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Video observation of the FMA 1 bottom longline fishery in 2018–19 and 2019–20

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Middleton, D.A.J.[1]; Abraham, E.R.[2] (2023). Video observation of the FMA 1 bottom longline fishery in 2018–19 and 2019–20.

***New Zealand Aquatic Environment and Biodiversity Report No. 302*. 42 p.**

Black petrel (*Procellaria parkinsoni*) and flesh-footed shearwater (*Ardenna carneipes*) are two of the seabird populations assessed as being at greatest risk from incidental captures in fisheries. These seabirds breed in north-eastern New Zealand, and are caught primarily by bottom longline vessels fishing in that area. In order to develop a methodology for monitoring seabird captures from video footage, and to gather data on capture rates, video cameras were used to film the hauling station on bottom longline vessels fishing within Fisheries Management Area (FMA) 1, off the north-east coast of New Zealand. This programme has been developed in collaboration with the fishers, who have volunteered their time and the use of their vessels.

Since 2016–17, this programme has been used to monitor between nine and twelve of the most active vessels in this fishery. In this report we present the results of the 2018–19 and 2019–20 data collection programme. Data were collected during 2019–20 as part of this project, with previous footage and data being made available by Trident Systems.

The electronic monitoring (EM) systems used for collecting footage consisted of a single camera on each vessel, positioned on a boom outboard from the hauling station. During 2019–20, a wheelhouse unit was used to record the footage, with the footage transferred into a review system using USB devices. Selected footage was reviewed to identify seabird captures, with selections sometimes being reviewed multiple times for quality control. Any seabird captures identified were then reviewed by a specialist to confirm the identification.

Footage collection during 2019–20 was impacted by several operational issues: the camera housings developed cracks that let water inside the housings; noisy fans and bright lights resulted in the crew switching the EM systems off, initially by removing fuses because switches were not installed; the system clock on one vessel failed leading to incorrect footage timings; and the coronavirus pandemic prevented system maintenance and data transfer during the lockdown period. In addition, one vessel had a fire as a result of damage to the EM system power cable which had a poorly located fuse. Despite these issues, footage was collected from 645 fishing events during November to May 2019–20 (17.7% of all bottom longline fishing events in FMA 1 over the period). In the snapper fishery (i.e., snapper target bottom longline events), footage was captured for 25.8% of the hooks set over this period, with 23.8% being reviewed for seabird captures. In contrast, 8.1% of hooks in the snapper fishery occurred during trips with human observers assigned to the vessel.

For the preceding season (November to May 2018–19), the footage collected by Trident Systems covered 700 bottom longline fishing events in FMA 1 (20.1%). In the snapper fishery, footage was captured for 26.2% of the hooks set over this period, with 24.7% being reviewed for seabird captures. Human observers were assigned to vessels in the snapper fishery for the period in which 7.4% of hooks were set.

In total, 65 seabird captures were recorded by video monitoring during 2019–20 (one of which was on a fishing event outside FMA 1), with a capture rate of 0.032 captures per 1000 hooks. The highest number of captures recorded from a single vessel was 24 captures. Flesh-footed shearwater was the most frequently caught species (48 captures), followed by black petrel (13 captures).

By using a statistical model, fitted to data from four years of video observation, to scale up these observed captures to the whole fishery, there were estimated to have been 296 (97.5% c.i.: 166 to 519) seabird

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captures in all bottom longline fishing in FMA 1 between October 2019 and May 2020. This corresponded to a capture rate of 0.038 (95% c.i.: 0.021 to 0.067) seabird captures per 1000 hooks set.

Over the 2019 and 2020 fishing years, there were 251 seabird captures reported by fishers from bottom longline fishing within FMA 1. Of these captures, 127 were reported from vessels participating in the video monitoring trial (a capture rate of 0.0148 seabird captures per 1000 hooks). There were 124 captures reported from other vessels, with a capture rate of 0.0078 seabird captures per 1000 hooks. The rate of reporting by vessels participating in the trial was around twice as high as the rate of reporting by other vessels.

The multiple reviews identifed an issue with the review accuracy. There were many seabird captures that were missed during the first review of the footage (there were 51 captures on footage that was multiple-reviewed, and of these 20 were on sections of footage that had no capture detected by the first reviewer). The video monitoring programme is reliant on the accuracy of the video review, and without the multiple review this would have led to significant under-reporting of seabird captures. Overall, however, despite the operational challenges, and despite the discrepancies seen in multiple reviews, the programme demonstrates that video monitoring can be used to collect data on seabird captures in bottom longline fisheries. The programme has allowed the effective coverage in snapper bottom longline fisheries to be expanded well beyond what has been possible with a traditional observer programme. The ability to assess the reviewer accuracy is unique to video observation; there is no equivalent assessment of the accuracy of data from traditional observer coverage. As the technology and the systems continue to develop, it is likely that the efficiency and accuracy of the video-monitoring will increase.

1. INTRODUCTION

Video observation, where electronic monitoring technologies (EM) are used to generate observational data that supplement or replace data obtained from the deployment of human observers on fishing vessels, has seen increasing use in New Zealand fisheries (Middleton & Guard 2021). The 'petrel project', where video observation has been used to monitor seabird captures in the bottom longline (BLL) fisheries in Fisheries Management Area 1 (FMA 1; Figure 1) is currently New Zealand's longest running video observation programme.

The programme dates back to 2012, when key participants in the snapper (*Chrysophrys auratus*; SNA) longline fisheries operating in FMA 1 (which aligns with the SNA 1 Quota Management Area) recognised that it was necessary to provide better information on what was happening in their fishery and, in particular, to demonstrate that interactions with seabirds were being managed to an acceptable environmental standard. The fishery interacts with several species of seabirds including black petrel (*Procellaria parkinsoni*), the seabird species typically assessed as being at greatest risk from New Zealand fisheries (Richard & Abraham 2020). An experimental assessment of video observation on a single bottom longline vessel in 2015, using flax seabird proxies to increase the number of observable events, found that 89% of proxy 'capture' events were detected via camera footage review (increasing to 94% with multiple reviews of the footage; Middleton et al. 2016).

In collaboration with key SNA 1 Licensed Fish Receivers, SNA 1 quota owners, the Ministry for Primary Industries (MPI), Department of Conservation, and the multi-stakeholder Black Petrel Working Group, the trial was expanded to become the black petrel EM project. From 2016–17 onwards, the programme has monitored between 9 and 12 of the most active vessels in the FMA 1 bottom longline fishery, with vessels participating voluntarily (Middleton & Guard 2021). The programme has focused on the November to May period when black petrels are breeding in New Zealand (Agreement on the Conservation of Albatrosses and Petrels 2009).

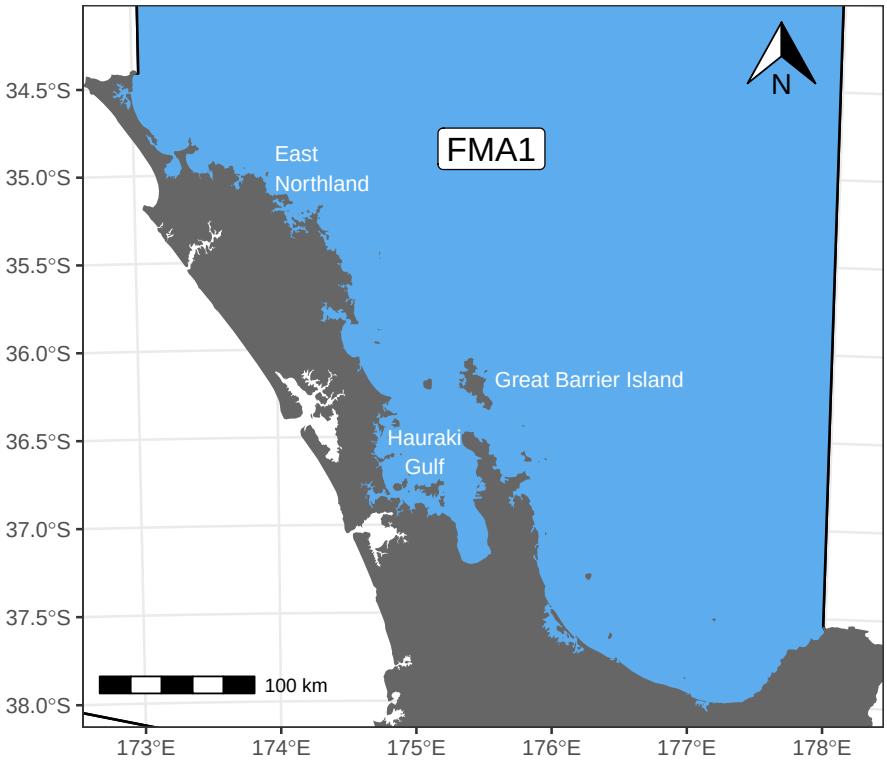

Figure 1: New Zealand Fisheries Management Areas with FMA 1 highlighted.

From 2016–17 to 2018–19, Trident Systems collected the required footage for the black petrel EM project, and Trident also reviewed the footage collected in 2016–17 and 2017–18. MPI contracted the National Institute of Water and Atmospheric Research (NIWA) to undertake an audit of 10% of the footage reviewed by Trident and to analyse the initial data from the trial (McKenzie 2021). The programme has been continued by Dragonfly Data Science under MPI project PSB2019–06, collecting footage from the 2019–20 season and reviewing both the 2018–19 and 2019–20 footage (in the remainder of this report we refer to the 2018–19 season as the 2019 fishing year, and similarly the 2019–20 season falls within the 2020 fishing year).

A recent analysis (Tremblay-Boyer & Abraham 2020) has demonstrated that fisher reporting of seabird captures increased, by around a factor of two, when vessels carried cameras as part of the programme. Data from the video observation programme are now being integrated alongside traditional observer data for use in producing fleet-scale estimates of seabird captures.

2. METHODS

2.1 EM systems

The EM systems used for collecting footage in 2019 are described by Middleton & Guard (2021). A single 'full hemisphere' camera was used on each vessel, positioned on a boom out from the hauling station (Figure 2a). This provided a view of the line as it was hauled, but also allowed panning and zooming within the image to view the area ahead and astern of the line hauling station, and also seaward.

Some footage at the start of the 2020 season was captured using the original EM systems deployed in 2016–17 but, at the start of the 2020 season, the EM systems on all participating vessels were replaced. The new systems used similar cameras, positioned as previously (Figure 2a), but were expected to provide higher performance, including increased frame rates (15 frames per second rather than 3 fps). A key difference from the previous hardware was that the new camera modules were simpler units, with the processing and storage being relocated to the wheelhouse unit rather than integrated alongside the sensor (Figure 2b). Footage recorded in 2020 was transferred from the vessels to the review system using USB storage devices; the 2019 footage was provided by Trident Systems.

2.2 Footage management and review

Footage recorded on board was catalogued and a copy processed for use within the review system. The review system was updated from that used in 2017 and 2018, but provided essentially the same data entry controls. Non-overlapping temporal 'slices' of the footage from a vessel, usually representing a port-to-port trip, were defined as the units for primary review. For the footage from 2019, an initial random selection of 50% of the slices was selected for review. A randomised-block design, selecting one of every two slices defined for a vessel, was employed. Any slices that overlapped with observer trips or had fisher-reported captures that were not part of the original random selection were also marked for review, and further footage was reviewed opportunistically.

Footage collection in 2020 was impacted by a variety of issues (detailed in the Results) so all valid footage obtained during the 2020 season was allocated for review. In both 2019 and 2020 some footage from October was included in the slices selected for review. A team of seven reviewers contributed to the primary reviewing of slices from 2019 and 2020. Slices were allocated to the review team and they worked through the available footage. Where discrepancies between the primary reviewing results and fisher reporting of captures became apparent (i.e., fishers reporting captures that were not identified by the reviewing), additional reviews of the slices were scheduled. Reviewers were unaware of the reasons for scheduling particular slices for review.

(a) Full hemisphere cameras deployed on an extendable boom out from the vessel haul station.

(b) The EM system wheelhouse units.

Figure 2: The EM systems used in the project. The systems illustrated are the versions deployed in late 2019.

In addition, two secondary reviewers were tasked with carrying out additional, blind reviews of slices that had already been reviewed by the primary review team. Slices for secondary review were selected at random from the pool of slices that had had primary reviews; slices where the primary reviewers had identified captures were up-weighted in this randomised selection process so that the secondary reviewers examined a higher proportion of slices with captures.

A two-stage reviewing process was carried out, consistent with the reviewing of footage from 2017 and 2018. The primary review of each slice focused on the identification of all seabird capture events. Short review slices, extending five minutes before and after each seabird capture event identified in the primary reviews, were then defined for expert review. The expert review focused on confirming that each capture met the MPI definition of a capture, identifying the species of the seabird, and confirming its status (alive/dead) and fate. A seabird is *caught* when it has become fixed, entangled, or checked so that it is prevented from moving freely.[3] Birds that are snagged momentarily, but then manage to free themselves, are not considered to have been caught.

During the primary review, reviewers viewed the footage in the slice from start to finish. For all periods where footage was available, reviewers classified:

Vessel/crew activity as in-port, steaming, setting, hauling, at-anchor or other;

Camera positioning as stowed or deployed; and

Footage quality as high, medium, low, or unusable, from the perspective of the review requirements (i.e., identifying seabird captures). When footage quality was reduced, reviewers also categorised the cause of the reduced quality.

[3] Non-Fish/Protected Species Catch Return (NFPSCR) Explanatory Notes (October 2008)

The review protocol allowed the reviewers to move through the slice at high speed (up to sixteen times real time, although a software update subsequently limited this to eight times) until hauling periods were identified. Haul footage was reviewed at no more than five times real time with a focus on identifying all seabird capture events. In addition to protected species capture events, reviewers could also record gear events, privacy events, Health & Safety events, or any other events (*ad hoc* events) that they considered should be recorded.

To facilitate data analysis at the fishing event level, an aggregate footage quality score was constructed that summarised the reviewer footage quality information over a hauling period. The different footage quality classifications were assigned a numeric score (high quality = 3, medium quality = 2, low quality = 1, unusable = 0) and these scores were multiplied by the proportion of the haul period falling within each classification. Thus, the quality score for a haul period ranged from 3, when there was high quality footage throughout an event, down to 0, for events where all footage was considered unusable. Where half of the haul period was considered medium quality and half labeled as low quality, the period would have an aggregate score of 1.5.

2.3 Fishery data

Coverage of the video observation programme was assessed within the sampling frame of the FMA 1 bottom longline fishery, defined as fishing effort reported to MPI using the bottom longline method and with a set start position within the FMA 1 area, or reported as starting in one of the FMA 1 statistical areas (i.e., if latitude or longitude data were missing). Fishing events meeting these criteria and occurring in the 2019 or 2020 fishing years were selected.

The video observation protocol focuses on the period when the line is hauled. From 1 October 2007, most inshore bottom longline data were reported on the Lining Trip Catch and Effort Return (LTCER). For each set, this form recorded only the date and time at the start of the haul. However, early in the 2020 fishing year most bottom longline vessels in FMA 1, including the EM fleet, transitioned to electronic reporting (ER; Table 1).

The ER data include information on the end time of the fishing event, in addition to the start of hauling, and therefore allow a hauling period to be defined. Hauling periods provide a useful basis for assessing coverage of the EM programme by calculating footage availability over these periods. To allow similar calculations for the 2019 fishing year, when the statutory data were reported on the Lining Trip Catch Effort Return (LTCER) and so only contain a hauling start time, we defined the haul end time to be either 20:00 hrs on the day on which hauling began, or the start of a subsequent setting period, whichever came sooner. While this is convenient for reporting purposes, it is apparent that this approach overestimates the duration of hauling periods in 2019 (Table 2, Figure 3) and so should be regarded instead as a period in which the haul is expected to have been completed.

Individual vessels are referred to in this report using anonymised vessel identifiers.

Table 1: Number of events and vessels using the different effort reporting forms for the full FMA 1 BLL fleet, and the petrel project EM fleet, in the 2020 fishing year. LTC is the Lining Trip Catch and Effort Return, LCE is the Lining Catch and Effort Return, and ERS - Lining indicates use of the Electronic Reporting regime introduced under the Fisheries (Reporting) Regulations 2017.

	All vessels		EM fleet	
Reporting form	Events	Vessels	Events	Vessels
ERS - Lining	6 250	47	1 666	9
LCE	19	1		
LTC	40	1	40	1

Table 2: Mean hauling period duration by vessel and fishing year, for vessels in the EM fleet. Vessel identifiers are anonymised. For 2020, the hauling period uses the hauling start and end times recorded via the Electronic Reporting system and the fleet comprised vessels that primarily targeted snapper. From 2019, the hauling periods were constructed using an assumed haul end time (see text), and the participating fleet comprised vessels targeting both snapper and bluenose (extitHyperoglyphe antarctica; BNS).

Vessel	Mean hauling duration (hours)
2019	
AaZ	6.7
AzZ	7.4
EvV	6.4
PkK	8.5
ShH	8.4
ShS	4.2
UfF	11.1
UfU	12.3
VvE	10.1
2020	
AzZ	3.5
ByB	2.2
PkK	4.8
QjJ	4.3
TgT	3.8
UfF	4.7
UfU	6.4
VvE	3.4
YbY	3.8

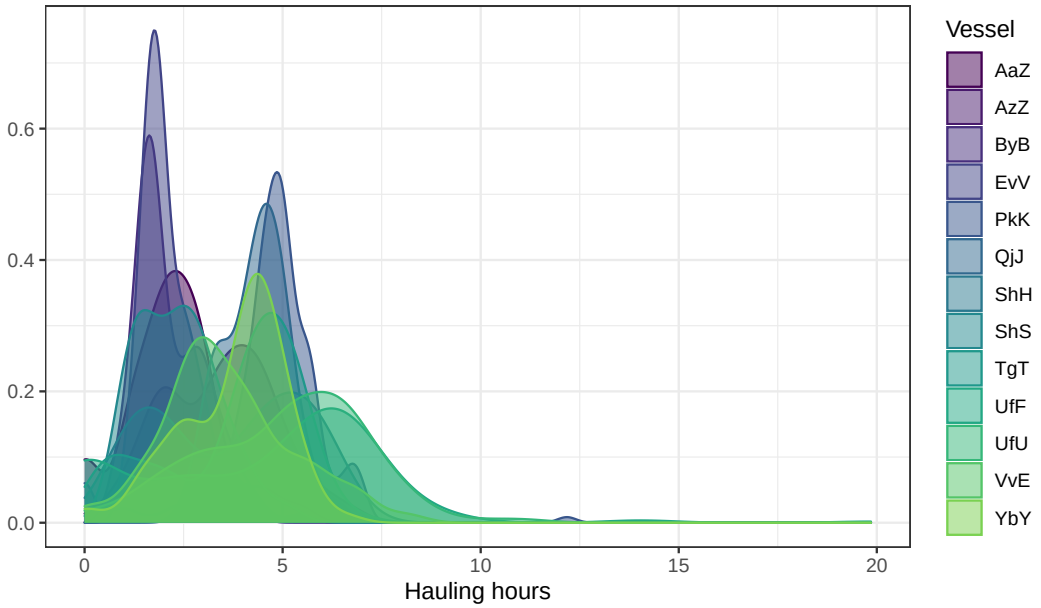

Figure 3: Distribution of hauling periods for vessels in the EM fleet reporting via the ER regime. One obvious outlier was corrected where the haul end date was recorded in the following month.

2.4 Linking EM and statutory data

To produce a linked dataset for use in fleet-level seabird capture estimation, the hauling periods in the statutory data were used to select video observation data that fell within these time ranges. Specifically, we identified haul periods (i.e., of which there is one per statutory fishing event) that lay within completed

reviews, and capture events that fell within haul periods. We calculated the proportion of the haul period where footage was available and the footage quality score based on the results of the first review. The linked dataset included data generated from the earlier years of the programme (Middleton & Guard 2021) and spanned the 2016–17 to 2019–20 seasons.

We identified that nine captures in the video observation data were not successfully linked to the statutory effort data using this approach. On further investigation all these events occurred on days when fishing was recorded in the statutory data, but outside the hauling period. Furthermore, all but one occurred in the 2020 season when vessels were using Electronic Reporting (and, hence, when the haul end period is more tightly defined). In most cases, the captures were recorded after the haul period had ended and suggest that the fisher had accidentally mis-recorded the end of hauling. In one case, it appeared that the fisher had forgotten to indicate that hauling had started so the records for the start and end of haul were within a few minutes.

To ensure that all captures identified by video observation were linked into the analysis dataset we implemented a backup linking approach whereby otherwise unlinked captures were linked based on the fishing date.

2.5 Estimating seabird captures

To place the video observations in context, a generalised linear model (GLM) was used to estimate seabird captures in FMA 1 bottom longline fisheries. The number of seabird captures identified by expert review (`expert_captures`), on each set, was assumed to be drawn from a negative-binomial distribution. The logarithm of the mean of the distribution was represented as a sum of covariates, with the coefficients of the covariates being estimated through statistical model fitting. The model fitting was carried out within a Bayesian framework using the software `brms` (Bürkner 2017). The covariates considered are defined in Table 3 and the model formula (in `brms` notation) was:

```
expert_captures | rate(observed_hooks)  ~ target +  s(month, bs='cc', k=6) +
          (1|year) + (1|vessel_alias) + (1|stat_area)
```

The model was initialised with unit normal priors on the coefficients of the covariates and on the standard deviation of the random effects. The default Gamma(0.01, 0.01) prior was used for the shape of the negative binomial distribution, a Normal(-10, 3) distribution was used for the prior of the intercept, and a default Student$_t$(3, 0, 2.5) distribution was used for the prior of the spline variance parameter. The model was run with four chains, for 1000 warm-up iterations and 1000 sampling iterations, so providing a total of 4000 samples of the posterior distribution. Convergence was assessed using the Gelman-Rubin $\hat{R}$ statistic (Gelman & Rubin 1992), which compares within chain and between chain variance. An $\hat{R}$ value of close to one indicates convergence.

The model was applied to the linked dataset, which had each video observation associated with a fisher-reported fishing event. The model was fitted to the events that had been video-reviewed (with the hooks observed being the total hooks on the fishing event, scaled down to the proportion of the haul that was observed). The model, with the coefficients estimated from the reviewed hauls, was then applied to all fisher-reported effort data from October 2019 to May 2020, to estimate total seabird captures in FMA 1 bottom longline fishing over that period. Few data were collected over the winter months (June to September) and so no estimates were made for this winter period.

Table 3: Parameters used in estimating seabird captures from video observation data.

Parameter	Representation	Definition
Captures	`expert_captures`	The number of seabirds capture on each set confirmed by expert review of the footage. Includes all species, and both live and dead captures. This is the response variable of the GLM.
Observed hooks	`rate(observed_hooks)`	The number of hooks reviewed on each set, derived from the fisher-reported total hooks set. If the number of hours of video observation was less than the number of hauling hours, then the number of observed hooks was the number of hooks set, multiplied by the ratio of the video reviewed hours to the total hauling hours. The number of observed hooks is included in the model to normalise the mean of the negative binomial distribution, on the assumption that the number of seabirds caught is proportional to the number of hooks set.
Target species	`target`	The fisher-declared target species of the set, either snapper (SNA) or other species (OTH).
Month	`s(month, bs='cc', k=6)`	The month of the set, as an integer. The month is represented in the model as a cyclic spline, with 6 knots. The spline smoothly joins December (month 12) and January (month 1).
Fishing year	`(1|year)`	The fishing year of the set (the fishing year runs from October 1 to September 30), included in the model as a random effect.
Vessel alias	`(1|vessel_alias)`	A unique code for each fishing vessel, included in the model as a random effect.
Statistical area	`(1|stat_area)`	The general statistical area of the start of the set, included in the model as a random effect.

3. RESULTS

3.1 The FMA 1 bottom longline fishery

The bottom longline fishery in FMA 1 operates year-round (Figure 4), dominated by snapper target fishing (Figure 5). There are typically 30 to 40 vessels active in the fishery (Figure 6). The EM programme in 2018–19 involved nine vessels. Nine vessels also participated in 2019–20 but, due to changes in the fishery there were only 5 vessels in common in the EM fleets for the two years. In particular, the EM fleet in 2020 focused entirely on snapper target vessels because the bluenose target fishery in FMA 1 had decreased following reductions in bluenose catch limits.

Vessels in the project fleet undertook 28% of the bottom longline effort in FMA 1 in the November to May period in the 2019 fishing year and 29% in the 2020 fishing year (Figure 7a). Expressed in terms of number of hooks set, this represents 36% of effort in the 2019 season and 41% in 2020 (Figure 7b).

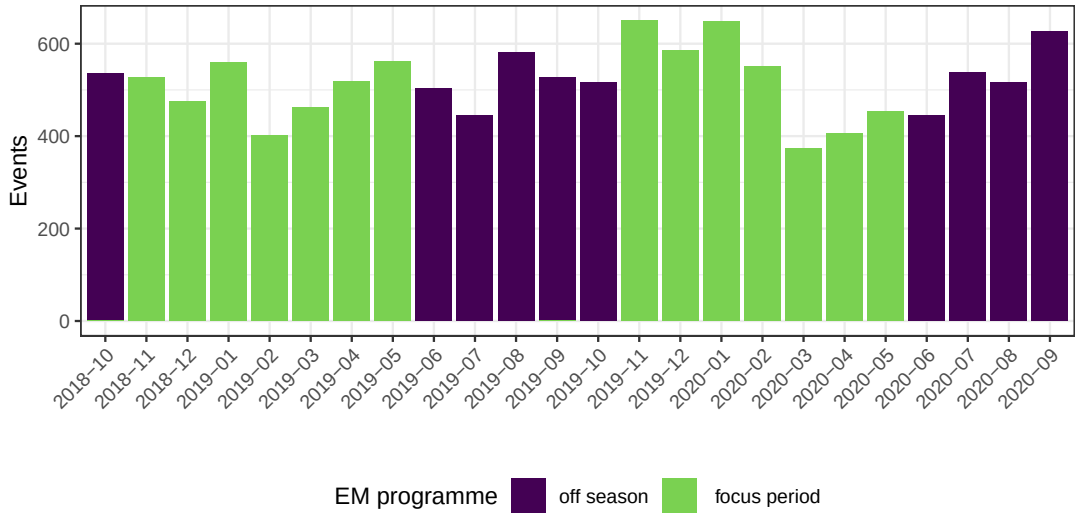

Figure 4: Bottom longline fishing events in FMA 1 in the 2019 and 2020 fishing years by month.

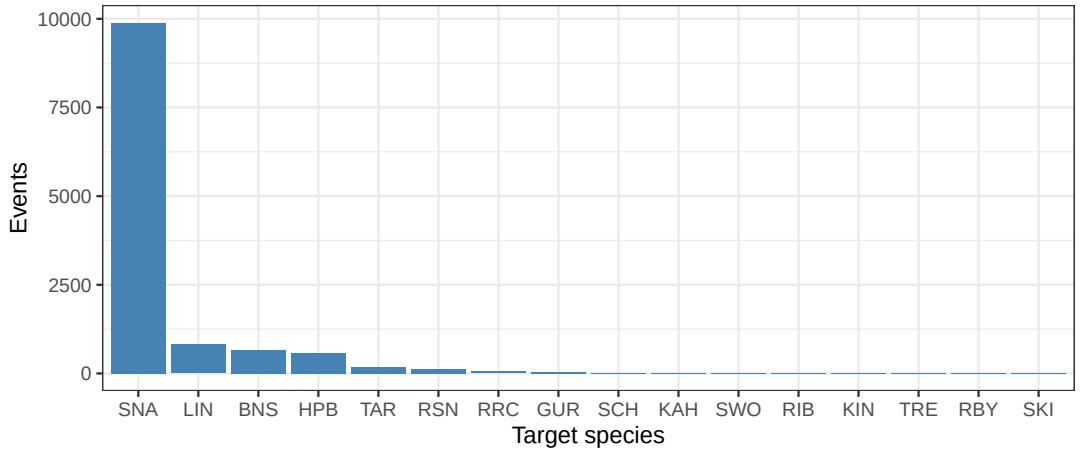

Figure 5: Bottom longline fishing events in FMA 1 in the 2019 and 2020 fishing years by target species: SNA, LIN (ling, *Genypterus blacodes*), BNS, HPB (Hapuku and bass, *Polyprion oxygeneios*, *Polyprion americanus*), TAR (Tarakihi, *Nemadactylus macropterus*, *Nemadactylus* sp.), RSN (Red snapper, *Centroberyx affinis*), RRC (Red scorpion fish, *Scorpaena cardinalis*, *Scorpaena papillosus*), GUR (Gurnard, *Chelidonichthys kumu*), SCH (School shark, *Galeorhinus galeus*), KAH (Kahawai, *Arripis trutta*, *Arripis xylabion*), SWO (Swordfish, *Xiphias gladius*), RIB (Ribaldo, *Mora moro*), KIN (Kingfish, *Seriola lalandi*), TRE (Trevally, *Pseudocaranx georgianus*), RBY (Rubyfish, *Plagiogeneion rubiginosum*), SKI (Gemfish, *Rexea* spp.).

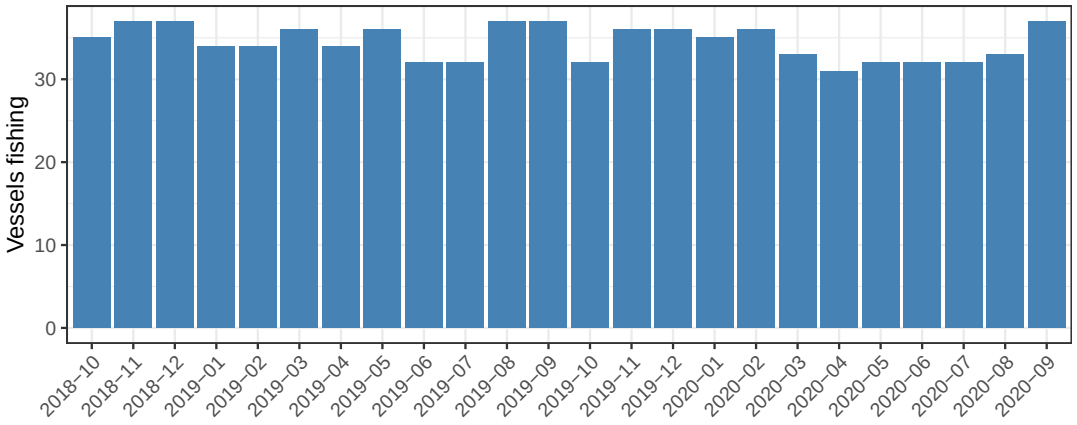

Figure 6: Bottom longline fishing vessels in FMA 1 in the 2019 and 2020 fishing years by month.

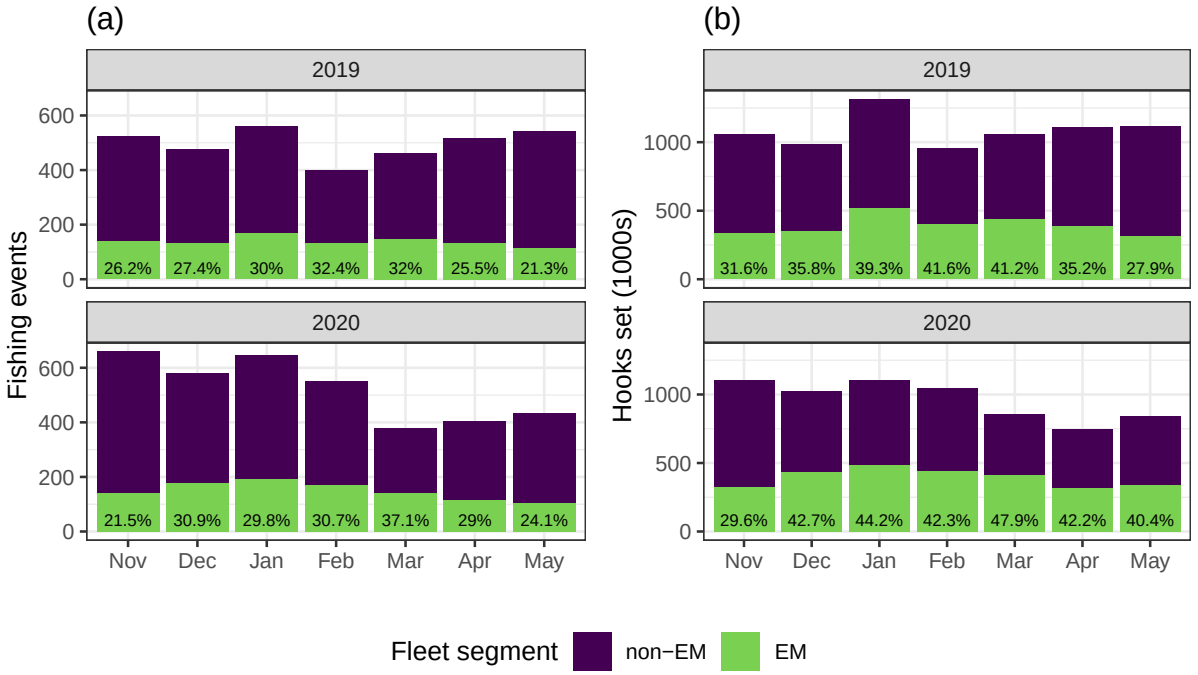

Figure 7: FMA 1 bottom longline effort in the 2019 and 2020 seasons, in terms of (a) fishing events and (b) hooks set, categorised according to whether vessels are part of the EM fleet. Note that this does not necessarily imply that EM footage was collected.

3.2 Footage collection

3.2.1 Operational aspects

The footage collection process in 2020 encountered a number of logistical challenges. Two issues with the new EM systems emerged early in the season:

- The domes that covered and protected the lens and sensor in the camera units (Figure 2a) developed hairline cracks; these allowed the ingress of moisture which condensed at times on the inside of the dome and led to fogging of the images. Due to diurnal temperature changes this did not always compromise imagery on a continuous basis. Camera units that developed cracked domes were swapped out during the programme to maintain footage collection while a longer term fix was developed.

- Fan noise and LED lights in the new wheelhouse units (Figure 2b) were found to disturb the crews of these small vessels. Fan noise was a concern when the vessels were at anchor, while the LED lights were a concern when the vessels were underway. As a result, participants were unwilling to operate the EM systems continuously as they had in previous seasons. The EM systems were typically powered up manually by the crew for the haul period.

The 2020 programme was also affected by the response to the COVID-19 pandemic. This impacted vessel operations, as operators responded to the altered market conditions, and the associated 'lockdown' prevented vessel visits for servicing the EM systems and use of courier services for returning footage for review. As a result, footage from the latter part of the 2020 programme was retrieved at the end of the programme rather than on a monthly basis.

A potentially serious health and safety incident occurred during the 2020 season when one of the participating vessels experienced an electrical fire in its engine room. A subsequent investigation indicated that the most likely scenario was that the wire powering the vessel's EM system arced after being damaged, creating the ignition source. This occurred following a scheduled port call as the vessel was heading from its berth to its intended fishing grounds. As a result of the efforts of the skipper and crew, the fire was identified and extinguished quickly, saving the vessel and surrounding environment from significant damage. An investigation of the incident indicated that the placement of the fuse in the EM system power supply was too far from the power source, and that the fuse placement had potentially been influenced by the system noise concerns and the crew's desire to be able to power down the systems. Because the systems were intended to record footage around the clock, they were not necessarily installed with isolation switches. This in turn led to the use of the fuses as switches to manage system noise. All EM system installations were subsequently reviewed with a focus on ensuring that crews could easily power down the systems when required, but with the expectation that they would be switched on during line hauling activity.

One EM system suffered an additional hardware problem with failure of the battery responsible for maintaining the EM system clock. In this situation, the EM system required network access to obtain the correct time, which is only available when the vessel is in cellular data range. Access to the cellular network was reduced as a result of the fact that systems were powered down, other than when hauling, rather than running continuously. As a result, footage from one vessel (referred to in this report as vessel ID UfU) may be incorrectly timestamped from February 2020.

Two sets of footage (one from 2019 and one from 2020) were initially loaded to the review system with erroneous timestamps; reviews of this footage were excluded as the timestamps on events defined by reviewers in this situation are incorrect. The affected 2019 footage was subsequently re-reviewed, but much of the affected 2020 footage was not reviewed as this footage was from the vessel with the clock problem.

3.2.2 Footage collection achieved

For the vessels in the project's EM fleet, Figure 8 indicates the monthly effort undertaken and whether EM footage was collected; in this case an event was considered to have footage if EM footage was recorded and catalogued for at least 80% of the haul period.

Overall footage availability for the FMA 1 bottom longline fleet (Table 4) indicates that coverage, expressed as hauling hours observed, was lower in November 2019 and 2020 than in the remainder of the season; this reflected the fact that the programme start-up was typically occurring in this period. When fully operational, the EM programme typically obtained footage from 20% to 30% of hauling hours, although this dropped below 20% in April and May 2020.

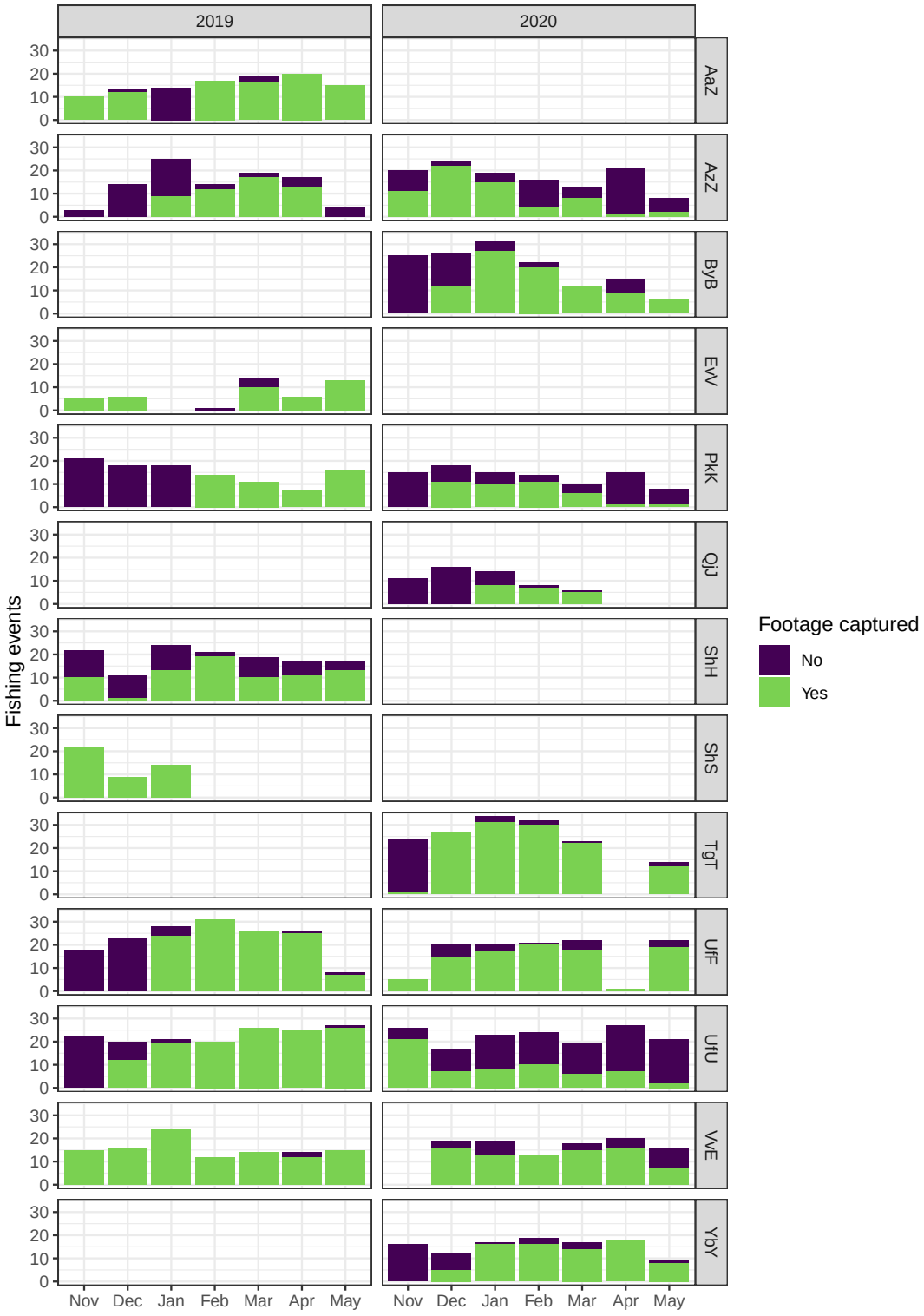

Figure 8: Fishing effort (fishing events in the statutory catch and effort data) by project vessel, fishing year, and month categorised according to whether footage was received from the vessel and catalogued in the review system database for more than 80% of the hauling period. Note that hauling hours are defined in 2020 from the ER data, but are assumed to be overestimated by the approach taken for 2019.

Monthly coverage of hauling hours by the EM fleet (Table 5) was near or above 90% in Feb–May 2019, despite the likely overestimation of the time spent hauling. In 2020 coverage peaked at 70% to 80% of hauling hours with between-vessel and between-month variation apparent (Table 6). The reduced coverage in 2020 is primarily attributable to the non-continuous powering of the EM systems, with some secondary impacts due to the operational disruption created by the COVID-19 lockdown.

Table 4: Monthly coverage (in terms of footage captured) for hauling periods of the FMA 1 BLL fleet in the 2019 and 2020 seasons.

	Hauling hours		
Month	Total	With footage	Coverage (%)
2019			
Nov	5418.8	580.0	10.7
Dec	5032.6	634.9	12.6
Jan	5959.0	1246.6	20.9
Feb	4391.9	1395.7	31.8
Mar	4871.2	1429.0	29.3
Apr	5224.9	1318.8	25.2
May	4924.3	1073.4	21.8
2020			
Nov	2170.7	303.3	14.0
Dec	1771.9	419.6	23.7
Jan	1924.8	519.7	27.0
Feb	1873.9	517.2	27.6
Mar	1422.6	455.8	32.0
Apr	1317.9	212.9	16.2
May	1401.1	266.1	19.0

Table 5: Monthly coverage (in terms of footage captured) for hauling periods of the EM fleet in the 2019 and 2020 seasons.

	Hauling hours		
Month	Total	With footage	Coverage (%)
2019			
Nov	1374.1	580.0	42.2
Dec	1349.3	634.9	47.1
Jan	1791.7	1246.6	69.6
Feb	1434.9	1395.7	97.3
Mar	1606.4	1429.0	89.0
Apr	1414.0	1318.8	93.3
May	1149.4	1073.4	93.4
2020			
Nov	679.5	303.3	44.6
Dec	649.6	419.6	64.6
Jan	696.9	519.7	74.6
Feb	663.0	517.2	78.0
Mar	619.5	455.8	73.6
Apr	464.0	212.9	45.9
May	474.6	266.1	56.1

Table 6: Monthly coverage (percentage of hauling hours with footage) for individual vessels in the EM fleet in the 2019 and 2020 seasons.

	Vessel	Nov	Dec	Jan	Feb	Mar	Apr	May
2019								
	AaZ	100.0	94.8	4.6	99.8	81.1	96.2	99.0
	AzZ	0.0	0.0	43.3	90.2	97.5	77.8	0.0
	EvV	100.0	100.0		0.0	73.3	100.0	99.9
	PkK	0.0	0.0	0.0	99.9	99.5	99.9	99.5
	ShH	52.5	21.4	65.4	95.2	50.7	82.1	83.1
	ShS	99.9	100.0	100.0				
	UfF	0.0	0.0	89.4	99.2	99.8	97.5	86.9
	UfU	0.0	75.1	95.7	98.1	97.6	99.1	98.4
	VvE	99.5	99.7	99.3	99.9	99.7	93.1	99.9
2020								
	AzZ	63.8	94.0	78.5	29.9	59.6	5.0	12.5
	ByB	0.0	51.6	88.4	88.5	100.0	63.0	74.0
	PkK	0.0	57.5	69.5	80.0	70.4	28.2	29.4
	QjJ	0.0	0.0	59.9	91.2	77.8		
	TgT	3.9	98.6	93.4	92.1	94.7		82.3
	UfF	100.0	82.5	87.2	96.9	79.2	98.3	84.5
	UfU	85.7	42.3	39.0	39.8	38.8	31.7	15.2
	VvE		83.6	74.5	98.9	85.5	74.0	42.6
	YbY	0.0	43.9	94.2	90.1	80.6	98.0	93.6

3.2.3 Coverage by event in the 2020 fishing year

In the 2019 season, the EM systems were powered and recording full time. However, did not occur in 2020, due to the noise of the new systems. To provide further insight into why vessels were not achieving full coverage of their hauling activity in 2020, hauls were classified according to whether they had ‘complete’ footage (defined as 95% of the hauling period with footage), ‘missing’ footage (no footage within the hauling period), or ‘incomplete’ footage (Figure 9, Figure 10).

For most records, hauls have either complete or missing footage. Missing footage arises when the EM system is non-functional, either due to a technical issue or because it was not turned on. Incomplete footage is assumed to indicate fishing events where fishers forgot to power on the system until hauling was underway.

This information was examined in-season and provided a basis for working with vessels to achieve coverage levels that were as high as possible, including examining patterns in more detail to assess whether incomplete footage was typically attributable to just missing the 95% threshold, and if performance changed over time (Figure 11).

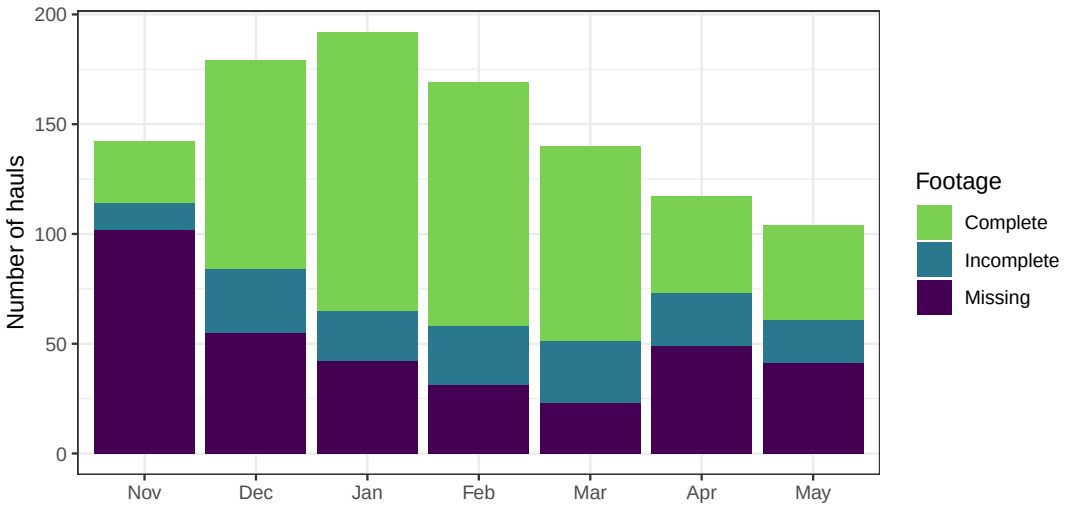

Figure 9: Classification of hauls by the EM fleet in the 2020 season by completeness of footage capture.

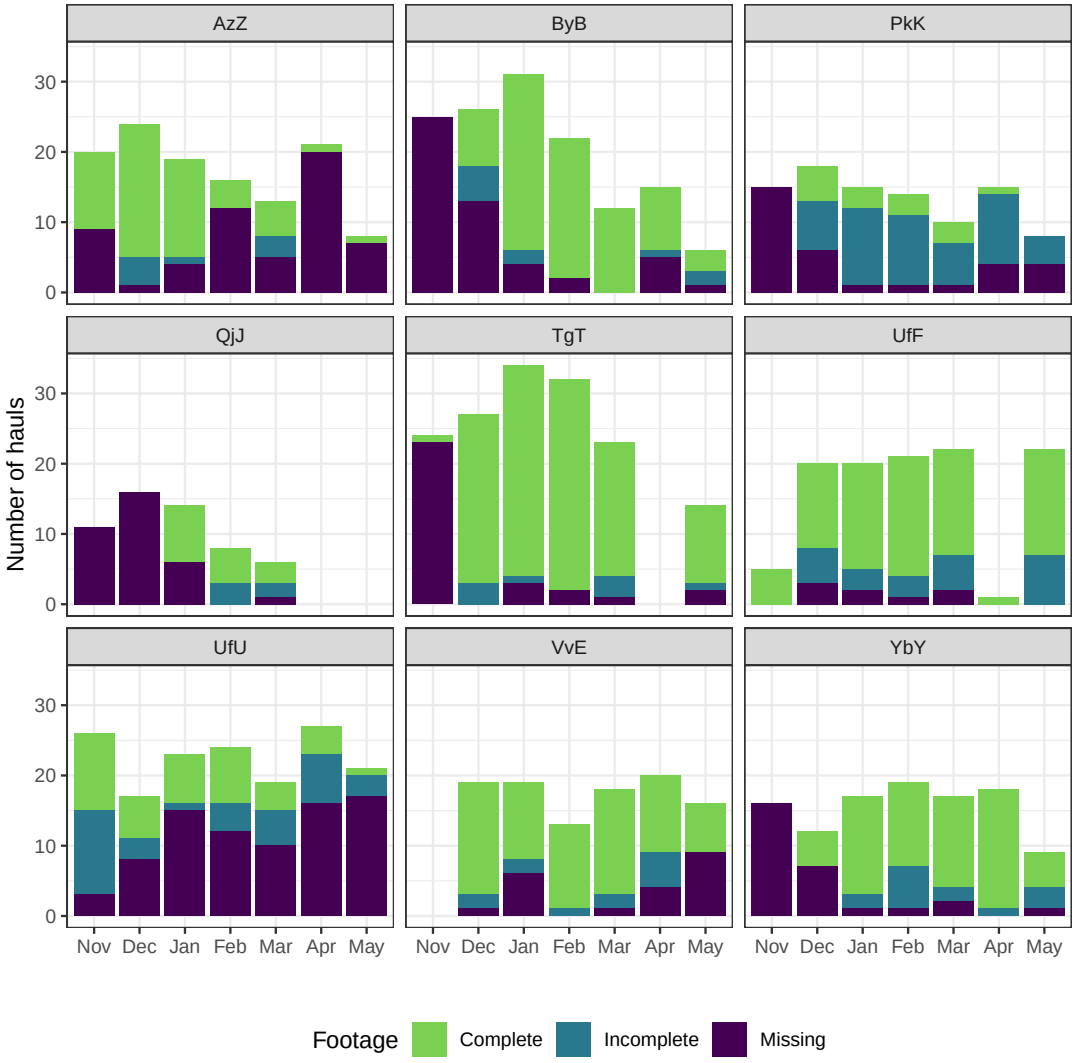

Figure 10: Classification of hauls in the 2020 season by individual vessels according to completeness of footage capture.

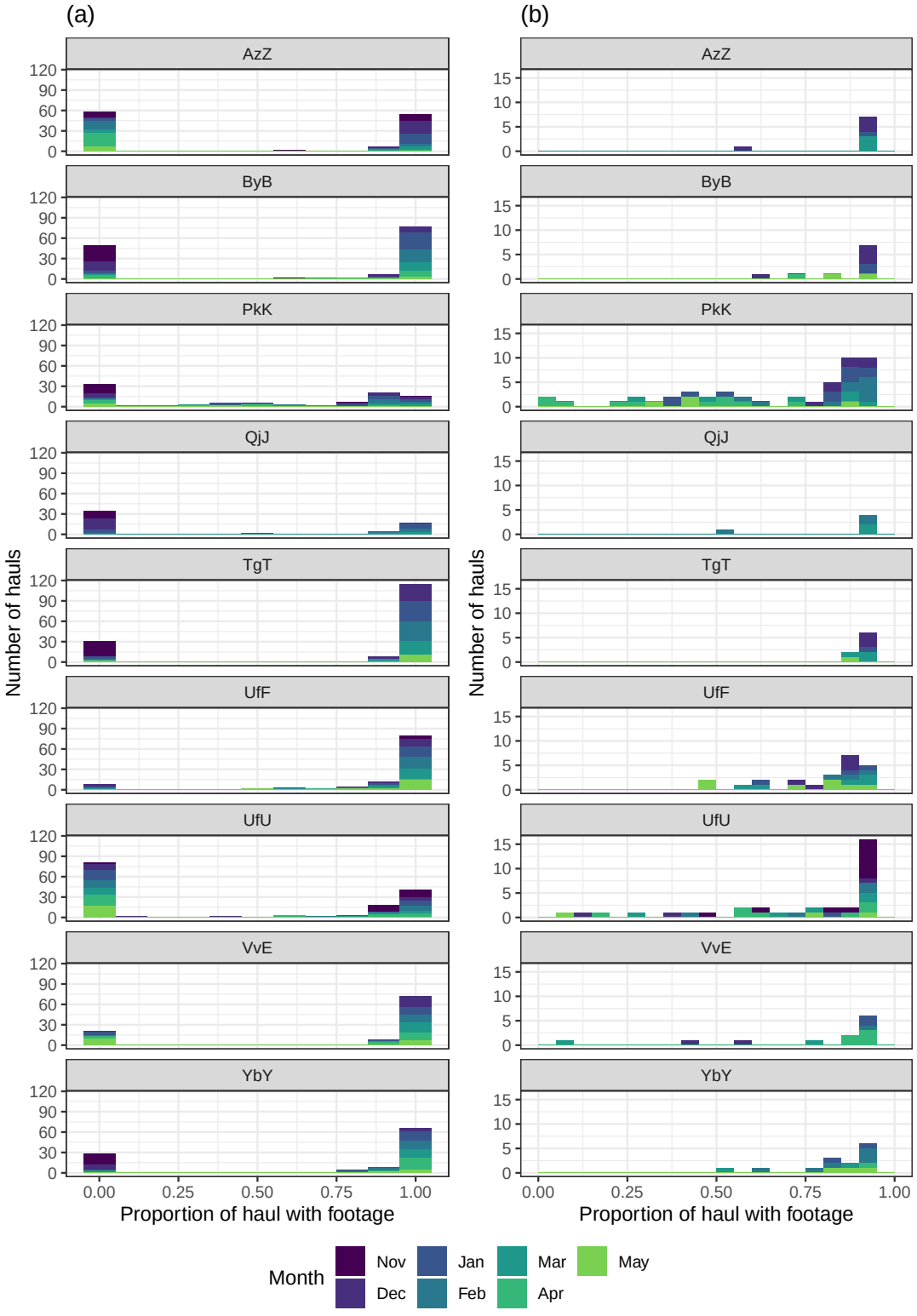

Figure 11: Vessel by vessel distributions of the proportion of hauling time with footage; (a) all hauls in the 2020 season, (b) hauls with incomplete footage.

3.3 Overall coverage

Graphical summaries of fishing effort, fisher-reporting of seabird captures, footage capture, and observer deployments are presented in Figure 12 for the 2019 fishing year, and in Figure 13 for the 2020 fishing year.

3.3.1 Fleet level coverage

In 2019, 3483 bottom longline fishing events took place in FMA 1 during the November–May period, and 700 (20.1%) had footage for at least 80% of the hauling period. For the same period, 243 fishing events (7%) were carried out when an observer was allocated to a vessel and were therefore potentially observed.

For the November–May season in 2020, 3646 bottom longline fishing events took place in FMA 1 during the November–May period and 645 (17.7%) had footage. Observers were allocated to a longline vessel for periods during which 308 fishing events (8.4%) were carried out and potentially observed.

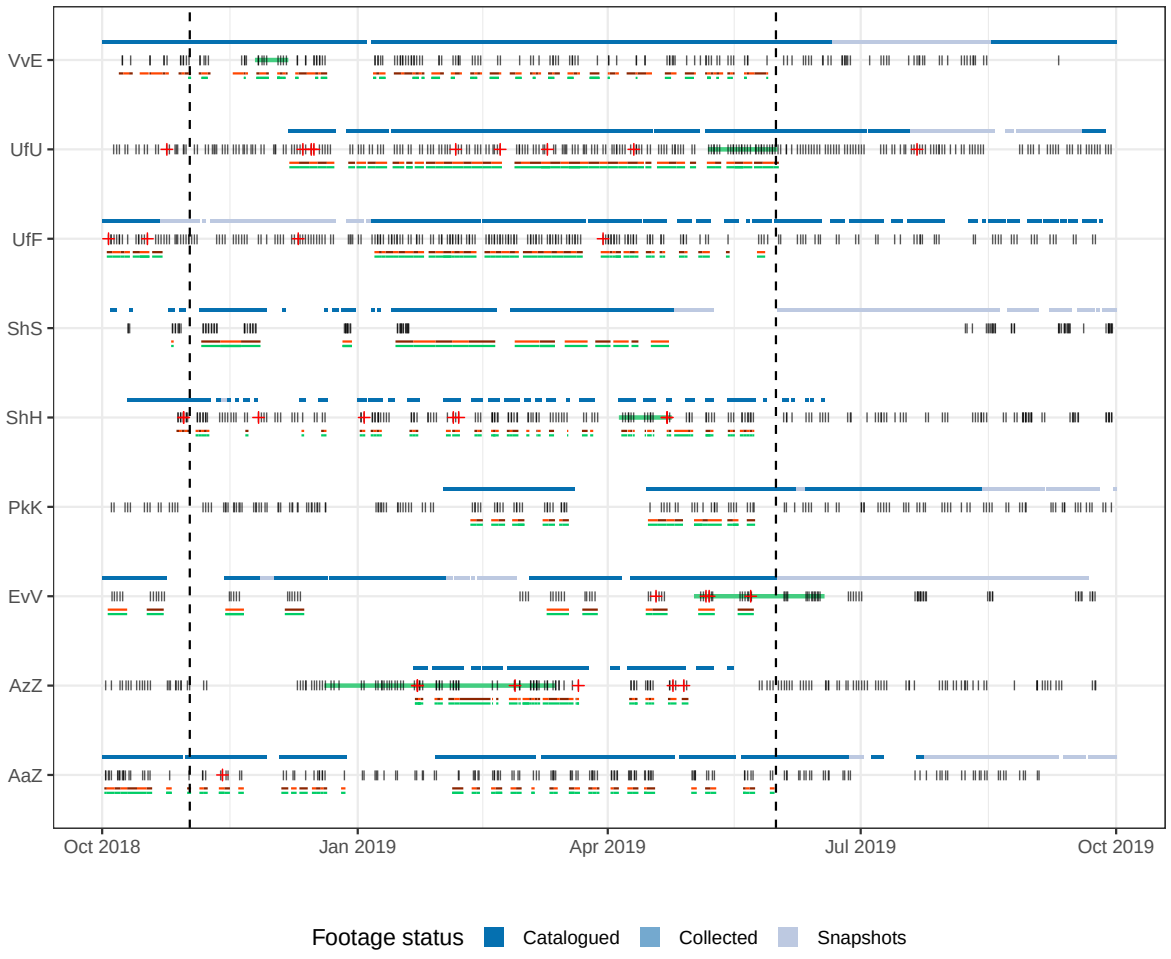

Figure 12: Bottom longline fishing events in FMA 1 (black vertical lines), fisher-reported captures (red crosses), observer deployments (green bars behind events), and footage for the EM fleet in 2019 (blue bars), with anonymised vessel identifiers. Trip slices defining port-to-port voyages are represented in the orange lines, with the different shades used to highlight boundaries between slices. Slices reviewed are indicated in green. The vertical dashed lines mark the boundaries of the period from 1 November to 31 May which is the focus of the programme.

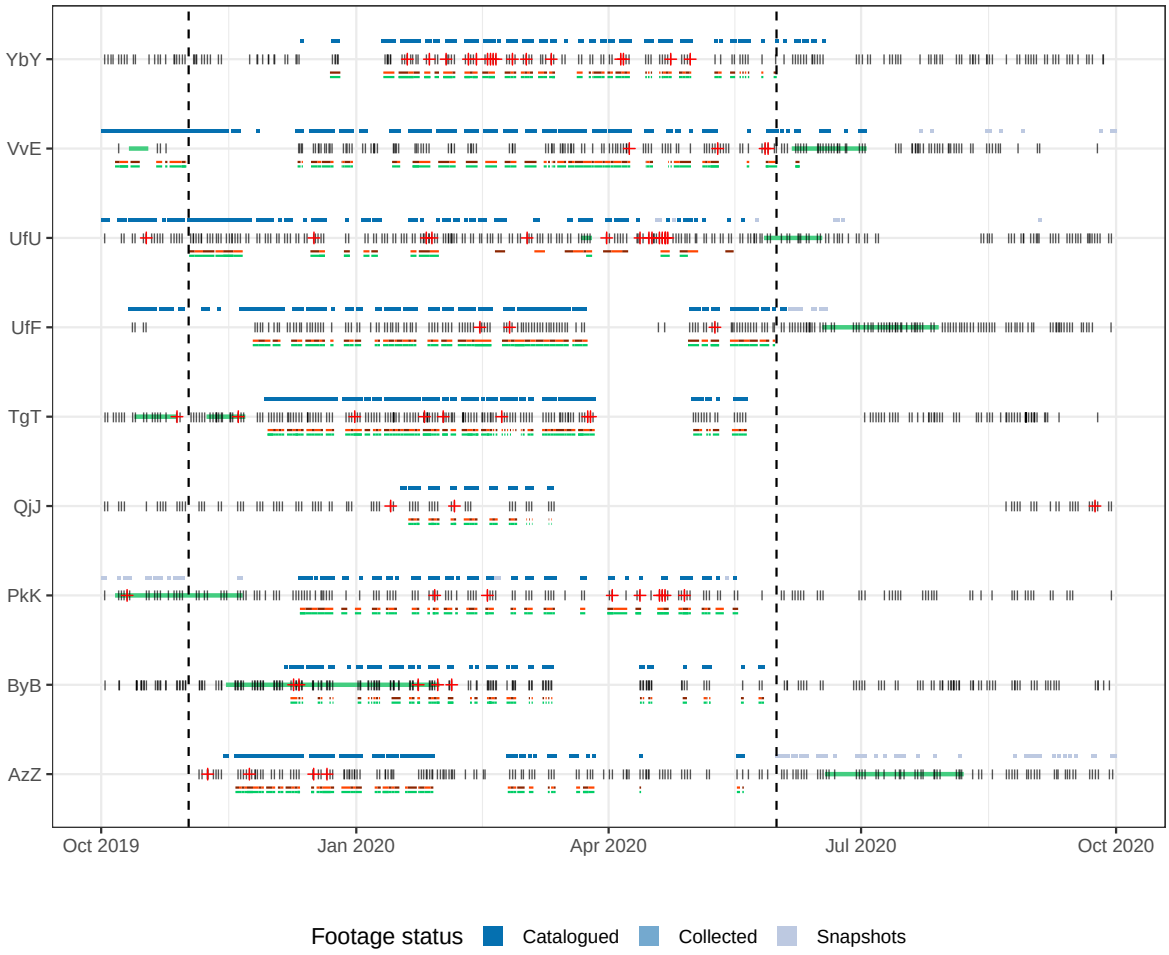

Figure 13: Bottom longline fishing events in FMA 1 (black vertical lines), fisher-reported captures (red crosses), observer deployments (green bars behind events), and footage for the EM fleet in 2020 (blue bars), with anonymised vessel identifiers. Trip slices defining port-to-port voyages are represented in the orange lines, with the different shades used to highlight boundaries between slices. Slices reviewed are indicated in green. The vertical dashed lines mark the boundaries of the period from 1 November to 31 May which is the focus of the programme.

3.3.2 Video observation coverage

The amount of footage captured from the EM fleet defines an upper bound for the coverage achieved by EM, but the actual coverage by the video observation process is dependent on the amount of footage that is reviewed to generate EM data.

Slices of footage representing port-to-port trips by vessels in the EM fleet were defined for periods when footage was available (Figure 12, Figure 13). A total of 801 slices fell within the periods 1 November 2018 to 31 May 2019 or 1 November 2019 to 31 May 2020. Slices varied in duration according to the fishing patterns of the vessels (Table 7). A total of 1325 fishing events were reported from periods when the footage was sliced.

The primary reviewing generated 905 reviews of 779 distinct slices: 335 from the 2019 season and 444 from the 2020 season. For 2019, 658 (18.9%) of bottom longline fishing events in FMA 1 were included in reviewed slices; in 2020, 612 (16.8%) events were part of the primary reviewing. Expressed in terms of coverage of hooks set to target snapper, video observation coverage in 2019 was 24.7% of effort and in 2020 was 23.8% of effort.

Table 7: Number of slices, and mean duration, by vessel, between November and May of the 2019 and 2020 fishing years combined.

Vessel	Slices available	Mean slice duration (days)
AaZ	41	1.8
AzZ	88	1.4
ByB	48	0.9
EvV	8	5.9
PkK	66	2.0
QjJ	25	0.9
ShH	59	1.1
ShS	16	6.5
TgT	80	1.3
UfF	108	2.0
UfU	74	3.1
VvE	132	1.6
YbY	56	1.4

3.4 Representativeness of coverage

In addition to assessing the volume of observational data available, it is useful to consider the extent to which this is representative of the fishery in terms of temporal and spatial patterns and the different target fishing activity.

Traditional, human observer coverage of the FMA 1 bottom longline fishery in 2019 was split evenly between vessels that were part of the EM fleet and other vessels. In 2020, observer coverage of the non-EM fleet increased although some deployments to the EM fleet continued (Figure 14).

3.4.1 Footage

The footage collected in 2019 and 2020 was broadly representative of the FMA 1 bottom longline fishery during the November to May season in terms of seasonal pattern (Figure 15), spatial distribution (Figure 16), and target species (Figure 17). The dip in coverage, relative to the fishery, in November 2019 is attributable to the transition to a new fleet and new hardware; most of the footage from November 2019 was collected on vessels that were part of the 2018–19 EM fleet. The 2019–20 fleet focused on vessels in the snapper target fishery, and so no bluenose target effort is represented in the 2020 footage.

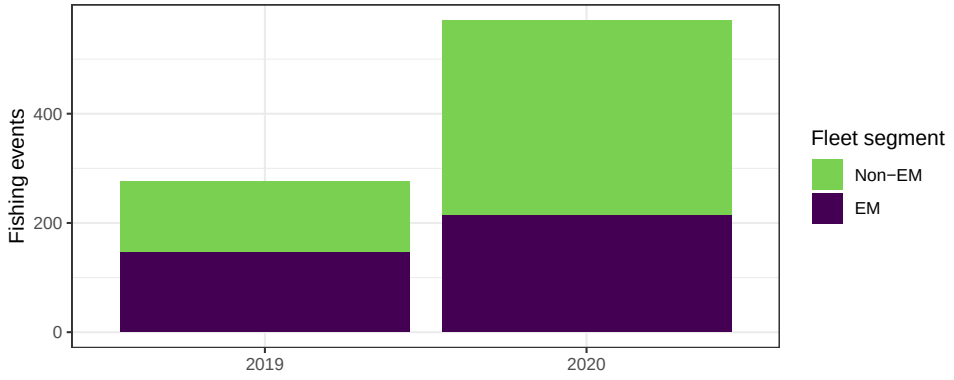

Figure 14: Fishing events during observer deployments in the 2019 and 2020 fishing years, grouped according to whether the vessels were part of the EM programme.

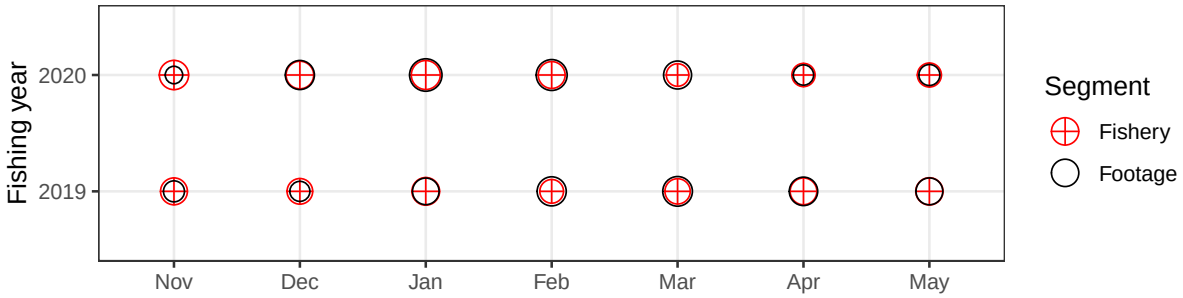

Figure 15: Footage collection representativeness by month for the Nov–May season in the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and footage proportions in a month will be the same.

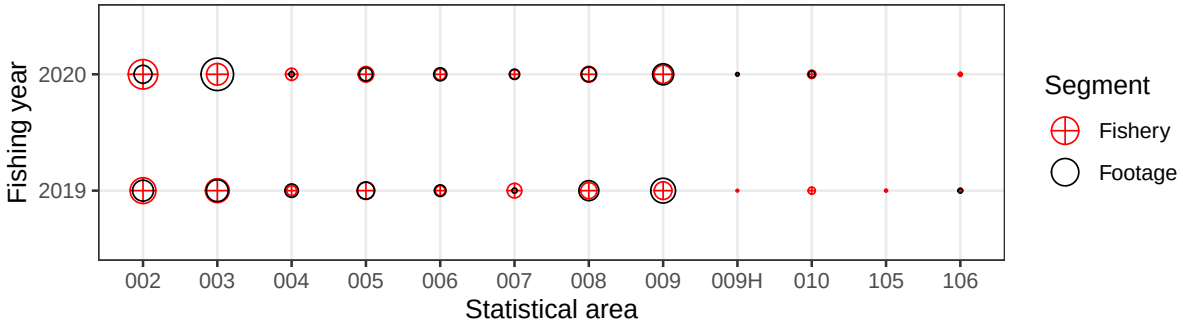

Figure 16: Footage collection representativeness by statistical area (see Figure 30 for location) for the Nov–May season in the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and footage proportions in an area will be the same.

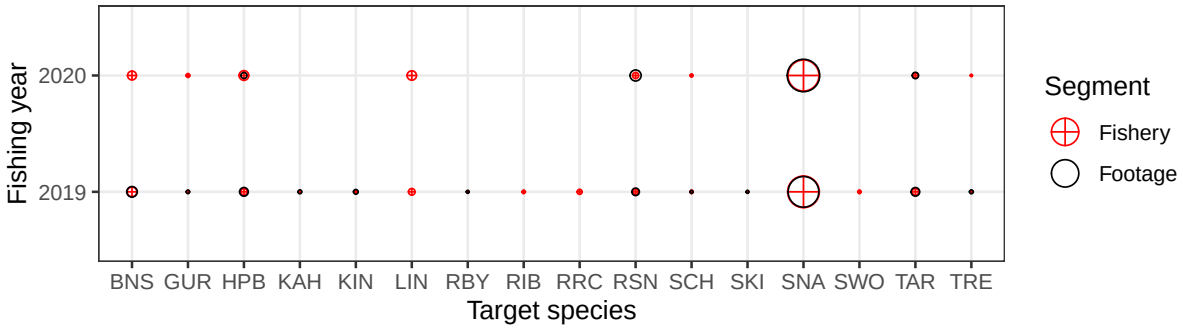

Figure 17: Footage collection representativeness by target species for the Nov–May season in the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and footage proportions for each target species will be the same. Species codes are defined in Figure 5.

3.4.2 Observer coverage

Observer coverage in 2019 was largely temporally representative of the 2019 season, but in 2020 coverage fell away in Feb–May, presumably as a result of COVID-19 restrictions (Figure 18). Spatial representativeness of observer coverage was variable in both 2019 and 2020 (Figure 19). Observer deployments in 2019 included effort in most key target species of the bottom longline fishery, but was largely focused on snapper target effort in 2020 (Figure 20).

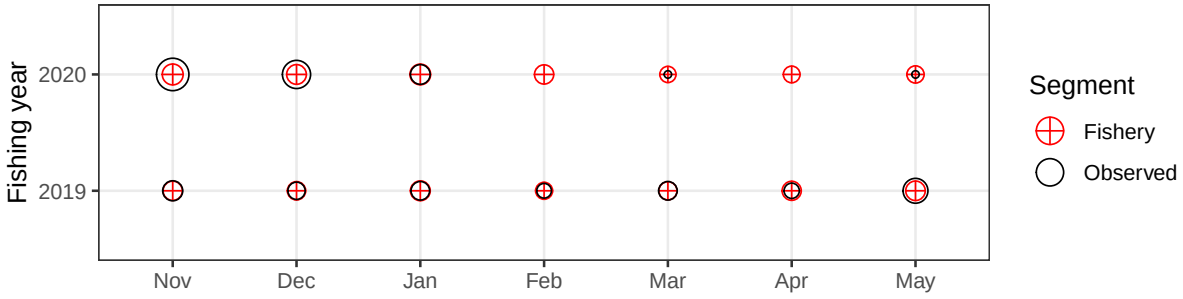

Figure 18: Observer coverage representativeness by month for the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and observed proportions in a month will be the same.

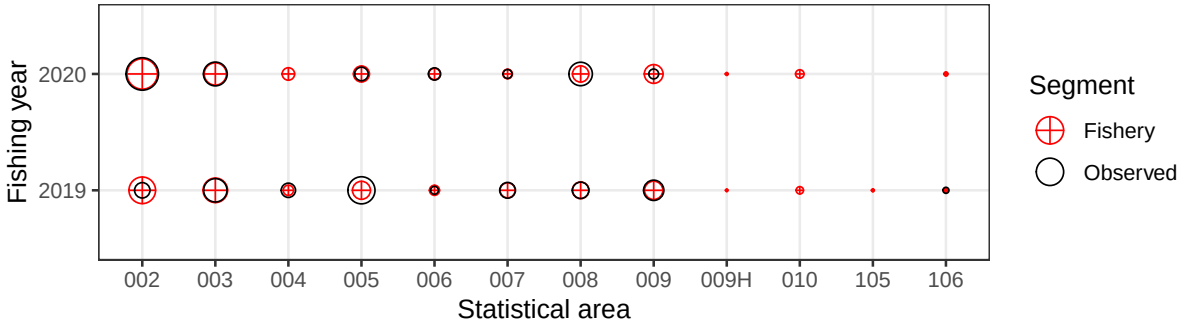

Figure 19: Observer coverage representativeness by statistical area (see Figure 30 for location) for the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and observed proportions in each area will be the same.

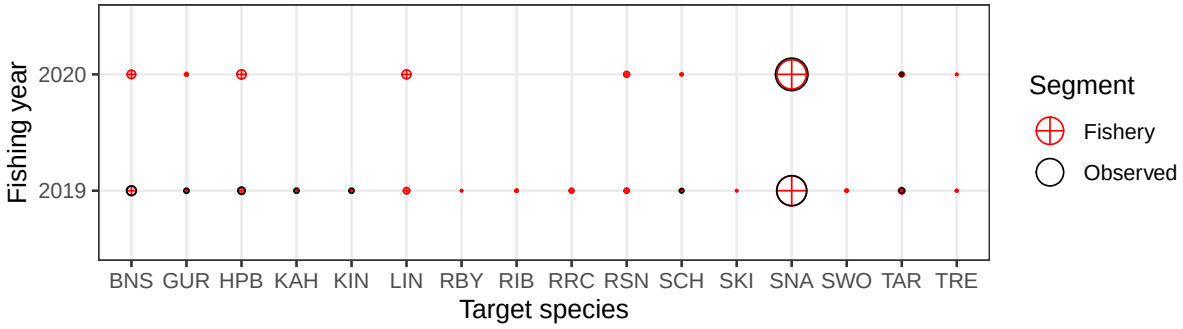

Figure 20: Observer coverage representativeness by target species for the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and observed proportions for each target species will be the same. Species codes are defined in Figure 5.

3.4.3 Reviewed footage

A high proportion of the footage collected in 2019 and 2020 has been reviewed and, as a result, representativeness of reviewed footage is similar to that of footage collected. The effort in reviewed slices was reasonably representative of the fishery by month (Figure 21), statistical area (Figure 22), and target (Figure 23) within the November to May season.

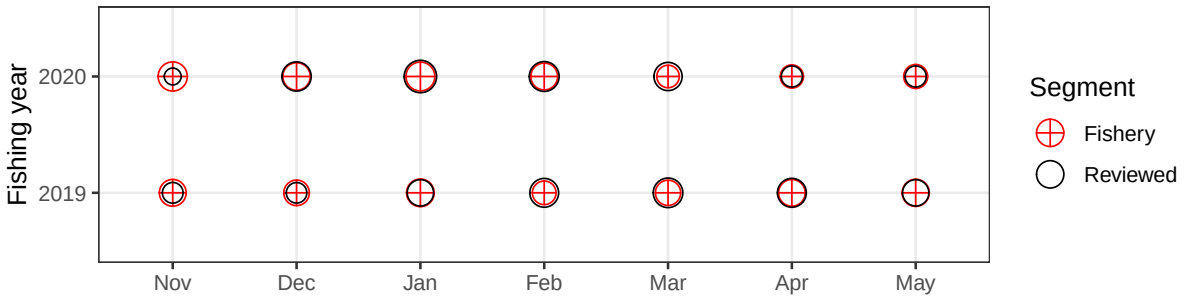

Figure 21: Reviewing representativeness by month for the Nov–May season in the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and reviewing proportions in a month will be the same.

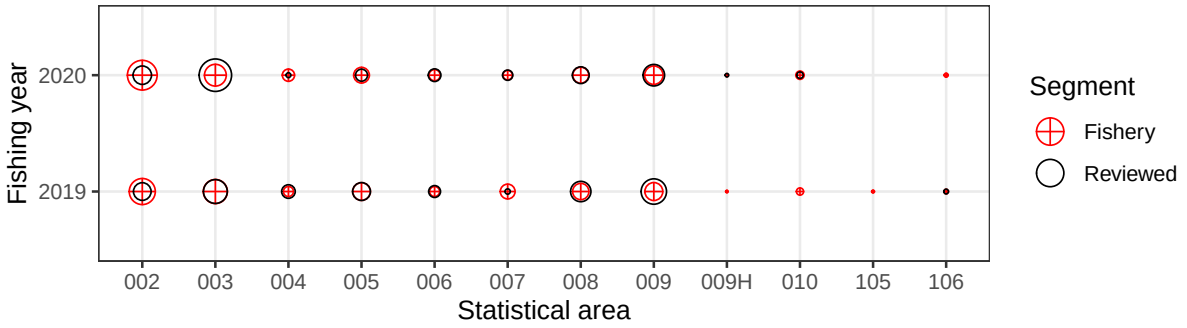

Figure 22: Reviewing representativeness by statistical area (see Figure 30 for location) for the Nov–May season in the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and reviewing proportions in each area will be the same.

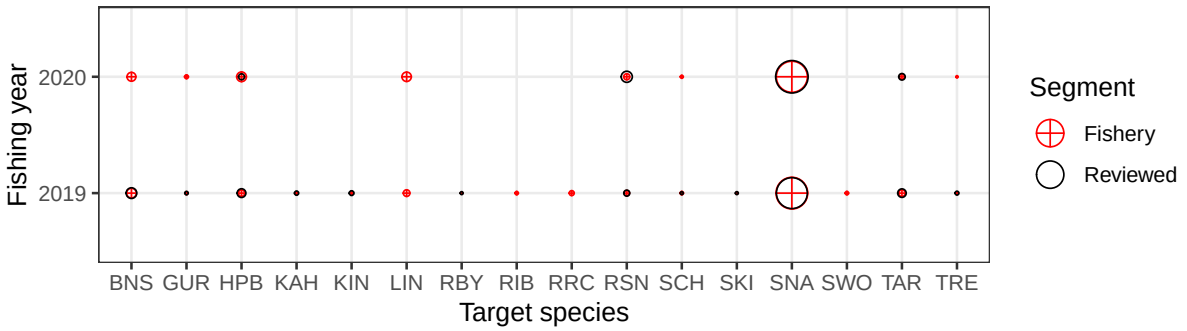

Figure 23: Reviewing representativeness by target species for the Nov–May season in the 2019 and 2020 fishing years. The area of the circles represents the proportion of the effort in the segment, by year. If coverage is completely representative, then the fishery and reviewing proportions for each target species will be the same. Species codes are defined in Figure 5.

3.5 Reviewing results

3.5.1 Assessment of footage quality

A key requirement for video observation is that the footage collected is fit for purpose, i.e., suitable for reviewers to generate the required observations. Because a slice may be reviewed multiple times, the assessments of footage quality presented here are based on the first review of a slice and are restricted to the haul period.

Assessment of camera deployment status (Figure 24) indicated that the vessels in the EM fleet were generally ensuring that the camera booms were deployed while fishing. Footage quality (Figure 25) varied between vessels and over time. There were quality issues during the programme startup in 2019, and the cracked domes and moisture ingress to the cameras impacted the quality of the footage from the new EM systems in 2020. Overall footage quality during hauling in 2020 was similar to that in 2019 (Table 8). Over the two years, between 5% and 7% of the footage was found to be unusable; between 62% and 68% was either low or medium quality; and between 25% and 32% was high quality.

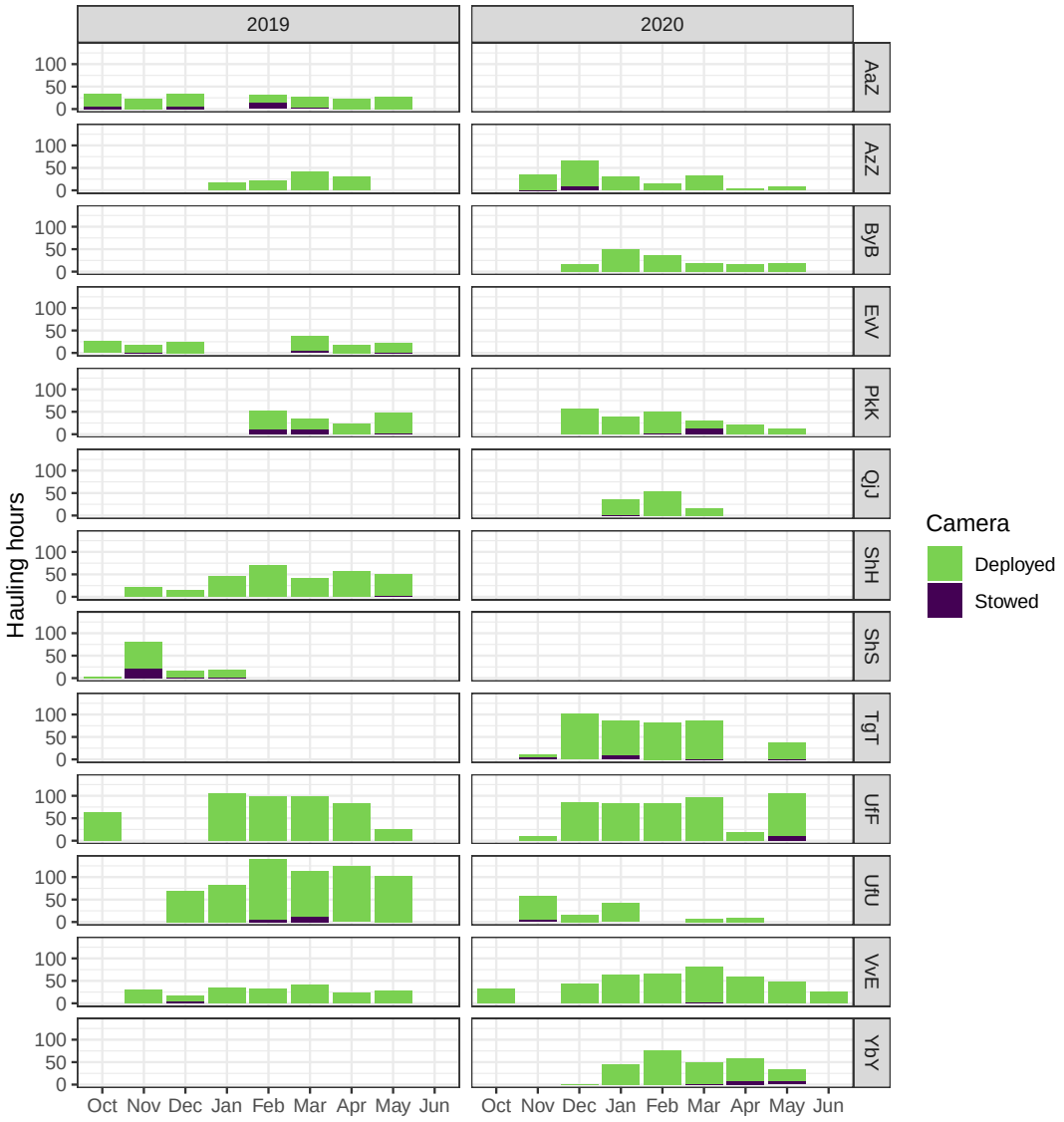

Figure 24: Hauling hours per vessel per month classified according to whether the camera was stowed or deployed, based on the first review of a slice.

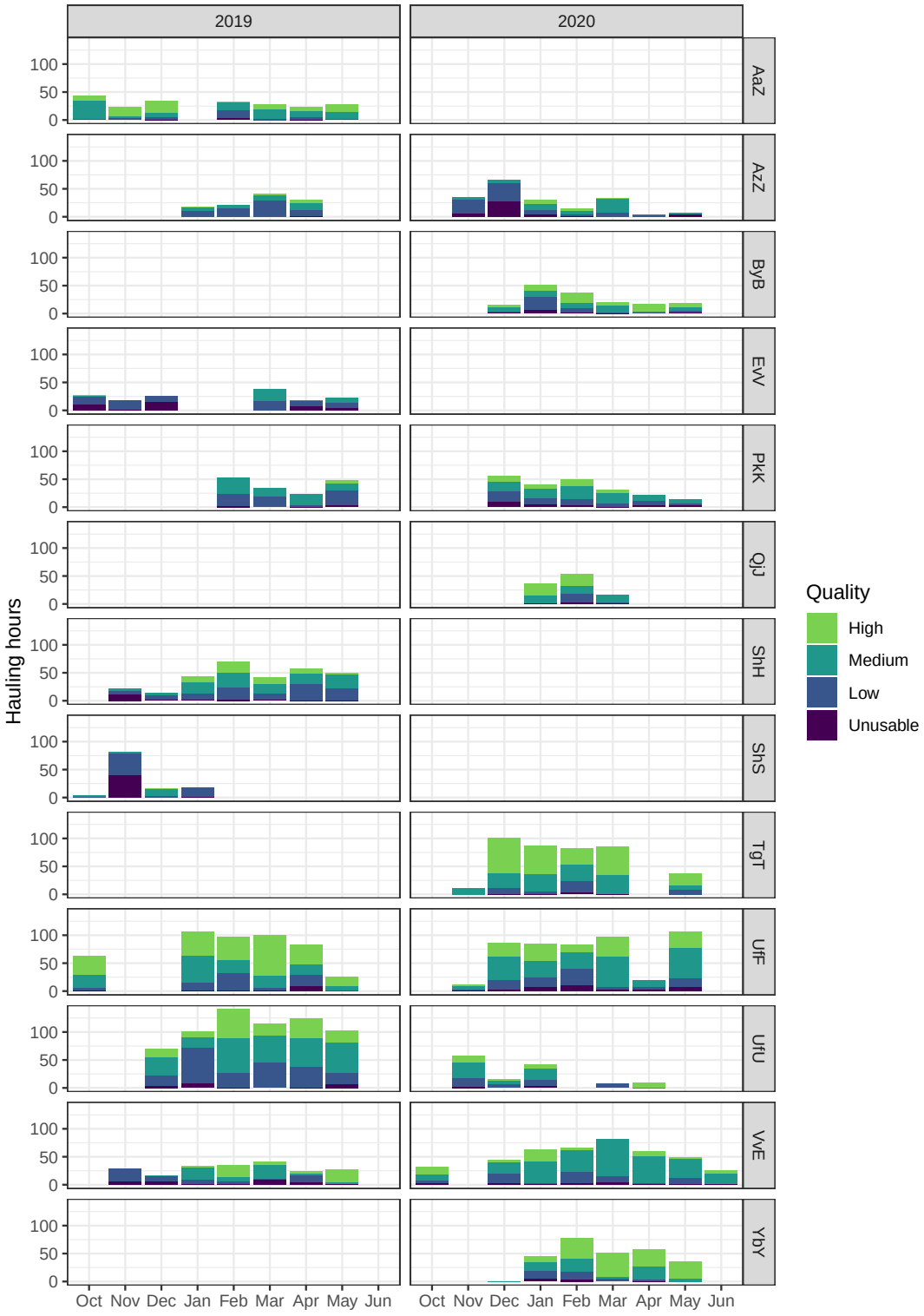

Figure 25: Hauling hours per vessel per month classified by footage quality, based on the first review of a slice.

Table 8: Overall reviewer-assessed footage quality during hauling by vessel and fishing year.

		Footage quality (% hours)			
Vessel	Fishing Year	High	Medium	Low	Unusable
AaZ	2019	37.8	43.4	17.1	1.6
AaZ	2020				
AzZ	2019	9.7	28.6	61.3	0.4
AzZ	2020	6.8	28.1	43.7	21.4
ByB	2019				
ByB	2020	37.9	27.0	28.8	6.3
EvV	2019	0.5	21.6	53.2	24.7
EvV	2020				
PkK	2019	4.6	46.1	46.2	3.1
PkK	2020	17.6	43.0	29.0	10.3
QjJ	2019				
QjJ	2020	41.5	37.8	17.9	2.9
ShH	2019	18.4	38.0	37.5	6.1
ShH	2020				
ShS	2019	0.2	14.0	51.5	34.3
ShS	2020				
TgT	2019				
TgT	2020	53.4	33.9	11.9	0.8
UfF	2019	51.3	29.2	17.1	2.5
UfF	2020	27.9	45.6	20.3	6.3
UfU	2019	23.7	40.5	32.9	2.8
UfU	2020	24.7	40.1	31.4	3.8
VvE	2019	28.6	28.4	30.6	12.4
VvE	2020	14.8	64.8	17.6	2.8
YbY	2019				
YbY	2020	57.1	25.5	14.3	3.2
All vessels	2019	25.7	34.5	33.1	6.7
All vessels	2020	31.7	41.2	21.4	5.7

3.5.2 Hauling hours

The reviewers identify the start and end of each hauling period during the reviewed slices. Over the two fishing years there were a total of 1159 vessel-days with hauling recorded by the video reviewers.

During 2019, there was a poor relationship between the hauling hours recorded by the video reviewers and the hours inferred from fishing effort records. This is because only the haul start time was recorded on the LTCER forms used by most of the fishers in that year, and the rest of the day (up until 8 pm) was assumed to be a potential hauling period. During 2020, most of the fishing was reported on electronic forms. These allowed for a haul start time and a haul end time to be recorded, so the haul duration is defined. During 2020, there was better agreement between the vessel-day haul times recorded by the fishers and by the video reviewers (Figure 26). The daily haul-time recorded by the video reviewers

tended to be less than by the fishers. The mean daily haul-time recorded by the fishers was 4.2 hours, while the mean daily haul-time recorded by video review was 3.9 hours. This was likely because the video reviewers recorded a change in activity during any substantial breaks in the hauling (i.e., lunch breaks, etc.).

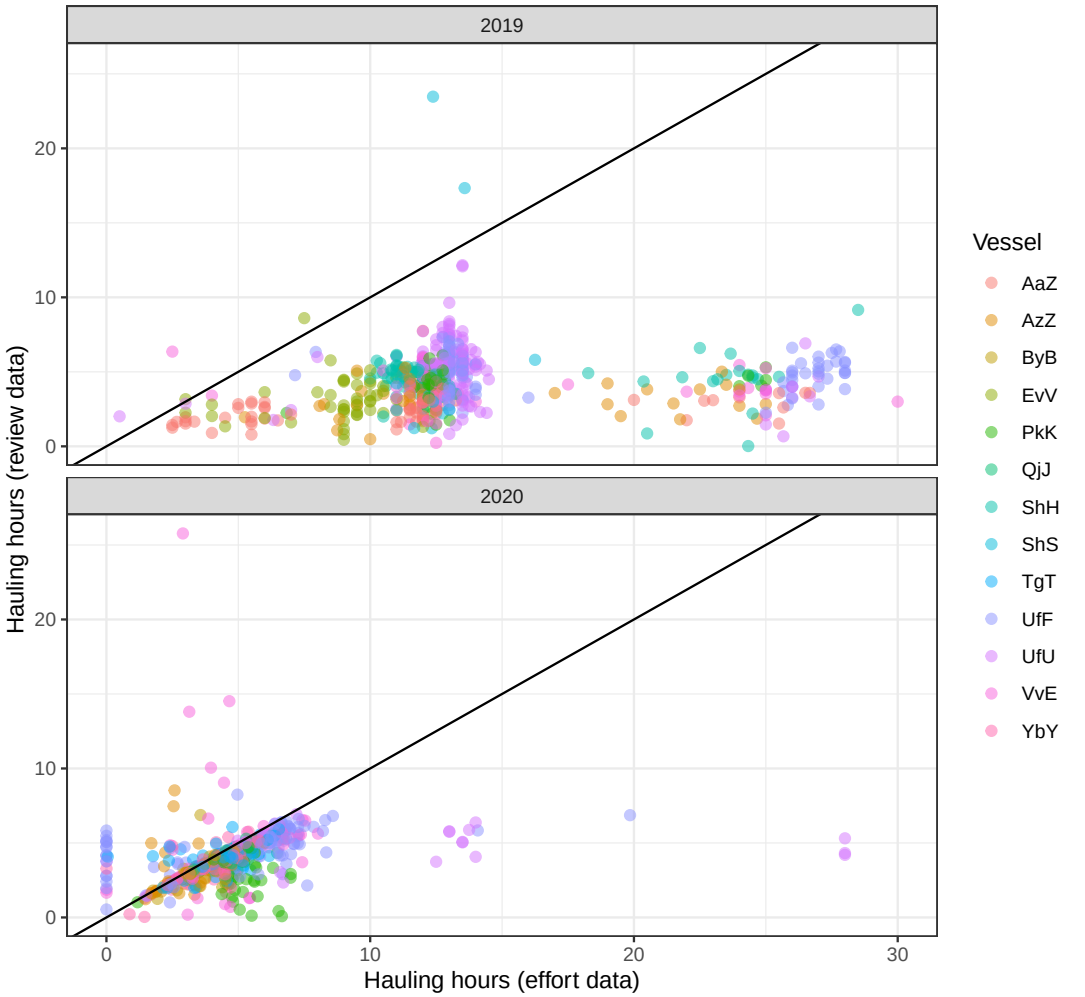

Figure 26: Hauling hours per vessel-day from reviewing and catch-effort data. For 2020 the effort data were from the Electronic Reporting system and hauling hours were based on the reported haul start and end times. For 2019, the effort data were from the LTCER form and haul end times were defined using the approach detailed in Section 2.3.

3.5.3 Multiple reviews

Multiple reviews were carried out for 114 slices which included 206 fishing events. Reviewers identified the same number of seabird captures on multiple reviews of 178 fishing events. However, the majority of events reviewed had no captures; of 32 events with multiple reviews and seabird captures detected on at least one review (Table 9) only 4 had no discrepancies in the number of seabird captures recorded. There are also 14 events where, despite multiple reviews, no seabird captures were detected by video observation but captures were reported by fishers.

There were 57 birds recorded caught by expert review on the footage that had multiple reviews. Of these captures, 20 were on footage slices that did not have any captures identified by the first reviewer. As an example, in event 4 (Table 9) the first reviewer did not report any captures, the second reviewer reported

six, and both the expert and the fisher-reported seven (which were identified as flesh-footed shearwater, *Ardenna carneipes*, captures). Around 40% of the captures were not identified in the footage by the first reviewer, and so would not have been recorded if the footage had only been reviewed a single time. Some of the captures that were missed by the first reviewer were on low quality footage (such as event 10 with a footage quality of 0.1, Table 9). However, the first reviewer also missed captures on events with high quality footage (such as event 10 with a footage quality of 3.0, Table 9).

The reviewers also reported potential captures that were not confirmed when the footage was subsequently reviewed by the expert. For example, in event 2 (Table 9) the reviewer noted potential captures, but these were identified by the expert as seaweed on the line. In this case the footage was low quality (a mean quality score of 0.2).

Table 9: Number of captures reported for fishing events with captures and multiple reviews. For each event, the table gives the number of captures reported by the first review, the second review, the expert, and the fisher. The mean quality of the footage is reported, and the expert notes are given (in the notes the numbers indicate the time associated with each comment).

	Review					
Event	1	2	Expert	Fisher	Quality	Expert reviewer notes
1	0	6	1	0	1.0	1137: - |1333:I could not find any seabird captures, is numerous pieces of seaweed coming up, which possibly have been mistaken for a seabird, as the video is very blurred.
2	11	0	0	0	0.2	1119:Can't seem to find a seabird capture, perhaps seaweed mistaken for a seabird?
3	13	4	6	1	0.4	1324: - |1323: - |1322: - |1325: - |1326: -
4	0	6	7	7	1.0	1601:Multiple XFS captures
5	0	6	0	0	1.4	1610:No seabird interaction found, several pieces of seaweed come up, which may have been mistaken for a bird?|1609:No seabird interactions found, lots of seaweed comes up which may have been misatken for birds.|1608:No seabird interaction found, seaweed comes up with some fish maybe mistaken for a bird?|1607:No seabird interaction found some seaweed come sup with fish, causing confusion?|1606:No seabird interacts found, several pieces of seaweeds come up with fish which may have been confused?
6	3	0	3	3	0.7	1425:Two seabird captures, both XFS|1424: -
7	1	4	3	4	3.0	1345: - |1612: - |1611: -
8	2	0	1	1	0.2	1361: -
9	1	3	4	0	1.0	1429:4 dead XFS caught
10	0	2	2	1	0.1	1587: - |1586: -
11	0	2	2	4	1.0	1598: - |1597: - |1578: -
12	2	0	1	0	0.1	1445: - |1444:Couldn't find a seabird capture - check right segment?
13	2	0	3	3	0.4	1600: - |1599: -
14	1	0	1	1	0.4	1123: -
15	1	0	1	1	0.2	1355: -
16	3	2	3	3	0.3	1408: - |1363: - |1362: -
17	1	0	0	0	0.1	1138:No seabird interaction found, some red-billed gulls come very close in to crew working, but are never caught
18	0	1	1	1	3.0	1605: -
19	0	1	2	1	0.3	1588: -
20	0	1	1	1	0.4	1589: -

(continued ...)

Table 9: Number of captures reported for fishing events with captures and multiple reviews. For each event, the table gives the number of captures reported by the first review, the second review, the expert, and the fisher. The mean quality of the footage is reported, and the expert notes are given (in the notes the numbers indicate the time associated with each comment). ***(continued)***

	Review					
Event	1	2	Expert	Fisher	Quality	Expert reviewer notes
21	0	1	1	0	0.4	1590: -
22	0	1	1	1	2.9	1604: -
23	0	1	1	1	0.5	1602: -
24	1	0	0	0	0.4	1342:I could not find a seabird capture event, could seaweed be confused with a bird?
25	0	1	1	2	0.1	1614: -
26	1	0	0	0	0.3	1422:No seabird capture found - check right segment?
27	2	1	2	3	0.2	1577: -
28	0	1	0	0	0.4	1615:No seabird interaction found, and I couldn't really see anything which might be confused with a bird.
29	2	2	2	0	1.0	1346: - |1121: -
30	0	0		1	0.7	
31	0	0		1	0.1	
32	1	1	1	1	1.0	1344: -
33	1	1	1	0	3.0	1439: -
34	0	0		1	1.0	
35	0	0		1	3.0	
36	0	0		1	3.0	
37	0	0		1	3.0	
38	0	0		1	0.6	
39	0	0		1	3.0	
40	0	0		1	0.2	
41	0	0		1	0.1	
42	1	1	1	3	0.1	1576: -
43	0	0		2		
44	0	0		1	0.0	
45	0	0		1		
46	0	0		1	0.3	

3.5.4 Seabird captures

Based on expert review of the video footage, there were 36 seabird captures during 2019, and 65 during 2020 (Figure 27). Around half of the seabird captures were dead (55.6% of captures during 2019, and 43.1% of captures during 2020). The highest number of captures recorded from a single vessel was 24 captures; these captures occurred on 14 different days during 2020.

Flesh-footed shearwater was the most frequently caught species (24 captures during 2019, and 48 captures during 2020), followed by black petrel (10 captures during 2019, and 13 captures during 2020). There were also three captures of black-backed gull (*Larus dominicanus*, one in 2019, and two during 2020); one capture of sooty shearwater (*Ardenna grisea*, in 2019), one capture of white-capped albatross (*Thalassarche cauta*, in 2020), and one capture of Buller's shearwater (*Ardenna bulleri*, in 2020). Flesh-footed shearwater were typically caught closer to shore, with black petrel caught further offshore (Figure 28).

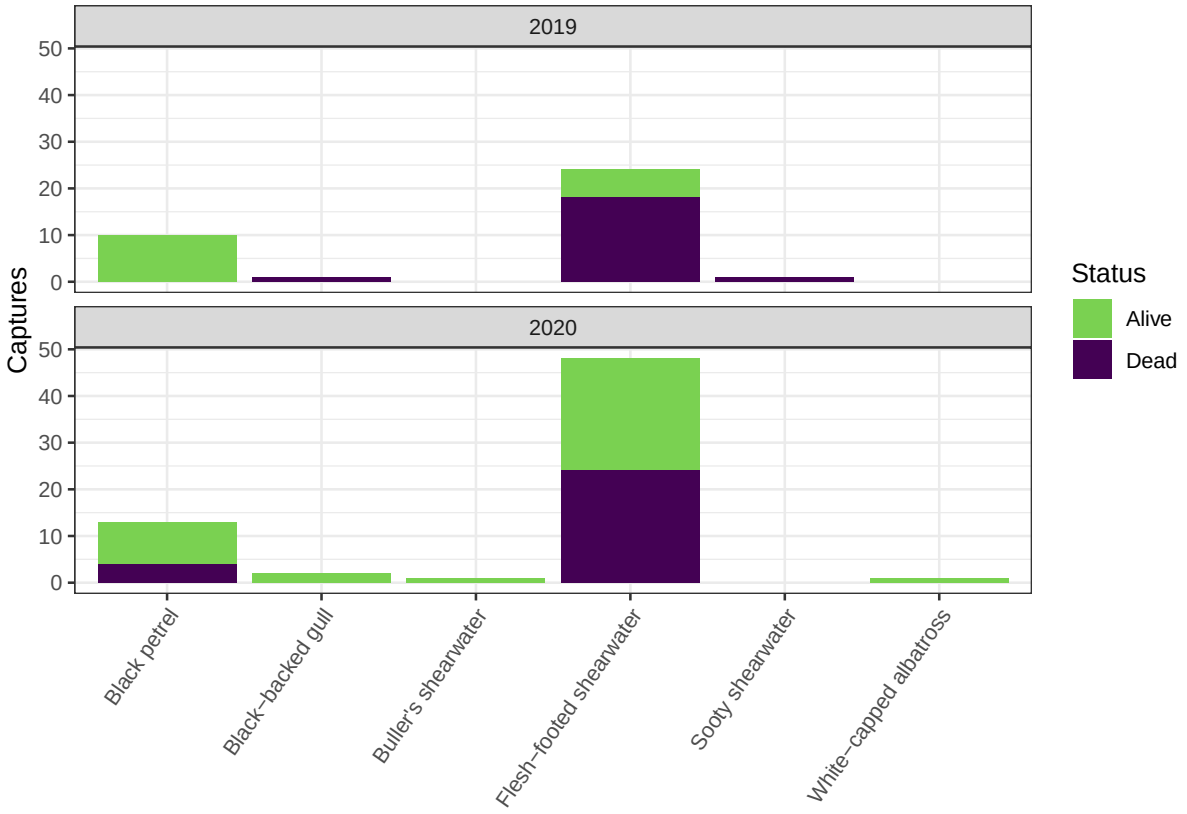

Figure 27: Seabird captures identified in the video observation programme.

3.5.5 The linked dataset

The video observations were linked to the fisher-reported effort data at an event by event level. This linked data set allowed for capture rates (seabird captures per 1000 hooks) to be determined, for comparison between video monitored and fisher-reported captures, and for estimation of total seabird captures.

During the 2020 fishing year, there were 31 vessel-days with fishing activity recorded from video review, but with no fishing included in the statutory data (5.2% of vessel-days during 2020 with video review). Video review on these days could not be straightforwardly linked with the fishing effort.

The linked data included 36 captures that occurred during the 2019 fishing year, and 64 captures from the 2020 fishing year. In addition data from the previous years were provided, and so the linked data also included 23 captures from 2017 and 48 captures from 2018.

From all the reviewed video observations in the linked dataset, the seabird capture rate was 0.014 captures per 1000 hooks during 2017; 0.033 captures per 1000 hooks during 2018; 0.02 captures per 1000 hooks during 2019; and 0.036 captures per 1000 hooks during 2020.

3.5.6 Fisher-reported captures

Over the 2019 and 2020 fishing years, there were 263 seabird captures reported by fishers from bottom longline fishing within FMA 1. Of these captures, 135 were reported from vessels participating in the video monitoring trial (a capture rate of 0.0158 seabird captures per 1000 hooks). There were 128 captures reported from other vessels, with a capture rate of 0.0081 seabird captures per 1000 hooks. The rate of reporting by vessels participating in the trial was around twice as high as the rate of reporting by other

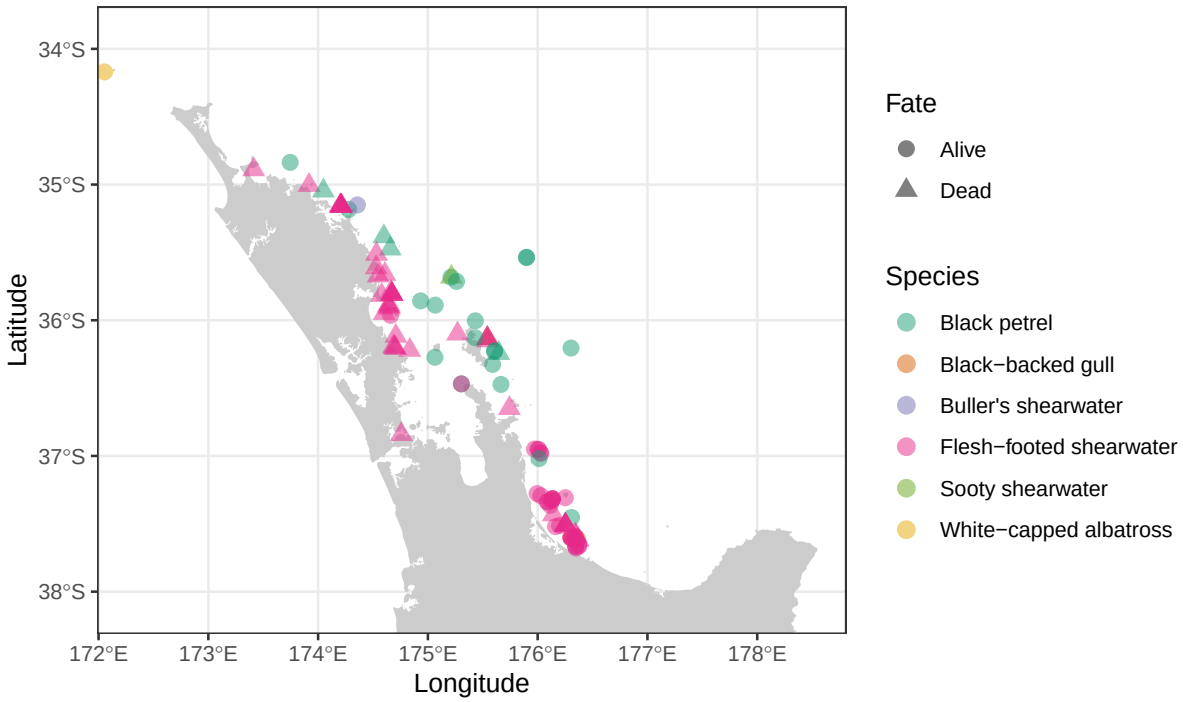

Figure 28: Locations of seabird captures identified in the video observation programme.

vessels. A more detailed analysis of data from the 2017 and 2018 fishing year also found a doubling in the reporting rate when vessels began participating in the trial (Tremblay-Boyer & Abraham 2020).

The linked dataset allowed the captures reported from the video monitoring to be compared with the captures reported by fishers. During 2019 and 2020, there were 100 seabird captures from video review in the linked dataset. On the fishing events that were video-reviewed, there were 100 fisher-reported captures. While the overall numbers of reported captures were similar, only 38 (38%) of the video-review captures were on events that had the same number of fisher-reported captures, so there was considerable discrepancy at an event by event level.

In the 2019 and 2020 fishing years, relatively few video data were collected during June to September (158 fishing events had video recorded, but only 3 events were reviewed, with no reported seabird captures) because the programme was focused on flesh-footed shearwater and black petrel. Both of these species migrate out of New Zealand waters during these months. The fisher reporting provides supporting evidence of a decline in the seabird captures during the winter. Of the 251 captures reported by fishers during 2019 and 2020, five occurred between June and September, a rate of 0.0006 seabirds per 1000 hooks (which compares with the overall average rate of 0.0103 seabirds per 1000 hooks).

3.6 Estimated seabird captures

The model of seabird captures converged (the $\hat{R}$ of all parameters was less than 1.01, and there were no divergent transitions). When used to predicted captures on the video-review data used to fit the model, the distributions of the numbers of seabirds caught per fishing event agreed for low numbers of captures (Figure 29) but the model estimated that up to 80 seabirds could be caught on a single haul. Capture events with this number of seabirds caught per haul have not been recorded in bottom longline fisheries

in FMA 1. The maximum number of captures seen in the video-review data on a single event was 14, and the maximum number recorded in observer data between 2001 and 2018 on a single event was 28. The consequence of model estimating these occasional very large number of captures per fishing event is an increase in the credible interval of the estimates. In recent work on seabird bycatch estimation, the parametrisation of the negative binomial distribution has been changed to make these large events less likely (Abraham & Richard 2020).

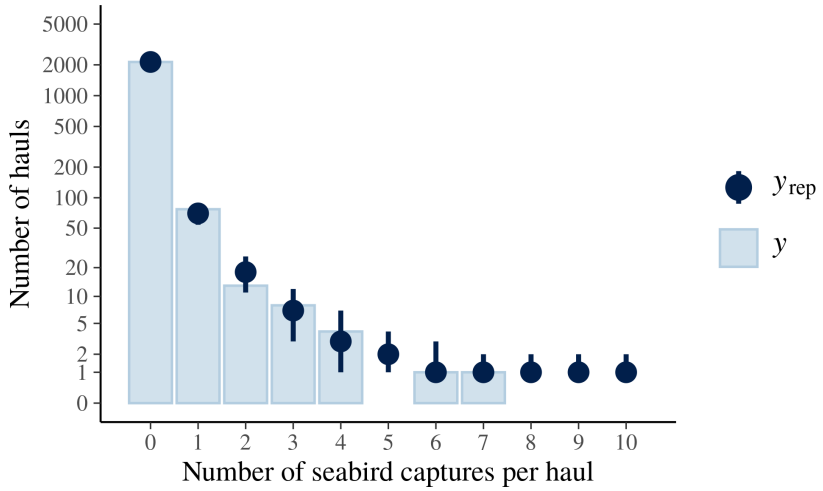

Figure 29: The distribution of seabirds caught per fishing event, taken from the video-review data used to fit the model (y, indicated by the bars, from the 2016/17 to 2019/20 fishing years), and from the posterior distribution of estimates taken from applying the model to the video-review data (y_{rep}, showing the mean and the 95% credible interval). The graph is truncated at 10; there was a single event with 14 seabirds caught on a haul, and the model estimated that 99% of capture events were of 10 or fewer birds (with 99.9% being of 25 or fewer birds).

There were an estimated 296 (97.5% c.i.: 166 to 519) seabird captures in all bottom longline fishing in Fisheries Management Area (FMA) 1 between October 2019 and May 2020. This corresponded to a capture rate of 0.038 (95% c.i.: 0.021 to 0.067) seabird captures per 1000 hooks set over this period. Estimation was not carried out for the winter period (June to September) as the model had high uncertainty over this period due to the lack of video observations. As most of the captures were of flesh-footed shearwater and black petrel, seabird captures may be assumed to be low over this period because both of these species migrate out of New Zealand waters during the winter.

The estimated seabird capture rate from the video review was similar to the rate of 0.038 (95% c.i.: 0.029 to 0.050) seabird captures per 1000 hooks, estimated for the Northland-Hauraki area during the 2017–18 fishing year (Abraham & Richard 2020)[4] (although the comparison is between fishing in different areas, and over different periods of the year). Note that the estimate based on observer data is derived from data collected over 11 years (between 2002–03 and 2017–18) and so has a lower uncertainty.

The highest captures were in Statistical Area 003, to the north and inshore of Great Barrier Island (Figure 30). Estimated captures were low in the inner Hauraki Gulf.

[4]https://psc.dragonfly.co.nz/2019v1/released/birds/bottom-longline/all-vessels/northland-and-hauraki/2017-18/

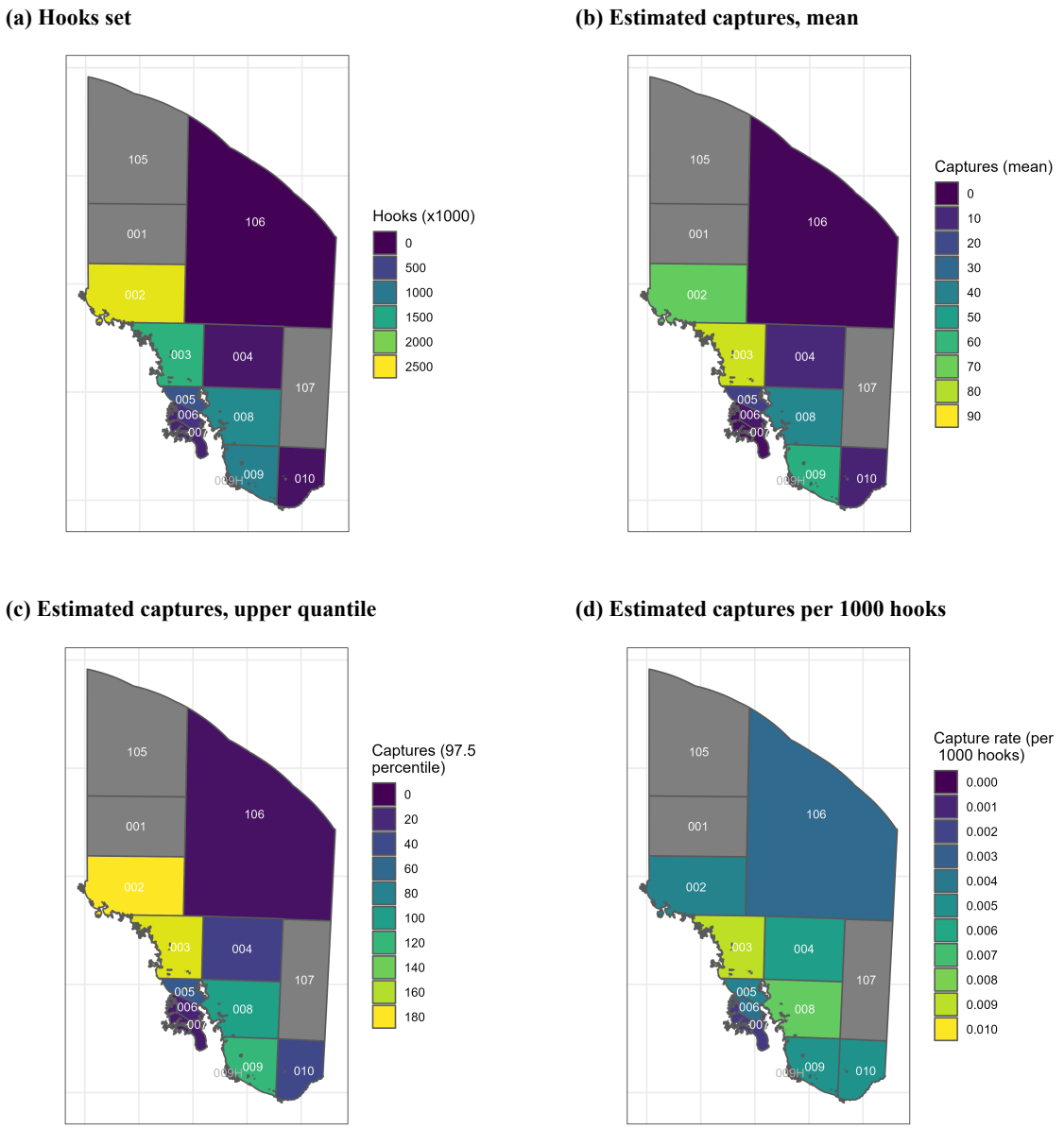

Figure 30: Estimated captures during the 2019–20 black petrel and flesh-footed shearwater breeding season (October 2019 to May 2020). The maps show the Statistical Areas in Fisheries Management Area 1. The Statistical Areas are coloured indicating: (a) the number of hooks set (thousands); (b) the mean estimated number of seabird captures (c) the upper quantile (97.5%) of the estimated seabird captures; (d) the mean estimated seabird capture rate (birds caught per 1000 hooks set). The rate was calculated for a single vessel (ShS), targeting snapper, and fishing during January.

There was no evidence of a change in the seabird catch rate over the four-year period included in the analysis (Figure 31). There were two vessels (YbY, AzZ) which had a 95% credible interval of the vessel random effect that was entirely above zero. These two vessels had the highest catch rate recorded from the video observations (0.133 and 0.078 captures per 1000 hooks, respectively). The monthly effect showed some evidence of an increase in capture rate in the autumn (March and April) when black petrel and flesh-footed shearwater are expected to be feeding in preparation for the northward migration. There was also evidence of a decrease in catch rate during the winter season, however, there was no video-review data available for July or August and so the uncertainty is high during the winter months. The model also estimated a target effect (snapper target, relative to other targets) of -0.75 (95% c.i.: -1.40 to -0.09). This effect is on the natural log scale, with the model estimating that seabird capture rates on snapper target fisheries are around half of the capture rates on bottom longline fishing targeting other species.

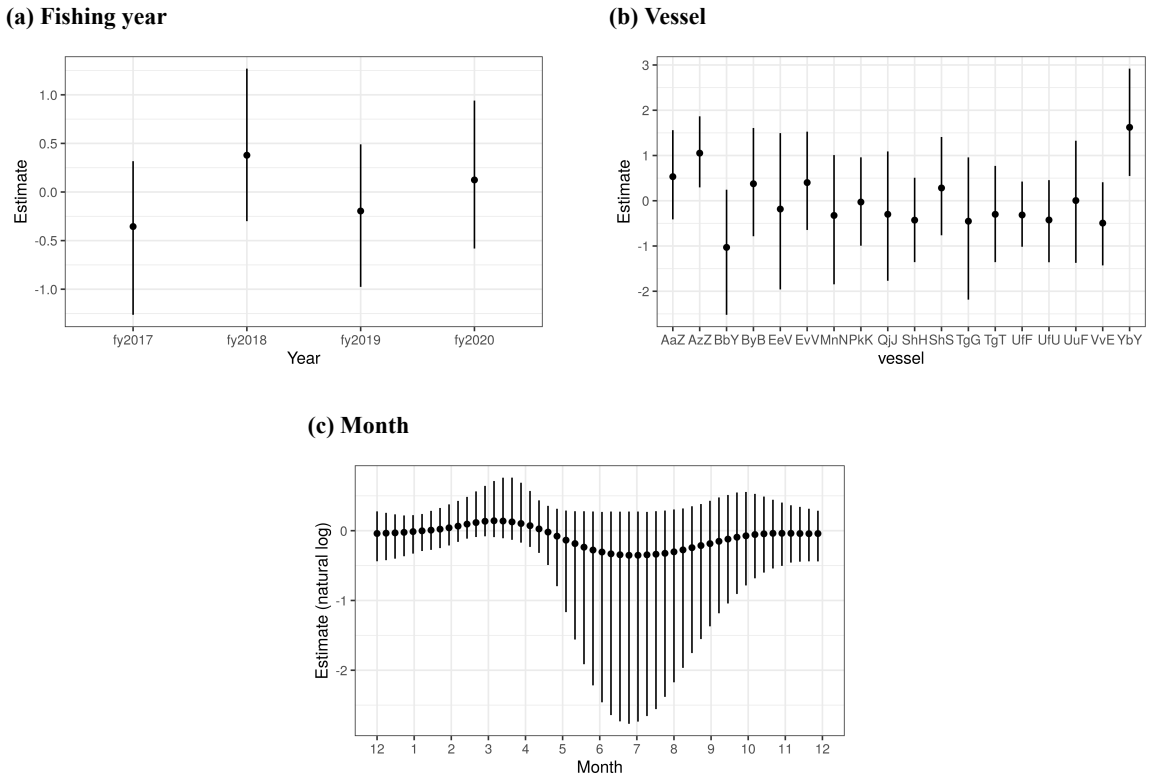

Figure 31: Estimated random effects: (a) fishing year, (b) fishing vessel, and (c) month, estimated using a cyclic spline. For each value, the figure gives the mean and the 95% credible interval of the random effect. The estimated effect is shown on the natural logarithmic scale.

4. DISCUSSION

The electronic monitoring (EM) system used in the 'petrel project' has been under constant development, with ongoing changes to the hardware (the camera and the onboard computers), to the software (the data ingestion and review systems), and the processes (management of data retrieval, quality assurance, and review). During the 2020 fishing year there were ongoing hardware issues. Many of the camera housings developed cracks that allowed water into the housing, degrading the image quality. In addition, the onboard computer system had flashing lights and a noisy fan, which meant that the vessels were inclined to switch the units off when they were not being used. This, in turn, led to coverage issues, because footage was not being collected continuously. Most seriously, the wish to switch the units on and off resulted in a fuse being installed in an accessible position, which was further than appropriate from the vessel battery. This was a contributing factor to a vessel fire.

These issues indicate the challenges of designing EM systems, and how small design decisions (such as a noisy fan) can have unintended consequences. While this may have been of no consequence on a larger vessel, on small bottom longline vessels that moor and shut down completely at night this noise was disruptive. We recommend that any changes to the EM system are trialled on a small number of vessels to identify problems before they are rolled out to the whole fleet.

The programme faced the challenge of disruption from COVID-19. The main impact was a delay in the footage retrieval, as footage was unable to be sent by courier. It also removed access for system maintenance. This impacted on the footage quality, as damaged cameras could not be fixed while the lockdown was in place.

There were ongoing problems with footage time-stamping, due to the onboard computers not having network access after system resets. These could be addressed in future by logging of GPS timestamps. More generally, the systems for managing the footage from collection through to ingestion into the review system required ongoing improvement. While there was intermittent network access to the onboard computers, it was not sufficient to allow for transmission of video footage via the network. Footage was transferred by USB sticks and this required considerable management, coordinating with the vessels and with the courier companies, and at times requiring vessel visits to retrieve the footage. At the beginning of the project, we had anticipated monthly upload of footage, however this could not be achieved because of the many touch points introduced by transferring USB sticks.

Despite these issues, the programme delivered video review of 23.8% of bottom longline effort targeting snapper between November 2019 and May 2020. This compares with coverage of the fishery by human observers of around 8% over the same period.

Vessels started using electronic reporting of their fishing effort before the 2020 fishing year. This had several benefits for the video-monitoring programme. Firstly, fishing effort data were available soon after the fishing, which allowed for more rapid assessment of the coverage of the video monitoring. Secondly, the electronic reporting data include a haul start and a haul end time, which improved the association between the video monitoring and the fisher-reported effort data.

However there were some issues with linking hauling activity identified by the video monitoring with hauls in the statutory data. Nine captures were observed outside of the hauling periods defined by the Electronic Reporting data and had to be linked based on fishing date. In addition, some vessel-days with fishing activity in the video observation data do not have fishing activity in the statutory data. This is a common problem with independent observer data, with a range of causes. These include: differing recording resolutions, the simplified definition of a fishing event that is necessary in the statutory data, and the possibility of recording errors. In the statutory data, especially the older, paper-form data, errors in recording or entering dates or positions can lead to misplaced events that are not selected for linking. There is also the potential for errors in the electronic data; for example, clock errors are possible in EM systems.

More detailed work could be undertaken to align these datasets, and to investigate the reasons for the disparity. A more detailed linking process has been routinely taken for the construction of the Protected Species Captures database (Abraham & Richard 2019). With the recent introduction of Electronic Reporting it may also be useful to assess the extent to which the issues we identified were teething issues as fishers came to grips with the new reporting regime, or represent more fundamental difficulties with the technology that will require further attention.

A key issue that emerged in the current analysis was that there were substantial discrepancies in the identification of seabird captures during multiple reviews. In footage that had multiple reviews, around 40% of the captures were not identified in the footage by the first reviewer, and so would not have been recorded if the footage had only been reviewed a single time. The footage quality issues may have partly caused this discrepancy, however, some captures were missed by the first reviewer on the high quality footage. There was some evidence that the second reviews were more accurate, and so there may also have been issues with reviewer training, inexperience, or fatigue. Multiple reviews allow for the assessment and monitoring of reviewer accuracy in identifying captures. We recommend that multiple reviews continue to be undertaken and that test data sets (with known captures) are developed to test and monitor reviewer performance.

Overall, the rate of reporting of seabird captures from fishers who participated in the programme was similar to the rates of seabird captures reported from video-monitoring. All events with fisher-reported captures were reviewed, however captures were not always identified in the video review even when they had been reported by the fishers. This may be due to issues with the association between the hauls identified in the video monitoring and in the fisher-reported effort, or it may be that the fishers are not always reporting the captures with the correct fishing event.

When used as input for a statistical model of seabird captures, there was an estimated total of 296 (97.5% c.i.: 166 to 519) seabird captures across all bottom longline fishing within FMA 1 in the 2020 fishing year. The capture rate was 0.038 (95% c.i.: 0.021 to 0.067) seabird captures per 1000 hooks; which was similar to the capture rate of 0.038 (95% c.i.: 0.029 to 0.050) seabird captures per 1000 hooks, estimated for bottom longline fishing in the Northland-Hauraki area during the 2017–18 fishing year.[5] The close agreement of these capture rates suggests that the video monitoring and the observer data are broadly aligned. A detailed comparison of the captures recorded from video review, by observers, and reported by fishers should be undertaken, so that the reporting of seabird captures can be better understood.

Overall, despite the operational challenges, and despite the discrepancies seen in multiple reviews, the programme demonstrates that video monitoring can be used to collect data on seabird captures in bottom longline fisheries. The programme has allowed the effective coverage in snapper bottom longline fisheries to be expanded well beyond what has been possible with a traditional observer programme. As the technology and the systems continue to develop, it is likely that the efficiency and accuracy of the video monitoring will increase.

[5] https://psc.dragonfly.co.nz/2019v1/released/birds/bottom-longline/all-vessels/northland-and-hauraki/2017-18/

5. ACKNOWLEDGEMENTS

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Footage in 2018–19 was collected by Trident Systems LP under contract to Leigh Fisheries Ltd, Moana New Zealand and Sanford Ltd, and with funding from SNA 1 and BNS 1 quota owners. The vessels monitored in the project participated in the project on a voluntary basis and their participation, and the cooperation of their crews, is gratefully acknowledged.

TeemFish provided and installed the EM hardware used for footage collection in 2019–20 and provided the video review infrastructure. A team of reviewers contracted by Dragonfly Data Science and Guards Management Services reviewed the footage, and the determinative review of all seabird captures identified was carried out by Mike Bell of Wildlife Management International.

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APPENDIX A: SEABIRD CAPTURES

Table A-1: Final (expert) assessment of seabird captures identified by video observation in the FMA 1 bottom longline fisheries in the 2019 and 2020 seasons.

Date	Species	Number	Status	Fate	Notes
2018-10-17	Sooty shearwater	1	Dead	Returned	Dead when hauled onboard, hook removed and bird held up breifly to camera, but not displayed very well. But ID confirmed.
2018-11-13	Flesh-footed shearwater	1	Alive	Returned	XFS caught during haul, held on side of boat, hook removed, and released overboard. Hooked in Bill.
2018-11-13	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, held on side of boat, hook removed, and released overboard. Hooked in leg or lower body.
2018-11-13	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, brought onboard, hook removed and released overboard. Hooked in bill.
2018-11-15	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, held on side of boat, hook removed and released overboard. Hooked in bill.
2018-11-15	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, held on side of boat, hook removed and released overboard. Hooked in bill.
2018-11-17	Black petrel	1	Alive	Returned	XBP caught on haul, brought on board for hook to be removed. Presumed released, although not clearly seen as video very blurry. Hooked in bill.
2018-11-17	Black petrel	1	Alive	Returned	XBP caught on haul, brought on board, hook removed and released overboard. Hooked in wing.
2018-12-03	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged bird brought up on haul, held on side of boat, hook removed and discarded. Not held up to camera.
2018-12-12	Black petrel	1	Alive	Returned	Caught on haul, bird brought aboard, and hook removed, and released overboard. Hooked in bill.
2018-12-13	Flesh-footed shearwater	1	Alive	Returned	Bird hooked in wing on haul, brought onboard and hook removed, then released overboard. Rough handling by crew.
2019-01-03	Flesh-footed shearwater	1	Dead	Retained	Dead XFS. Crew clean camera before holding up bird very well to camera. Bird retained after.
2019-01-03	Flesh-footed shearwater	1	Dead	Returned	XFS thrown overboard, this may be a bird previously held up to camera and recorded as retained as picked up from this area of boat. May need double checking.
2019-01-03	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, held up to camera well, and then returned to sea.
2019-01-03	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, held up to camera well, then discarded to sea.
2019-01-22	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hook in body or leg, held on side of boat, hook removed and allowed to drop in to sea. Not held up to camera at all.
2019-02-05	Black petrel	1	Alive	Returned	Caught on haul, hooked in bill, partially brought aboard, hook removed and released, rough handling.
2019-02-05	Black petrel	1	Alive	Returned	Bird dived and caught in bill by hook, hook removed by crew and released over board.
2019-02-06	Black petrel	1	Alive	Returned	Caught on haul, held on side of boat, hook removed and released. Hooked in bill.
2019-02-21	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, held on side of boat, hook removed and discarded to sea. Not held up to camera at all.

(continued ...)

Table A-1: Final (expert) assessment of seabird captures identified by video observation in the FMA 1 bottom longline fisheries in the 2019 and 2020 seasons. ***(continued)***

Date	Species	Number	Status	Fate	Notes
2019-02-21	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, held on side of boat, hook removed and discarded to sea. Not held up to camera. Hooked in wing.
2019-02-21	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, held on side of boat, hook removed and discarded to sea. Not held up to camera, Hooked in lower body.
2019-02-21	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, brought onboard, hook removed and discarded to sea. Not held up to camera. Hooked in bill.
2019-03-10	Black petrel	1	Alive	Returned	Caught on haul, brought on board and hook removed. Hooked in bill.
2019-03-13	Black petrel	1	Alive	Returned	XBP takes bait while crew trying to sort a large tangle, looks like bird is just tangled in line rather than hooked, as it frees itself as crew try to pull it in.
2019-03-21	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged bird brought on deck, hook removed and thrown over board. Held up very briefly to camera. Hooked in Bill.
2019-03-21	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged bird pulled up on haul, hook removed, briefly held up to camera, and bird thrown overboard. Hooked in Bill.
2019-03-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, briefly held up to camera then discarded to sea.
2019-03-30	Black petrel	1	Alive	Returned	Caught on Haul, hooked in leg or lower body, brought onboard where one crew member held bird down, whilst second crew member removed hook. Released over board after hook removed
2019-04-22	Flesh-footed shearwater	1	Dead	Retained	Dead XFS brought up on haul, hooked in bill. Crew cleans camera before showing bird to camera. Crew seems very interested in birds leg, is this bird banded? possibly retained.
2019-04-24	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in wing, briefly held up to camera then discarded to sea.
2019-04-28	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, not held up to camera just discarded to sea.
2019-04-28	Black-backed gull	1	Dead	Returned	Dead southern black backed gull brought up on haul, juvenile bird, hooked in wing. Not held up to camera at all.
2019-04-28	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, not held up to camera just discarded overboard.
2019-04-28	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, not held up to camera just immediately discarded.
2019-05-22	Black petrel	1	Alive	Returned	XBP hooked on haul, brought on board, held down and hook removed, briefly held up to camera and released.
2019-12-11	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, held on side of boat, hook removed and discarded to sea. Not held up to camera. Hooked in leg or lower body.
2019-12-16	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged bird pulled up on haul. Hook removed and thrown over board. Not held up to camera.

(continued ...)

Table A-1: Final (expert) assessment of seabird captures identified by video observation in the FMA 1 bottom longline fisheries in the 2019 and 2020 seasons. ***(continued)***

Date	Species	Number	Status	Fate	Notes
2019-12-19	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, brought onboard breifly to remove hook, then discared overboard. Not held up to camera.
2019-12-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, very breifly held up to camera by crew.
2019-12-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, very breifly held up to camera, and returned to sea.
2019-12-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in wing, not held up to camera, just thrown overboard.
2019-12-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, not held to camera, just thrown overboard.
2019-12-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, breifly held up to camera then discarded to sea.
2019-12-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in wing, briefly held to camera and discarded to sea.
2019-12-21	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in wing, briefly held to camera then discarded to sea.
2019-12-31	Flesh-footed shearwater	1	Dead	Retained	Dead XFS brought up on haul, hooked in wing. Very well held up to camera by crew. Bird retained.
2020-01-19	Flesh-footed shearwater	1	Dead	Unknown	Dead XFS brought up on haul, hooked in bill. Unsure if retained or returned, as crew move out of sight with bird.
2020-01-19	Flesh-footed shearwater	1	Dead	Retained	Dead XFS brought up on haul, hooked in bill, well held to camera. Possibly retained, not seen to be returned to sea.
2020-01-23	Flesh-footed shearwater	1	Alive	Returned	Bird caught on haul through bill, brought on board briefly and hook removed and bird returned alive to sea.
2020-01-25	Buller's shearwater	1	Alive	Returned	XBS caught on haul, hooked in bill, brought onboard and hook removed and bird released.
2020-01-26	Black petrel	1	Alive	Returned	XBP caught on haul, brought on board, covered with towel and held down by one crew member, hook removed by second, and released overboard. Hooked in wing.
2020-01-27	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hook in bill, brought onboard hook removed and released. Crew had trouble restraining bird.
2020-01-27	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in bill. Brought onboard, held down and hook removed, released overboard.
2020-02-02	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hook in bill, brought onboard, held down hook removed and released.
2020-02-03	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, brought onboard hook removed and released
2020-02-04	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged bird brought on board, hook removed and thrown back to sea. Hooked in wing.
2020-02-04	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, breifly held up to camera, then duscarded to sea.
2020-02-04	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up in haul, hooked in wing, breifly held to camera then discarded to sea.
2020-02-05	Flesh-footed shearwater	1	Dead	Returned	Dead XFS brought up on haul, hooked in bill, well held up to camera then returned to sea.
2020-02-10	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in wing, brought onboard held down and hook removed. Released overboard after.

(continued ...)

Table A-1: Final (expert) assessment of seabird captures identified by video observation in the FMA 1 bottom longline fisheries in the 2019 and 2020 seasons. ***(continued)***

Date	Species	Number	Status	Fate	Notes
2020-02-12	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in wing, brought on board and held down and hook removed, and then released.
2020-02-12	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, brought onboard, but looks like hook came out on its on and bird headed back to sea.
2020-02-14	Black petrel	1	Alive	Returned	XBP caught on haul, hooked in bill, brought on board, held down and hook removed. released on other side of boat.
2020-02-16	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, brought onboard and hook removed, hooked in wing or body.
2020-02-17	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in bill, brought onboard hook removed and released.
2020-02-19	Flesh-footed shearwater	1	Alive	Returned	Bird caught on haul, brought onboard, hook removed and bird released.
2020-02-19	Flesh-footed shearwater	1	Alive	Returned	Bird caught during haul, brought onboard, hook removed and released
2020-02-19	Flesh-footed shearwater	1	Alive	Returned	Caught on haul, bird brought on board, hook removed and bird released.
2020-02-19	Flesh-footed shearwater	1	Alive	Returned	Caught on haul, brought on board, hook removed and bird released
2020-02-19	Flesh-footed shearwater	1	Dead	Unknown	Dead waterlogged bird brought on board during haul, breifly held to camera. Unsure if bird retained or returned to sea due to camera angles.
2020-02-19	Flesh-footed shearwater	1	Alive	Returned	Caught on haul, brought on board, hook removed and bird released overboard.
2020-02-22	Flesh-footed shearwater	1	Dead	Retained	Dead waterlogged bird brought on board, held up to camera very well by crew.
2020-02-22	Flesh-footed shearwater	1	Dead	Retained	Dead waterlogged bird brought on board, hooked in bill. Bird retained.
2020-02-25	Black petrel	1	Alive	Returned	XBP caught on haul, brought onboard, hook removed and released overboard. Hooked in bill.
2020-03-02	Flesh-footed shearwater	1	Alive	Returned	XFS hooked on haul, brought onboard, held down and hook removed. Released over board.
2020-03-14	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, held on side of boat, hook removed and discarded to sea. Not held up to camera. Hooked in wing.
2020-03-24	Black petrel	1	Dead	Returned	Dead waterlogged XBP caught. looks like it fell off hook before brought onboard, so crew recovered bird using landing net. Then held up really well to camera.
2020-03-24	Black petrel	1	Dead	Returned	Dead waterlogged XBP caught, brought on board, hook removed, held up very well to camera, then discarded overboard.
2020-03-25	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, brought onboard, hook removed, and held up well to camera, then discarded overboard. Hooked in bill.
2020-03-28	White-capped albatross	1	Alive	Returned	XM gets hooked in wing during haul, held on side of boat hook removed easily and bird released without being brought on board.
2020-04-02	Black petrel	1	Alive	Returned	XBP caught on haul, hooked in bill, brought onboard, hook removed and released.

(continued ...)

Table A-1: Final (expert) assessment of seabird captures identified by video observation in the FMA 1 bottom longline fisheries in the 2019 and 2020 seasons. ***(continued)***

Date	Species	Number	Status	Fate	Notes
2020-04-05	Black-backed gull	1	Alive	Returned	Immature southern black-backed gull hooked by bill during haul after grabbing bait, brought onboard, held down and hook removed, and released overboard.
2020-04-06	Flesh-footed shearwater	1	Alive	Returned	XFS hooked on haul after taking bait, brought onboard and hook removed. Hooked in Bill.
2020-04-06	Black-backed gull	1	Alive	Returned	Immature XBG caught on hook during haul, brought on board and presume hook removed and bird released, but not clearly seen due to camera angle.
2020-04-06	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS brought onboard, hook removed and discarded overboard. Not held up to camera at all.
2020-04-07	Black petrel	1	Dead	Returned	Dead XBP brought up on haul, hook removed and briefly held to camera, then discarded overboard.
2020-04-12	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in bill, held on side of boat, hook removed and released
2020-04-20	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hook in bill, held on side of boat, hook removed and released.
2020-04-20	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in bill, held on side of boat hook removed and released.
2020-04-21	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hook in bill, held on side of boat, hook removed and released
2020-04-21	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in wing, held on side of boat, hook removed and released.
2020-04-23	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in bill, brought on board, hook removed and released.
2020-04-26	Black petrel	1	Alive	Returned	During haul a large group of birds attracted to line when a large fish is brought up, a crew member catches a XBP with a landing net and roughly flicks it out. Unsure why this is done, very unusual interaction.
2020-04-29	Flesh-footed shearwater	1	Alive	Returned	XFS caught on haul, hooked in bill, held on side of boat, hook removed and released.
2020-04-30	Black petrel	1	Alive	Returned	XBP caught during haul, brought onboard, held down, hook removed, and relaased overboard. Hooked in Bill.
2020-05-07	Flesh-footed shearwater	1	Dead	Returned	Dead waterlogged XFS caught, held on side of boat, hook removed and discarded to sea. Not held up to camera. Hooked in Bill.
2020-05-08	Black petrel	1	Alive	Returned	XBP caught on haul, bird held on side of boat and hook removed, rough handling.
2020-05-09	Black petrel	1	Dead	Returned	Dead XBP brought up on haul, crew clean camera prior to holding bird up to camera well.
2020-05-09	Black petrel	1	Alive	Returned	XBP caught on haul, hooked in bill, brought onboard, held down and hook removed. Crew do a OK job restraining bird.
2020-05-09	Black petrel	1	Alive	Returned	XBP caught on haul, hooked in bill, brought onboard, held down and hook removed, released overboard.