Setting mitigation for small longline vessels

Development of an Adaptive Management tool for line setting

A collaboration between Fisheries Inshore New Zealand and the Department of Conservation

Introduction

The small vessel surface and bottom longline fisheries contribute to the risk faced by several seabirds from commercial fishing activity. There is continued effort from the commercial fishing industry to mitigate impacts and reduce risk to seabirds. As part of the process of continued approval, further developments are being looked at to build on the toolbox of measures available to fishers.

Ensuring that baited hooks sink below the depths at which seabirds forage is a key mitigation strategy in longline fisheries. Regulated mitigation regimes often take a “one size fits all” input-based approach to specifying how lines must be configured to mitigate bycatch. However, actual sink rates are variable due to a variety of factors such as oceanographic conditions, vessel fishing practices, and target species.

Further understanding sink rates is important in order to provide fishers with set by set feedback on sink rates achieved, promoting real time adaption of fishing practices to achieve recommended rates. Fisheries Inshore New Zealand (FINZ) and the Department of Conservation (DOC) initiated this project to deploy time/depth recorders (TDRs) to provide close-to-real-time information to vessel operators on the sink-rates of their longline gear. We are using a model of TDR made by Zebra-tech called a Wet Tag (Figure 1). The use of different techniques to record sink rates is not unique. The unique differentiating aspect of this project is the development of data collection techniques that facilitate real time feedback loops. This will enable adaptive management on the water by fishers to make data-informed operational decisions to reduce risk within a trip.

Figure 1: Current Zebra-tech Wet Tag design.

These Wet Tags are attached to longline gear, record time and depth, and then, upon haul-back, transmit that data back to a smart device wirelessly. We are developing an algorithm that can be programmed into an app that would then process this data and present the information back to the fisher. Developing a user-friendly interface for presenting time and depth data will provide fishers real-time information on their gear and how it is operating with scientific observations, allowing the fisher to adapt efficiently and effectively in a way that best suits their unique operation.

Key players and roles

Department of Conservation – Funding and project oversight

Fisheries Inshore New Zealand – Project Management and coordination

Pisces Research (formerly Trident Systems) – Research provider, developing algorithm for processing and displaying of data

Zebratech – Technology provider, design and production of Wet Tags.

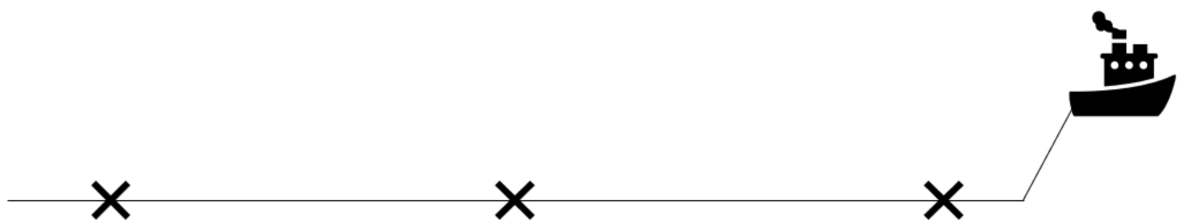
Operators and fishers – in kind support for this project. Collection and submission of data

Methods

Wet Tags are designed to turn on and begin logging time and depth when they reach a certain depth (about 1.2m). Multiple tags are deployed on longline gear, and we will compare using 3 Wet Tags or 9 Wet Tags (Figure 2) to determine what is the best number to understand sink-rates across the whole span of longline gear. Additionally, we will be investigating ideal placement of Wet Tags on the gear as well (for example directly next to a weight vs. directly next to a float).

When the gear is retrieved, the data is then downloaded by the fisher on to a smart device, where it can then be transmitted to a central repository where the data is processed. The data will then be displayed in a graphic format back to the operator to demonstrate how quickly their gear sank during operation (Figure 3).

3 Wet Tag approach:



9 Wet Tag approach:

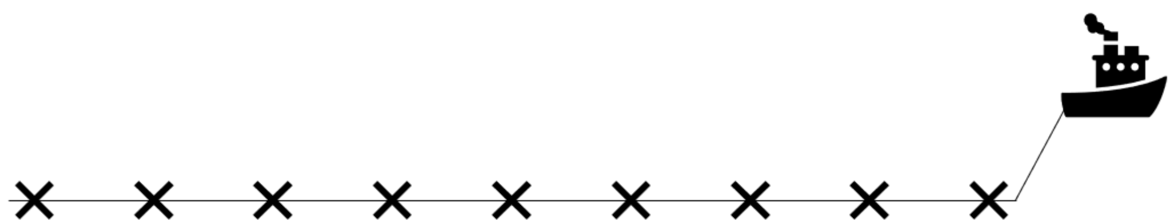


Figure 2: 3 Wet Tag vs 9 Wet Tag approach.

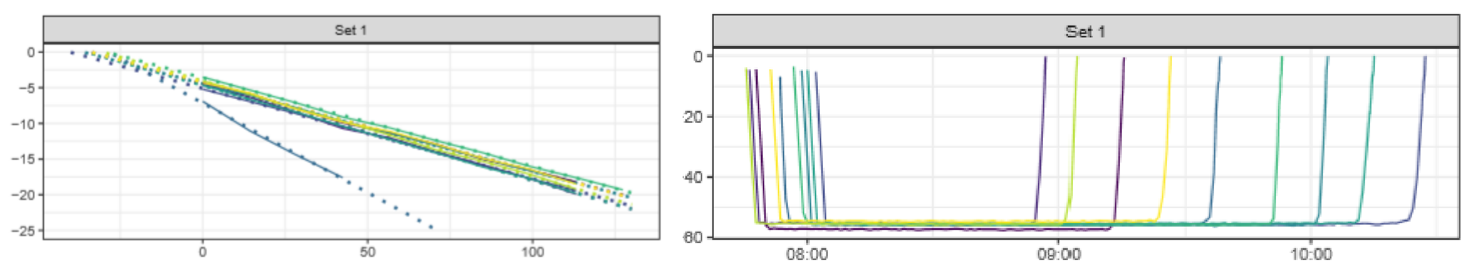


Figure 3: Preliminary examples of user interface formats for displaying sink rate data. Each color represents a different sensor. This user interface format will be developed with feedback from vessel operators.

Progress report

Below is a summary of the progress that has been made thus far on this project.

We have made good forward progress on the development of the Wet Tags, deploying them on a few vessels, and developing the code and algorithms for processing the data. Recently we have implemented a plan for moving forward during mitigation responses for COVID-19 (see page 7 for further details).

Table 1: Summary of project actions and progress since its inception up to March 2020

Date	Items
August 2019	• Ordered 10 Wet Tags to test • Conducted dock-side tests in Wellington to observe if sensors were working correctly (see Appendix 1[1])
September 2019	• Deployed these 10 Wet Tags on a bottom longline vessel and made observations on Wet Tag performance and ease of data download and transmission • 3 sensors were left with vessel to continue to use and so we could develop algorithm for receiving and processing data • See Appendix 2 for a full report of this trip
October/November 2019	• Analysed data that was collected on the vessel • With tags that were left on the vessel, began receiving data • Began back-end coding for automated receiving of data from vessel • In observing Wet Tag data, we wondered whether having the data of the first 5 meters missing would be a concern (see Table 1, item 2) • Decided to conduct more field work with CEFAS time-depth recorders, that record a time and depth at a much more frequent rate than the Wet Tags. We would then compare the CEFAS data with the Wet Tag data and see if they were substantially different from one another. We also reviewed other studies that had conducted similar work
December 2019	• Collected data using the CEFAS sensors and the Wet Tag sensors on the same vessel
January 2020	• Determined that based on the CEFAS data, the Wet Tags collected sufficient information as they were currently designed and coded (see Table 2, item 2, and Appendix 2 for a full report). • Undertook further shore based testing to isolate data download problems experienced with the initial batch of tags
February 2020	• Ordered the remaining 80 Wet Tags, with an improved jacket design, and updated firmware
March 2020	New Zealand implemented the level 4 COVID-19 alert restrictions from midnight on 25 March 2020. The status of the sink rate project at that time was: • An initial batch of ten updated Wet Tags had been received from Zebra-Tech • Shore-based testing confirmed that these tags did not appear to suffer from the communication difficulties experienced with the initial tags • A revised version of the Zebra-Tech app provided an improved mechanism for data download

[1] Trident Systems ceased to take business after the first report was published. Pisces Research is now the research provider for this contract.

	• Six of these tags were dispatched on 25 Match 2020 for distribution to the two vessels that were initial participants in the study • The remainder of the Wet Tags ordered for the project were delivered from Zebra-Tech and collected on 24 March 2020

Technical developments

During the course of this project, we have had several questions and issues to resolve, which is inevitable for any project. Resolving these issues has provided good information and learnings for future development and to aid in the rollout of Wet Tags to more vessels.

Table 2: Summary of question and issues and their resolution over the course of this project thus far.

Item	Question and/or Issue	Resolution
1	Manual download of data challenging for a commercial fishing operation	Data is now automatically downloaded on to a smart device without needing manual input for each tag from the operator
2	Concerns over Wet Tags turning on deeper than expected, and not recording sink-rates in shallow water	When using the CEFAS sensors (TDRs that could be programmed with a more frequent logging rate), we determined the Wet Tags collected sufficient information as they were currently designed and coded
3	Connection issues with certain phone models	This has been resolved
4	App is not available in Microsoft store	App is now available in Microsoft store
5	The interface when more than one sensor connects was initially confusing	Developed a better interface that is more user-friendly and intuitive
6	Issues with time zones	Resolved
7	Unable to 'batch' datafiles (send more than one Wet Tag data at same time)	Resolved by allowing users to attach more than one file in a data transmission
8	Unforeseen safety issues	With crew feedback, found that they were safe to use in normal longline operations
9	Ability to attach sensors to the gear	Found Wet Tags to be easy to attach with standard longline equipment (snaps and line)

Impacts and mitigation of COVID-19

Under the level 4 restrictions, fishing - as a food production activity - is considered an essential service and can continue. However, there is some ambiguity around the extent to which associated fisheries research and management activity can or should continue.

Generally, the project can continue to make some progress but much of the planned data collection will be delayed until COVID-19 restrictions are lifted.

To be completed per this contract

For the remainder of this project, we plan to deploy the remaining 80 tags to bottom longline and surface longline vessels as soon as we are feasibly able to once COVID-19 mitigation restrictions are lifted. We will be continuing to develop the framework of receiving the data from all vessels and displaying the data in a visual form that is useful to the operators. Initially, this will involve directly sending graphs or diagrams to the vessel operators. Eventually, this will be incorporated in to an app so that vessel operators will be able to see this information directly following retrieval of gear.

Ultimately, when the work is completed, we will submit a final report on the work that was conducted for this contract. As mentioned above, timelines have been extended due to COVID-19 related delays. Currently, a final report is scheduled for September 2020.

Once the goals of this project are complete, there will be following projects to observe if fishers change their fishing behaviour (e.g. slow their vessels down to achieve a faster sink rate) based on the information provided by the Wet Tags, and also comparing sink-rate data and adaptive behaviour data to bycatch rates.

Appendix 1: Initial Testing of New Wet Tag Firm-Ware

Initial testing of new Wet Tag firmware

David A. J. Middleton and Brianna King

Last revised: **02 September 2019**

1 Introduction

As part of Department of Conservation project MIT2018-03, Zebratech Wet Tags[1] are being deployed to measure line sink rates on bottom and surface longline vessels. The Wet Tags record depth and temperature at a fixed interval. For this project, a new version of the Wet Tag firmware (WetTag BLE - Line Speed Version 1.00) has been developed to log these parameters at a 5 second interval whenever the tag is at depths shallower than 20 metres.

Prior to deployment on a fishing vessel, the new tags have been tested by deploying these on a weighted line from a local wharf. The purpose of these trials was primarily to check the tag wake up and data download process.

02 September 2019

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[1] https://www.zebra-tech.co.nz/wet-tag-data-collection-fisheries/

2 Wharf deployments of Wet Tags

2.1 Download focussed testing

An initial deployment of a Wet Tag (unit #5153) was carried out on 29 August 2019. The tag was lowered from the wharf to the end of the rope, left to soak for a couple of minutes, then retrieved. On retrieval, the tag was immediately visible via the ZebraTech BLE app, and the data was downloaded.

Subsequent plotting of the data from the drop (Figure 1) showed:

- the first reading from the tag was logged at a depth of approximately 3 m;
- the recorded temperature reduced steadily during the short deployment, suggesting that the sensor was simply acclimating to the ambient water temperature.

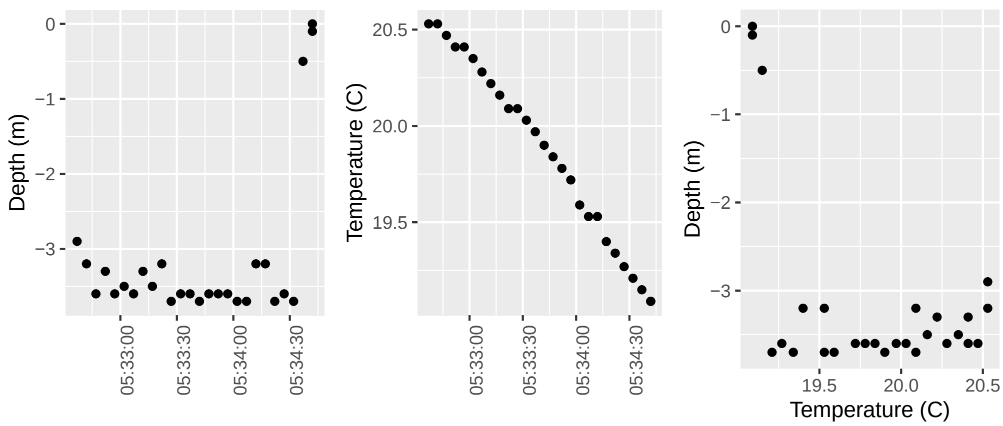

Figure 1: Drop 1, from testing on 29 August 2019.

The tags are activated by immersion to a nominal depth of 1.5 m (subject to barometric pressure variation). A question arising from this initial deployment was whether the delay in tag activation might reduce the value of the data for assessing line sink rates.

2.2 Activation focussed testing

Further testing was carried out on 2 September 2019 to assess whether the tags could be induced to start recording earlier in the deployment if they were deployed wet (e.g. after immersion in a bucket), rather than dry.

The test tag was therefore immersed on the line to 'bucket depth' then subsequently to the end of the line as before. This resulted in similar data to the initial deployment (Figure 2), and inspection of the file indicated that data were logged at the expected 5 s interval from the start of recording (Table 1).

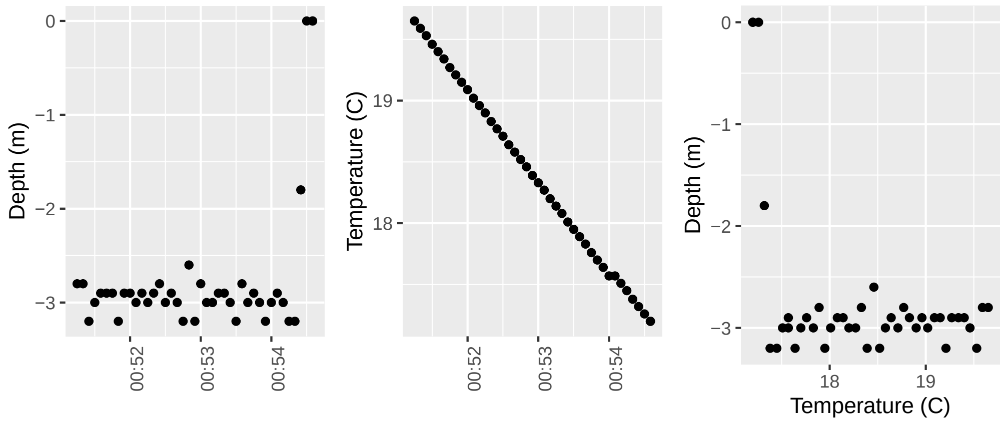

Figure 2: Drop 2, from testing on 2 September 2019.

Table 1: The first five rows of data recorded on drop 2.

datetime	Depth	Temp
2019-09-02 00:51:15	2.8	19.65
2019-09-02 00:51:20	2.8	19.59
2019-09-02 00:51:25	3.2	19.53
2019-09-02 00:51:30	3.0	19.46
2019-09-02 00:51:35	2.9	19.40

The deployment was repeated, focussing on lifting the tag from the 'bucket depth' deployment for a short period (i.e. simulating the tag being taken from the bucket and attached to the line) then lowered more slowly on the weighted line (Figure 3). On this occasion:

- there was evidence that the initial 'bucket' immersion was successful in activating recording prior to the main deployment. This is most evident in the greater than 5 s gap in the initial data rows (Table 2);
- the slower drop and retrieval allowed these phases to be recorded more clearly in the depth-time profile.

Note that the temperature sensor was still acclimating to ambient temperatures through the short deployment, so the plotted temperature-depth profile is simply an artefact of this process.

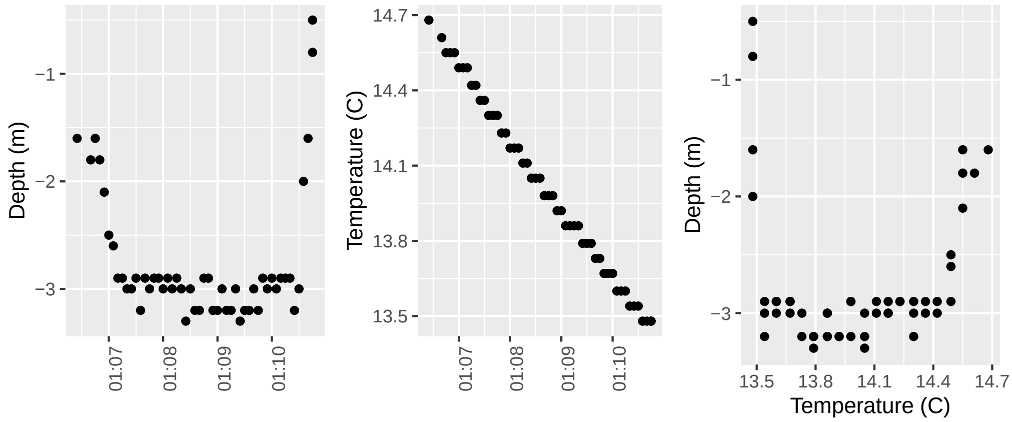

Figure 3: Drop 3, from testing on 2 September 2019.

Table 2: The first five rows of data recorded on drop 3.

datetime	Depth	Temp
2019-09-02 01:06:25	1.6	14.68
2019-09-02 01:06:40	1.8	14.61
2019-09-02 01:06:45	1.6	14.55
2019-09-02 01:06:50	1.8	14.55
2019-09-02 01:06:55	2.1	14.55

3 Conclusions

1. Download of the data via the Zebratech app was straightforward, but it remains to be seen how convenient this process will be during an actual haul operation;

2. Encouraging the Wet Tags to activate, by immersing these in water prior to deployment, may improve the resolution of data collected immediately after setting;

3. Further testing should be at sea, in the context of a real fishing operation.

Appendix 2: At-sea tests of Wet Tags for measuring line sink rate

At-sea tests of Wet Tags for measuring line sink rate

Report for Fisheries Inshore NZ

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EXECUTIVE SUMMARY

Initial at-sea tests of Wet Tags for measuring line sink rate were carried out on two trips on an inshore bottom longline vessel.

On an initial trip in September 2019, deployments of nine tags on each of three sets found that most parts of the line sank at rate between 0.3 m s^{-1} and 0.4 m s^{-1}. However, in the middle of each set, sink rates around 0.7 m s^{-1} were observed, apparently due to the addition of additional weights. Assuming a setting speed of 5.5 kn, the estimated depth at 50 m astern was typically 6 m to 8 m, although the fastest sinking (mid-line) tags reached 10 m to 13 m depth at 50 m astern.

The key uncertainty from the initial trip was line sink rates in the upper 4 m of the water column, before the Wet Tags started recording. However, data from a second trip, during which Wet Tags were paired with tags recording at a fixed 1 s interval, indicated that the assumption of a fixed sink rate from the surface to 20 m was reasonable.

A time recording bug in the Wet Tag download app, and logistics of crew downloading the Wet Tags on a routine basis, are the key areas of focus as the Wet Tags are deployed for routine use on additional vessels.

1. INTRODUCTION

As part of Department of Conservation project MIT2018-03, Zebra-Tech Wet Tags[1] are being deployed to measure line sink rates on bottom and surface longline vessels. The Wet Tags were selected because they are low-cost, robust devices with a long battery life, designed for deploying on fishing gear to record depth and temperature. For this project, a new version of the Wet Tag firmware (WetTag BLE - Line Speed Version 1.00) has been developed to log these parameters at a 5 second interval whenever the tag is at depths shallower than 20 metres.

Following initial testing of the tags on a line from a wharf (Middleton & King 2019), an initial at-sea trip was carried out. A report of the logistics of sensor deployment and retrieval on the trip has been prepared separately (King 2019). Following analyses of the data from the initial trip, a second trip was carried out with the Wet Tags paired with CEFAS Technology Limited G5 Data Storage Tags[2] (DSTs) to investigate the impacts of a delay in the start of data logging observed in the Wet Tags.

2. METHODS

2.1 Data inventory

During the initial test trip, 27 Wet Tag deployments were carried out during 3 bottom longline sets. Twenty-eight data files were returned by email from downloading of the tags, although two did not contain any data points. King (2019) noted that the interface of the app used to download the tags was somewhat confusing; it appears that the empty files resulted from trying to download data from a tag twice in quick succession – presumably due to uncertainty over which tags had been downloaded and which still had data.

On the second trip, data from 17 files recorded 16 Wet Tag deployments carried out during 2 bottom longline sets. Data from the 10 DSTs were provided in individual files, from which 18 deployments of the DSTs were identifed.

2.2 Processing the raw data

2.2.1 Wet Tags

Although the Wet Tags record data only when immersed for a period, and stop recording soon after retrieval, not all data points recorded are of interest. Files may contain additional data points from manufacturing tests, triggering as a result of atmospheric pressure changes during transportation, or 'dunks' to activate the tags to allow data downloading.

As a result of these factors, a two stage approach was adopted to data loading:

[1] https://www.zebra-tech.co.nz/wet-tag-data-collection-fisheries/
[2] https://www.cefastechnology.co.uk/products/data-storage-tags/g5/

1. Each data file was loaded into a database. The contents of the files were split between two tables; the file header was separated into a per-file record in a metadata table, while the data points were loaded into a data table with a record per data point;

2. Data from individual tags was processed to identify tag *deployments*. Tag deployments are sequences of data points consistent with a tag being deployed to depth then retrieved. In these sequences the interval between datapoints is generally 5 s when the tag is shallower than 20 m, or 60 s when deeper. However, at the transition between the shallow and deep phases of a deployment, between-datapoint intervals ranging from 5 s and 70 s may occur.

Deployments were identified as sequences of data points with an interval of between 5 s to 75 s between points. Deployments of less than 600 s were ignored. Filtering deployments to retain only those longer than 10 min allowed the deployments to be separated into those on longline sets versus those that were logged due to tag activation dunks or other testing.

Grouping deployments with overlapping time ranges allowed the tag deployments on each set to be identified without requiring any additional recording (i.e. no recording of which tags were deployed when is required by the crew of the vessel).

2.2.2 Time zone errors

On the second trip, data were downloaded from the Wet Tags with an updated version of the Zebra-Tech BLE app. The key change in the app was the recording of the download location in the file header. However, the use of the location service appears to have introduced some time recording issues. All file download times were recorded in local time rather than the intended UTC, and nine files had the times of the data points recorded as local time rather than UTC. For the trial trip, these were able to be corrected based on knowledge that only two sets were undertaken.

2.2.3 CEFAS DSTs

To ensure that data were recorded for the full set, the CEFAS DSTs were configured to record data at 1 s intervals between 06:30 and 17:00 on the day of the second test trip. As a result, the individual deployments were identified in the CEFAS tag data by smoothing the recorded depth and locating the start and end of the set from the rate of change in the smoothed depth data.

3. RESULTS

3.1 Initial trip: 17 September 2019

From the 28 files downloaded on the trip, 4158 data points were loaded from 10 Wet Tags. A total of 58 deployments of the tags were identified, but only 27 exceeded the 10 min threshold used to identify deployments of the tags on a longline set. Grouping the deployments based on overlapping deployment times identified 3 groups, matching the three sets carried out on the trip (King 2019).

3.2 Logging start depths

Time-depth profiles from the three sets are illustrated in Figure 1. It is evident in these profiles that the tags do not start logging until they have reached a depth of around 5 m, sometimes deeper (Figure 2).

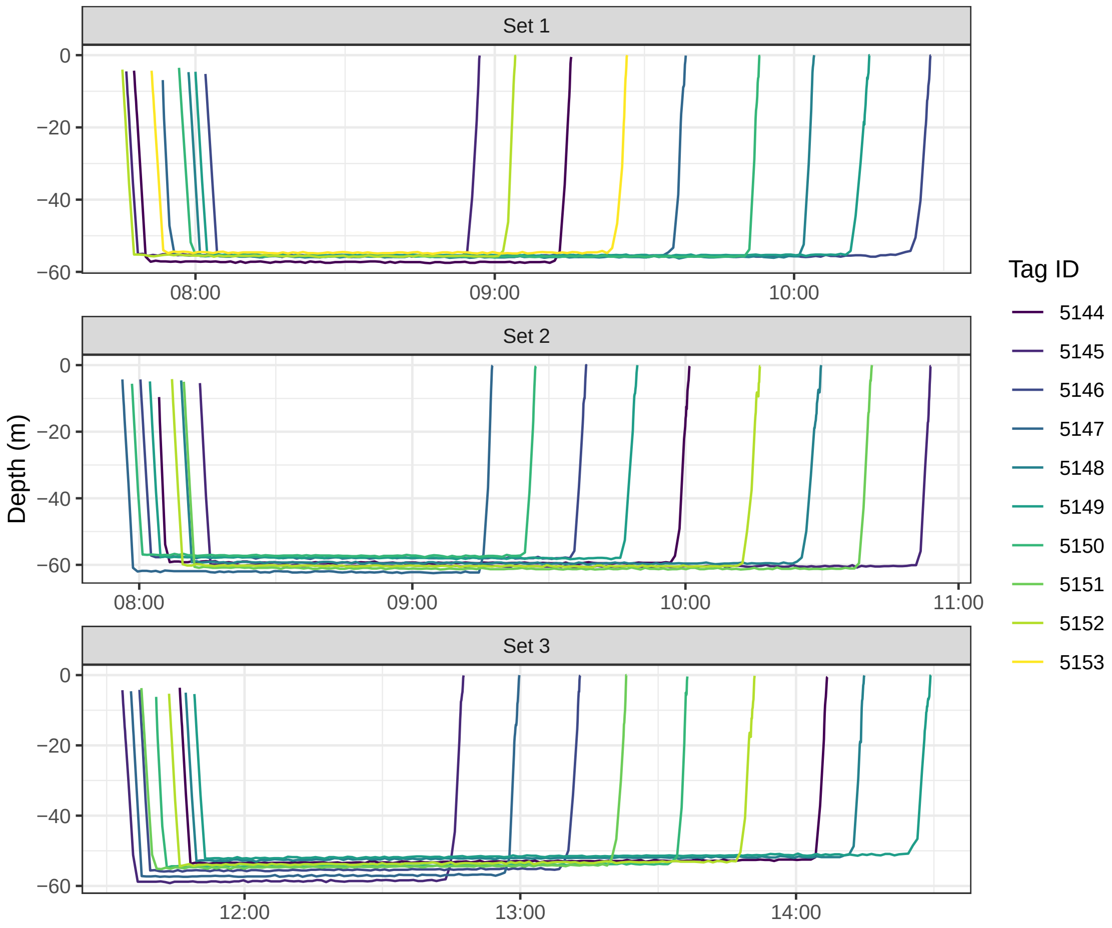

Figure 1: Individual tag depth profiles, grouped by set.

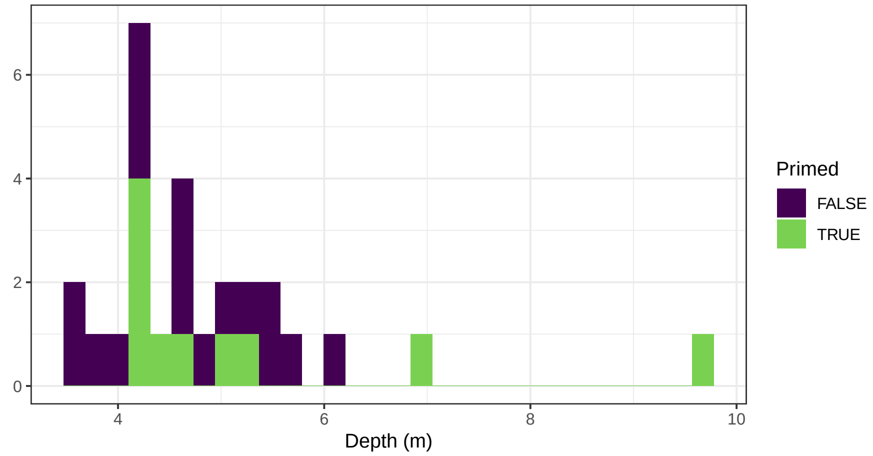

Figure 2: The distribution of first depth recorded across all deployments on the trip, categorised according to whether the tag was primed by immersion in water prior to deployment.

On the first two sets, King (2019) experimented with 'priming' alternate tags. On the first set, the primed tags were immersed in a bucket of water and on the second, in deeper water in a slurry bin. However, there is little evidence that the attempted priming had any impact on the depth at which the tags started logging (Figure 1, Figure 2).

3.2.1 Sink rates

Sink rates, calculated for the period during which each tag is sinking through the top 20 m of the water column during line deployment, show a consistent pattern across the three sets (Figure 3).

Most parts of the line show a sink rate between 0.3 m s^{-1} and 0.4 m s^{-1}; however, in the middle of each set, sink rates around 0.7 m s^{-1} are evident (Table 1). This mid-line effect corresponds with the attachment of additional floats and weights near the centre of the line, as documented by King (2019).

Table 1: Mean sink rates (m/s) by tag position and set.

	Deployment order on line								
Set	1	2	3	4	5	6	7	8	9
1	0.380	0.385	0.348	0.355	0.713	0.351	0.342	0.380	0.355
2	0.409	0.397	0.392	0.426	0.730	0.434	0.411	0.403	0.423
3	0.331	0.372	0.380	0.344	0.595	0.366	0.375	0.372	0.362

3.2.2 Depth vs distance

The Fisheries (Seabird Mitigation Measures—Bottom Longlines) Circular 2018 requires that all vessels 7 m or greater in overall length must use a streamer line during the

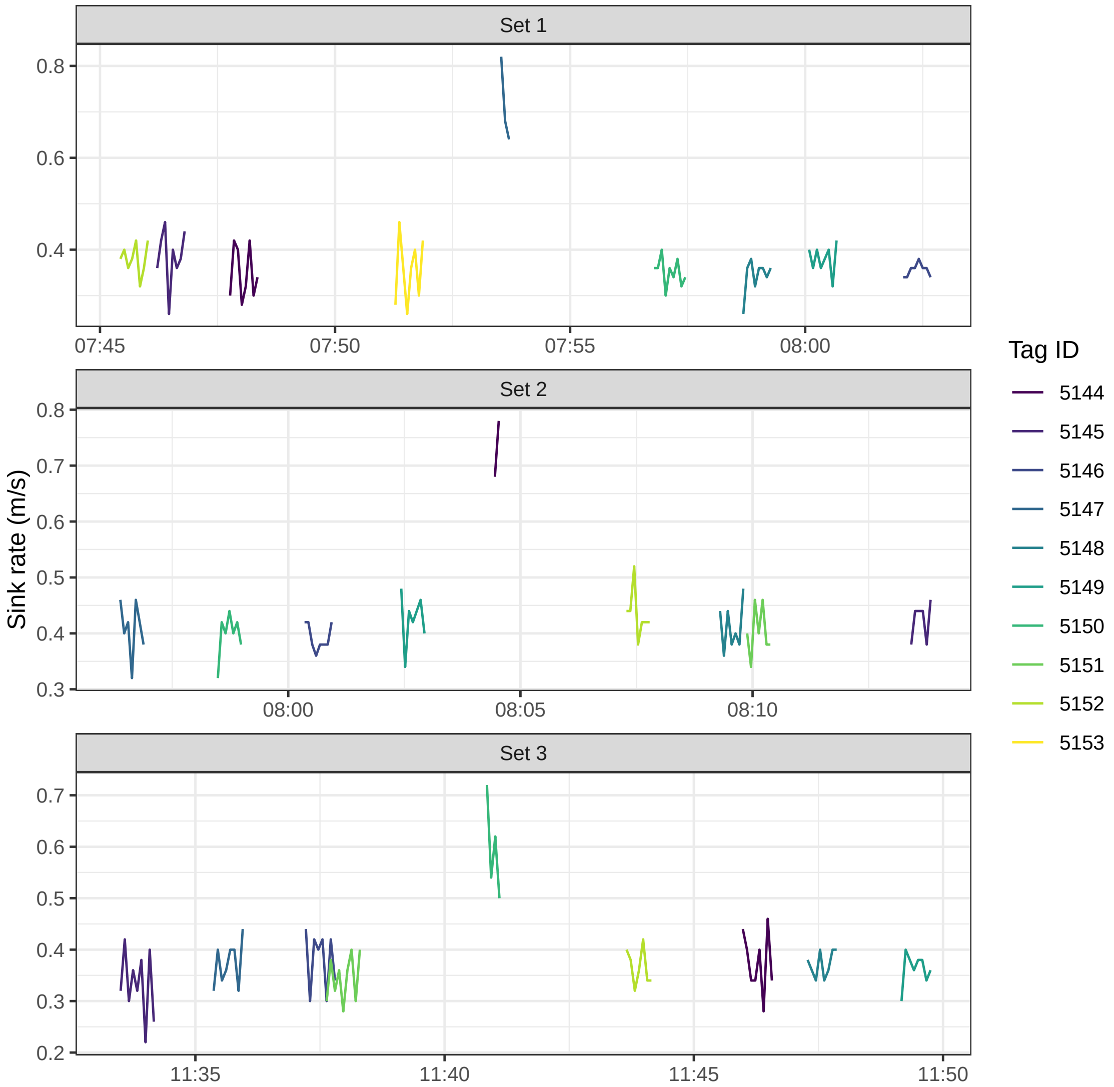

Figure 3: Sink rate of deployed tags in the top 20 metres of the water column.

setting of bottom longlines. For vessels 7 m to 20 m in overall length, the streamer line must achieve a minimum aerial extent of 50 m.

For streamer lines to be fully effective, hooks should have sunk outside the diving depth of seabirds by the time they have travelled from the vessel to the end of the streamer line. For each depth recording, the distance behind the vessel can be estimated based on elapsed time and vessel setting speed. On this trip, setting speeds were typically 5.5 kn (King 2019). Depth versus elapsed distance from the first data point recorded on a tag deployment is illustrated in Figure 4.

The delay in tag activation after entering the water requires than an allowance is made for the distance travelled by the tag astern of the vessel before the first data point is recorded. Over the period from tag activation (generally around 5 m depth) to the end of the fine-scale recording phase at 20 m, the relationship between tag depth and estimated distance astern is more or less linear (Figure 4). Assuming this relationship holds from the time the tag enters the water, extrapolation using a linear model indicates that the first data point is not recorded until the tag is around 30 m astern of the vessel (Figure 5).

Two methods for estimating the tag depth when 50 m astern of the vessel were employed:

- using linear models fitted to the recorded depth and estimated distance travelled between data points; and
- applying the mean sink rate in the top 20 m of the water column to the estimated time the vessel takes to travel 50 m.

In both cases the vessel speed during setting was set at 5.5 kn, and the vessel assumed to be travelling in a straight line. The two methods yield very similar results (Figure 6) for these data. For the majority of the tags, the estimated depth at 50 m astern is 6 m to 8 m, although the fastest sinking (mid-line) tags reach 10 m to 13 m depth at 50 m astern (Figure 6).

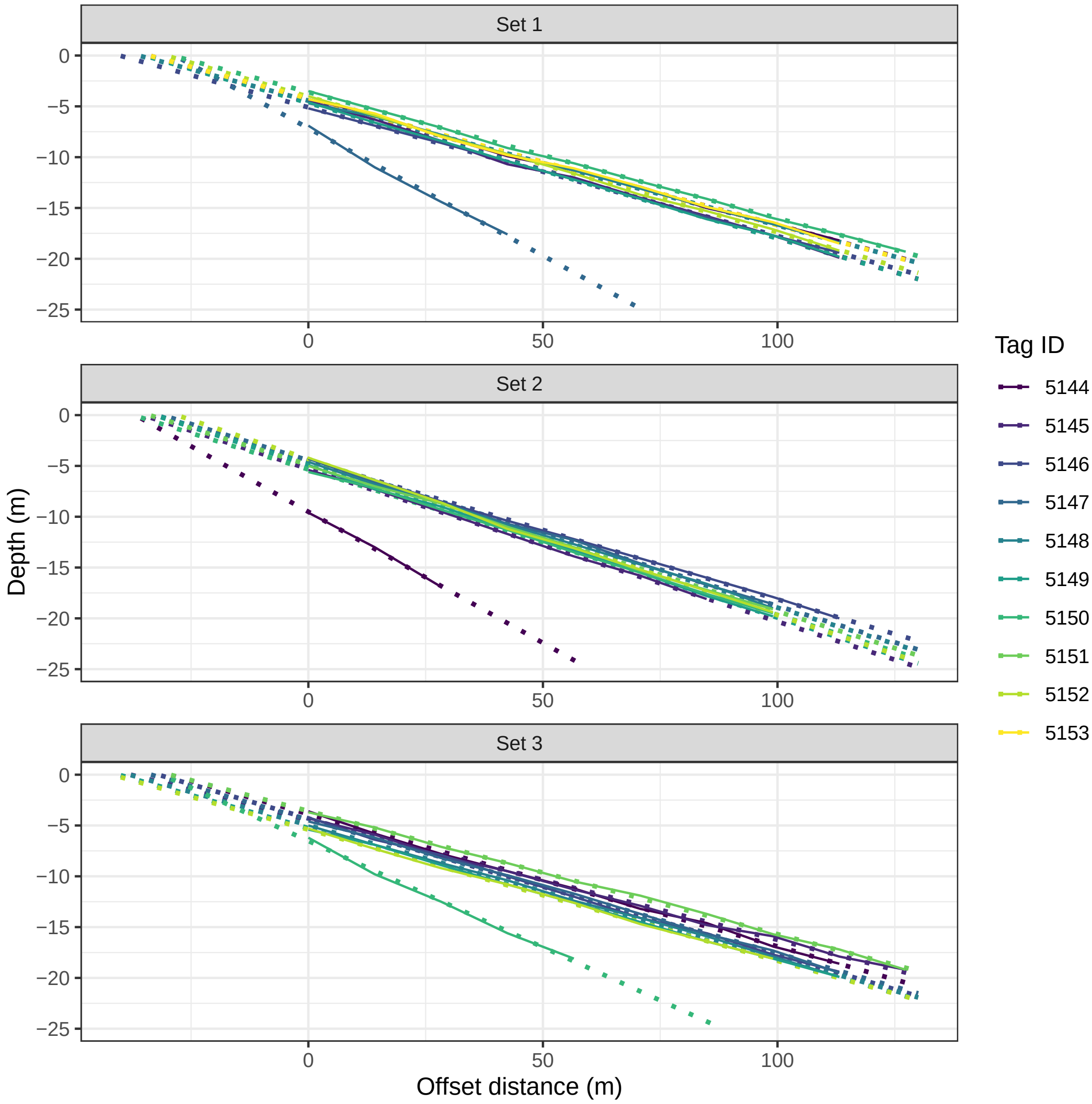

Figure 4: Tag depth vs estimated distance behind the vessel during setting. Here, offset distance refers to the estimated distance from the first tag depth record on the deployment. Solid lines indicate where tag data is available while dotted lines indicate extrapolation using a linear model of depth as a function of distance.

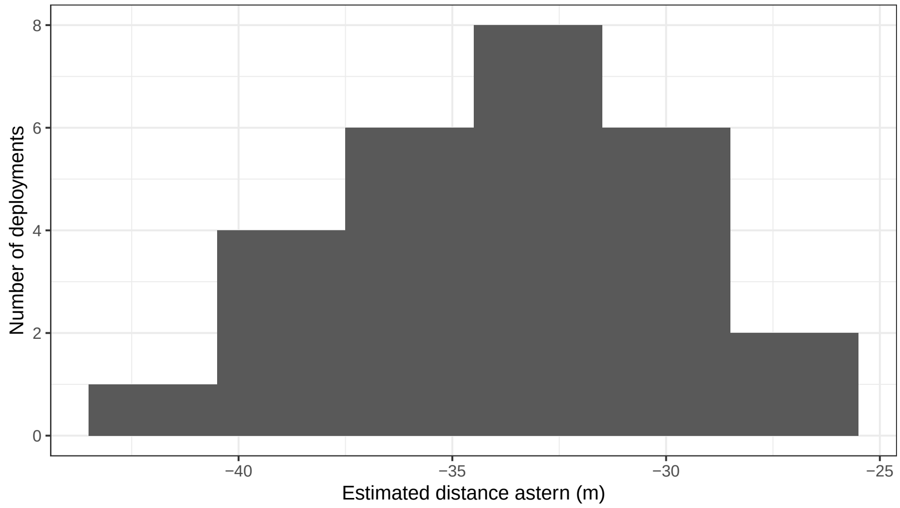

Figure 5: Histogram of estimated distance astern of the vessel at which the first data point is recorded.

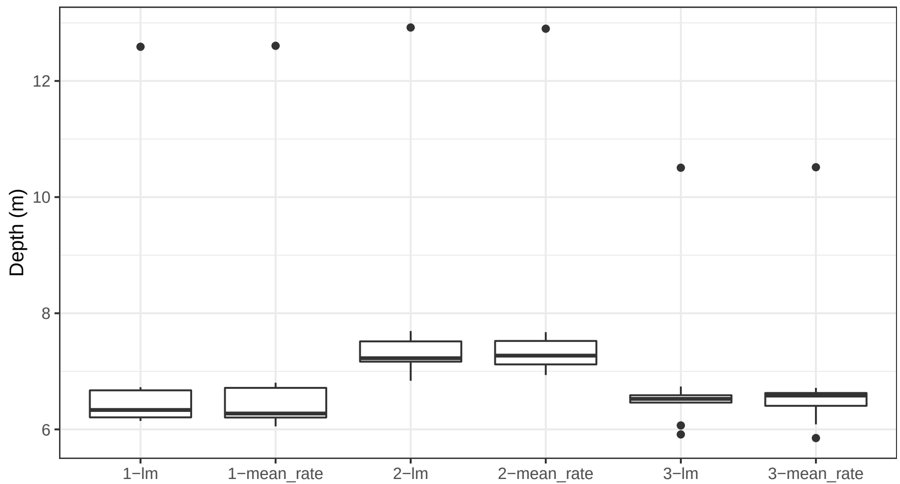

Figure 6: Estimated tag depth at 50 metres astern of the vessel, for the three sets and two estimation methods; lm: linear models fitted to tag depth and estimated distance between readings, and mean_rate: mean sink rate multiplied by the time taken to travel 50 metres.

3.3 Second trip: 10 December 2019

From the 17 files downloaded from Wet Tags on the second trip, 2288 data points were loaded from 9 Wet Tags. A total of 39 deployments of the tags were identified, but only 16 exceeded the 10 min threshold used to identify deployments of the tags on a longline set. Grouping the deployments based on overlapping deployment times identified two groups, corresponding to separate sets (Figure 7).

The 10 CEFAS DSTs recorded 336 180 data points, and 18 deployments were identified from the two sets (Figure 8). In contrast to the Wet Tags which consistently record a depth close to zero at the end of each profile (Figure 7), it is apparent that the CEFAS DSTs vary in the 'surface' depth recorded (Figure 8). Furthermore, the recorded depth when the DSTs were at the surface drifted through the day (Figure A-1). However, for the purpose of this study, it was not necessary to pursue the calibration of the DST recorded depths.

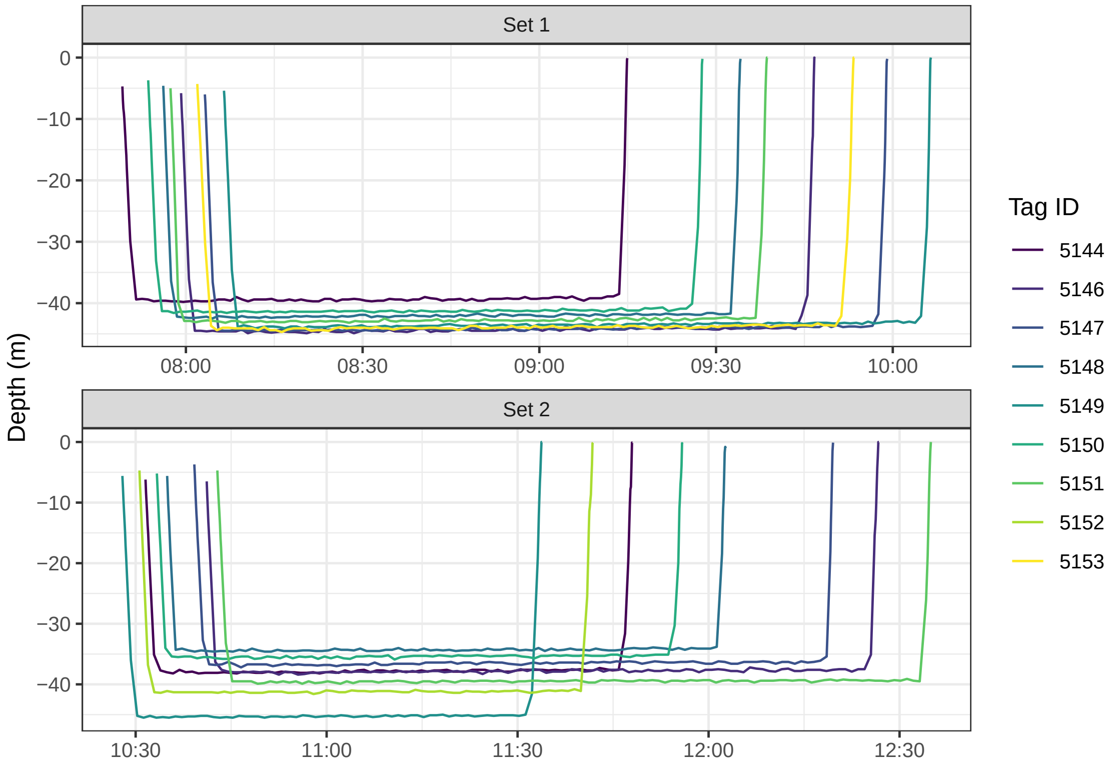

Figure 7: Individual tag depth profiles for Wet Tags deployed on the second trip, grouped by set.

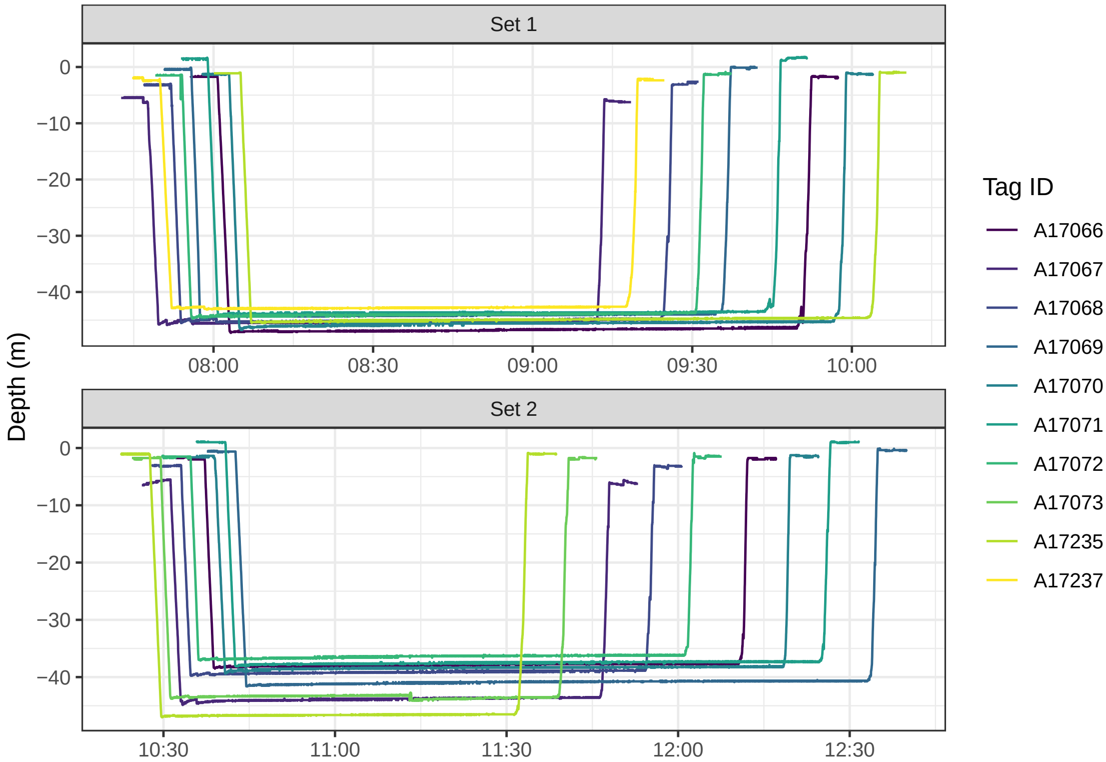

Figure 8: Individual tag depth profiles CEFAS DSTs deployed on the second trip, grouped by set.

3.3.1 Tag pairings

The time stamps on the data from the Wet Tags and CEFAS tags appear to be sufficiently well aligned that the tag pairings are readily apparent (Figure 9 and Figure 10).

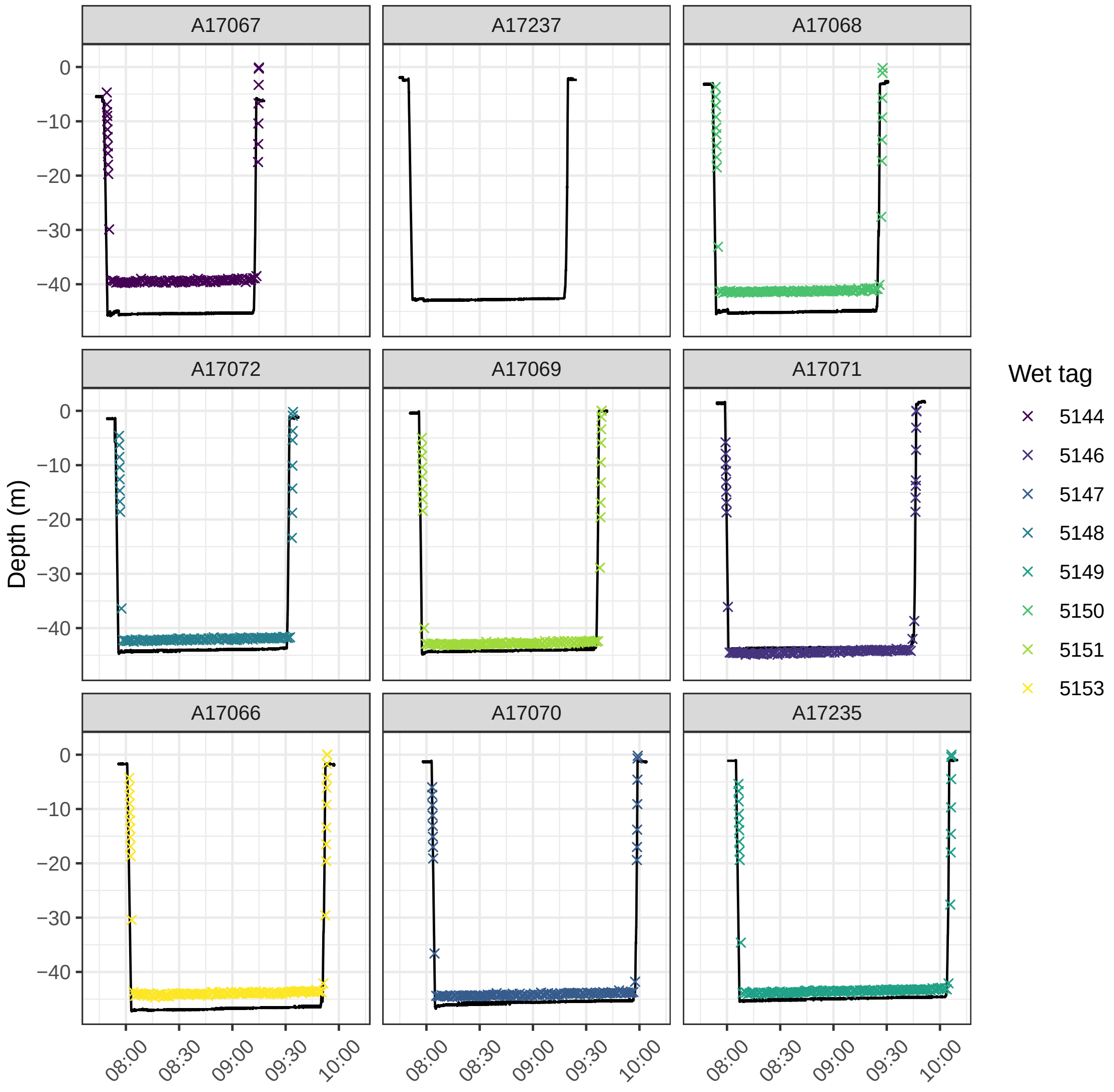

Figure 9: Tag depth profiles for CEFAS and Wet Tag pairings on set 1.

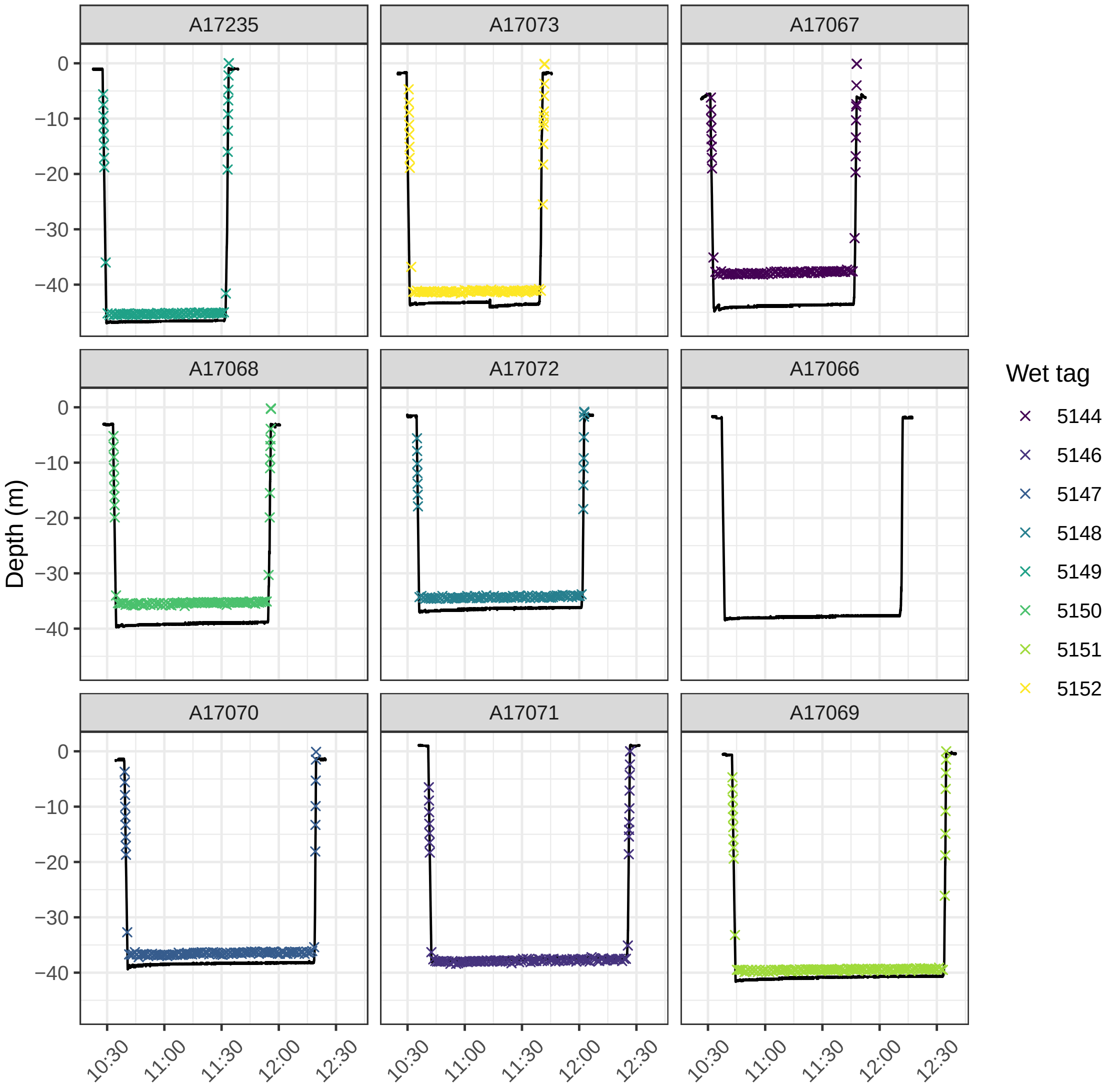

Figure 10: Tag depth profiles for CEFAS and Wet Tag pairings on set 2.

3.3.2 Sink rates

Sink rates, calculated between sequential data points for the period during which each tag is sinking through the top 20 m of the water column during line deployment, are similar for the Wet Tags and the DSTs (Figure 11). For the DSTs, lower sink rates are typically recorded only for the initial 1 s intervals at the start of a set, with the tags thereafter sinking at a consistent rate.

Time-depth profiles for pairs of Wet Tags and CEFAS DSTs often do not perfectly overlap due to differences in time synchronisation and depth calibration (Figure 12). However, the profiles are parallel, indicating that the two tags are recording the same sink rate. Furthermore the profiles from the DSTs are approximately linear, indicating that the sink rate is consistent in the upper few metres of the water column before the Wet Tags start recording.

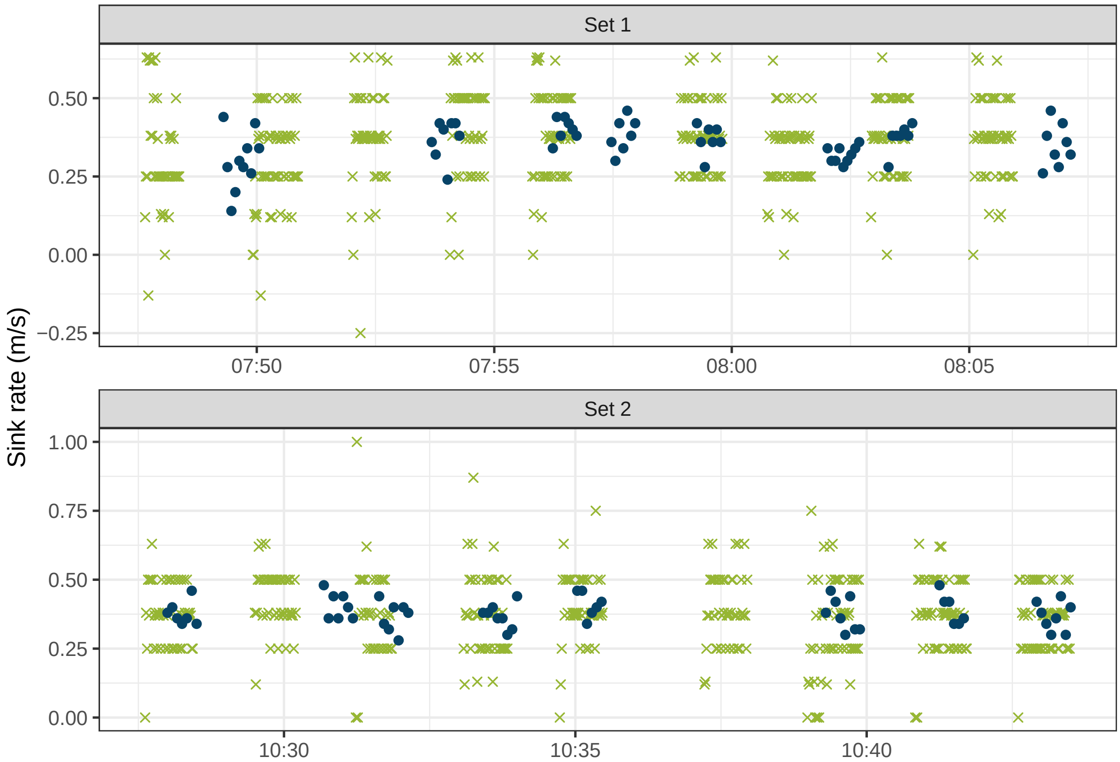

Figure 11: Sink rate estimates for sequential tag readings in the top 20 metres of the water column. Green crosses indicate sink rate estimates from the CEFAS tags and blue circles from the Wet Tags.

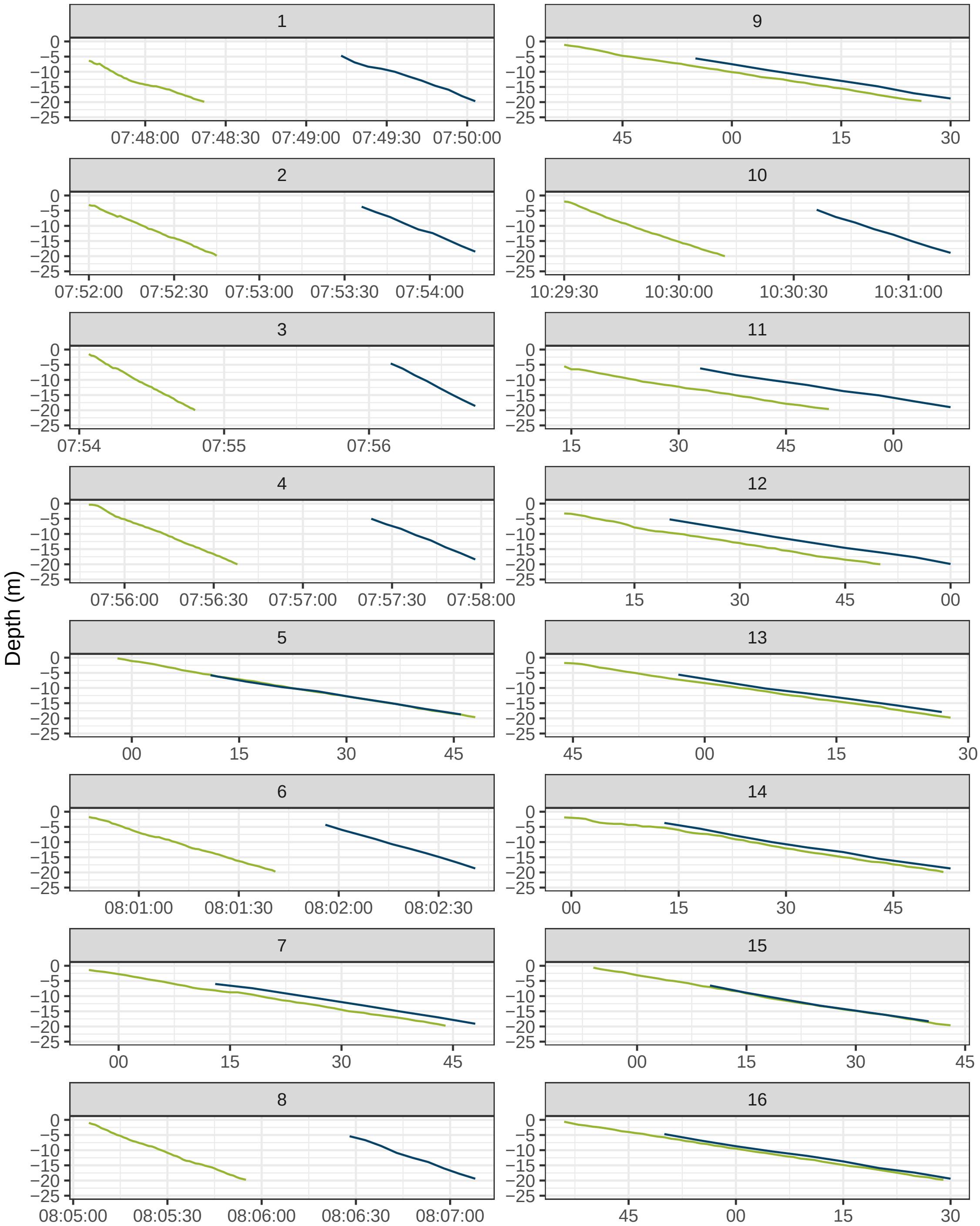

Figure 12: Tag depth vs time for CEFAS (green) and Wet Tags (blue) during setting to 20 m depth.

4. DISCUSSION

Wet Tags deployed on longlines appear to be a suitable device for measuring line sink rates. The updated Wet Tag firmware, that records line depth at a five-second interval when less than 20 m deep, allows sufficient data to be collected from the setting phase of the fishing operation for the line depth profiles to be well-determined from the tag data.

The key concern about the Wet Tags, evident from the results of the initial trip, was the fact that the devices do not start recording until depths of around 5 m. However, paired data collected during a second trip using programmable time-depth recording tags set to log data at a 1 s interval, confirmed that the assumption that the line sinks at a constant rate is appropriate. As a result, despite the delay in the start of logging by the Wet Tags, their data can be used to estimate the depth reached by the line when 50 m astern of the vessel.

On the initial trip Wet Tag data indicated that most parts of the line sank at rate between 0.3 $m\,s^{-1}$ and 0.4 $m\,s^{-1}$. However, in the middle of each set, sink rates around 0.7 $m\,s^{-1}$ were observed, apparently due to the addition of additional weights. This 'mid-line effect' was not observed on the second trip (Figure 11) suggesting that a different weighting regime was operated by the vessel on that occasion.

Assuming a setting speed of 5.5 kn, the estimated depth reached by the line at 50 m astern (i.e. at the maximum extent of the streamer line) was typically 6 m to 8 m, although the fastest sinking tags reached 10 m to 13 m depth at 50 m astern.

VMS data (Appendix B) indicate that on the first and third set the vessel setting speed might have been slightly faster than during the second set. The slower setting speed on the second set may be responsible for the slightly higher sink rates recorded (Figure 3). Where the vessel speed is underestimated, the estimated depth of the line at 50 m astern will be overestimated. This suggests that, when communicating results, estimated line depths at 50 m astern should be provided for a plausible range of setting speeds rather than a point estimate.

Next steps in the project involve deploying the Wet Tags on a wider range of vessels, including surface longline vessels. Logistical priorities include:

- ensuring that the local vs UTC time stamp bug in the Zebra-Tech BLE app is resolved;
- establishing whether the start of logging can be made quicker in future Wet Tags;
- ensuring that the vessel crew can reliably download and submit data from all Wet Tag deployments; and
- discussing the results to date with vessel crew and operators to establish the most useful statistics for reporting back to operators on link sink rates.

5. ACKNOWLEDGEMENTS

The copoeration of the operator and crew of the vessel involved in these initial trials is gratefully acknowledged. The Department of Conservation Conservation Services Programme is funding the project MIT2018-03. Furthermore, CSP staff loaned the CEFAS TDR tags used for comparison with the Wet Tags.

6. REFERENCES

King, B. (2019). *TDR sampling: F/V ABCD, September 17th – September 18th, 2019*. Report for Fisheries Inshore New Zealand, 30 September 2019. Wellington.

Middleton, D. A. J. & King, B. (2019). *Initial testing of new Wet Tag firmware*. Note for Fisheries Inshore New Zealand, 10 September 2019. Wellington.

APPENDIX A CEFAS DSTs full-day depth data

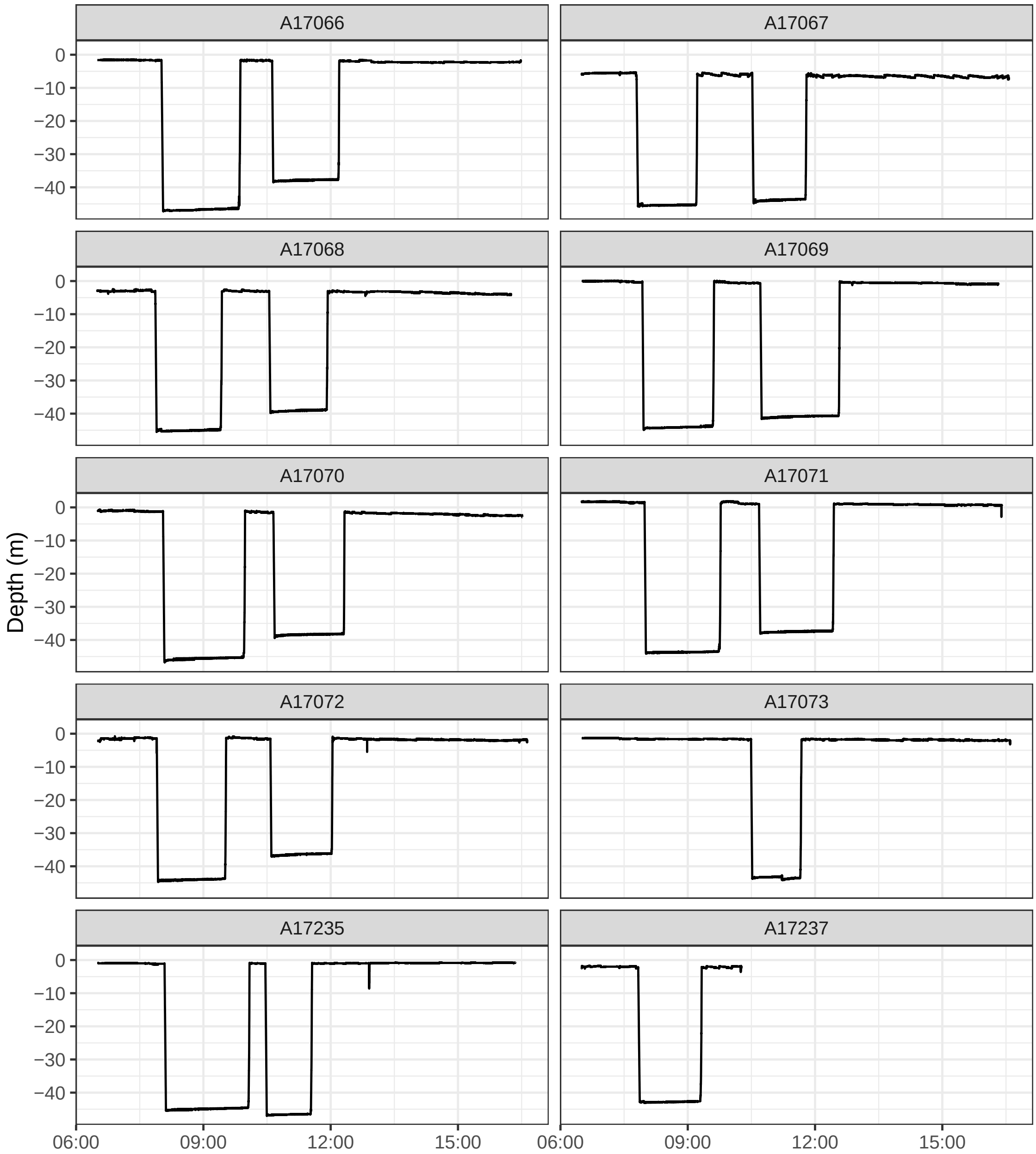

Figure A-1: Daily tag depth profiles for the CEFAS DSTs deployed on the second trip.

APPENDIX B VMS data estimates of vessel speed from the initial trip

The deployment start times of the first and last Wet Tag on each set were used to extract Vessel Monitoring System (VMS) data for the vessel during setting. These data were available from the voluntary VMS established for SNA 1 Commercial by Trident Systems, and provide position data at a 5 min interval. Speed was calculated betwen sequential positions, assuming a straight track between points (Figure B-2).

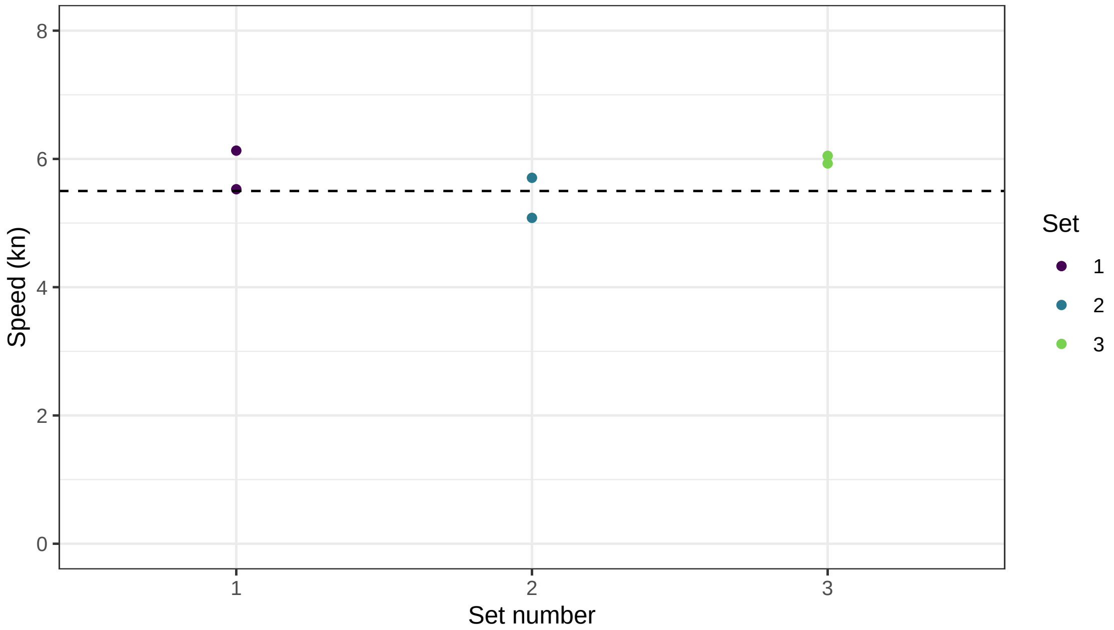

Figure B-2: Estimates of vessel speed (knots) from VMS data on the initial trip.