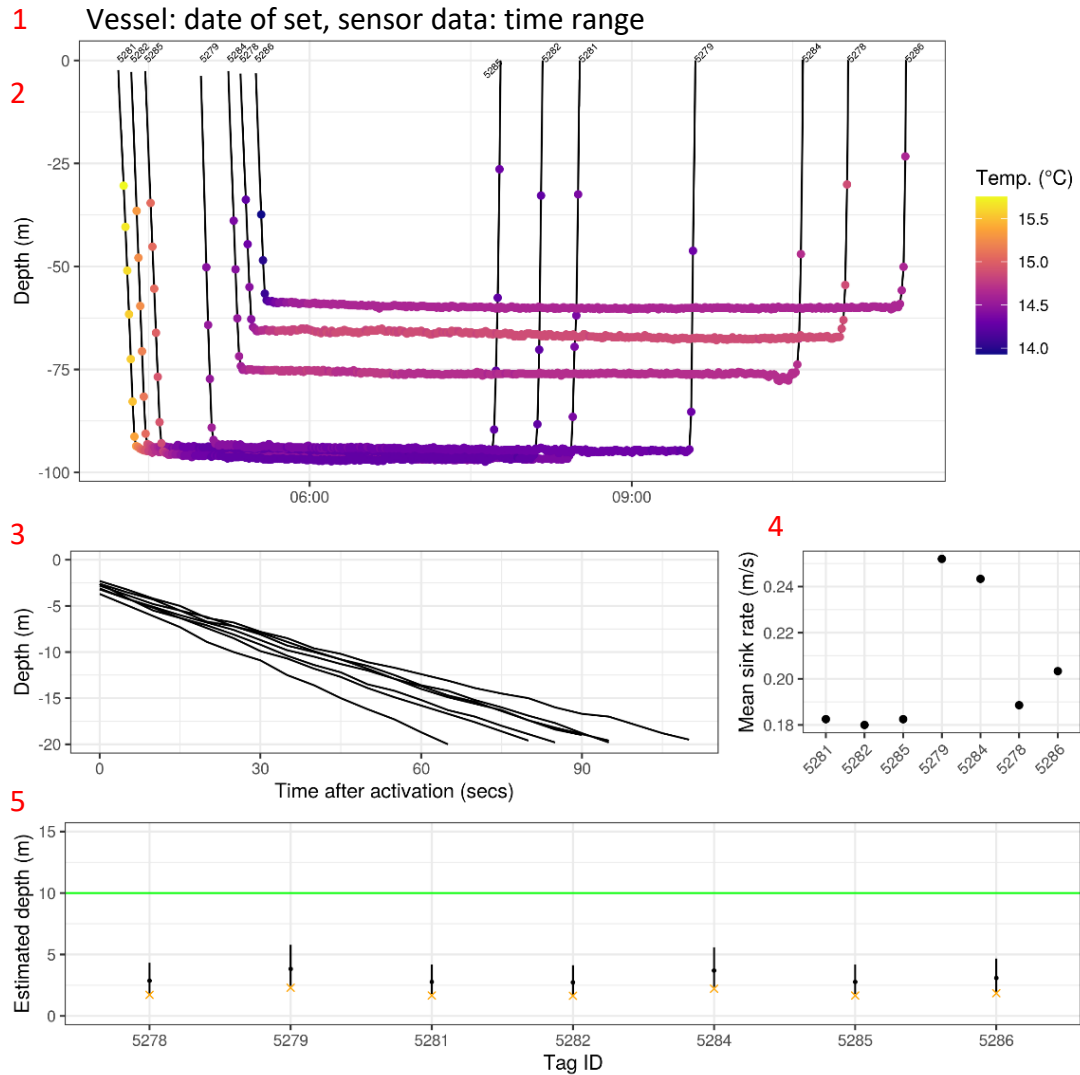


Figure 7: The set-by-set presentation of Wet Tag data provided to participating fishers, with the key areas annotated (see text for details).

2. A plot showing time/depth/temperature profiles for each sensor deployed on the line. Time and depth were indicated by the black line while temperature measurements were shown by the coloured points. Temperature measurements were only shown for depths greater than 20 m, when the sensor has a one-minute interval between data points. The temperature sensor in the tags has a slow response time and so the temperature data collected at shallower depths, when the sensor is recording at a 5 s interval, are not expected to be accurate.
3. A plot showing time-depth profiles for each tag from the time it started recording until it reached a depth of 20m. This is the high-resolution data collection phase when points are collected at a 5 s interval to allow sink rates to be calculated.
4. The plot to the right of the middle row showed the mean sink rate calculated for the deployment phase of each tag profile, restricted to data collected at depths up

to 10 m.

5. A plot showing the estimated depth of hooks at the limits of streamer line aerial extents. The black points indicated the best estimate of depth using the skipper or vessel operator's estimate of the aerial extent achieved by the streamer line, the typical setting speed, and line entry distance astern of the vessel. The black line indicated the potential range on the depth estimate, using the minimum and maximum setting speeds and line entry distances. The orange cross indicated the estimated depth for the typical setting parameters, but with the minimum statutory aerial extent for the streamer line.

For each vessel, operators could also view a plot summarising estimates of the hook depth at the end of the streamer line over time; in these graphics the best estimate of hook depth at the end of the streamer line from each sensor was summarised as a per-set boxplot (Figure 8).

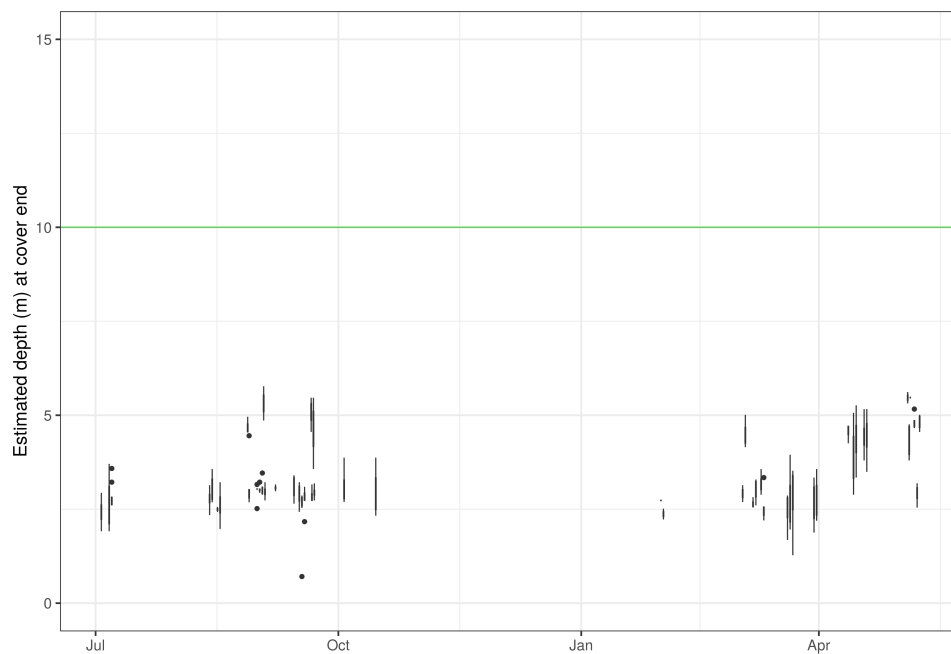


Figure 8: Example of a summary graphic showing per-vessel estimates of hook depth at the aerial extent of the streamer line, over time.

3. RESULTS

Initial testing of the Wet Tags for sink rate measurement was reported by Middleton et al. (2020a). This comprised testing of tag deployments from a local wharf and two trips undertaken by project staff when the initial batch of Wet Tags configured for sink-rate measurement was tested on a bottom longline vessel.

The at-sea testing indicated that, while the Wet Tags reliably recorded line profiles, the tags did not start logging until they had reached a depth of around 5 m, sometimes deeper. On the second trip, Wet Tags were deployed alongside higher-resolution, continuously logging TDRs. The resulting data suggested that assuming the line sinks at a constant rate was appropriate.

3.1 Uptake

Wet Tags were dispatched to the operators of nine bottom and nine surface longline vessels as envisaged by the deployment schedule. However, data were ultimately received from fewer vessels (Table 1).

A total of 1034 individual Wet Tag deployments were identified in the submitted data from 288 individual line sets, of which 264 were matched to the statutory catch-effort data.

Most of the bottom longline sets were from snapper target fishing on the east and west coasts of the northern North Island (Table 2). All the surface longline effort was targeting southern bluefin tuna, but included fishing off the east coasts of both the North and South Islands (Figure 9).

Table 1: Number of participating vessels, by fishing method. BLL indicates bottom longlining and SLL is surface longlining.

Fishing method	Vessels returning data
BLL	6
SLL	2

Table 2: The fishing method and target species for longline sets with Wet Tag deployments, matched to fishing events in the statutory catch-effort data.

Fishing method	Target species	Number of sets
BLL	GUR	1
BLL	RSN	5
BLL	SNA	193
SLL	STN	62

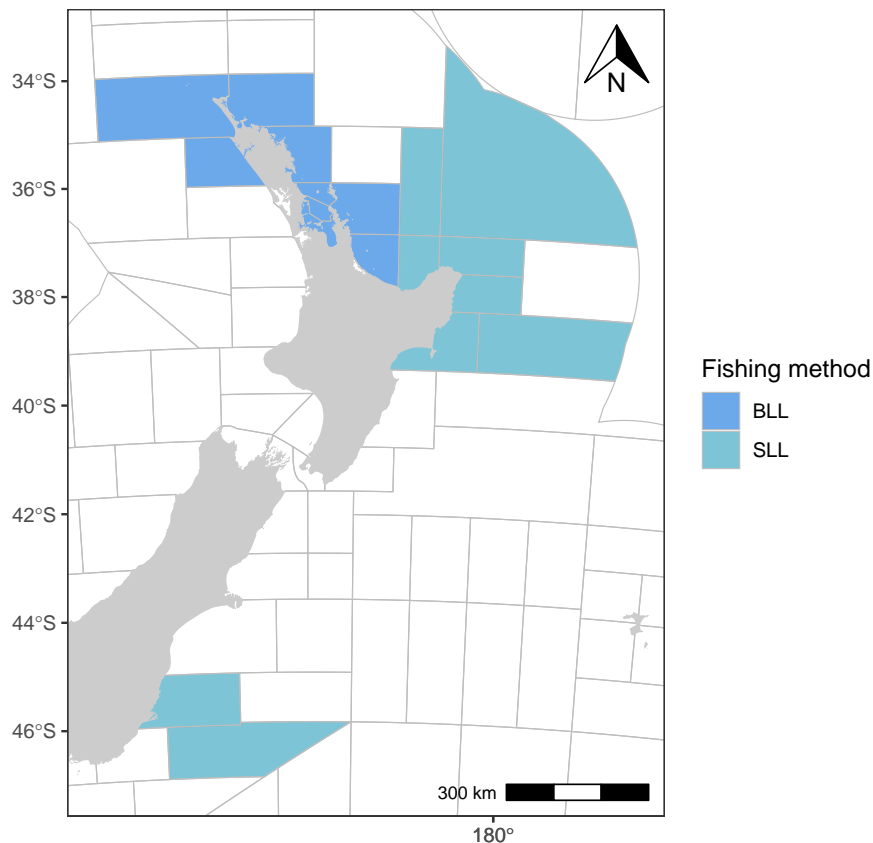


Figure 9: Statistical areas with sink rate data from bottom and surface longlining.

3.2 Recorded sink rates

Sink rates were able to be calculated for 953 deployments where sufficient data points were logged in the top 10 m of the water column.

In general, the line sink rates recorded from surface longline vessels were slower than from bottom longline vessels (Figure 10). The typical sink rates achieved by different bottom longline vessels varied by a factor of around two, although within-vessel variation was substantial.

Differences in sink rate were reflected in the estimated depths of hooks at the aerial extent of the streamer line (Figure 11), with median estimated depths for bottom longline vessels ranging from 3 m to 5.2 m. For the two bottom longline vessels that returned the greatest volume of data, there is an indication that the sink rates achieved vary with the depth in which the line was set with slower sink rates when setting in deeper water (Figure 12).

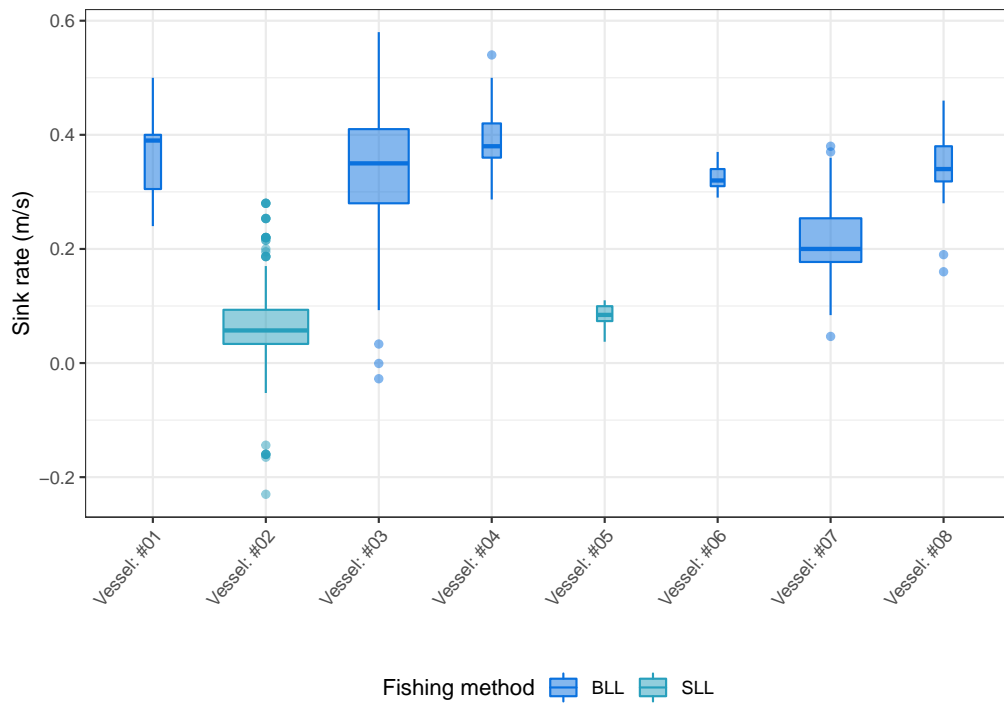


Figure 10: The distribution of mean sink rate to 10 m depth, by vessel. Boxplot widths are scaled to the square root of the number of Wet Tag deployments recorded from a vessel.

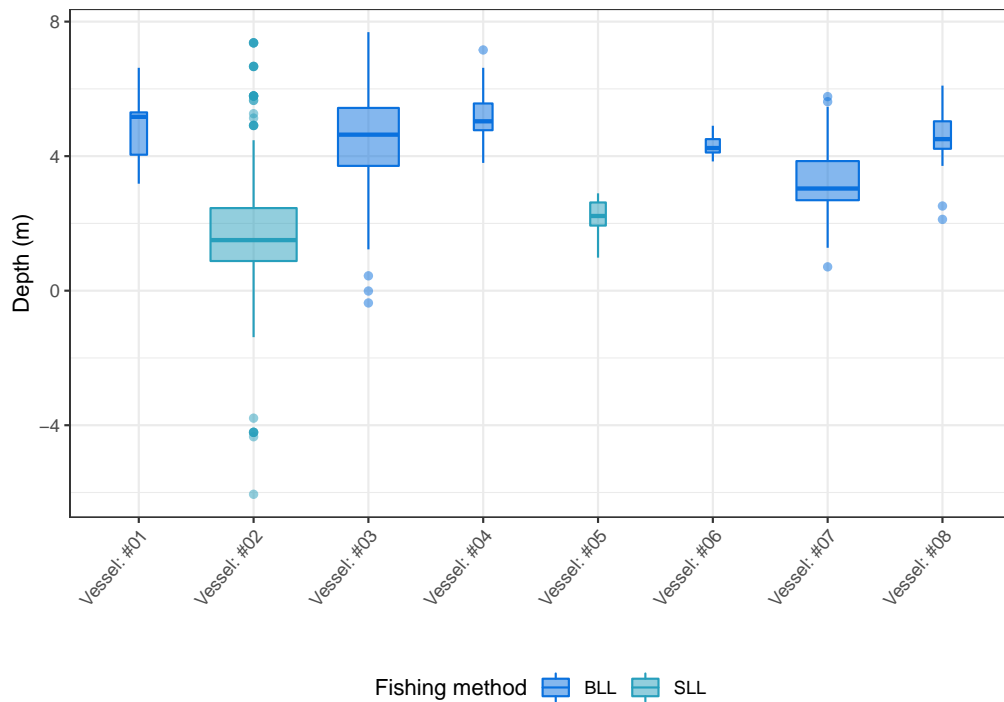


Figure 11: The distribution of estimated hook depths at the aerial extent of the streamer line, by vessel. Boxplot widths are scaled to the square root of the number of Wet Tag deployments recorded from a vessel.

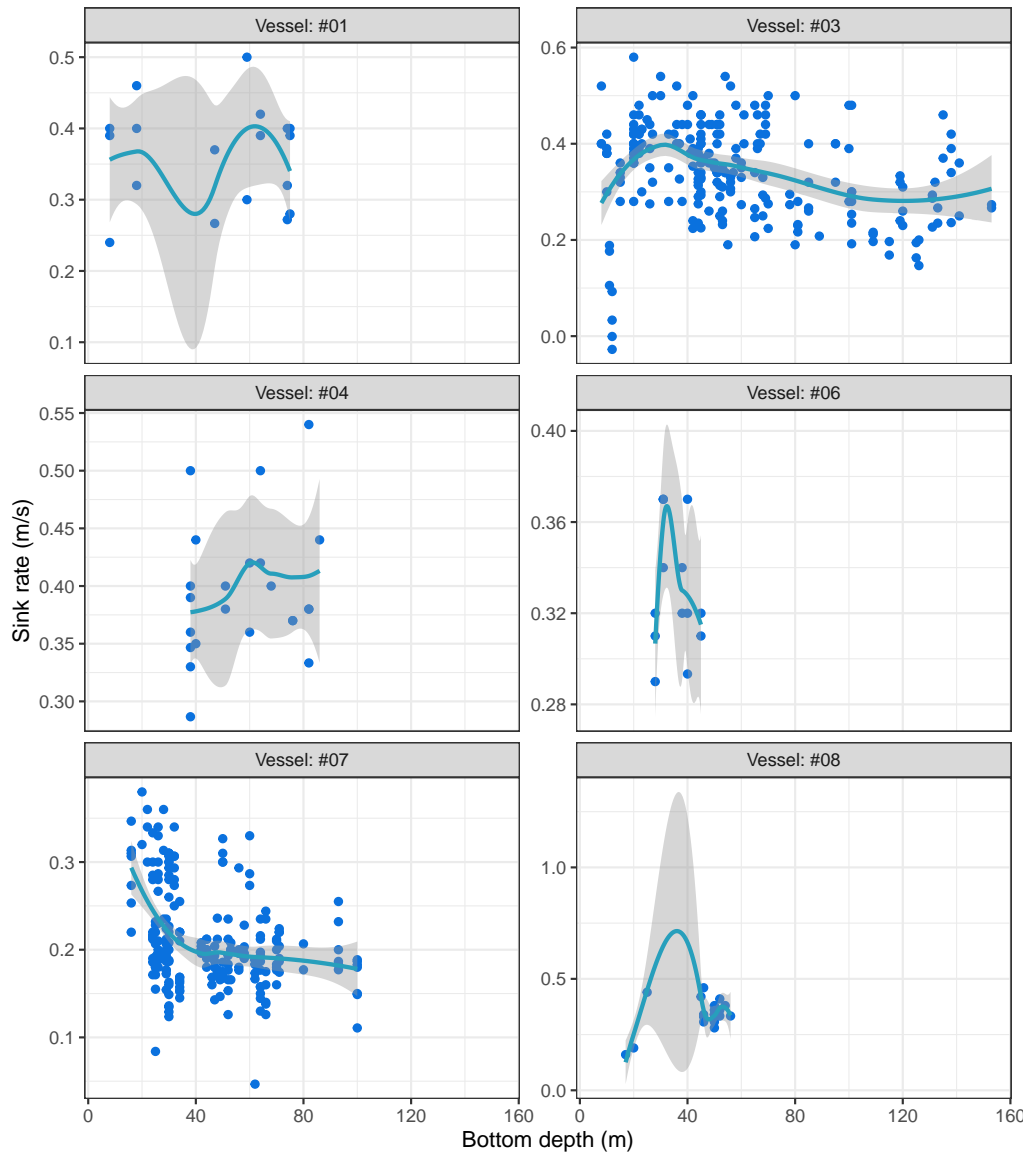


Figure 12: The relationship between mean sink rate to 10 m depth and reported bottom depth of the set, for the participating bottom longline vessels.

Wet Tags were deployed in the bottom longline fishery attached by short rope tethers to standard clips. Thus the Wet Tags essentially sank at the same rate as the backbone, and the same assumption applies to baited hooks. For BLL, snoods are short and so this assumption is reasonable. However, in the case of SLL snoods are longer and are initially cast from the vessel, with hooks sinking freely to a depth determined by the snood length, before transitioning to sink at the same speed as the backbone.

Initially surface longline fishers opted to deploy the Wet Tags on snoods without baited hooks, due to a concern over sensor loss due to 'bite offs'. However, this implies that the initial sink rate will be the sink rate of the Wet Tag, which may differ from that of a baited hook. Therefore, in the 2021 season, SLL fishers were encouraged to deploy snoods with Wet Tags and with/without baited hooks. The increased sink rate due to the baited hook is evident in density plots of sink rate from the two seasons (Figure 13).

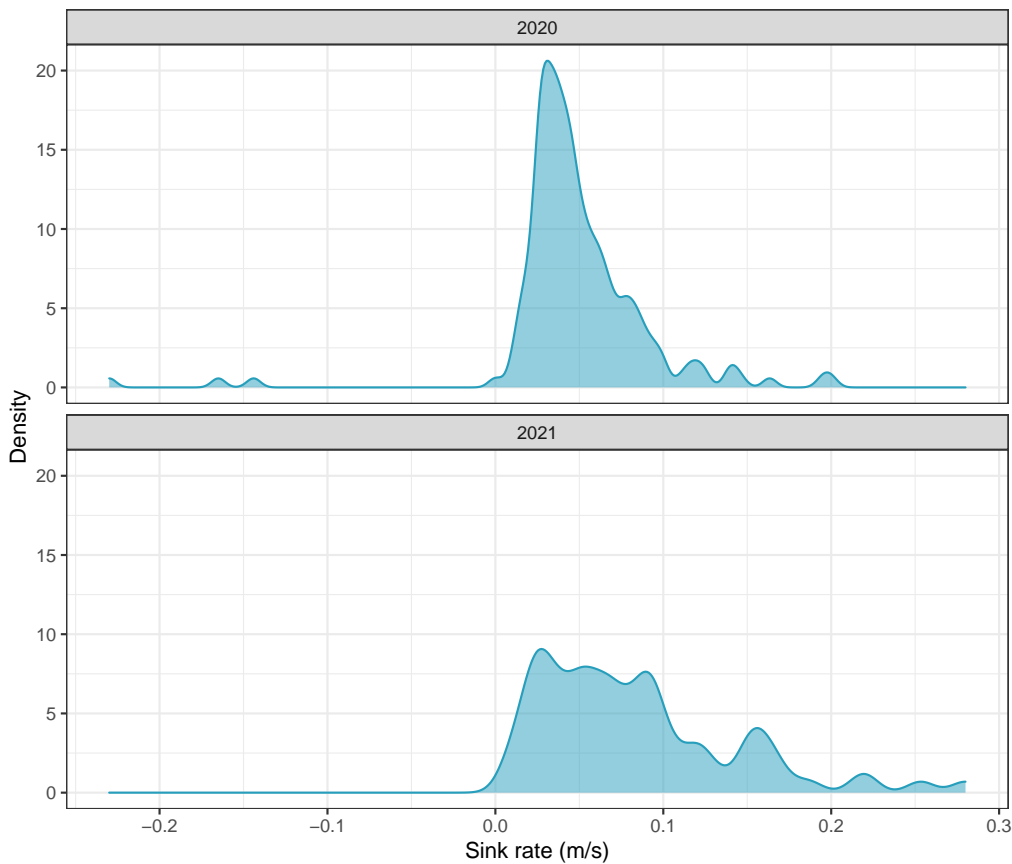


Figure 13: The distribution of mean sink rate to 10 m depth, for Wet Tags deployments on sets with and without fisher-reported seabird captures.

Seabirds were reported captured on three bottom longline sets and one. Given the low number of events, any conclusions are necessarily tentative but Wet Tags deployed on bottom longline sets with seabird captures tended to be at the lower end of the range of recorded sink rates (Figure 14).

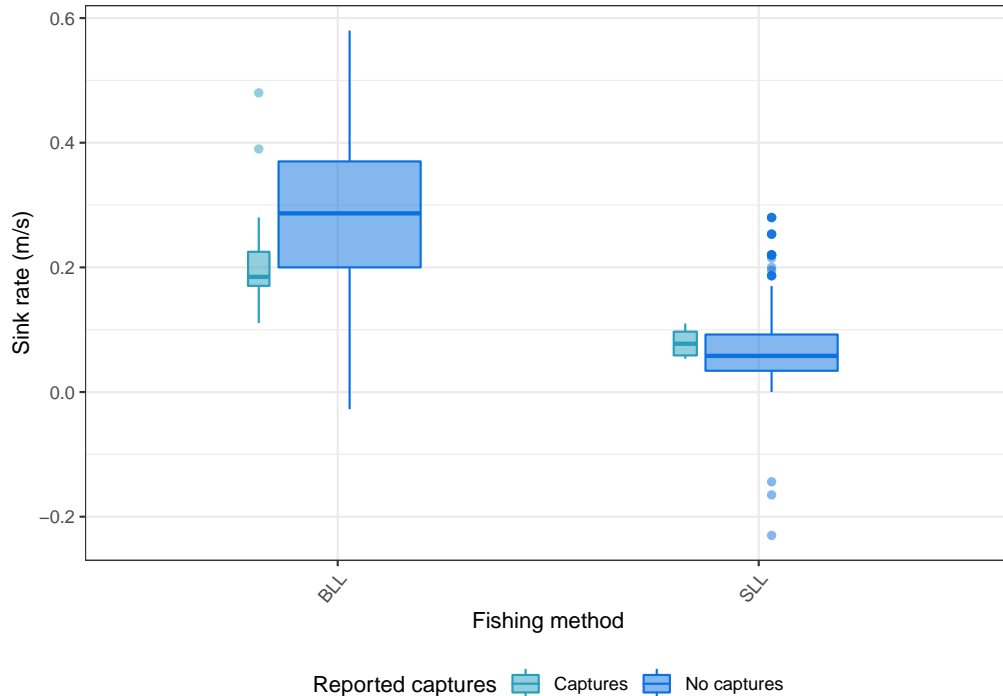


Figure 14: The distribution of mean sink rate to 10 m depth, for Wet Tags deployments on sets with and without fisher-reported seabird captures.

3.3 Fisher feedback

At the end of the project, debriefs with participants aimed to gather feedback on the value of the project and the challenges encountered. Discussions were guided by the following questions:

- Did you find the Wet Tags useful?
- Do you feel that knowing the actual sink rates of your gear would make you change the sink rates?
- Did you add weight/take weight away/adjust setting speed as a result of knowing your sink rate? If not, why not?
- What were the biggest challenges in using the Wet Tags?
- How did you find connecting the Wet Tags to your phone?
- How did you find using the app?

- How did you find sending the data?
- Did you find the way the sink rates were presented informative?
- What is your key recommendation for improving the Wet Tag programme?

Three participants (one SLL skipper and two BLL vessel managers) have provided the majority of the feedback; their views are those of the most engaged participants in the project and so do not reflect the views of those vessel operators that were provided with Wet Tags but ultimately did not submit any data.

In general, the active participants were enthusiastic about the project and the information generated. They recognised the importance of data that verified/checked their gear performance, but were more focussed on detecting longer term drift in performance away from the expected norms (e.g. due to crew changes) than set-by-set modifications. On the water changes in weighting regime are already made in response to known seasonal variations in risk of seabird interaction, and in response to observed seabird behaviour. One participant was strongly in favour of continued use of TDRs rather than bottle tests, noting that the latter were considered unreliable in the conditions prevailing in the inshore BLL fishery.

The Wet Tag data is primarily seen as useful in confirming that the expected gear performance is maintained, although it would be expected to be used more intensively in any situation where gear modification or initial setup to meet a performance standard was required. Vessels managers have noted between trip differences in sink rates from the Wet Tag data to-date and have used these as a basis for discussions with crew.

In addition to the data from the initial line sink phase, the active participants reported that the depth and temperature profiles from the whole set were useful.

With one exception, participants found data download and submission challenging. The challenges included:

- compatibility issues that limited the platforms where the apps functioned (e.g. the Zebra-Tech BLE app was unable to function on recent iOS devices for most of the project);
- varying familiarity with the required smartdevices. For example, one fisher did not use a smartphone, while others were more basic users. One skipper, while a highly competent smartphone user, found the 'auto-offload' function of the Zebra-Tech BLE app too intrusive. It required to be in the foreground to be operational, and was therefore interrupted by incoming calls etc.;
- maintaining the engagement of the crew that might be best placed to download data using the apps, but not key users of the data. In one case, the vessel manager chose to download the data periodically from vessels, rather than delegate this task to crew.

Overall, the feedback indicated a strong desire to see the data download and submission process improved, both for any continuation with current participants and any expansion of the programme. Investing in improving and 'beta' testing a new download regime was recommended as a key next step for the programme. Autonomous download as sensors are retrieved (removing the need for any later sensor re-activation to download) and automatic data submission were strong recommendations.

Improvements in the data collection regime would provide the opportunity for a renewed focus on the best approaches for presenting near real-time data summaries back to vessel operators. One operator noted the need to be able to correct the parameters used in calculating expected hook depths. While the Demitto app provided the opportunity for different settings to be configured, autonomous download generally does not provide the opportunity for these to be entered on a set-by-set basis, and it was suggested that an interactive interface should be provided for these to be corrected subsequently.

The BLL fishery participants, in particular, noted the need to obtain representative data across the fleet which would entail expanding the programme to other fishers, including those not normally at the forefront of new data collection initiatives.

4. DISCUSSION

The Wet Tag programme successfully put robust time-depth recording technology into the hands of fishers for routine use in fishing operations. Uptake and participation in the programme was lower than anticipated due, at least in part, to the impact of the COVID-19 response in 2020 which limited interactions with participants, and disrupted their fishing operations requiring a focus on re-defining their normal business at the expense of involvement in new initiatives. However, the active participants in the programme have been generally positive about the technology, valuing the data summaries and the fact that these provide rich information about time/depth profiles rather than simply verifying initial sink rates.

The key technological challenge for the programme has been data download and submission. Initial problems with the sensor firmware that led to difficulties in communicating with the Wet Tags were identified and addressed, but variations in the hardware and operating system software of the smart devices used for app downloading persisted throughout the project. Automatic and autonomous download of Wet Tags was tested on one vessel, as an additional development in the capabilities of Deck Units deployed for the Moana Project. This was largely successful, although did limit the ability for fishers to input different parameters relevant to estimation of hook depths. Improvement of the data download and transmission process is a key requirement for continuation or expansion of the programme.

Feedback on the data summaries compiled from the Wet Tag data submissions was positive. Estimation of hook depths at the limits of the streamer line aerial coverage required fishers to supply estimates of setting speed, streamer aerial coverage, and line entry point astern of the vessel. For the most part these were constructed using fixed estimates of these parameters, albeit with ranges on setting speed and the distance astern that the line entered the water. The Demitto app provides the opportunity for these parameters to be updated by fishers as part of the data submission process but, given the clear preference for autonomous data retrieval in future, other mechanisms for setting these parameters need to be considered. In the case of setting speed, the vessel tracking data from the statutory Geographic Position Reporting (GPR) system¹² would probably provide the best option for calculating setting speeds on a set-by-set basis. Another option is to allow fishers to enter these parameters retrospectively; this would also provide the opportunity for the outputs to be used in an exploratory manner.

A disadvantage of the Wet Tags for measuring initial sink rate is the delay in the start of data logging imposed by the trigger depth/time approach. The consequence of this delay has been investigated by logging parallel data from a number of sets using high-resolution TDRs with logging manually initiated when the units are still on deck.

<Further discussion of recent comparative results to go here>

<Tag placement on SLL and BLL; tag loss from baited snoods vs adjustment to sink rate>

<Positioning of multiple tags on a line>

¹²<https://legislation.govt.nz/regulation/public/2017/0155/latest/DLM7330540.htm>

This project used tags that were rated to depths of 150 m. There is a trade off between maximum depth rating and the resolution of the data available from the sensors; the decision to use 150 m rated sensors was made in order to provide the highest resolution data possible, while accepting that this would limit the target fisheries that could be investigated. For example, bluenose target bottom lining was not able to be included because a significant part of the bluenose target effort is in depths below 150 m.

The selected depth rating was found to be a problem for the Wet Tags deployed in some surface longline sets. Although the target fishing depths were shallower than 150 m, some parts of the line with attached sensors went on 'excursions' to deeper depths as a result of the catch of fish (possibly blue sharks) that dived when they became hooked. The pressure sensors in two Wet Tags were overpressurised and damaged by this process. A 250 m rated tag has been sourced and will be tested in the SLL fishery, with the aim of determining whether the resolution of the resulting data is still adequate for estimating initial sink rates.

4.1 Summary of recommendations

1. Continue the deployment of Wet Tags (or similar robust, fisher-friendly TDRs, ideally with reduced trigger delays) to provide vessel operators with ongoing information on line setting speeds.
2. Hold method-specific fisher workshops to share results to-date and secure ongoing engagement, including from the sectors of the fleet that have not participated.
3. Focus on autonomous data retrieval solutions for both current and additional participants.
4. Consider use of statutory GPR data for estimating setting speeds on a set-by-set basis.
5. Adopt standardised approaches for deployment of Wet Tags in BLL and SLL fisheries.
6. Provide fishers with interactive tools for exploring the impacts of different parameters (i.e. sink rate, setting speed, distance astern, streamer line aerial extent, gear setup) on the hook depths achieved within the streamer line coverage.
7. Further investigate the relationship between line entry point astern of the vessel and weighting regime.
8. Continue to work with fishers to refine the reporting of sink rate results in a manner that supports best practice vessel operations. Potentially include baseline gear testing and trip-by-trip monitoring for deviations from expected performance, rather than set-by-set feedback.

5. ACKNOWLEDGEMENTS

This work was funded by the Department of Conservation's Conservation Services Programme project MIT2018-03. Fisheries New Zealand supplied the statutory data that was linked to the Wet Tag deployment information. We are grateful to the participating fishing companies and skippers. The contributions of Darrin Fabricus, Mike Te Pou and Zak Olsen were particularly notable. Feedback from members of the CSP Technical Working Group, especially Igor Debski and Dave Goad was helpful in refining the use of the Wet Tag data. Additional testing of multiple TDRs by Dave Goad, funded by the Department of Conservation, was valuable in determining the limits of the Wet Tag data.

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