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The extent and intensity of seabed contact by trawl gear using fisher-reported and geospatial position reporting data, 1990 to 2023

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TABLE OF CONTENTS

PLAIN LANGUAGE SUMMARY

This report provides estimates of the spatial extent and frequency of trawl fishing on the seafloor within New Zealand's Exclusive Economic Zone (EEZ) and Territorial Sea (TS), focusing on areas open to trawling down to 1600 metres deep. It covers deepwater fisheries from 1990 to 2023, inshore fisheries from 2008 to 2023, and combines both as "All Stocks" from 2008 onwards.

Using fisher-reported start and end points, and a method that assumes trawl paths follow straight lines between those points, the study analyses trends in different measures of seabed contact for these groupings. The measures include the area in square kilometres of the overall trawl footprints and aggregate (cumulative footprint) areas by year and all years combined, the number of tows, the number of cells contacted (a 5 km × 5 km grid overlaid on the fishable area), and the number of 'new' cells contacted each year that had previously not been contacted.

Key findings include:

- All Stocks (2008–2023): The area of seabed contacted each year declined over time, with the lowest footprint recorded in 2023. Each year, trawling activity affected between 1.7% and 2.3% of the total EEZ + TS seafloor, and between 5.0% and 6.8% of the fishable area (areas open to trawling down to 1600 m). The number of trawl tows dropped from nearly 89 000 in 2010 to about 55 000 in 2023.
- Deepwater Fisheries (1990–2023): The footprint expanded during the 1990s, reached its highest levels in the early 2000s, and then steadily declined to 2020, remaining relatively stable since. There was little expansion of effort into new cells in 2023 (8 cells and 4.3 km^2 footprint), with new cells probably representing the very edges of fished areas.
- Inshore Fisheries (2008–2023): The footprint decreased from a peak in 2010 to its lowest in 2023, covering less than 1% of the EEZ +TS and about 2% of the fishable area in recent years. There was little expansion of effort into new cells in 2023 (14 cells and 3.6 km^2 footprint), with new cells probably representing the very edges of fished areas.

Geospatial Position Reporting (GPR) data, introduced in 2018–19, allows for more accurate mapping of trawl paths by tracking vessel movements during fishing. This report also compares the straight-line method to a hybrid method, which combines GPR and fisher-reported data, to see how estimates differ for a selection of inshore and deepwater target species/species groups. It was found that the aggregate swept areas are almost universally higher for the hybrid approach but other measures can be more variable.

The project also explored whether GPR data could be used to create standard trawl paths to correct older records. While the approach shows promise, it is computationally demanding and unlikely to offer practical benefits for current fisheries management.

EXECUTIVE SUMMARY

MacGibbon, D.J.[1]; Wood, B.A.[1]; Mules, R.[2] (2026). The extent and intensity of seabed contact by trawl gear using fisher-reported and geospatial position reporting data, 1990 to 2023.
***New Zealand Aquatic Environment and Biodiversity Report No. 372.* 360 p.**

This report presents the spatial analysis of bottom-contacting trawl effort within the New Zealand 200 nautical mile Exclusive Economic Zone and Territorial Sea (EEZ+TS), in waters open to trawling down to 1600 m in depth (the 'fishable area'), for different time periods, based on available data.

The main All Stocks, Deepwater, and Inshore analyses in this study were conducted using a straightline approach where the path a vessel took is assumed to have been a straight line between the reported start and end positions of the tow. Separate analyses were done that took a hybrid approach where any available Geospatial Position Reporting data for a tow are used to create a trawl path using successive positions between the reported start and end positions of a tow.

The All Stocks (deepwater and inshore fishstocks) analysis was completed for the 2007–08 (2008) to 2022–23 (2023) fishing years. During this period, the seabed area contacted by trawl gear for All Stocks was estimated to be between 68 780 and 94 536 km^2 each year, generally decreasing over the 16 years, with the lowest value estimated for 2023. Reported tow data reflect a decreasing amount of bottom-contacting trawl effort over the same period; the number of tows steadily dropped from 88 744 in 2010 to 54 733 in 2023. The annual aggregated area (i.e., the sum of the swept areas of the bottom-contacting trawls) for the All Stocks analysis decreased from a peak of 162 871 km^2 in 2010 to a low of 121 374 km^2 in 2023. The All Stocks analysis estimated a 16-year total aggregate area of 2 329 566 km^2 and total footprint of 320 649 km^2. Annually, between 2008 and 2023 the All Stocks footprint contacted 1.7–2.3% of the EEZ+TS seafloor and 5.0–6.8% of the fishable area each year.

In the 34-year time series for deepwater data (1990–2023), there was a steady increase in the footprint from under 48 000 km^2 in 1990 to a sustained period of contact ranging between 72 001 to 80 550 km^2 during 1998 to 2003, followed by a steady decrease to 39 649 km^2 in 2020. The annual aggregated area contacted was highest from 1997 to 2003, exceeding 150 000 km^2 in all years during this period. This reduced to under 100 000 km^2 from 2006 on, with a low in 2009 (78 924 km^2), another peak at 95 627 km^2 in 2018, and a drop to 79 906 km^2 in 2023, the fourth lowest in the time series. The deepwater analysis estimated a 34-year total aggregate area of 3 773 288 km^2 and total footprint of 357 847 km^2, with this overall deepwater footprint representing 8.7% of the EEZ+TS and 25.9% of the fishable area. Between 1990 and 2023, the annual footprint contacted 1–2% of the EEZ+TS and 2.9–5.8% of the fishable area (peaks in 2002 and 2003).

The 2008–2023 inshore footprint also decreased, from a peak of 46 679 km^2 in 2010 to a low of 27 843 km^2 in 2023. This annual contact was equivalent to 0.7–1.1% of the EEZ+TS seafloor area, and 2.0–3.4% of the fishable area, with the lowest values estimated for 2023. The annual aggregated area contacted during these years ranged from a low in 2023 (41 394 km^2) to a peak in 2010 (75 857 km^2). These results are further discussed to indicate the intensity of contact, the frequency of contact (comparing annual data), and any areas contacted in one year but not in previous years.

Methods were developed to assess the potential of developing standard tows using Geospatial Reporting (GPR) data and whether it could be applied retrospectively to data that pre-dates GPR. Results suggest it is possible but computer-intensive and likely to be of little use to current day management needs.

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A hybrid approach to estimating the footprint and other metrics was undertaken using a combination of straight-line and GPR data and compared to the traditional method that assumes a straight-line in between start and end positions of trawl tows. This was applied to the All Stocks, deepwater, inshore, and a variety of inshore and deepwater target fisheries to compare the two approaches. The hybrid approach almost universally estimated higher aggregate areas than the straight-line methods, whereas other measures of contact were variable between the two approaches.

Please note that several plots in the Appendices of this report were removed in accordance with Fisheries New Zealand's Data Confidentiality guidelines for publication on the internet.

1. INTRODUCTION

Estimating the intensity and extent of bottom-contacting fishing activity within New Zealand waters is a research area that supports Fisheries New Zealand in working to meet fisheries management objectives relating to benthic habitats. The National Fisheries Plan for Deepwater and Middle-depth Fisheries (Fisheries New Zealand 2019) includes an objective to "*Manage deepwater and middle-depth fisheries to avoid, remedy or mitigate the adverse effects of these fisheries on benthic habitats*" and the National Inshore Finfish Fisheries Plan includes an objective to "*Manage inshore finfish fisheries to avoid, remedy or mitigate adverse effects on benthic habitats*" (Fisheries New Zealand 2022). The primary bottom-contacting mobile fishing methods are trawling for finfish, squid, and scampi, as well as dredging for shellfish (oysters and scallops).

Bottom-contacting trawling is conducted mainly in continental shelf waters at depths defined by the distribution of target species, generally in waters shallower than 1600 m (Baird et al. 2011). Past trawl footprint projects have considered trawl tows to be bottom contacting where bottom trawl gear is used or where midwater trawl gear is used within one metre of the seafloor (for example Baird & Mules 2021a, 2021b, MacGibbon & Mules 2023). MacGibbon et al. (2024) also considered the footprint including midwater trawl within 5 m and 10 m of the seabed, but the changes to the footprint and aggregate area were minimal and it is not possible to assess what proportion of an individual midwater trawling event occurred at the given height. The assumption that the entire event is bottom contacting could be quite incorrect as skippers alter the depth to target schools of fish, and could result in an overestimation of bottom contact by the fisheries using this method. While this is still a problem with the 1 m definition of midwater trawling constituting bottom contact that has been used in most trawl footprints, this criterion has been used in this study. Skippers of trawl vessels operating these gears reported their commercial fishing activity on different form types up until the Electronic Reporting System (ERS) was introduced and phased in between October 2017 and the end of 2019. The ERS system is now used exclusively.

Trawl Catch Effort and Processing Return (TCEPR) forms were introduced in October 1989 and were used if the vessel was over 28 m in overall length or if the vessel was required by the Director-General of Fisheries to do so (as required by the Fisheries (Reporting) Regulations 1990). The TCEPR was predominantly used to report data from vessels in the deepwater fleet (operating mainly in waters deeper than 200 m) up until October 2017 when the ERS was introduced.

Daily trawl effort by vessels under 28 m in overall length operating in inshore waters around New Zealand was primarily reported on Catch Effort Landing Return (CELR) forms from October 1989. Skippers of some small inshore trawl vessels instead reported effort on TCEPRs from the mid-1990s (see Baird et al. 2011). The CELR form for trawl data was replaced in October 2007 by a more comprehensive form, the Trawl Catch Effort Return (TCER) which reported tow-by-tow information rather than a daily summary. From January 2019, the use of ERS for data collection was gradually implemented throughout other commercial fishing fleets, including the inshore trawl and dredge vessels.

The TCER, TCEPR, and ERS data provide tow-by-tow information that can be used to generate annual trawl footprints that represent the area of the seafloor contacted by trawl gear. Previously, trawl footprints have been determined using, where available, TCEPR and TCER data extracted from the Fisheries New Zealand database *warehou* (see for example, Baird et al. 2011, Black et al. 2013, Baird et al. 2015, Baird & Wood 2018, Baird & Mules 2021a, b, MacGibbon & Mules 2023), generally for fishing years since 1989–90. In 2018, the trawl footprint analysis for deepwater vessels was re-run and updated, using the Fisheries New Zealand CatchMapper software tool (Osborne 2018) and data extracted from the Enterprise Data Warehouse (EDW) – a database that includes the *warehou* form-based data as well as the ERS data (Baird & Mules 2019). In 2019, the footprint analysis was extended to include the inshore fleet activity, based on data up to the end of the 2019 fishing year (Baird & Mules 2021b) and has been extended since to include subsequent fishing years.

Algorithms implemented in the CatchMapper tool estimated a trawl end point for tows that had been recorded on the TCER form used by most of the inshore fleet.

The overall objective of Fisheries New Zealand research project BEN2023-01 was to provide updated annual estimates of the extent and intensity of seabed contact by trawl gear and to progress the development of methods to estimate and track seabed contact using new data sources.

Past trawl footprint projects (Baird et al. 2011, Black et al. 2013, Baird & Wood 2018, Baird et al. 2015, Baird & Wood 2018, Baird & Mules 2019, 2021a, b, MacGibbon & Mules 2023, and MacGibbon et al. 2024) have assumed that the path of any given individual trawl event is a straight-line between the start and end positions of the event. While it is well known that this is often not the case, this has been accepted as a limitation of the data available. The introduction of Geospatial Position Reporting (GPR) data from the 2018–19 fishing year provided the opportunity to create more realistic trawl paths by using the positions where GPR devices on vessels 'pinged' in between the fisher-reported start and end positions. MacGibbon & Mules (2023) developed a method to use the intervening GPR pings to create trawl tracks for the 2019–20 fishing year (too few vessels had GPR devices installed in 2018–19 for this fishing year to be considered useful for developing the method).

While the overall footprint for the year did not increase much when compared to the traditional 'straight-line' method, the overall aggregate area was substantially higher when incorporating GPR data. They found that not all fishing events had associated GPR pings which can be due to tows being of a short duration where devices did not ping in between the start and end of a tow, or some vessels not having GPR devices installed at that time. For 2019–20, when considering the footprints and aggregate areas where tows did have associated GPR data, the overall GPR footprint was 4% larger than the straight-line footprint, and the overall aggregate area was 33% larger. GPR tows will always be longer than the equivalent ERS the straight-line method, unless of course the GPR tow is an actual straight-line. The true path a trawl tow took can deviate substantially from a straight line between the start and end points reported. As such, when these longer tows are laid over one another to form the aggregate area, it is logical that the aggregate area will be larger than the straight-line equivalent as a longer tow will have a higher swept area.

The Aquatic Environment Working Group (AEWG) accepted that the GPR method was likely to result in more accurate trawl paths and hence more accurate footprints and aggregate areas. It was noted that even with full coverage of vessels with GPR devices, there is still a problem that some fishing events have no associated GPR data, usually when events begin and end in between GPR pings. It was agreed that a more realistic result would be obtained if a 'hybrid' method was used. i.e., GPR data is used for all fishing events where it is available, and the straight-line method is used for all fishing events where it is not.

There is now full implementation of GPR devices across the New Zealand deepwater and inshore trawl fleets and four complete fishing years covered under the project (up to and including the 2022–23 fishing year), as well as partial implementation from 2018–19. As such, BEN2023-01 is revisiting the use of GPR data and compares the straight-line method to a hybrid method in which GPR data is used for tows where it is available and the straight-line method is used for tows where it is not. This is done overall to see if there are any differences, as well as looking at a selection of individual inshore and deepwater target fisheries to see if there are any specific differences by fishery. A hybrid method is necessary rather than a total GPR approach for two main reasons. The first is that a straightline approximation is all that is possible for the era that pre-dates the introduction of GPR devices on fishing vessels. The second is due to the ping rate of GPR devices. The rate at which GPR devices ping can vary from around 10 minutes to once an hour. As some fishing events, particularly those focused on underwater topographic features (UTFs), can take less than one hour it is possible that some fishing events will not be captured by GPR because the event will have begun and ended in between pings. As such, the reported start and end positions are the only available data with which to construct a trawl path and a straight line has to be assumed for these events.

While it is assumed that the hybrid method will produce more realistic and accurate results, the annual footprints and overall time series footprint from prior to 2018–19 can only use the straight-line method. BEN2023-01 also investigated the development of techniques whereby trawl paths created using GPR data could be used to inform the likely trawl paths of straight-line data from the pre-GPR era of the time series.

1.1 Specific objectives

The specific objectives addressed in this report are:

1. To help MPI groom fisher-reported and GPR data, develop a hybrid approach using both GPR and ER data, and to report on and compare summary statistics and trends estimated using different approaches up to the 2022–23 fishing year.
2. Assess the effect of the introduction of a hybrid approach on footprint estimations for key inshore target species and deepwater tier 1 target species.
3. Broader outcomes.

2. METHODS

2.1 Trawl fishery analyses – straight-line approach

The methods below describe the data exploration and grooming and the preparation for the trawl footprint spatial analysis. These methods build on those developed and described by Baird et al. (2011), Black et al. (2013), and Baird & Wood (2018) for TCEPR data; Baird et al. (2015), and Baird & Wood (2018) for TCER data; Baird & Mules (2019, 2021a, b), MacGibbon & Mules (2023), and MacGibbon et al. (2024) using the spatial software CatchMapper.

Fishery data sources

The Fisheries New Zealand Spatial Intelligence team accessed all TCEPR, TCER, and ERS trawl effort data from the EDW for the 1990–2023 fishing years as data extract RepLog 15658. The TCEPR data provided information about each fishing operation, with tow-by-tow records of latitude and longitude and date-time for the start and end of each tow, target species, tow duration, tow speed, and gear parameters, amongst others. The TCERs provided similar tow-by-tow data, but with start of tow position information only, necessitating the generation of an endpoint (see Baird et al. 2015). The ERS collects data similar to the TCEPR, but the position data are at a finer resolution. TCER and TCEPR data are generally recorded in degrees to one or two decimal places, whereas ERS data are recorded to four decimal places.

Fishery data grooming and treatment

Grooming routines followed those used in previous analyses (see references in Section 2.1) with some refinements where it was deemed that improvements could be made. A complete extract of the commercial data going back to 1989 was made and were groomed again so that the latest grooming routines could be applied to all years in the data set and not just the most recent years since the last analyses. Refinements can be made to certain aspects of grooming algorithms, for example, allowing a longer maximum tow length for certain target fisheries in certain areas (such as orange roughy on the Challenger Plateau) when knowledge of fisher behaviour comes to light, allowing for more accurate estimation of the footprint and aggregate area. Changes to the EDW database over time may also mean that re-extracting data is necessary, to make data collected from different time periods, or stored in different database structures, comparable. Summary data are given in Appendix A. Broad queries on all bottom and midwater trawl data were run using the R statistical program (R Core Team 2024) to isolate duplicates or missing data. Particular attention in the grooming was given to variables required to characterise the effort: location/area fished, date and time, gear type, target species, number of tows, fishing duration, towing speed, vessel characteristics, and depth.

The deepwater component included the Tier 1 and Tier 2 deepwater fishstocks (Fisheries New Zealand 2019) listed in Table 1. The estimation of the inshore footprint is based on reported effort for the inshore target stocks listed in Table 2. This list is based on requests from Fisheries New Zealand for the previous trawl footprint project (MacGibbon et al. 2024). Although summaries are not provided by species or tier in this project from 1990, Tables 1 and 2 are included to show what fisheries were used to inform the data extract (NB: some selected individual target/target groups are included, but only for the purposes of comparing the traditional ‘straight-line method’ of estimating the footprint and aggregate area with the methods incorporating GPR data, covering from 2019 onwards only, when GPR data first became available).

Table 1: Tier 1 and Tier 2 deepwater Fishstocks with bottom-contacting trawl effort reported during fishing years 1990–2023 (see Fisheries New Zealand 2020 for Fishstock boundaries).

Code: Fishstock	Common name	Scientific name
Tier 1		
HAK: all	Hake	*Merluccius australis*
HOK: all	Hoki	*Macruronus novaezelandiae*
JMA: JMA 3, 7	Jack mackerels	*Trachurus declivis*, *T. murphyi*, *T. novaezealandiae*
LIN: LIN 3, 4, 5, 6, 7	Ling	*Genypterus blacodes*
OEO: all	Oreo species	*Allocyttus niger*, *Neocyttus rhomboidalis, Pseudocyttus*
ORH: all	Orange roughy	*Hoplostethus atlanticus*
SBW: all	Southern blue whiting	*Micromesistius australis*
SCI: all	Scampi	*Metanephrops challengeri*
SQU: all	Arrow squid	*Nototodarus sloanii*, *N. gouldi*
Tier 2		
BAR: BAR 4, 5, 7	Barracouta	*Thyrsites atun*
BYX: all	Alfonsino	*Beryx splendens*, *B. decadactylus*
CDL: all	Black cardinal fish	*Epigonus telescopus*
EMA: EMA 3, 7	English mackerel	*Scomber australasicus*
FRO: FRO 3, 4, 5, 6, 7, 8, 9	Frostfish	*Lepidopus caudatus*
GSH: GSH 4, 5, 6	Dark ghost shark	*Hydrolagus novaezelandiae*
LDO: all	Lookdown dory	*Cyttus traversi*
PRK: all	Prawn killer	*Ibacus alticrenatus*
PTO: all	Patagonian toothfish	*Dissostichus eleginoides*
RBT: all	Redbait	*Emmelichthys nitidus*
RBY: all	Rubyfish	*Plagiogeneion rubiginosum*
RIB: RIB 3, 4, 5, 6, 7, 8	Ribaldo	*Mora moro*
SKI: SKI 3, 7	Gemfish	*Rexea solandri*
SPD: SPD 4, 5	Spiny dogfish	*Squalus acanthias*
SPE: SPE 3, 4, 5, 6, 7	Sea perch	*Helicolenus percoides*
SWA: all	Silver warehou	*Seriolella punctata*
WWA: all	White warehou	*Seriolella caerulea*

Table 2: Inshore Fishstocks for which there was trawl effort during fishing years 2008–2023 (see Fisheries New Zealand 2020 for Fishstock boundaries).

Code: Fishstock	Common name	Scientific name
BAR 1	Barracouta	*Thyrsites atun*
ELE 3, 5, 7	Elephantfish	*Callorhinus millii*
FLA 1,2,3,7	Flatfish	*Rhombosolea retiaria, R. plebeia, R. tapirina, Pelotretis flavilatus*
GSH 1, 2, 3, 7, 8, 9	Dark ghost shark	*Hydrolagus novaezealandiae*
GUR 1, 2, 3, 7, 8	Red gurnard	*Chelidonichthys kumu*
JDO 1, 2, 3, 7	John dory	*Zeus faber*
KAH 1, 2, 3, 8	Kahawai	*Arripis trutta*
LEA 1, 2, 3	Leatherjacket	*Parika scaber*
LIN 1, 2, 8, 9	Ling	*Genypterus blacodes*
MOK 1, 3	Moki	*Latridopsis ciliaris*
RCO 2, 3, 7	Red cod	*Pseudophycis bachus*
RSK 7,3	Rough skate	*Zearaja nasuta*
SCH 1, 2, 3, 5, 7, 8	School shark	*Galeorhinus galeus*
SKI 1, 2	Gemfish	*Rexea solandri*
SNA 1, 2, 3, 7, 8	Snapper	*Chrysophrys auratus*
SPD 1, 3, 7	Spiny dogfish	*Squalus acanthias*
SPO 2, 7, 8	Rig	*Mustelus lenticulatus*
SSK 3	Smooth skate	*Dipturus innominatus*
STA 2, 3, 4, 5	Giant stargazer	*Kathetostoma giganteum*
TAR 1, 2, 3, 4, 5, 7,	Tarakihi	*Nemadactylus macropterus*
TRE 1, 2, 3, 7	Trevally	*Pseudocaranx dentex*
WAR 1, 2, 3, 7, 8	Blue warehou	*Seriolella brama*

GIS layers for estimating the overlap of the bottom-contacting trawl footprint

Bathymetry sourced from the General Bathymetric Chart of the Oceans (GEBCO) was used to limit the fishable area to a depth of 1600 m (Figure 1), the depth that is close to the depth limit of current trawling effort. Areas shallower than 1600 m closed to trawling are excluded from the fishable area. Closures represent those in place currently and are applied uniformly across all fishing years. These are the same data used in the previous trawl footprint (MacGibbon & Mules 2023).

Note that all the spatial overlap and area calculations were made from data in the following projection: Albers Equal Area Projection (central meridian at 175° E, standard parallels at 30° S and 50° S, and the latitude of origin at 40° S). The bathymetry layer was then overlaid on a 5 km × 5 km analysis grid and a depth value for each layer was assigned to each cell in the grid based on the midpoint of each 25 km^2 cell.

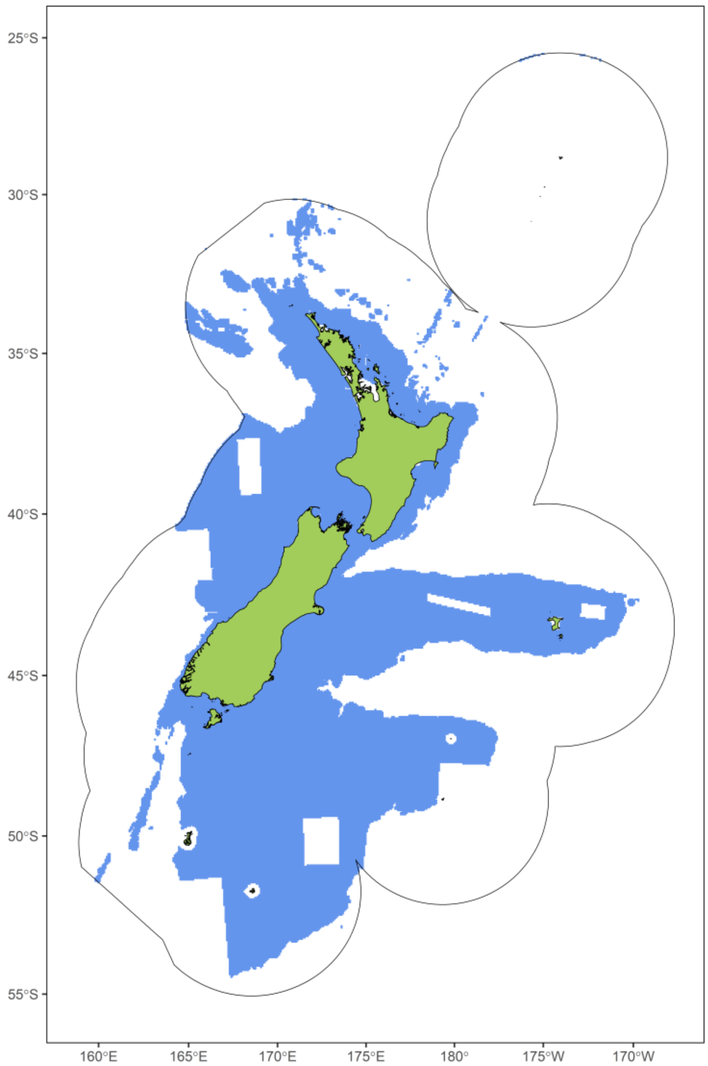


Figure 1: The 'fishable' area from 0–1600 m (blue) within the 200 nautical-mile Exclusive Economic Zone (includes the territotial sea). Areas closed to bottom trawling have been removed from the fishable area (includes benthic protected areas, closed seamounts, cable lanes, marine farms, and marine reserves). The total area of the Exclusive Economic Zone is 4.1 million km^2. The total fishable area with closures removed is 1.4 million km^2.

2.2 Generation of trawl fishery spatial output

The reported trawl data include position and operational information that allow spatial analysis and presentation. However, each data type requires different treatment to generate swept area estimates. TCEPR data include both start and end positions (generally to the nearest one minute of arc, or about 1.852 km). TCER data have tow start positions only, at the same resolution as TCEPR data. ERS data include start and end positions to a finer resolution than TCEPR data. Thus, the groomed data are treated separately (by form type) before being combined to develop the swept area statistics. The methods described below follow those used and fully described by Baird et al. (2011) and Black et al. (2013) for TCEPR data and Baird et al. (2015), Baird & Mules (2021a, b), and MacGibbon & Mules (2023) for TCER data.

Where latitude and longitude data were truncated to the nearest minute of arc (TCEPR and TCER data) many tows appear to start at the same location because of the lower resolution of the data. To better represent and estimate the likely extent of seabed contact and limit the artificial patchiness of effort created by the resolution of the data, the start and finish positions were randomly jittered using an offset of ± 0.5 minute. The jittered values were stored as new fields in the data set. The finer resolution of the ERS data meant that start and finish positions were not jittered as they were deemed to be sufficiently accurate.

Note that the reported position data represent where the vessel was at the time the net was deemed to have reached (and left) fishing depth rather than the location of the net. No attempt has been made to correct for the position of the net in this project. Although methods do exist, such as those used by MacGibbon et al. (2024) in project BEN2022-01 to refine effort on individual seamounts, there are several reasons they haven't been used here. Data prior to 2019 when the ERS was implemented have had jittering applied as explained above. This adds uncertainty to the precise locations even before attempting to correct for the location of the net behind the vessel and will often exceed the likely distance between the net and the vessel, particularly in shallow water where warp lengths are likely to be shorter. Warp length is not typically recorded and the likely length is assumed based on the depth recorded which is not always reliable. Further, with the straight-line approach, it is assumed that the course of a tow goes directly from the start to the end positions. But the true course taken to get from the start to the end position could be quite different and hence where the net really was in relation to the reported start position of the vessel could in fact potentially be anywhere. In fact if the tow went in the opposite direction of the end position before doubling back, the 'correction' could be the complete opposite of reality. Corrections for the position of a net relative to the vessel have the potential to be useful where the course of the tow is known, and on small scales such as determining if individual tows occurred on individual seamounts or in a given, discrete area. On wider scales such as those reported on in this project, there is little utility in applying it.

Preparation for estimating swept area from TCER forms

The TCER data provide only the start position of a tow, no end position is recorded. Although a measure of swept area can be calculated, based on the duration of the tow and tow speed, the swept area cannot be spatially represented, other than as a circle centred on the start position. To create a trawl track, the methods described by Baird et al. (2015) were used, whereby, within a trip, a tow direction was generated from the bearing between the start position of a tow and the start position of the next tow. A distance measure (in kilometres) was estimated from tow speed and tow duration data and used with the estimated bearing to generate finish coordinates.

TCER data are characterised by a relatively small number of tows per trip (Baird et al. 2015) and a substantial number of tows on a given trip had no following tow to use as a bearing for the next tow (this is because the final tow of a trip had no subsequent tow to use as a bearing). Thus, the last tows of a trip are identified, as are trips with only one tow, and, for each of these, a bearing was estimated based on the median estimated bearing values from other tows by the same vessel for the same target species within 1/30th of a degree north/south or east/west, using a minimum number of two tows. This was used to generate finish coordinates (as above). Where this failed, tow end coordinates were generated by using the median estimated bearing values from tows of the same target species within 1/30th of a degree north/south or east/west, using a minimum number of two tows.

Spatial allocation of tows

Several unreported variables were generated on a tow-by-tow basis to provide spatial representation of each tow:

Doorspread. The distance between the two trawl doors provides a measure of the width of the trawl path used to estimate the potential area of the seafloor contacted by the trawl gear, that is, the swept area. This measure is not reported on commercial data forms, so previous footprint studies have applied doorspread values to each tow (with agreement on these values from members of the Fisheries New Zealand Aquatic Environment Working Group), based on vessel size, target species, and known gear parameters, including the number of nets used to reflect differences in the spread of gear depending on vessel size (see, for example, Baird & Wood 2018). The estimated doorspread values used in this study were assigned according to vessel size (overall length), target, and the number of nets used (based on the "number of nets" data which were first collected on the TCER and TCEPR forms in the 2008 fishing year), informed further by observer data. Data from the hoki/hake/ling (HOK/HAK/LIN) stock assessment projects (Sira Ballara, NIWA, pers. comm.) were used to identify those tows in the effort data that used twin trawls before 2008. (see Figure 9 in Section 4.1 for definitions of vessel categories and types). The assigned doorspreads were the same as used by MacGibbon & Mules 2023 and MacGibbon et al. 2024 as below in Table 3:

Table 3: Assigned doorspreads used in the analyses by vessel category, target species, and number of nets used. * includes one D category vessel.

Vessel category	Vessel length	Target	Number of nets	Assigned doorspread
A	<20	Any	1	70
A	20–28	Any	1	100
A	<20–28	SCI	1	50
A	<20–28	SCI	2	70
B	28–46	SCI	2	70
B	28–46	Any	1	150
C	46–82	Any except HAK/HOK/LIN/SWA	1	150
C	46–82	HAK/HOK/LIN/SWA	1	200
C*	46–82	HAK/HOK/LIN/SWA	2	400
D (BATM)	>82	Any	1	150
D	>82	Any	1	200

Tow distance. A distance for each trawl track (kilometres) was calculated from the finalised start and fishing positions, assuming a straight-line tow.

Speed-time distance. A second distance value (kilometres) was calculated for each tow; this was based on the speed and the tow duration (the difference between the reported tow start and finish times) for use with the TCER data and for some deepwater target TCEPR tows where short tows on hills resulted in the coordinates of the start and finish location being the same.

Each tow was converted into a trackline (distance between the start and finish locations). Scampi, arrow squid, and hake tows were permitted a maximum length of 70 km and a maximum tow distance for other species was set at 55.56 km (after Black & Tilney 2017, Baird & Mules 2019). A median distance (calculated from the straight-line tow distance by target species) was applied to the start points of those tows that exceeded the prescribed maximum lengths, and new end points were generated in GIS by shortening the trackline to the median distance.

Assignment of tow data to cells

To aid in the categorisation and analysis of the data, a grid of approximately 25-km^2 cells was created as a database table and joined to the TCER, TCEPR, and ERS effort table. This 5×5 km cell size has been used in previous work and is considered reasonable by successive Aquatic Environment Working Group meetings, as the unit of analysis for trawl swept areas on a broad scale such as the EEZ+TS. This grid was generated in the Albers Conic Equal Area Projection and re-projected to latitude and longitude degrees to overlay with groomed effort data as a basis for spatial analysis to quantify the amount of effort per cell (intensity) over time and to generate an indicative 'footprint' of trawl effort on the seafloor. While all tows are assigned to cells, the estimation of the footprint and aggregate area is estimated based on the swept area of each tow, not the area of the cell. Only the portion of any particular cell that has been contacted contributes to the actual footprint or aggregate area. For example, a cell may be 25 km^2 in area, but if only half of it has been trawled, only half of its area is counted towards the footprint (12.5 km^2).

For area-based calculations, the data were re-projected to the Albers Conic Equal Area projection to minimise distortion caused by converging lines of longitude with increasing latitude using degrees as the coordinate units.

This study used the estimated *swept area* for each tow (in square kilometres), hereafter referred to as the *swept area*, to estimate the extent (the footprint) and intensity (aggregate swept area) of seabed contact by trawl fishing.

1. *Swept area* is the area derived from the tow distance as the straight-line measurement between start and finish positions and the assigned doorspread.
2. *Aggregate swept area* (Figure 2, left panel) is the total summed swept area for a particular period. This exceeds the footprint because it includes the swept areas of all tows, including those that overlap.
3. *Trawl footprint* is the area (square kilometres) that represents the seafloor area estimated to have been contacted by trawl gear (Figure 2, right panel).

For each cell, the sum of the area of all the portions of the estimated doorspread trawl polygons that lie within that cell was calculated. Thus, a cell in any given fishing year may have an aggregate swept area of 0 km^2 (no contact) or 25 km^2 (contacted area is equal to the cell size), or for example 100 km^2, suggesting that for that year, the swept contacted area was four times the cell area; whereas the maximum possible trawl *footprint* in a cell is 25 km^2 (i.e. equal to the area of a cell).

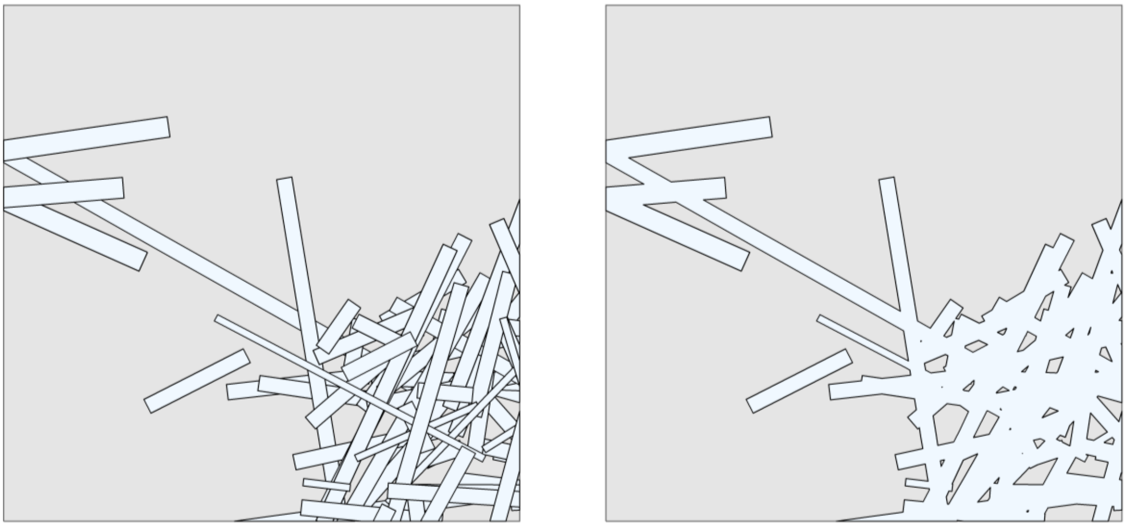


Figure 2: A 25-km^2 cell showing the trawl polygons representing the aggregate area (i.e., the sum of the swept areas of the bottom-contacting trawls) shown in the left panel and the footprint that represents the seafloor area estimated to have been contacted by those same trawls in that cell in the right panel.

2.3 Estimation of newly trawled area using identification of 'new' cells contacted

The extent of the trawl footprint will vary in each footprint project analysis because: (i) a full set of data is extracted for each project and includes the most recent fishing year of data, as well as any updates to the underlying previous years of data; (ii) the use of random jittering (Section 2.2) will produce slight changes in the location of each jittered position in each analysis; (iii) refinements to grooming algorithms can produce slight changes in the location and distance of trawls. To identify areas that are newly contacted by the annual footprint in the most recent year, the footprint of the previous years (e.g., for the combined 1990–2021 fishing years) can be directly compared with the most recent year (e.g., 2022) in GIS. Baird & Mules (2019) showed that this method identified small slivers of footprint from the most recent year in areas of dense contact and concluded that because of the inherent uncertainty in the estimation of the swept area—from the resolution of the start and finish data, the treatment of the trawl trackline as a straight-line, and the use of generic doorspread values—much of this ‘new’ area may not represent expansion of the footprint extent.

An alternative method to identify areas of expansion/exploration in the most recent year is a cell-based comparison, based on the 25-km^2 cell footprint. Thus, any cells in the most recent analysis year that were not identified as contacted in the combined previous years are identified as ‘new’ cells (Baird & Mules 2019): that is, cells with no previous trawl contact (within the time series of analysis) indicate newly trawled areas that represent an extension of bottom trawling. This is the method used in this analysis.

2.4 Underlying assumptions in trawl fishery spatial analysis and representation

The effort data used here represent subsets of the total commercial trawl effort data reported during these years. First, data are for tows where bottom trawl gear was used or midwater trawl gear was used within 1 m of the seafloor, and second, the data are restricted to three data sources (TCER (2008–2020 fishing years), TCEPR (1990–2018), and ERS (2018–2023).

Some underlying assumptions need to be stated.

1. Each time series has an artificial start and end. The study treats the first fishing year of data, for example, 1990 (deepwater) or 2008 (inshore, all stocks), as the start of fishing in each area, and thus any discussion of trends is relative to the fishing year at the beginning of the time series.
2. It is assumed that the paths (trackline) of all tows follow a straight-line between the reported or estimated start and end positions. In reality, tows may follow contours and may include turns, but the data as reported on these forms do not allow any determination of actual tow path. The duration-speed distance measure provides some measure of a tow path distance and where this differs from the trackline distance it is assumed to be closer to the ‘real’ length of a tow.
3. It is assumed that the gear is in contact with the seafloor between the trawl doors and throughout the tow.
4. It is assumed that gear used by similar sized vessels fishing for the same target species have the same doorspread, and that there are no differences in the way in which skippers operate or rig their gear.
5. The resolution of most of the position data is to the nearest minute (about 1.852 km, assuming no allowance for latitudinal changes).
6. The measure of swept area will be indicative and may well be better estimated for certain target species where fishing effort is carried out by larger vessels with gear parameters that are better understood.
7. The irregular nature of the seafloor is ignored, and it is assumed that, within each cell, the seafloor is homogeneous.
8. The patchy distribution of fishing is in part due to avoidance of areas of the seafloor that are unfishable because of undersea formations or habitats such as sponge gardens that fishers may describe as ‘foul ground’. The hybrid approach has the potential to reveal areas that are avoided as they reveal the ‘true’ path taken by trawlers, although this assumes that tows that have been mapped using a straight-line approach do not obscure tows mapped with a GPR approach in the same hybrid data set.

2.5 Trawl fishery analyses – Hybrid approach

GPR data were extracted from the Enterprise Data Warehouse from the 2018–19 to 2022–23 fishing years when GPR devices were first implemented. Coverage in in 2018–19 was low but has still been incorporated into the analyses as a hybrid approach is being developed whereby GPR data is used wherever available but the straight-line approach is used otherwise. The combination of using GPR approximations where available and the straight-line approximations otherwise is why this is referred to hereafter as a *hybrid* approach.

GPR devices report vessel position at whatever rate they are set to and with no regard to what activity they are engaged in (e.g., no distinction between steaming, searching, and trawling). The start and end positions of tows were identified from those reported by ERS forms using identical grooming algorithms applied to the data prior to being incorporated into the GPR data. Successive locations of the vessel were then determined by any GPR locations that occurred in between the ERS start and end positions. Grooming of GPR data was undertaken based on the speed and distance between adjacent locations to identify obvious errors. As some fishing events, particularly those focused on underwater topographic features (UTFs), can take less than one hour it is possible that some fishing events will not be captured by GPR because the event will have begun and ended in between pings. In these sorts of instances, straight line approximations are used.

The same agreed doorspread values for various vessel classes described in section 2.2. were then applied to the GPR tow lines to give an estimate of the area swept for each fishing event. It should also be noted that because tow paths created using previously used methods are a straight-line, an individual tow in isolation can only have a footprint, not an aggregate area. The aggregate area in a given data set created from straight-line tows can only be the result of individual tows that have crossed paths with other tows. Tow paths created from GPR data, however, can cross back over their own paths by, for example, going round in circles or doubling back in the direction they have just come from. This means that an individual tow can have an aggregate area using this method, and this is included in the total aggregate area estimate for the GPR data.

2.6 The use of GPR data to correct historical straight-line data

Part of Objective 2 seeks to assess whether distinct tow patterns can be detected in the GPR data, develop 'standard, known tows', and test the feasibility of applying these retrospectively to straight-line data that pre-dates GPR data (i.e. pre-2019–20 fishing year). The aim of this, if successful, is to improve the likely footprint and aggregate area for the entire time series back to 1990 for deepwater, and back to 2008 for All Stocks and inshore when all tows have been treated as a straight-line due to the limitations in the data.

The methods used here are as follows:

1. Manually identify dense areas of trawl activity where distinct and consistent patterns of trawling activity were evident and likely to be amenable to this type of analysis.
2. Normalise the directions of tows (e.g., where tows run generally east-west, reverse the direction of west-east tows).
3. Add evenly spaced vertices to each track (giving 25 points per track).
4. Create 'standard tow' lines by determining the geometric mean and median of each of the 25 points and creating new lines from these coordinates.
5. Determine spatial similarity statistics to assess how well the standard tow represented the actual tracks:
    1. Frechet distance - a measure of spatial similarity between two curves and
    2. Hausdorff distance -a measure of mutual proximity between tow features between each track and the standard tows.
6. Comparing the range and distribution of these measurements between the various sets of points and track lines in the data provides a statistically repeatable measurement of 'geographic closeness' which describes the fit of the calculated points and lines to the recorded ones.
7. Three sets of tow data were selected for analyses, although the location and target details were excluded to ensure fisher confidentiality.

3. RESULTS: ALL STOCKS FOOTPRINT 2008–2023 (straight-line approach)

3.1 Number of tows

For the combined 2008–2023 fishing years, 2 279 394 bottom-contacting tows (>98%) were retained for the spatial analyses. Deepwater fishstocks accounted for about 57% of all tows and inshore fishstocks for about 43%. Less than 1% of tows were assigned to targets not defined in the deepwater or inshore stocks defined in Tables 1 and 2, but are legitimate target species and included for All Stocks analyses. By form type, 64% of tows were from TCEPRs; 24% from TCERs; and 12% from ERS data collection (Table A1 in Appendix A). These forms were introduced in different years over the time series, with the TCEPR providing the first tow-by-tow data collection for vessels over 28 m, generally fishing deeper waters within the New Zealand EEZ, with the first data collection year being 1 October 1989 to 30 September 1990 (referred to hereafter as the 1990 fishing year). It is this form that provides the backbone of the All Stocks data, and the deepwater component has been supplemented from the mid-1990s with inshore effort from *some* of the inshore fleet that voluntarily reported on TCEPR forms, primarily inshore vessels targeting snapper, but also other inshore target species that were most likely fished by these same snapper vessels.

Other inshore effort continued to be recorded on CELRs which collected data only at a daily resolution on a target-statistical area basis. The summary data for annual effort recorded on CELRs are given in Table A2, along with the annual TCER, TCEPR, and ERS tows for the conventional, 5-m, and 10-m footprints. These data show that during the early to mid-1990s the amount of overall trawl effort (number of tows) each year is substantially higher than what is included in the TCEPR tow data; however, the resolution of CELR reporting means that these data cannot be used for tow-by-tow spatial analysis. CELR forms only recorded the number of trawls carried out each day for a given combination of target species and statistical areas (hence the number of *tows* is always higher than the number of *records* for the CELR data in any given year). Start and end positions, or other information that would allow for a track line to be created (and then swept area) were not recorded on this form type. Apart from five records totalling 21 tows in 2019, no data have been recorded on CELR forms after 2017. In the 2023 fishing year, 54 733 tows were used to inform the All Stocks analyses (Table A2), 34 tows were excluded from the analyses, 12 of these had coordinates that placed them on land, 5 were in closed areas, and 14 were deeper than 1600 m (Table B1).

When the CELR form was superseded with the introduction of the TCER on 1 October 2007 (2008 fishing year), a new set of data was available for spatial analysis alongside the TCEPR data. Lastly, the move to ERS data away from TCEPR during 2018 for deepwater fishstocks and away from TCER in 2019 for inshore fishstocks has provided similar data but at a finer resolution and, for inshore data, an endpoint for each tow. The change of reporting form type and the data collected on each form during the time series needs to be considered when interpreting these data. For the All Stocks data set, the most comprehensive time period, where both deepwater and inshore effort was reported with tow location data, is from 2008 on. Hence, further analyses on the All Stocks data set are presented from 2008 onwards, while acknowledging that there was a substantial amount of fishing effort prior to this.

3.2 Spatial coverage

The extent of the All Stocks seafloor contact is summarised by year in Table 4. Overall, the data available for all stocks indicate that, within the fishable area (areas open to trawling shallower than 1600 m), 30 665 25-km^2 cells were contacted over the 16 years, with a total aggregate area of 2 329 566.6 km^2, and a footprint of 320 648.5 km^2. In the period 2008–2023, 97.6% of the aggregate area and 96.9% of the footprint area were within the fishable area. On an annual basis, this ranged from 96.6–99.8% for the aggregate area and 95.6–99.7% for the footprint. Other effort was excluded where coordinates placed effort on land or in closed areas (see Appendix B). All further references to the aggregate and footprint in areas in this document are for the fishable area.

Table 4: The number of contacted 25-km^2 cells, the aggregate area, and the footprint area for All Stocks in the fishable area, and the percent of the EEZ+TS seafloor and the fishable area seafloor that was contacted by the footprint, by year for 2008–2023.

Fishing year	No. of cells	Aggregate area (km^2)	Footprint (km^2)	EEZ+TS (%)	Fishable (%)
2008	18 470	154 219.6	92 148.1	2.2	6.7
2009	18 013	151 961.1	90 060.5	2.2	6.5
2010	18 022	162 870.6	94 536.1	2.3	6.8
2011	17 673	156 172.6	91 584.1	2.2	6.6
2012	17 165	152 278.4	88 006.0	2.1	6.4
2013	16 305	146 203.1	85 794.1	2.1	6.2
2014	17 366	151 882.2	90 360.1	2.2	6.5
2015	17 481	149 183.0	89 084.7	2.2	6.4
2016	17 519	146 385.9	86 314.8	2.1	6.2
2017	17 508	154 371.7	88 093.4	2.1	6.4
2018	16 993	158 128.4	88 413.4	2.2	6.4
2019	15 665	142 230.7	80 235.5	2.0	5.8
2020	13 866	128 893.7	69 784.2	1.7	5.1
2021	14 436	129 285.7	73 996.4	1.8	5.4
2022	13 794	124 125.7	70 566.3	1.7	5.1
2023	14 210	121 374.1	68 779.6	1.7	5.0
All	30 665	2 329 566.6	320 648.5	7.8	23.2

All Stocks footprint. Overall, the trawl footprint of 320 648.5 km^2 represents 7.8% of the EEZ+TS seafloor area and 23.2% of the fishable area (Table 4). The annual footprint values are shown in Figure 3, the All Stocks data (shown as grey bars) starts from 2008, the year in which inshore data could be effectively included in the All Stocks data set with individual event-level recording of fishing effort. The annual footprint was relatively steady from 2008–2018 at around 85 700 km^2 to 94 600 km^2. There was a drop to just over 80 000 km^2 in 2019 followed by a further drop in 2020 to 69 700 km^2. The footprint increased slightly to just under 74 000 km^2 in 2021, dropped again to about 70 600 km^2 in 2022, then dropped again to 68 779.6 km^2 in 2023, the lowest in the time series. Overall, the five most recent years are the lowest in the All Stocks 16-year time series. The spatial distribution of the All Stocks footprint for all years combined and for 2023 is shown in Figure 4.

All Stocks aggregate area. The All Stocks data set had an aggregate area of 2 329 566.6 km^2 for the 16-year time series. The aggregate area followed a similar pattern to the footprint, being relatively steady from about 2008 to 2018, ranging between about 146 000 km^2 and close to 163 000 km^2 (Figure 5). As with the footprint, there was a drop in the aggregate area in 2019 to around 142 300 km^2, followed by a further drop to just under 128 900 km^2. There was a slight increase in 2021 to 129 286 km^2 which dropped again in 2022 to just over 124 200 km^2, and then a further drop in 2023 to just under 121 400 km^2, the lowest in the time series. As for the footprint, the aggregate areas for the last five years are the lowest in the 16-year time series. The spatial distribution of the All Stocks aggregate area for all years combined and for 2024 is shown in Figure 6.

All Stocks number of cells. Over the 16 years in this data set, 30 665 cells were contacted in the All Stocks footprint (Table 4). Predictably, the number of cells contacted each year for the All Stocks data set followed a similar pattern to the footprint and aggregate area, being relatively steady from 2008 to 2018, ranging from 16 305 cells to 18 470 cells. The highest number of cells contacted was in 2008, which did not coincide with the largest footprint and aggregate area (both in 2010); this suggests that fishing can be more widely spread at times, perhaps when exploring new areas. However, generally there was a logical correlation between the size of the footprint and the number of cells contacted. As for the footprint and aggregate area, the number of cells contacted decreased in 2019 to 15 665, then decreased again in 2020 to 13 866 cells, then increased slightly to 14 436 cells in 2021, decreased again in 2022 to 13 794, the lowest in the time series. In 2023, the number of cells contacted increased slightly to 14 210, despite the corresponding aggregate area and footprint being the lowest in the time series.

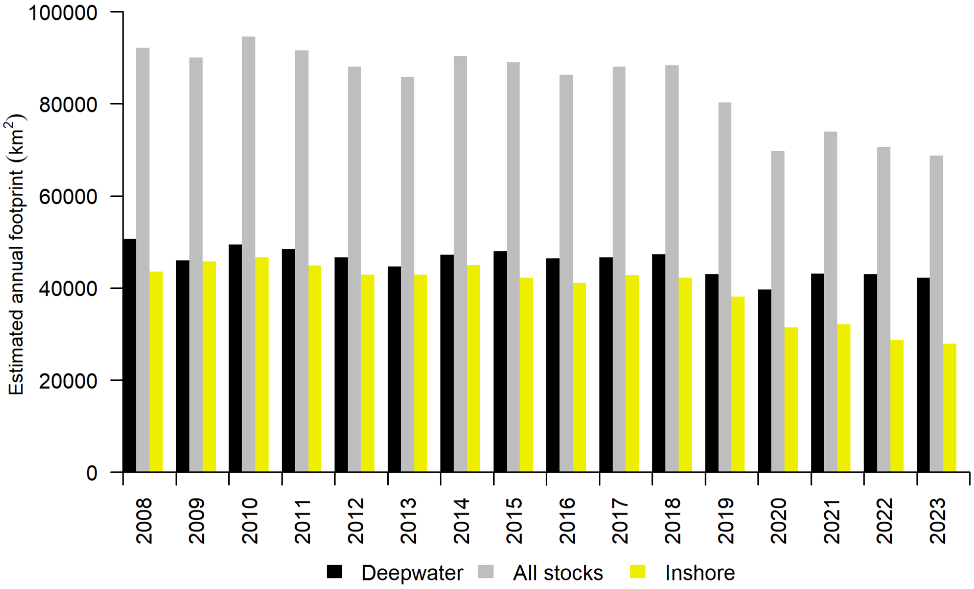


Figure 3: Annual estimated footprint for All Stocks, Deepwater stocks, and Inshore stocks, 2008–2023. The data represent TCEPR (2008–2018), TCER (2008–2020), and ERS (2018–2023) bottom-contacting effort.

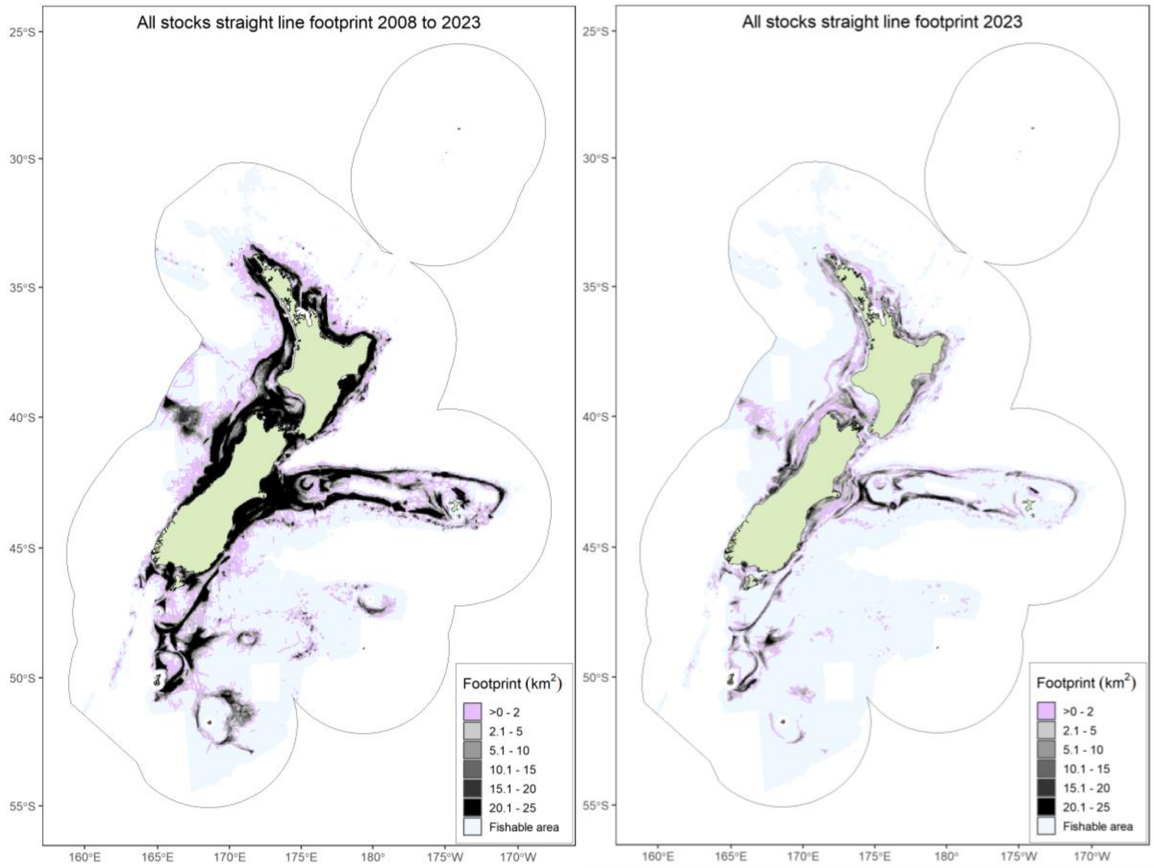


Figure 4: Distribution of the All Stocks footprint represented by 25-km^2 cells, 2008–2023 and 2023.

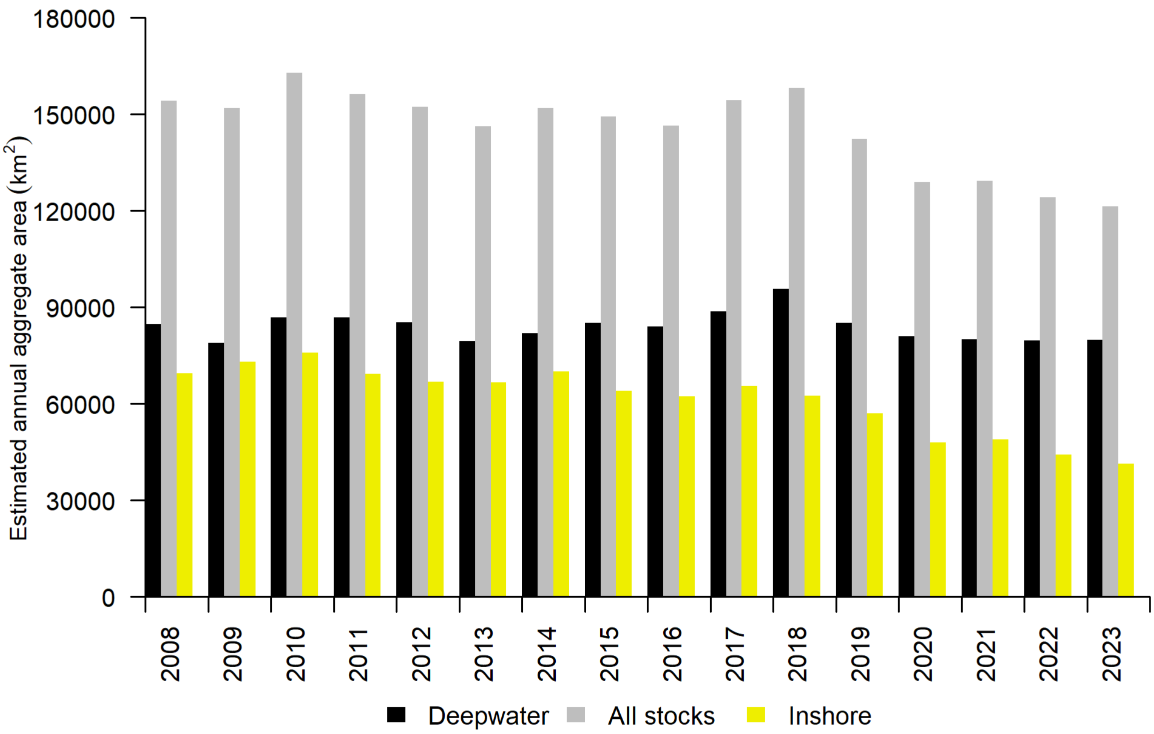


Figure 5: Annual estimated aggregate area for All Stocks, Deepwater stocks, and Inshore stocks, 2008–2023. The data represent TCEPR (2008–2018), TCER (2008–2020), and ERS (2018–2023) bottom-contacting effort.

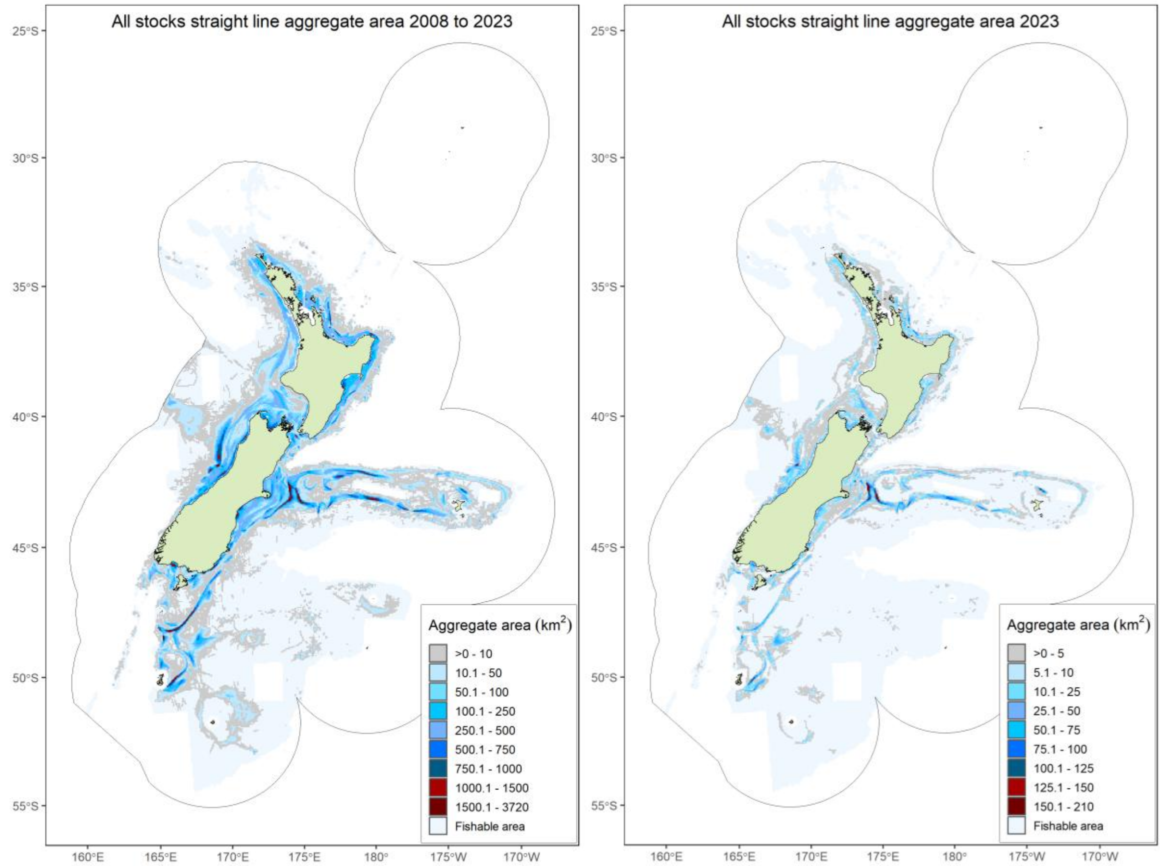


Figure 6: Distribution of the All Stocks aggregate area represented by 25-km^2 cells, 2008–2023 and 2023.

3.3 Extent of new areas contacted across the 2008–2023 time series

A measure of change across all years is the number of cells contacted in a year that were not contacted in previous years (e.g., cells in 2012 that were not contacted in 2008–2011); these cells are referred to as 'new cells'. These cells provide a way in which to isolate new areas that have been contacted, beyond the usual fishing areas. From a total of 18 470 cells contacted in the 2008 fishing year, 2851 cells were contacted for the first time in 2009, 1839 were contacted for the first time in 2010, and 1469 in 2011 (Table 5). Since 2012 fewer than 1000 new cells have been contacted each year. Apart from slight increases in 2014 and 2022, the number of cells contacted each year has decreased, with fewer than 500 cells each year after 2017, and under 200 in each of the last three years. The estimated trawl footprint and aggregate area within these new cells provides an indication of the extent of area newly contacted and the intensity of contact in those newly contacted areas. For most years given in Table 5, there is little difference between the aggregate area and the footprint, and the areas are small and likely to represent the edge of the main fishing areas. For 2009–2023, the annual new cell footprint represents between 82.0 and 98.1% of the new cell aggregate area. Where estimates of footprint and aggregate area are close in size, it suggests that the swept area of the tows is spread out within each new cell, without much overlap between tows. It is likely that these new cells represent the very edges of fished areas and/or small amounts of exploratory fishing. It should be noted that the All Stocks data set has more new cells contacted in recent years than either the deepwater or inshore data sets (see sections 4.3 and 5.3 below). This is due to the truncated nature of the All Stocks data set compared with the deepwater data set. A substantial amount of the 'new' areas for All Stocks (beginning in 2008) is not new for the deepwater data set (beginning in 1990).

Table 5: For All Stocks data, the number of cells contacted in 2008 and the number of 'new' cells contacted in subsequent years and the aggregate area and footprint estimated for those new cells, where data for 2009 represent cells contacted in 2009 but not in 2008, and data for 2010 represent cells contacted in 2008–2009 but not in 2010, etc.

Number of cells contacted in 2008 = 18 470

Fishing year	No. new cells	Aggregate area (km^2)	Footprint (km^2)	Footprint as % aggregate area
2009	2 851	2 586.5	2 372.2	91.7
2010	1 839	1 606.5	1 508.5	93.9
2011	1 469	1 849.7	1 517.4	82.0
2012	903	546.8	529.0	96.7
2013	782	851.9	795.2	93.3
2014	878	924.8	870.8	94.2
2015	863	897.7	850.0	94.7
2016	676	440.9	426.5	96.7
2017	530	443.2	425.3	96.0
2018	460	299.6	288.5	96.3
2019	240	256.8	247.5	96.4
2020	221	341.3	328.1	96.1
2021	146	185.3	175.7	94.8
2022	190	198.1	194.4	98.1
2023	147	147.7	142.0	96.1

3.4 Intensity

For the combined 2008–2023 All Stocks data, the median number of tows that contacted a cell was 25 (mean of 215), and 50% of cells were contacted by between 4 and 197 tows, with a maximum of 7091 tows over the total data set (Table 6). By year, the maximum number of tows in a cell ranged from 536 (off Hawke Bay in 2015) to 827 (Hokitika Trench in 2018).

Table 6: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for the All Stocks data, for the combined fishing years 2008–2023. Annual summaries are given in Table 7.

	Minimum	1st quarter	Median	Mean	3rd quarter	Maximum
No. of tows	1.0	4.0	25.0	215.1	197.0	7 091.0
Aggregate area (km^2)	<0.1	1.3	9.0	76.0	69.9	3 905.1
Footprint (km^2)	<0.1	1.2	6.8	10.5	21.3	25.0

The maximum aggregate area for any one cell for the combined 2008–2023 period was 3905.1 km^2 (Table 6). The top ten cells with the highest total aggregate area ranged between 2220.5 and 3905.1 km^2. Two of these cells are just to the east of the Auckland Islands (2220.1–2380 km^2), two are off the southern edge of the Stewart-Snares Shelf (2642–2662.9 km^2), four are to the east of this near the southern edge of the Stewart Snares Shelf (2571.6–3152.4 km^2), and two off the west coast of the South Island in the Hokitika Trench (3147.3–3905.1 km^2). By year, the maximum aggregate area for a cell ranged from 208.3 km^2 to 446.4 km^2 (the same cell in both 2017 and 2020, in the Hokitika Trench).

However, only two of the top cells by aggregate area for the entire time period are also in the top cells by tow count, both of these being in the Hokitika Trench (6627–6856 tows). The other top cells by tow count were on the lower east coast of the South Island near Kaka Point (five cells ranging between 5347–6829 tows), mid-east coast of the South Island near Timaru (one cell, 5747 tows), one cell in Tasman Bay (5685 tows), and one cell in Hawke Bay (6856 tows, the highest in the top ten cells by tow count).

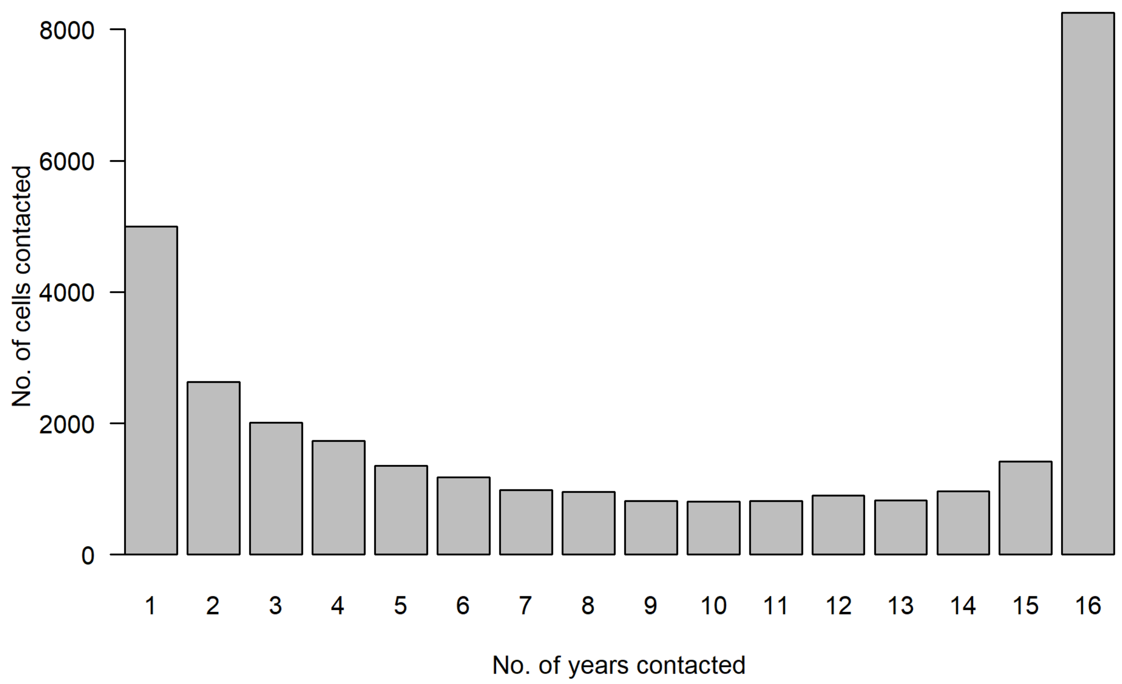
Table 7: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for All Stocks data, 2008–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001. The maximum footprint is 25 km^2 in all years because this is the maximum possible as cells are 25 km^2 in area,

Fishing	No. of tows					Aggregate area (km^2)					Footprint (km^2)				
year	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max
2008	2	8	25.3	29.0	599	0.8	2.9	8.3	9.6	243.6	0.8	2.6	5.0	7.6	25
2009	2	8	24.9	28.0	564	0.8	2.7	8.4	9.6	286.0	0.7	2.5	5.0	7.6	25
2010	2	9	26.5	29.0	623	0.8	3.0	9.0	10.3	214.2	0.7	2.7	5.2	8.1	25
2011	2	9	25.6	30.0	662	0.7	2.9	8.8	10.3	284.9	0.7	2.6	5.2	8.1	25
2012	2	9	25.6	29.0	540	0.7	3.0	8.9	10.0	250.7	0.7	2.7	5.1	7.9	25
2013	2	9	26.6	31.0	685	0.8	3.1	9.0	10.5	281.3	0.8	2.9	5.3	8.1	25
2014	2	9	25.5	30.0	564	0.8	3.1	8.7	10.2	290.1	0.8	2.8	5.2	8.0	25
2015	2	9	24.1	28.0	536	0.8	2.9	8.5	9.7	327.6	0.8	2.7	5.1	7.7	25
2016	2	8	23.8	27.0	602	0.7	2.7	8.4	9.3	335.2	0.7	2.5	4.9	7.4	25
2017	2	8	24.4	28.0	613	0.8	2.9	8.8	9.5	208.3	0.8	2.6	5.0	7.5	25
2018	2	9	24.6	29.0	827	0.8	3.1	9.3	10.3	403.5	0.8	2.8	5.2	7.9	25
2019	2	9	24.8	29.0	616	0.8	3.1	9.1	10.5	296.9	0.8	2.8	5.1	7.9	25
2020	3	10	25.5	30.0	724	0.9	3.4	9.3	10.1	446.4	0.8	2.9	5.0	7.5	25
2021	3	10	24.6	29.2	594	0.9	3.6	9.0	10.4	225.7	0.8	3.1	5.1	7.7	25
2022	3	10	24.2	29.0	650	0.9	3.5	9.0	10.2	210.9	0.8	3.1	5.1	7.6	25
2023	2	9	22.6	26.0	563	0.8	3.1	8.5	9.5	289.1	0.8	2.7	4.8	7.2	25

3.5 Number of years contacted

Of the 30 665 cells contacted by the total All Stocks footprint between 2008 and 2023, 16% (n = 5000) were contacted in one year only, 9% (n = 2643) in 2 years, and 7% (n = 2013) in 3 years (Figure 7, upper plot). In total, 27% of cells (n = 8250) were contacted every year. Figure 8 (left plot) shows the spatial distribution of the number of years contacted per cell. Both inshore and deepwater footprints have significant areas that have been contacted in every year in the data set.

Of cells that were contacted, 46% (n = 14 210) were contacted in the most recent year, 66% (n = 20 120) have been contacted in the last five years, and 87% (n = 26 772) have been contacted in the last ten years (Figure 7, lower plot). The spatial distribution of cells contacted by the most recent year of contact is shown in Figure 8 (right plot). Much of the plot area is occupied by fishing effort from the most recent fishing year (2023). This includes most of the coastal inshore areas, the Challenger Plateau, the Stewart Snares Shelf, Auckland and Campbell Islands, and the north and south Chatham Rise.



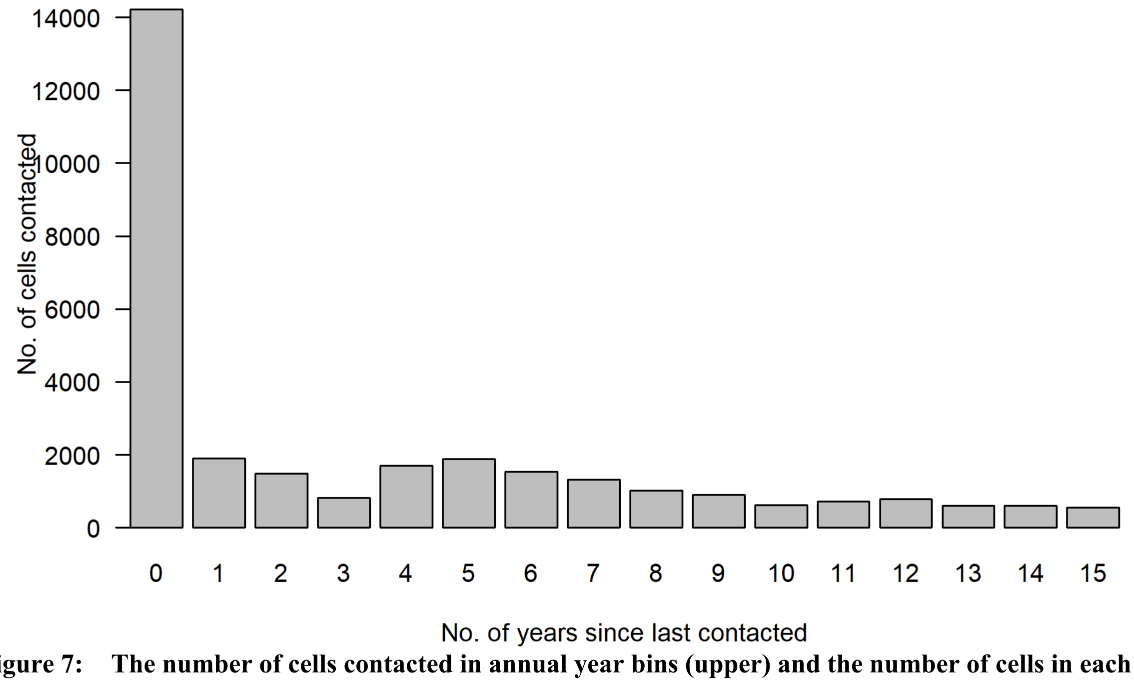


Figure 7: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for the All Stocks data set for 2008–2023.

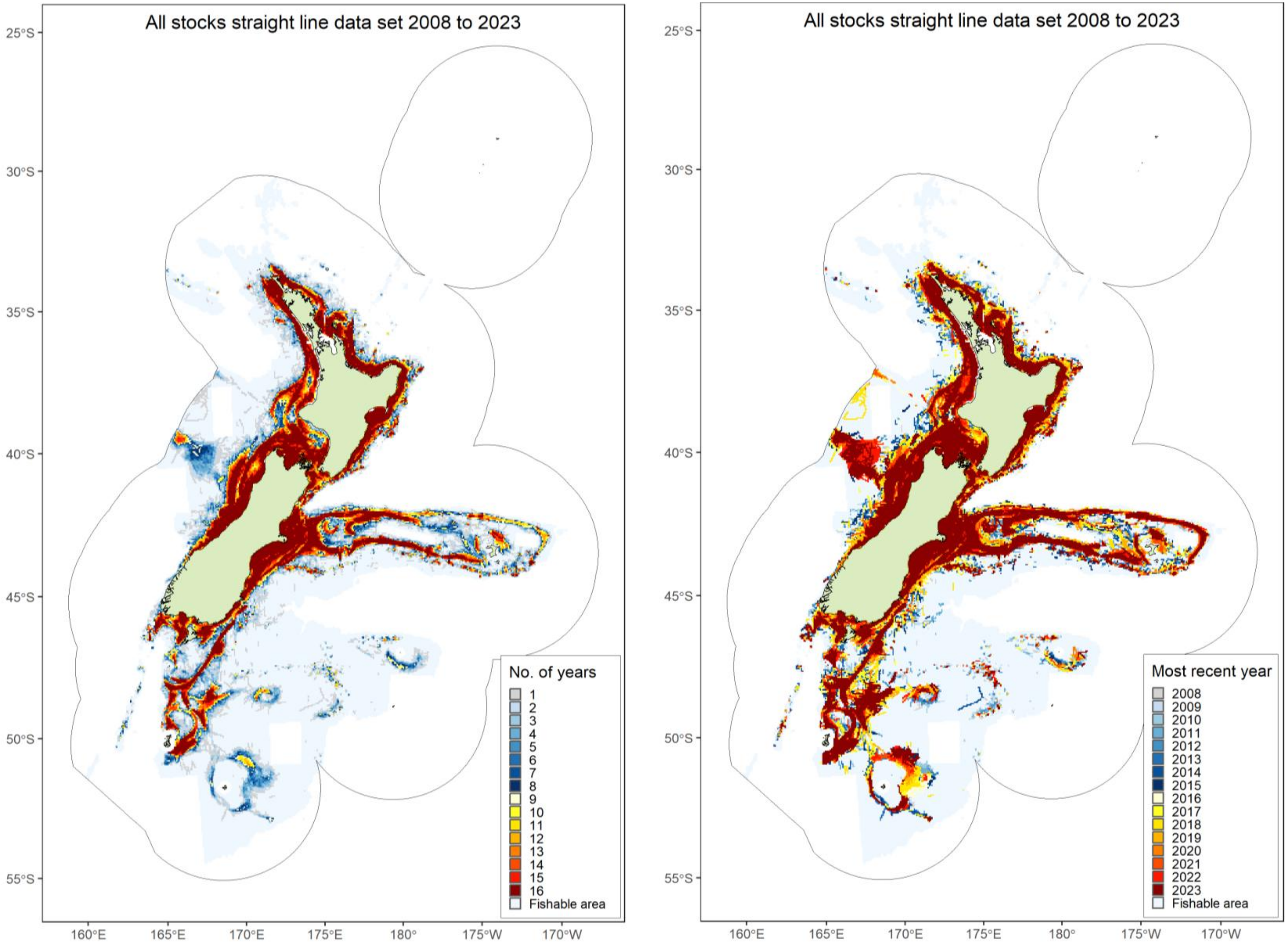


Figure 8: Distribution of the All Stocks cells, by the number of years contacted (left), and by most recent year fished (right) between 2008 and 2023.

4. RESULTS: DEEPWATER FISHSTOCKS TRAWL FOOTPRINT 1990–2023 (straight-line approach)

4.1 Deepwater data

During 1990–2023, a total of 569 unique vessels reported bottom-contacting effort that targeted deepwater Tier 1 and Tier 2 species (Table C1 in Appendix C). Note the brief for this study did not involve providing summaries by tier or target species (other than for comparisons between the straight-line and GPR methods), and this section provides summaries only for deepwater fisheries as a whole. The number of unique vessels in any fishing year ranged between 71 and 165. Table 1 is included only to inform the reader what species comprise the data set used for deepwater analyses. These vessels represented both foreign and domestic fleets and over time there have been substantial changes in the numbers of vessels and the type and size of vessels in this data set. The numbers of vessels in most vessel groups have decreased over the years, especially the foreign-owned fleets and this is reflected in the decrease in reported tows by these vessels (Figure 9). Different trawl gear set-ups have been used by these vessel groups to target a variety of deepwater species and, until there is better information on the spread of gear that contacts the seafloor, vessels in each group are considered to have similar bottom contact in these analyses.

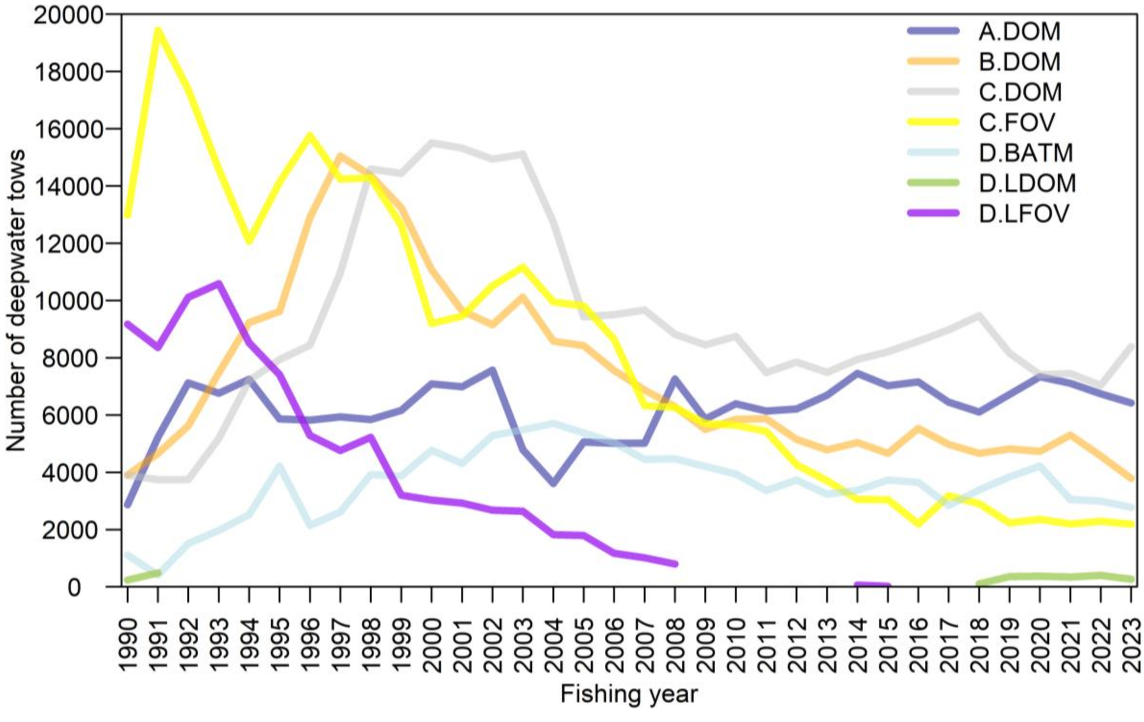


Figure 9: The number of bottom-contacting tows reported by vessels that targeted Tier 1 and Tier 2 deepwater fishstocks during 1990–2023, by year and vessel type. A.DOM is domestic vessel ≤ 28 m in length; B.DOM is domestic vessel > 28 m and ≤ 46 m; C.DOM is domestic vessel > 46 and ≤ 82 m; C.FOV is foreign-owned vessel > 46 and ≤ 82 m; D.BATM is foreign-owned vessel of 104 m in length; D.LDOM is domestic vessel > 82 m; and D.LFOV is foreign-owned vessel > 82 m long.

The underlying tow data and results of analyses based on the deepwater Tier 1 and Tier 2 fishstocks are presented in Table C1 in Appendix C. Tier 1 and Tier 2 species are defined in Table 1. The tow data are from TCEPRs from 1990 to 2020, TCERs from 2008 to 2020, and ERS from 2018 to 2023 (Table C1). Over the time series, the number of bottom-contacting tows increased from just under 34 000 in 1990 to over 58 000 in 1998, then decreased in most years to about 33 350 tows in 2007. The introduction of TCER forms saw a small increase in 2008 but the overall decreasing pattern in the numbers of tows continued, with between about 24 000 and 30 600 tows during 2009–2022. In 2023, there were just under 24 000 tows, which is the lowest in the time series, and the three most recent years have the three lowest numbers of tows in the time series. Data reported on TCER and TCEPR forms were last present in the data set in 2020 but accounted for less than 0.1% of the total. Since 2021, data were entirely reported on ERS forms.

4.2 Spatial extent

The annual totals of cells, aggregate swept area, and footprint for all deepwater fishstocks are given in Table 8.

For all years, the deepwater fishstock effort contacted 37 501 25-km^2 cells, based on the total estimated aggregate area of almost 3.8 million km^2 and a total footprint of 357 847 km^2, equivalent to about 9.5% of the aggregate area. Overall, the footprint contacted 8.7% of the area of the EEZ+TS and 25.9% of the fishable area. The greatest annual overlap was during 1992–2004, with peak overlap in 2002 and 2003 (2% in both years) but from 2006 the footprint overlap has been 1.0–1.2% of the EEZ+TS and 2.9–3.7% of the fishable area (1.0 and 3.1%, respectively, in 2023, the most recent year covered by the study).

The annual aggregate area increased each year (except 1994 and 1996) to a peak in 1998 of 171 192 km^2, ranged from about 150 000–156 000 km^2 during 1999–2003, followed by a sharp decline in 2004 and 2005 (around 131 000 km^2 and 110 000 km^2, respectively). In 2006 the aggregate area dropped below 100 000 km^2 and has remained below this ever since, levelling out at between almost 80 000 and 95 600 km^2 during 2007–2023. The lowest aggregate area in the time series was 79 730.4 km^2 in 2022, which increased slightly to 79 905.8 km^2 in 2023.

The footprint generally followed the trend of the aggregate area in the 1990s, but the peak annual spread as measured by the footprint (at about 80 550 km^2) and numbers of cells (16 910 cells) was during 2002 whereas the peak aggregate area was in 1998. Subsequently, the footprint decreased to about 50 000–51 000 km^2 during 2006–2008 and has been below 50 000 km^2 since 2009. The footprint of 39 649 km^2 in 2020 is the lowest in the time series; the footprint increased slightly in 2021 and 2022 to just over 43 000 km^2 in both years, then decreased again slightly in 2023 to just over 42 000 km^2. The number of cells contacted steadily decreased after the peak in the early 2000s to a series minimum of 9206 in 2020, corresponding with the lowest footprint. The last five years have seen a relatively steady number of cells contacted (between about 9200 and 10 000) and steady footprint each year, with both measures being the lowest in the time series.

The spatial distribution of the footprint and aggregate area for all years combined, and for 2023, is shown in Figure 10. The footprint for all years combined (1990–2023) is highest in Challenger Plateau, west coast South Island, Puysegur Trench, the Stewart Snares Shelf, Auckland and Campbell Islands, north and south Chatham Rise, and areas around the east coast North Island. In 2023, these areas are all still fished but the extent within each region is substantially reduced. A similar pattern is seen with the aggregate area.

Table 8: **The number of cells contacted by the deepwater bottom-contact trawls, the aggregate area, the footprint area, and the footprint as a percent of the EEZ+TS (4.1 million km^2) and the fishable area (1.39 million km^2) for 1990–2023.**

Fishing year	No. of cells	Aggregate (km^2)	Footprint (km^2)	%EEZ+TS	% fishable
1990	12 143	101 351.0	47 282.7	1.2	3.4
1991	13 090	125 983.4	54 643.1	1.3	4.0
1992	14 284	136 998.0	66 418.7	1.6	4.8
1993	13 643	139 862.2	66 653.5	1.6	4.8
1994	13 016	121 793.3	56 717.6	1.4	4.1
1995	13 211	144 576.1	61 586.0	1.5	4.5
1996	13 301	143 971.3	62 272.7	1.5	4.5
1997	13 542	154 843.4	68 310.7	1.7	4.9
1998	15 054	171 192.2	76 602.2	1.9	5.5
1999	14 741	155 873.7	72 001.2	1.8	5.2
2000	15 061	149 983.0	73 606.7	1.8	5.3
2001	15 131	150 025.6	75 649.5	1.8	5.5
2002	16 910	154 333.2	80 549.5	2.0	5.8
2003	15 793	156 052.0	80 109.9	2.0	5.8
2004	14 119	130 758.1	67 337.8	1.6	4.9
2005	13 226	110 005.4	53 883.1	1.3	3.9
2006	12 269	94 662.5	49 809.6	1.2	3.6
2007	12 127	87 705.8	49 943.8	1.2	3.6
2008	13 128	84 782.6	50 614.3	1.2	3.7
2009	12 272	78 923.5	45 937.4	1.1	3.3
2010	12 480	86 899.9	49 460.7	1.2	3.6
2011	12 044	86 804.9	48 465.2	1.2	3.5
2012	11 421	85 296.6	46 636.8	1.1	3.4
2013	10 693	79 506.2	44 600.0	1.1	3.2
2014	11 745	81 877.6	47 171.8	1.2	3.4
2015	11 539	85 143.8	47 966.1	1.2	3.5
2016	11 550	83 916.8	46 449.1	1.1	3.4
2017	11 466	88 703.0	46 599.9	1.1	3.4
2018	10 870	95 626.6	47 363.9	1.2	3.4
2019	9 981	85 204.7	43 027.4	1.0	3.1
2020	9 206	80 936.9	39 649.3	1.0	2.9
2021	9 763	80 058.5	43 054.1	1.1	3.1
2022	9 428	79 730.4	42 950.8	1.0	3.1
2023	9610	79 905.8	42 158.3	1.0	3.1
Total	37 501	3 773 287.8	357 846.6	8.7	25.9

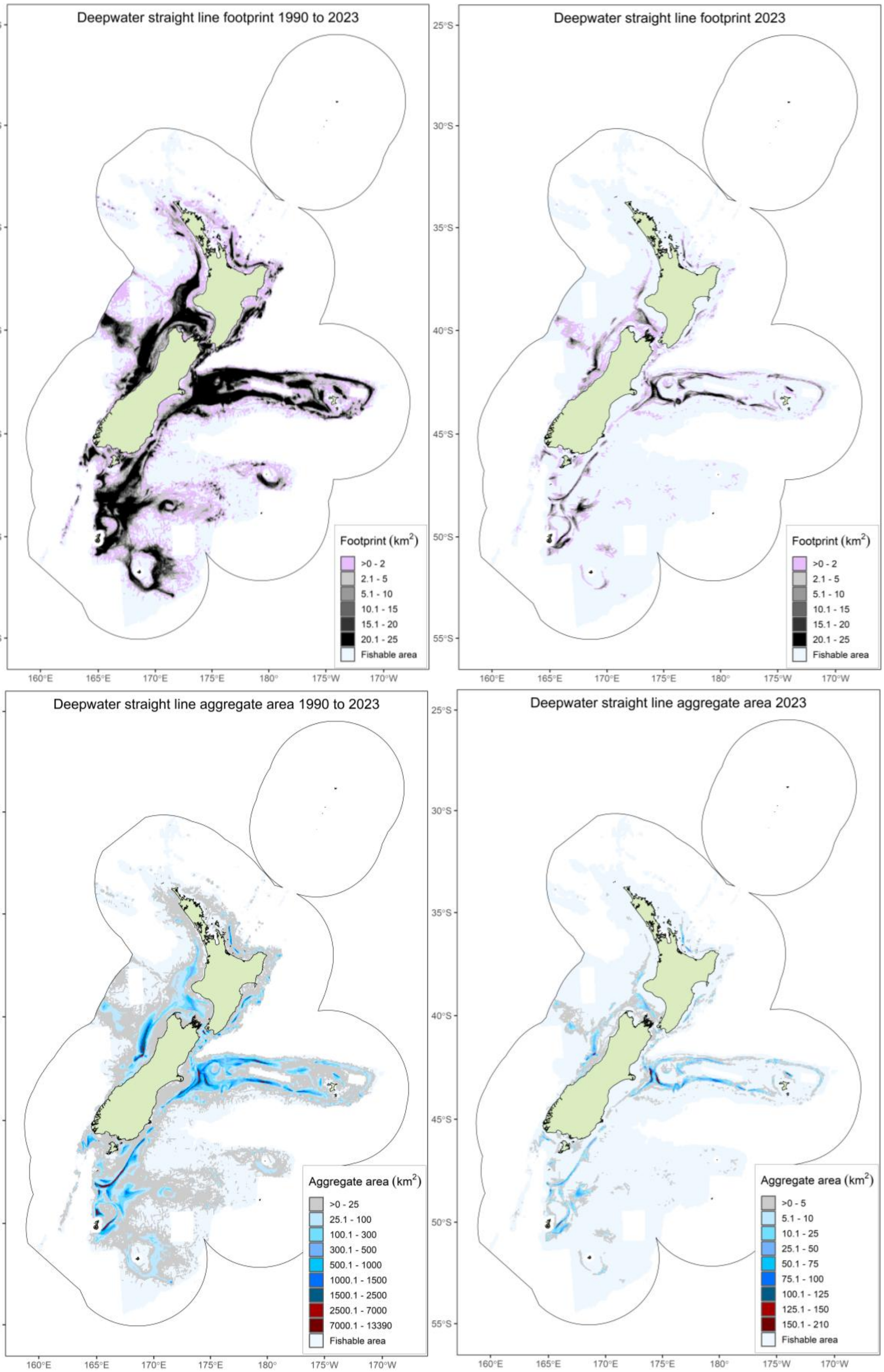


Figure 10: Distribution of the deepwater fishstocks footprint (upper plots) and aggregate area (lower plots), by 25-km^2 cells, 1990–2023 (left) and 2023 (right).

4.3 Extent of new cells contacted across the 2008–2023 time series

The number of cells that were fished in one year, but not in previous years, is shown in Table 9 for the combined deepwater fishstocks, where the base footprint was created from the 1990–1994 fishing years during which time 24 027 unique cells were contacted. It is evident from Table 9 that in many of these years the contact in the new cells is of low intensity; there is little difference between the aggregate area and the footprint of these new cells (no difference in 2018 and 2023), and as a percentage of the aggregate area, the footprint ranges between 81.0 and 100% (mean 93.5%). This could indicate exploratory fishing or be an artefact of the methodology used to generate the spatial data (i.e., the jittering of positions could cause the start or end of a tow to be shifted into a 'new' cell). However, in years of higher effort and increased swept areas (as seen in 1998–2000), the number of new cells increased and the aggregate area relative to the footprint was greater.

Overall, there has been a decrease over time in the number of new cells contacted each year. In addition, the footprint expressed as a percentage of the aggregate area has increased over time, which suggests that the extents of different deepwater fisheries are essentially established. ERS data is not jittered as TCEPR and TCER data is (due to the increased precision in position reporting), which also prevents the possibility of the start or end of a tow being shifted into a cell that has not previously been fished through an artefact of the jittering process. Only 8 new cells were contacted in 2023, the lowest in the time series. The footprint and aggregate areas were identical (just 4.3 km^2), meaning that all new areas trawled were only trawled once.

Table 9: The number of cells contacted in a year that had not been contacted in previous years, and the aggregate area and footprint within those new cells for deepwater fisheries. A base of 24 027 cells were contacted in 1990–94, and, for example, there were 1151 cells that were contacted in 1995 (but not in 1990–94) with an aggregate area of 985.6 km^2 and a footprint of 868.7 km^2.

Fishing year	No. new cells	Aggregate area (km^2)	Footprint (km^2)	Footprint as % of aggregate area
No. cells contacted in 1990–94 = 24 027				
1995	1 151	985.6	868.7	88.1
1996	1 254	1018.7	904.8	88.8
1997	999	841.2	790.3	93.9
1998	1 476	1923.5	1559.0	81.1
1999	1 248	1287.3	1091.8	84.8
2000	1 184	1553.7	1367.5	88.0
2001	743	722.7	620.9	85.9
2002	1 225	1053.5	1015.8	96.4
2003	667	753.2	673.3	89.4
2004	321	345.6	314.6	91.0
2005	598	617.8	544.4	88.1
2006	254	118.4	113.4	95.8
2007	279	157.3	150.4	95.6
2008	330	197.8	187.0	94.5
2009	247	110.6	107.1	96.8
2010	189	76.7	74.8	97.5
2011	175	85.3	72.2	84.6
2012	100	38.1	37.5	98.4
2013	88	40.0	39.6	99.0
2014	88	33.8	33.1	97.9
2015	189	153.0	144.6	94.5
2016	191	121.1	115.1	95.0
2017	111	68.5	65.7	95.9
2018	110	30.4	30.4	100.0
2019	68	92.1	87.6	95.1
2020	54	40.7	40.5	99.5
2021	70	72.2	69.9	96.8
2022	57	53.2	53.1	99.8
2023	8	4.3	4.3	100.0

4.4 Intensity

For the combined 1990–2023 deepwater fishstocks data, the median number of tows that contacted a cell was 16 (mean of 203.3), and 50% of cells were contacted by between 3 and 96 tows, with a maximum of 20 499 tows over the total data set (Table 10). The top ten cells by tow count for the 34-year time period were entirely on the southern end of the Stewart-Snares Shelf except for one cell in Cook Strait.

Table 10: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for the deepwater fishstocks data, for the combined fishing years 1990–2023.

	Minimum	1st quarter	Median	Mean	3rd quarter	Maximum
No. of tows	1.0	3.0	16.0	203.3	96.0	20 499.0
Aggregate area (km^2)	<0.1	1.1	6.3	100.6	40.9	13 439.4
Footprint (km^2)	<0.1	1.1	5.4	9.5	18.7	25.0

The median number of tows in a cell in a year was about 4 tows during 1990–2023 (Table 11). The mean numbers increased during the 1990s to 2003 (peaking at about 22–23 tows per cell between 1995 and 1998) before decreasing, then remaining relatively steady at about 14–16 tows from 2009 to 2017, and about 16–18 tows between 2019 and 2023. At the same time the maximum number of tows per cell decreased from over 1000 in most years until 2006, to around 500 tows until 2017, increasing to between 568 and 821 tows until 2020, then dropping again to 483 tows in 2021, to 440 tows in 2022, and increasing slightly to 470 tows in 2023.

The annual median values for the aggregate areas in a cell ranged from 1.3–2.3 km^2, with 2022 having the highest (2.3 km^2), whereas the means ranged between 6.4 and 11.4 km^2, with peak years during the mid-1990s to mid-2000s (Table 11). The maximum aggregate areas in a cell were mostly during 1991–1995, at 812–1651 km^2, and in 2004 and 2005 (at about 933–956 km^2). Unsurprisingly, these coincide with years in the peak maximum number of tows in a cell, and the maximum aggregate area follows an overall declining pattern over the time period as does the maximum number of tows in a cell. Figure 10 illustrates the areas where fishing was most intense in 1990–2023 and 2023. For 1990–2023, fishing was most intense on the west coast of the South Island, Cook Strait, the northern and southern parts of the western Chatham Rise, Stewart Snares Shelf, and Auckland Islands. Most of these areas are less intensely fished now, with the most intensely fished areas being the west coast of the South Island, and the western end of the Chatham Rise. The extent of intensity within these areas has also reduced. For the entire time period, nine of the top ten cells by aggregate area are on the Stewart-Snares Shelf (eight of these cells were also in the top ten by tow count) and one cell was on the west coast of the South Island at the Hokitika Trench.

The footprint estimates in comparison with aggregate area values indicated that many cells have low levels of contact with the median in most years being under 2 km^2 and means mostly under 5 km^2 (Table 11). The maximum footprint in all years is 25 km^2, equivalent to the total area of a cell, although most cells are not contacted to this extent.

Table 11: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for deepwater data, 1990–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

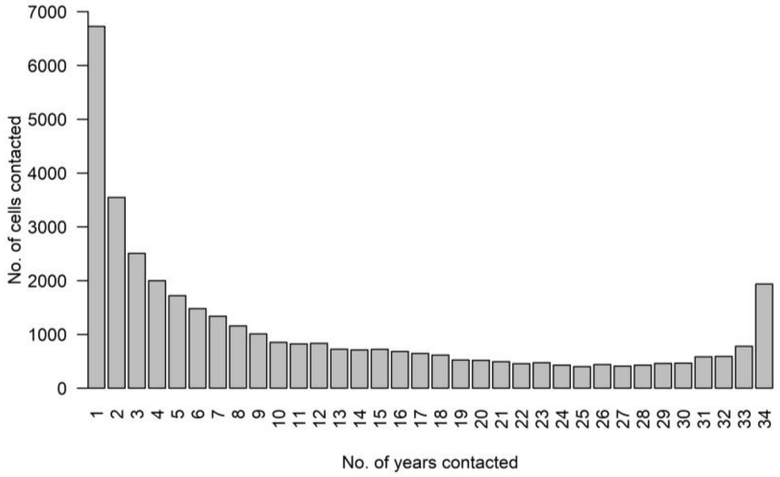
Fishing	No. of tows					Footprint (km^2)					Aggregate area (km^2)				
year	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max
1990	1	3	16.5	12.0	1 093	0.5	1.2	3.9	5.0	25.0	0.5	1.3	8.3	5.8	724.8
1991	1	3	19.7	13.0	2 414	0.6	1.5	4.2	5.1	25.0	0.6	1.5	9.6	6.0	1 651.0
1992	1	4	19.9	16.0	1 293	0.6	1.8	4.6	6.3	25.0	0.7	1.9	9.6	7.5	836.4
1993	1	5	20.4	18.0	1 858	0.7	2.0	4.9	6.8	25.0	0.7	2.1	10.3	8.4	1 394.3
1994	1	4	20.0	15.0	1 280	0.6	1.6	4.4	5.8	25.0	0.6	1.7	9.4	6.9	812.0
1995	1	4	22.0	17.0	1 139	0.6	1.8	4.7	6.3	25.0	0.6	1.8	10.9	7.7	890.4
1996	1	4	22.0	17.0	1 312	0.6	1.6	4.7	6.2	25.0	0.6	1.6	10.8	7.5	615.7
1997	1	4	22.9	19.0	1 402	0.6	1.8	5.0	7.2	25.0	0.6	1.9	11.4	9.0	537.7
1998	1	4	22.4	19.0	880	0.6	1.8	5.1	7.1	25.0	0.6	1.8	11.4	8.8	450.9
1999	1	4	21.2	18.0	1 214	0.6	1.7	4.9	6.5	25.0	0.6	1.7	10.6	8.1	747.6
2000	1	4	20.1	18.0	830	0.6	1.7	4.9	6.7	25.0	0.6	1.8	10.0	8.4	403.9
2001	1	4	19.8	19.0	836	0.7	1.8	5.0	6.9	25.0	0.7	1.8	9.9	8.6	583.0
2002	1	4	18.7	17.0	1 060	0.6	1.7	4.8	6.5	25.0	0.6	1.8	9.1	7.9	707.5
2003	1	5	19.5	18.0	998	0.7	2.0	5.1	7.3	25.0	0.7	2.0	9.9	9.0	681.0
2004	1	5	18.1	16.0	1 440	0.7	1.9	4.8	6.7	25.0	0.7	2.0	9.3	8.2	933.4
2005	1	4	17.6	14.0	1 476	0.6	1.5	4.1	5.2	25.0	0.6	1.6	8.3	6.2	955.8
2006	1	4	17.0	14.0	941	0.5	1.5	4.1	5.2	25.0	0.5	1.5	7.7	6.1	597.1
2007	1	4	16.2	16.0	563	0.6	1.6	4.1	5.7	25.0	0.6	1.7	7.2	6.8	281.9
2008	1	4	15.0	14.0	570	0.6	1.6	3.9	5.1	25.0	0.6	1.7	6.5	6.0	243.6
2009	1	4	13.5	12.0	469	0.5	1.4	3.7	4.7	25.0	0.5	1.5	6.4	5.4	286.0
2010	1	4	13.9	13.0	507	0.5	1.5	4.0	5.1	25.0	0.5	1.5	7.0	5.9	214.2
2011	1	4	14.4	13.0	482	0.5	1.4	4.0	5.1	25.0	0.5	1.5	7.2	5.9	284.9
2012	1	4	14.5	13.0	419	0.5	1.5	4.1	5.2	25.0	0.5	1.5	7.5	6.1	250.7
2013	1	4	14.8	14.0	455	0.5	1.6	4.2	5.6	25.0	0.5	1.7	7.4	6.5	281.3
2014	1	4	13.7	12.0	461	0.5	1.5	4.0	5.3	25.0	0.5	1.5	7.0	6.2	289.3
2015	1	4	14.2	13.0	517	0.5	1.5	4.2	5.4	25.0	0.5	1.5	7.4	6.3	326.8
2016	1	3	14.4	12.0	572	0.5	1.4	4.0	5.2	25.0	0.5	1.4	7.3	6.1	334.9
2017	1	3	14.6	12.0	413	0.5	1.4	4.1	5.0	25.0	0.5	1.5	7.7	5.9	208.3

Fishing	No. of tows					Footprint (km^2)					Aggregate area (km^2)				
year	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max
2018	1	4	15.9	13.0	821	0.5	1.6	4.4	5.7	25.0	0.5	1.7	8.8	7.0	401.6
2019	1	4	16.8	14.0	568	0.5	1.6	4.3	5.7	25.0	0.5	1.7	8.5	7.1	296.9
2020	2	5	18.3	16.0	724	0.6	1.8	4.3	5.8	25.0	0.6	2.0	8.8	7.4	446.4
2021	2	5	16.9	15.0	483	0.6	2.0	4.4	6.1	25.0	0.6	2.1	8.2	7.6	225.4
2022	2	5	16.9	17.0	440	0.6	2.1	4.6	6.4	25.0	0.6	2.3	8.5	8.0	210.9
2023	2	5	16.5	15.0	470	0.6	1.9	4.4	6.1	25.0	0.6	2.0	8.3	7.6	289.1

4.5 Number of years contacted

Of the 37 501 cells contacted by the 1990–2023 deepwater footprint, 60% had 10 years or less of contact: 18% were contacted in 1 year, 9% in 2 years, 7% in 3 years, and 5% in 4 years. Another 5% were contacted each year in the 34-year data set (Figure 11, upper plot). The spatial distribution of these cells, by number of years contacted is shown in Figure 12 (left hand plot). The most fished areas coincide with areas known to support the major deepwater fisheries: west coast south Island, Cook Strait, Puysegur Trench, Stewart Snares Shelf, Campbell Plateau and Chatham Rise (hoki, hake, ling, silver warehou, white warehou); Taranaki (jack mackerels); Challenger Plateau and various locations along the east coast of the North Island (orange roughy).

Of cells contacted by the deepwater footprint, about 26% (n = 9610) were contacted in 2023, and 5% (n = 2033 cells) were last contacted in 2022 another 14% were last contacted during 2018–2021, and about 15% have not been contacted since 2000 (Figure 11, lower plot). The spatial distribution of these cells by the last year fished is shown in Figure 12 (right hand plot). Many cells in the location of areas known to support major deepwater fisheries mentioned in the previous paragraph have been contacted in the most recent (2023) fishing year.



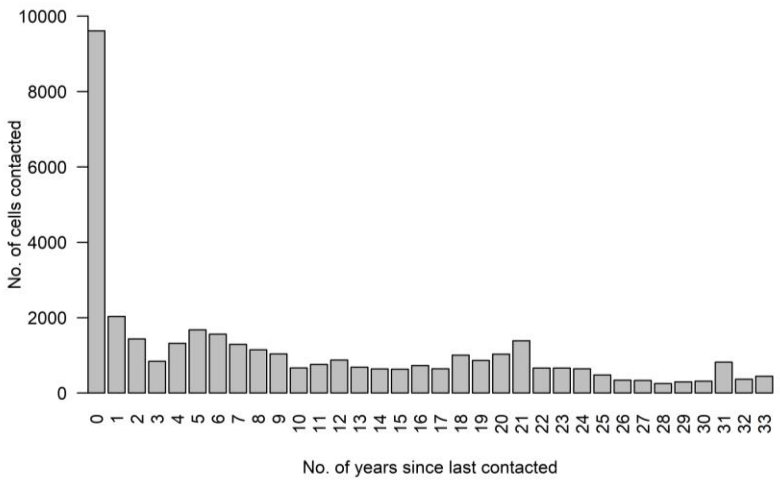
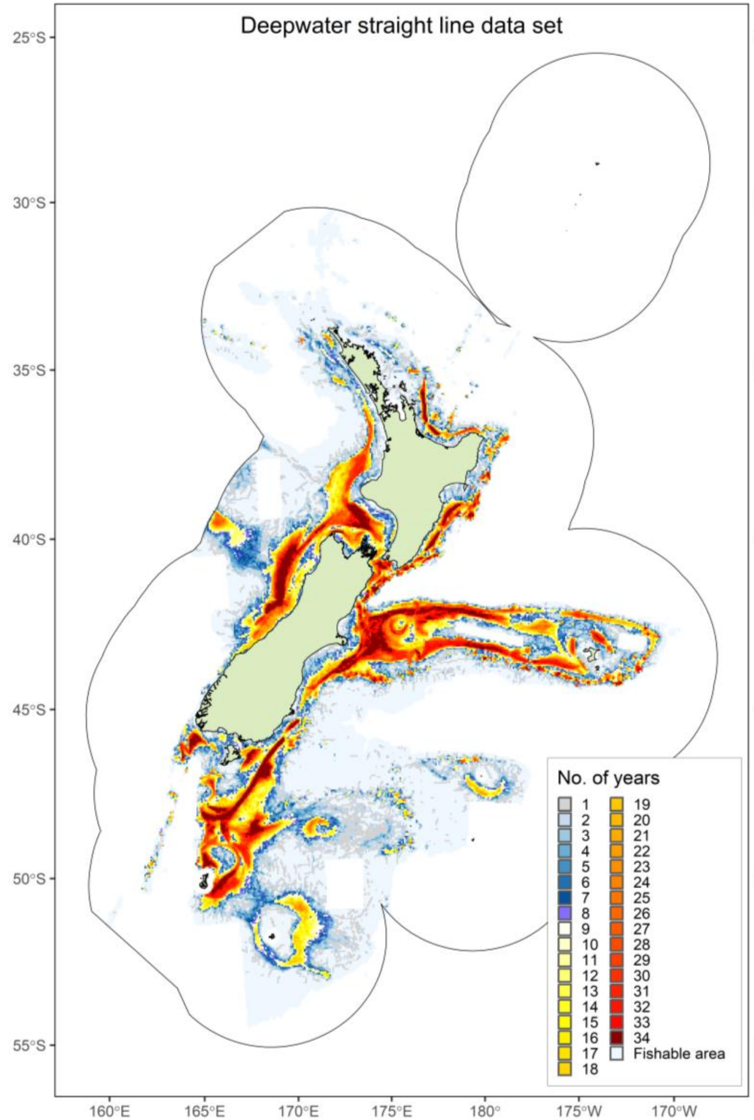


Figure 11: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 1990–2023.



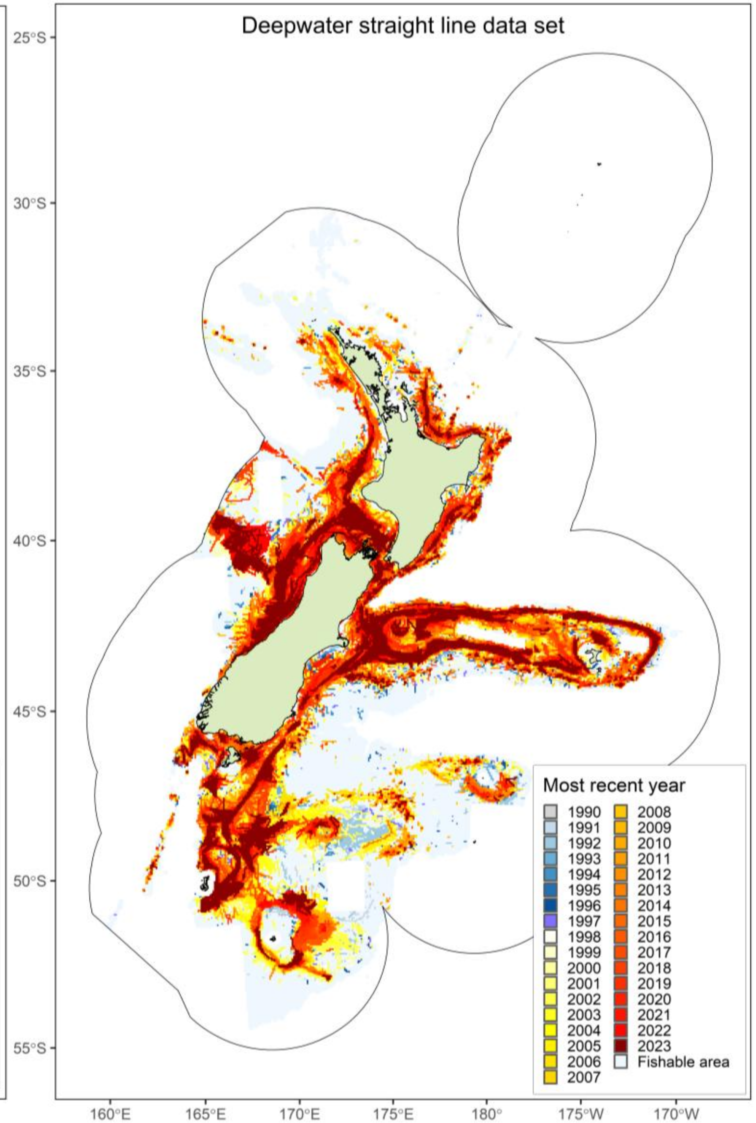


Figure 12: Distribution of the deepwater cells, by the number of years contacted (left), and by the most recent year fished (right) between 1990 and 2023.

5. RESULTS: INSHORE TRAWL FOOTPRINT, 2008–2023 (straight-line approach)

5.1 Inshore data

The groomed inshore data for 2008–2023 yielded a data set of 729 338 bottom-contacting tows for the spatial analysis (Table 12). For the 16-year time series, the main form type used to report inshore data was the TCER (68.4% of inshore bottom-contacting tows), with another 11.3% from TCEPRs and 20.3% from ERS. The TCER and TCEPR forms are now obsolete, having been superseded by the ERS, which has accounted for 99% of tows in 2020 and 100% in each of the last three years. Note that the ERS form was introduced in the 2018 fishing year, being phased in until becoming the exclusive means of reporting fishing effort.

The brief for this study does not include analyses by species or fishstock (other than some select target/target groups to compare the straight-line and hybrid methods), but the fishstocks included are listed in Table 2 to inform the reader which fishstocks comprise the inshore data set.

Over the 16 years, the number of vessels steadily dropped from 216 in 2008 to 116 in 2023 (Table 12). Throughout the time series, most tows have been carried out by smaller vessels under 28 metres in length (category ‘A’), accounting for between 92.5 and 97.5% of all inshore tows, or 95.3% for all years combined (Table 13). A total of 3.9% of tows for the time period were carried out by vessels between 28 and 46 metres (category ‘B’), 0.3% by vessels between 46 and 82 metres (category ‘C’) and 0.5% by vessels over 82 metres in length (category ‘D’). Past footprint projects (e.g., Baird & Mules 2021a, b, MacGibbon & Mules 2023) have found that larger vessels categorised as having targeted ‘inshore’ species were mainly targeting barracouta.

The effort dropped from a peak in 2010 (at 58 039 bottom-contacting tows) to a low in 2023 (30 892 tows). There has been an overall declining pattern in the number of tows throughout the time series.

Table 12: Total number of bottom contacting inshore tows for each year, and the percentage of TCER, TCEPR, and ERS forms, and the number of vessels each year.

Year	Total no. of tows	TCE	TCP	ERS	No. of vessels
2008	50 716	82.3	17.7	0.0	216
2009	52 494	82.9	17.1	0.0	196
2010	58 039	84.9	15.1	0.0	203
2011	53 214	84.3	15.7	0.0	208
2012	52 716	85.0	15.0	0.0	192
2013	53 244	87.2	12.8	0.0	182
2014	52 767	85.2	14.8	0.0	180
2015	46 578	85.6	14.4	0.0	170
2016	45 660	86.4	13.6	0.0	171
2017	46 734	85.3	14.7	0.0	162
2018	42 903	86.5	8.4	5.1	153
2019	39 406	68.5	3.3	28.3	149
2020	35 397	1.0	0.0	99	142
2021	35 868	0.0	0.0	100	140
2022	32 710	0.0	0.0	100	127
2023	30 892	0.0	0.0	100	116
All years	729 338	68.4	11.3	20.3	303

Table 13: Percentage of tows by vessel length category and total number of bottom-contacting tows for each year. See Section 2.2.2 for vessel category definitions.

Year	A	B	C	D	Total
2008	92.5	6.9	0.5	0.1	50 716
2009	93.1	6.3	0.4	0.1	52 494
2010	94.8	4.4	0.2	0.6	58 039
2011	95.7	3.5	0.3	0.5	53 214
2012	97.1	2.2	0.5	0.2	52 716
2013	97.5	1.9	0.1	0.5	53 244
2014	96.0	3.3	0.1	0.6	52 767
2015	96.0	3.2	0.3	0.6	46 578
2016	96.4	3.1	0.3	0.2	45 660
2017	95.2	3.9	0.3	0.6	46 734
2018	94.8	4.1	0.2	0.9	42 903
2019	95.1	4.5	0.1	0.3	39 406
2020	94.0	5.1	0.1	0.9	35 397
2021	94.7	4.0	0.3	1.0	35 868
2022	95.3	3.6	0.2	1.0	32 710
2023	96.0	2.9	0.4	0.7	30 892
All years	95.3	3.9	0.3	0.5	729 338

5.2 Spatial extent

Overall, 15 102 cells were contacted by trawls with inshore targets (based on TCERs, TCEPRs, and ERS data) during 2008–2023, with the swept areas for all tows summing to an estimated aggregate area of 984 451 km^2 to give an overall footprint of 152 311 km^2 (Table 14). This footprint represented 3.7% of the EEZ+TS and 11% of the fishable area; and the 2023 footprint represented 0.7% of the EEZ+TS and 2% of the fishable area.

Table 14: Annual summary for the spatial overlap of the inshore bottom-contacting effort for 2008–2023 and the overlap (%) with the EEZ+TS (4 111 569.7 km^2) and fishable area (1 391 680 km^2).

Fishing year	No. cells	Aggregate (km^2)	Footprint (km^2)	% EEZ+TS	% fishable
2008	9 374	69 383.8	43 567.8	1.1	3.2
2009	9 300	72 955.4	45 805.7	1.1	3.3
2010	9 407	75 857.4	46 679.1	1.1	3.4
2011	9 530	69 279.4	44 829.6	1.1	3.2
2012	9 214	66 873.1	42 924.6	1.0	3.1
2013	9 115	66 598.4	42 840.8	1.0	3.1
2014	9 508	69 928.9	44 935.5	1.1	3.3
2015	9 419	63 914.4	42 255.8	1.0	3.1
2016	9 288	62 297.3	41 049.4	1.0	3.0
2017	9 413	65 572.4	42 772.1	1.0	3.1
2018	9 119	62 383.7	42 197.3	1.0	3.1
2019	8 612	56 964.0	38 098.0	0.9	2.8
2020	7 040	47 915.3	31 455.7	0.8	2.3
2021	7 074	48 967.9	32 064.4	0.8	2.3
2022	6 497	44 256.1	28 718.9	0.7	2.1
2023	6 613	41 393.7	27 842.5	0.7	2.0
2008–2023	15 102	984 541.3	152 310.9	3.7	11.0

Between 2008 and 2018, the number of cells contacted ranged between 9115 (2013) and 9525 (2011). In 2019 the number of cells contacted dropped below 9000 to 8612, then again to just over 7000 cells in each of 2020 and 2021. The number of cells contacted dropped again in 2022 to the lowest in the time series at 6497 then increased slightly to 6613 in 2023. The aggregate area was generally over 65 000 km^2 (peak in 2010 at 75 857 km^2) until 2015 when it decreased in most years to a low of 41 394 km^2 in 2023, coinciding with the lowest overall footprint even though the number of cells contacted increased slightly in 2023 compared with 2022.

A similar trend was seen in the estimated footprint; during 2008–2018 the footprint was always above 40 000 km^2, but this dropped in 2019 to 38 098 km^2, then further still to 31 456 km^2 in 2020, before a small increase in 2021 to 31 993 km^2 in 2021, before dropping again to 28 719 in 2022 and again to 27 483 km^2 in 2023, the lowest in the time series.

For all measures of contact, the five most recent years are the five lowest values, with 2023 being the lowest in the time series for both aggregate area and footprint.

The spatial distribution of the 2008–2023 and 2023 footprints and aggregate areas are shown in Figure 13. The overall range of the inshore footprint in 2023 is much smaller than that of the full 16-year time series as would be expected when measures of contact are at a time series low. In 2023 the footprint around the North Island was highest in Kaipara, outer Hauraki Gulf, Bay of Plenty, Cape Runaway, and Hawke Bay. For the South Island the 2023 footprint was highest in Tasman Bay, mid and lower east coast South Island, mid-west coast South Island, and south coast South Island. Predictably, the aggregate area shows a similar pattern. Following very low inshore fishing around the Chatham Islands in 2022 compared to past effort, there was no inshore effort at all in 2023.

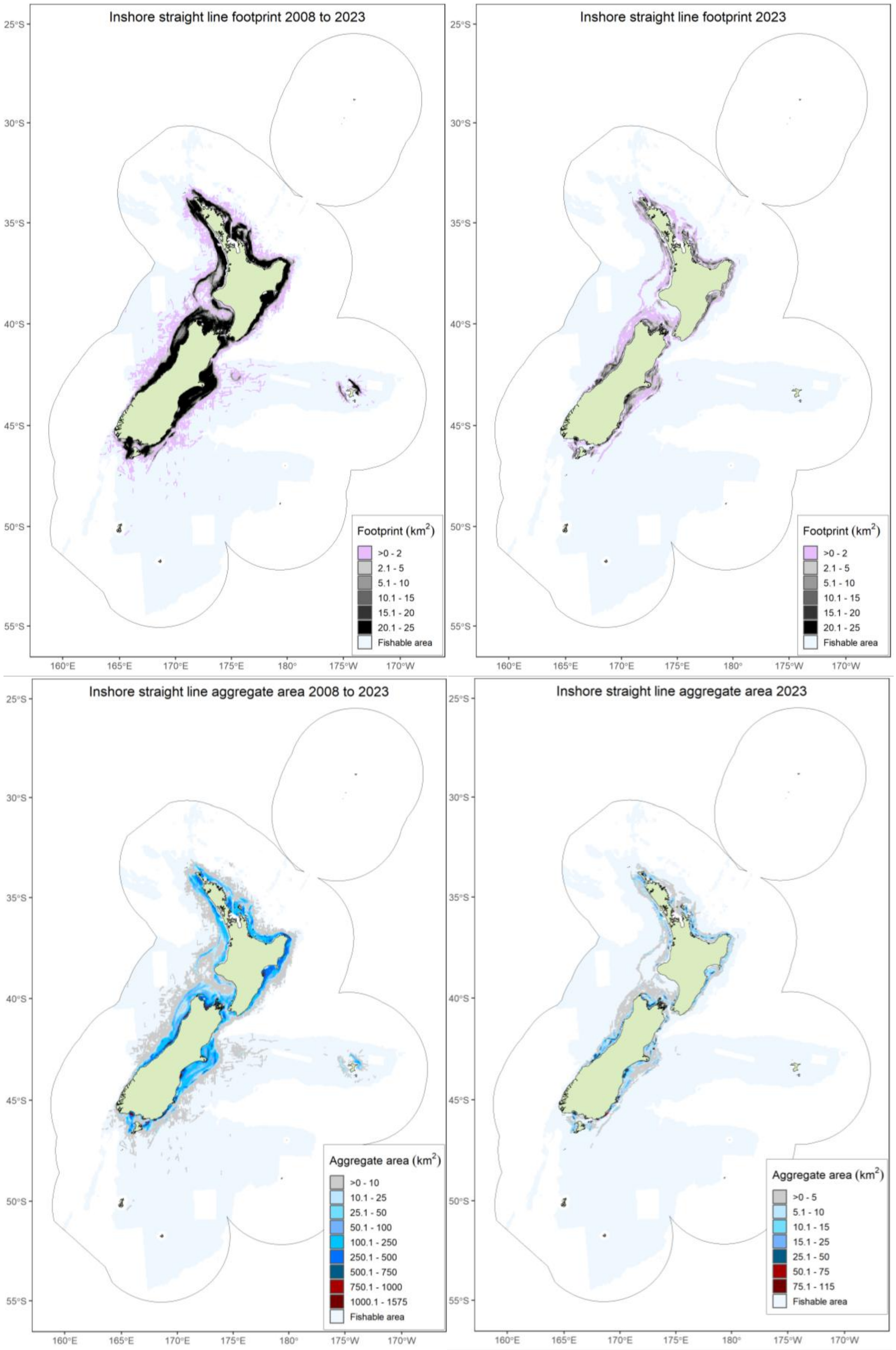


Figure 13: Distribution of the inshore fishstocks footprint (upper maps) and aggregate area (lower), by 25-km^2 cells, 2008–2022 (left) and 2023 (right).

5.3 Extent of new cells contacted across the 2008–2023 time series

The number of cells that were fished in one year, but not in previous years is shown in Table 15 for all inshore data, where the base footprint was the 2008 footprint. These data are limited in extent because data before the 2008 fishing year were not available to generate a spatial analysis, and as explained in Section 3, the substantial data from CELR data collection that occurred before the 2008 fishing year are not included here. Thus, Table 15 provides data relative to 2008 only. As with the deepwater data, it is evident that in most of the years the contact in the new cells is of low intensity, because there is little difference between the aggregate area and the footprint, and in some years they are in fact the same (e.g., 2020, 2022, and 2023). This is likely (in part) to be an artefact of the jittering methodology used to generate the spatial data and also the creation of endpoints of TCER tows prior to ERS being introduced which reports positions to a finer resolution than either TCEPR or TCER forms did (ERS positions are not jittered). In other instances, new cells could just represent the very edges of established fishing areas or limited exploratory fishing. It is also very likely that many of these 'new cells' were fished in years before 2008, but the reporting methods prior to the introduction of the TCER make it impossible to determine this.

Table 15: For the inshore fishstocks, the number of cells contacted in a year, that had not been contacted in previous years, and the aggregate area and footprint within those cells. A base of 9374 cells were contacted in 2008 (the fishing year that tow-level data were first collected for all inshore fisheries), and, for example, 1443 cells were contacted in 2009 (but not in 2008), with an aggregate area of 852.7 km^2 and footprint of 795 km^2, 957 cells were contacted in 2010 but not in 2008–2009, with an aggregate area of 612.3 km^2 and a footprint of 542.9 km^2.

Fishing year	No. new cells	Aggregate area (km^2)	Footprint (km^2)	Footprint as % aggregate area
No. cells contacted in 2008 = 9 374				
2009	1 443	852.7	795.0	93.2
2010	957	612.3	542.9	88.7
2011	793	323.7	315.8	97.6
2012	483	163.8	160.1	97.7
2013	367	138.3	135.5	98.0
2014	410	167.0	163.2	97.7
2015	320	135.7	132.9	97.9
2016	297	83.0	82.8	99.8
2017	244	73.4	73.2	99.7
2018	189	63.2	63.1	99.8
2019	125	38.4	37.6	97.9
2020	69	24.0	24.0	100.0
2021	7	4.3	3.7	86.0
2022	10	3.6	3.6	100.0
2023	14	3.6	3.6	100.0

5.4 Intensity

For the combined 2008–2023 inshore fishstocks data, the median number of tows that contacted a cell was 31, (mean of 258.7), and 50% of cells were contacted by between 3 and 296 tows, with a maximum of 6856 tows over the total data set (cumulative total over all years) (Table 16).

The median number of tows in a cell in a year was about 12 tows during 2008–2023 (Table 17). The mean numbers were relatively steady from 2008–2014 at around 28–29 tows per cell, before decreasing slightly to around 26–27 tows thereafter, with 2023 having the lowest mean at 24.5 tows. The maximum number of tows however has fluctuated more during this time ranging between 403 and 684 tows per cell. In 2023, the maximum number of tows in a cell was 563, a substantial decrease from 2022 (mean of 649 tows).

For the combined 2008–2023 inshore data, the median aggregate area for a cell was 7.0 km^2 (mean 65.2 km^2), and 50% of cells had an aggregate area of between 0.7 and 74.7 km^2, with a maximum of 1688.2 km^2 (Table 16). For the annual data, the aggregate area has fluctuated somewhat, ranging between 95.9 km^2 (in 2020) and 170.2 km^2 (in 2013) but appears to be declining overall (Table 17).

The top ten cells by aggregate area for the 16-year time period were off Kaka Point on the lower east coast of the South Island (five cells, 1189–1688 km^2), mid-east coast of the South Island near Timaru (three cells, 1281–1461 km^2), just south of Te Waewae Bay (one cell, 1363 km^2), and southern Hawke Bay (one cell, 1331 km^2).

The top ten cells by tow count for the 16-year time period were in southern Hawke Bay (one cell, 6856 tows), followed by the lower east coast of the South Island (five cells, 5337–6822 tows), mid-east coast of the South Island just south of Timaru (two cells, 5274–5745 tows), inner Tasman Bay (one cell, 5684 tows), and the area just south of Te Waewae Bay (one cell, 5322 tows). The only cell that was not in the top ten by aggregate area was the one in inner Tasman Bay, which was still the 22nd most intensely fished cell as measured by aggregate area (1042 km^2). This is not surprising; it is logical that there would be a correlation between tow count and aggregate area. While it is possible that feature-based fishing might have relatively low aggregate areas for a given number of tows, inshore fishing tends not to be based on underwater features.

The footprint estimates in comparison with aggregate area values indicated that many cells have low levels of contact with all years having medians under 3 km^2 and means 5 km^2 or less (Table 17). The maximum footprint in all years is close to 25 km^2, the total area of a cell, though most cells are not contacted to this extent. While no cell was completely contacted in any one year, many cells have been when considering the whole time period combined (Table 16).

Table 16: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for the inshore data, for the combined fishing years 2008–2023. Annual summaries are given in Table 17.

	Minimum	1st quarter	Median	Mean	3rd quarter	Maximum
No. of tows	1.0	3.0	31.0	258.7	296.0	6 856
Aggregate area (km^2)	<0.1	0.7	7.0	65.2	74.7	1 688.2
Footprint (km^2)	<0.1	1.0	5.0	10.0	22.0	25.0

Table 17: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for inshore data, 2008–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 (where cells were contacted) and the minimum values for the footprint and aggregate areas was < 0.0001.

Fishing	No. of tows					Aggregate area (km^2)					Footprint (km^2)				
year	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max	1st Qu	Median	Mean	3rd Qu	Max
2008	2	11	28.7	34	579	0.6	2.5	7.4	9.2	153.5	0.5	2.3	4.6	7.3	24.8
2009	2	12	30.4	37	564	0.6	2.9	7.8	9.9	135.8	0.5	2.6	4.9	7.8	24.7
2010	3	12	32.3	38	623	0.6	2.9	8.1	9.7	138.4	0.6	2.7	5.0	7.6	24.8
2011	2	11	29.2	37	661	0.5	2.6	7.3	9.4	137.7	0.5	2.4	4.7	7.5	24.8
2012	3	13	29.7	36	540	0.6	2.9	7.3	8.9	131.6	0.6	2.7	4.7	7.2	24.8
2013	3	12	30.2	36	684	0.6	2.8	7.3	9.1	170.2	0.6	2.6	4.7	7.2	24.9
2014	3	12	29.6	36	563	0.6	2.9	7.4	9.0	142.6	0.6	2.6	4.7	7.2	24.6
2015	3	11	27.2	32	536	0.6	2.6	6.8	8.3	110.3	0.6	2.4	4.5	6.7	23.9
2016	2	11	26.9	32	602	0.6	2.6	6.7	8.1	142.4	0.5	2.4	4.4	6.7	24.5
2017	3	11	27.6	34	613	0.6	2.7	7.0	8.6	166.4	0.6	2.5	4.5	6.9	24.8
2018	3	12	26.8	35	507	0.7	2.8	6.8	9.1	104.8	0.6	2.6	4.6	7.2	23.9
2019	3	10	25.6	33	616	0.6	2.5	6.6	8.7	107.1	0.5	2.3	4.4	6.9	24.4
2020	4	13	26.3	33	403	0.8	3.2	6.8	8.8	95.9	0.8	2.8	4.5	6.8	24.0
2021	4	14	26.9	34	592	0.8	3.4	6.9	9.2	132.5	0.8	2.9	4.5	7.1	23.8
2022	4	13	26.9	34	649	0.8	3.1	6.8	8.8	112.0	0.8	2.7	4.4	6.7	23.6
2023	4	12	24.5	31	563	0.8	2.9	6.3	8.3	114.5	0.7	2.6	4.2	6.5	24.1

5.5 Number of years contacted

Of the 15 102 cells contacted by the 2008–2023 inshore footprint, 48% (7317 cells) had under 10 years of contact, 19% (2859 cells) were contacted in 1 year, 8% (1208 cells) in 2 years, 6% (906 cells) in 3 years, and 4% (604 cells) in 4 years. 33% were contacted each year in the 16-year data set (Figure 14, upper plot). The spatial distribution of these cells, by number of years contacted is shown in Figure 15 (left hand plot). Most cell around the entire coastline have contact in all 16 years in this time period. Beyond that the number of years fished for most cells drops to around 10–11 years and then just a few (1–3) years. Cells around the Chatham Islands have more variation in the number of years contacted (5–13 years) as does the area north of the Taranaki Bight and to the west of Raglan and Kawhia. Notable coastal areas with no contact include the lower west coast of the South Island between Secretary Island and Resolution Island. The steep topography here makes this area unsuitable to trawling and it very quickly drops away beyond 1600 m (the limit of the fishable area in this study). Other notable areas with no contact include very close inshore on the west coast of the North Island and in the Hauraki Gulf. While most of these areas have been fished, they are currently closed to trawling and area closures in this study are applied retrospectively to include all years in the data set whether trawling was banned in a given area for the entire time period or not.

Of cells that were contacted by the inshore footprint, 44% (n = 6613) were contacted in the most recent year, 71% (n = 10 682) have been contacted in the last five years, and 88% (n = 13 357) have been contacted in the last ten years (Figure 14, lower plot). The areas that have been contacted every year during the period covered by the study are mostly coastal and found most of the way around the coastlines of both the North and South Islands (Figure 15, left hand plot) The most notable gaps in effort around the coast are off the west coast of the North Island (extensive closures to protect Maui dolphins) and Fiordland, which is due in part to benthic protected areas being in place, as well as steep topography which is difficult to trawl on. The spatial distribution of the most recent year in which cells have been contacted in is shown in Figure 15 (right hand plot). Most of the coastal area has been fished in the most recent fishing year covered by this study (2023), as has a smaller area around the Mernoo Bank. There was no inshore effort around the Chatham Islands in the 2023 fishing year.

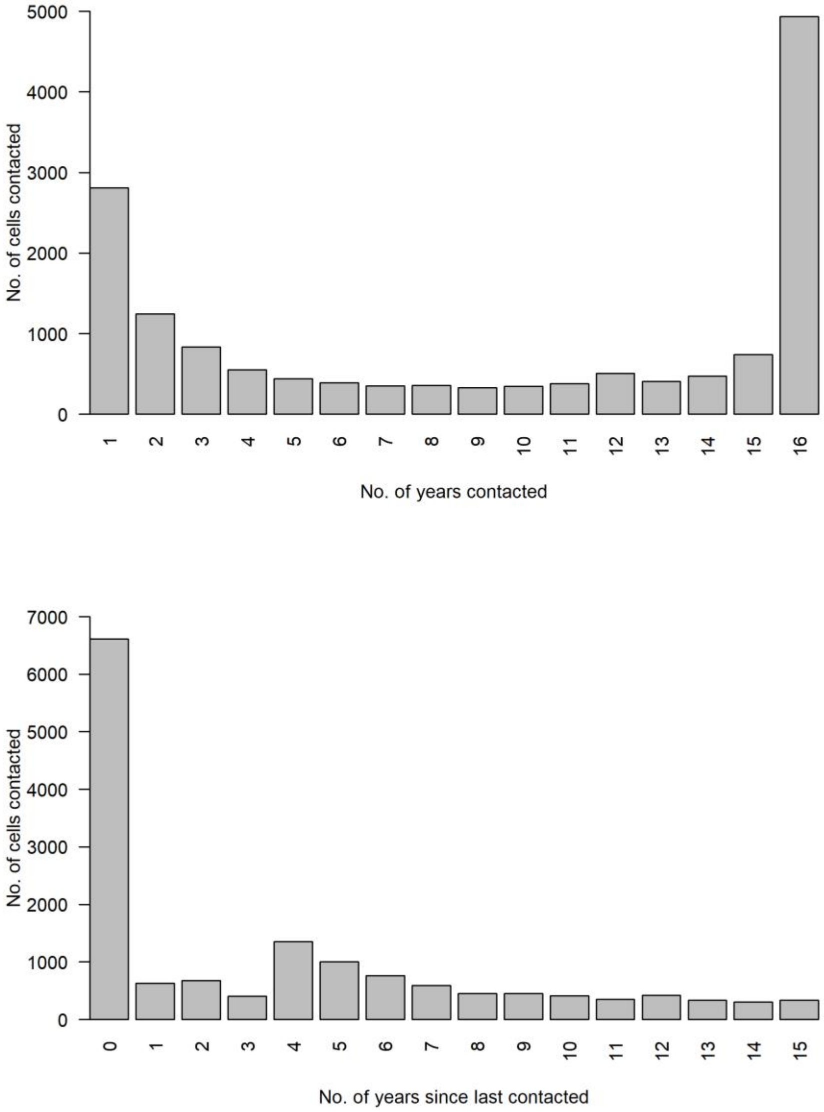


Figure 14: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2008–2023.

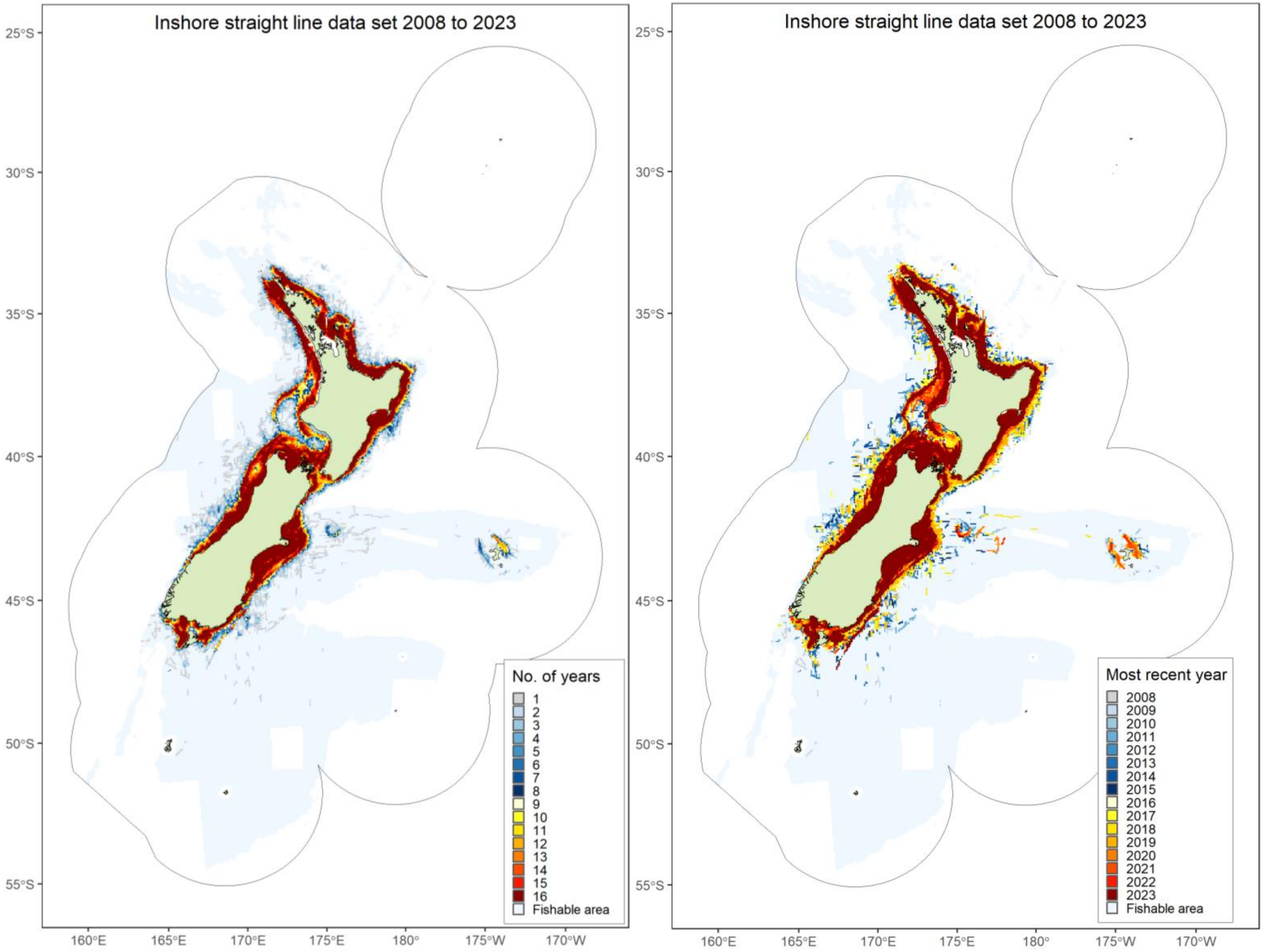


Figure 15: Distribution of the inshore cells, by the number of years contacted (left), and by the most recent year fished (right) between 2008 and 2023.

6. RESULTS: USING GPR DATA TO CORRECT HISTORICAL STRAIGHT-LINE DATA

The three areas selected to assess the feasibility of detecting 'standard tows' are shown below in Figure 16.

The first data set (left hand plot in Figure 16) were very much straight-lines, like parallel tramline tracks for both the straight-line and hybrid data. Given that the tows were already largely straight-lines, so was the standard tow and adding the 25 vertices to non-GPR track lines made little difference.

The second data set of trawls (centre plot in Figure 16) consistently followed the coast in the GPR data, very different from the straight-line tracks between the start and finish positions. Many GPR trawls followed a U-shape, ending near the start point, others only followed one leg. No meaningful standard tow was easily derived, but a more selective approach could remedy this. The coastal pattern is already evident in the GPR data.

The third set of trawls (right hand plot in Figure 16) showed a consistent avoidance of a central area which was not apparent in the straight-line data. While almost all GPR trawls curved around the 'hole', the tow direction showed no clear pattern, covering 360°, so no 'standard tow' was relevant.

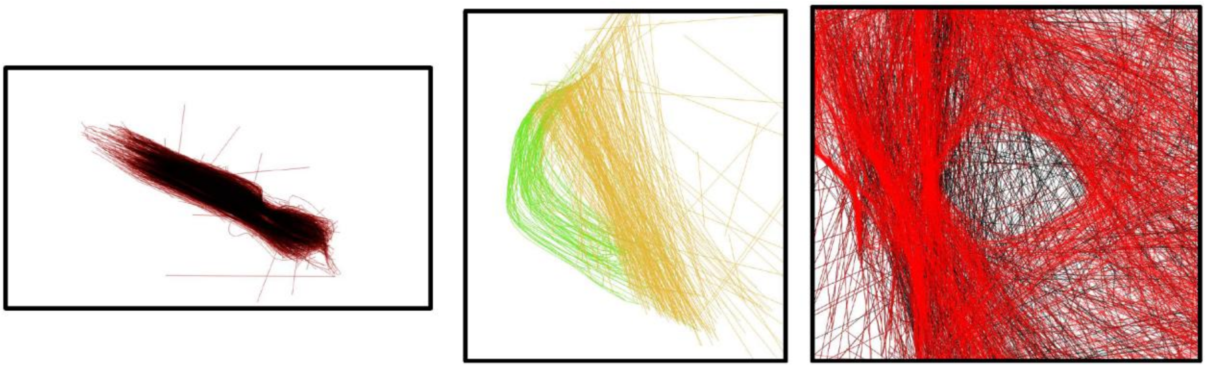


Figure 16: The three areas selected to assess the feasibility of detecting 'standard tows'. The black or orange lines depict the tows using the straight-line method, and the red or green lines are the equivalent tow lines using the GPR data.

7. RESULTS: ALL STOCKS, COMPARISONS OF THE STRAIGHT-LINE AND HYBRID METHODS (2019–2023)

The hybrid approach to estimating trawl footprint has been applied from the 2019 fishing year onward, coinciding with the introduction of GPR devices on some vessels. While coverage was low in this year, there is GPR data available and it is considered to provide a better representation of trawl paths than the straight-line method. As such, we will begin hybrid analyses that make use of GPR data from 2019, even if the improvements are only to a relatively small number of fishing events in 2019.

Data from prior to 2019 are *not* considered for the hybrid method here because we seek to assess what effect the hybrid method has when compared to the straight-line method. As GPR data are only available for 5 out of 34 years for deepwater, and 5 out of 16 years for inshore and All Stocks data sets, the straight-line method will drown out any differences between the two methods that may exist for the various measures of contact investigated. For the purposes of comparison, by only considering straight-line data 2019 onwards when GPR data became available, it will be easier to identify what, if any, differences exist.

The total number of tows, number of straight-line tows (for which there is no corresponding GPR data), number of tows with GPR data, and the percentage of total tows that had GPR data is given by fishing year in Appendix D in Table D1. As mentioned, coverage was low in 2019 with just 48.7% of all tows having at least one GPR ping occurring between the start and end positions given in the ERS reporting forms. This increased rapidly to 92% in 2020, then 95%, 95.6%, and 97% in each of the last three years respectively. While all vessels are supposed to have GPR devices fitted, there will always be some tows without GPR data for a variety of reasons including equipment failure, and tows that began and ended before GPR devices could ping.

The median GPR ping rate of vessels in the All Stocks data set that ping at least once every 11 minutes, and those that ping once every 11 minutes or longer is given in Table D2. Most vessels ping more frequently than once every 11 minutes, and the percentage of total vessels that ping at least as frequently as that has increased over the five-year time period from 63.7% in 2019 to 82.1% in 2023. More frequent pings in between start and finish positions allow for more successive trawl tracks to be constructed and allow for more realistic trawl paths to be constructed (see section 2.5).

7.1 All Stocks hybrid and straight-line comparison: spatial extent

The number of cells contacted, aggregate area, and footprint for the All Stocks hybrid and straight-line data sets are given in Table 18. For each measure of contact the ratio is expressed as a percentage of the hybrid value to the straight-line value. Where values are below 100%, this means the hybrid value is smaller than the corresponding straight-line value, and where greater than 100% the hybrid value is larger than the straight-line. Similarly, when metrics such as the number of cells, number of tows, aggregate area, or footprint have a negative value it is because the hybrid value is less than the corresponding straight-line value.

Table 18: The number of cells, aggregate area (km^2), and footprint (km^2) for the All Stocks hybrid and straight-line data sets. The ratio for each measure of contact is expressed as a percentage of the hybrid value to the straight-line value.

	Cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	15 646	15 665	99.9	180 120.1	142 230.7	126.6	83 768.6	80 235.5	104.4
2020	13 646	13 866	98.4	170 741.4	128 893.7	132.5	72 630.1	69 784.2	104.1
2021	14 352	14 436	99.4	169 730.5	129 285.7	131.3	76 975.1	73 996.4	104.0
2022	13 688	13 794	99.2	166 851.4	124 125.7	134.4	73 230.3	70 566.3	103.8
2023	14 061	14 210	99.0	170 833.6	121 374.1	140.7	73 566.5	68 779.6	107.0

The ratios for the number of cells contacted ranged between 98.4 and 99.9%, representing a close match between the two data sets in all five years covered, but indicating that the hybrid data set contacted fewer cells each year, by between -220 and -19 cells. The closest match is in 2019, and while there is little difference in all years, this is the smallest difference and is quite likely to be related to the fact that only a small proportion of the New Zealand fishing fleet had begun to use GPR devices in this year.

For the aggregate area, the ratios are substantially higher than for the number of cells contacted, ranging between 126.6% and 140.7% (differences of between 37 890 and 49 460 km^2), meaning that in all years, the hybrid data set gave higher aggregate areas than the straight-line data set. This was first shown in the study by MacGibbon & Mules (2023) which developed the methods used here to incorporate GPR data. GPR tows will always be longer than the equivalent straight-line method, unless of course the GPR tow is an actual straight-line. As such, when these longer tows are laid over one another to form the aggregate area, it is logical that the aggregate area will be larger than the straight-line equivalent as a longer tow will have a higher swept area. Figure 17 below, taken from Mules & MacGibbon (2023) demonstrates the potentially vast differences between the tows calculated using the hybrid method and the straight-line method. The degree of difference will vary, but the plots below have been selected as good candidates to demonstrate how different they can potentially be, in terms of both shape and distance (and hence swept area).

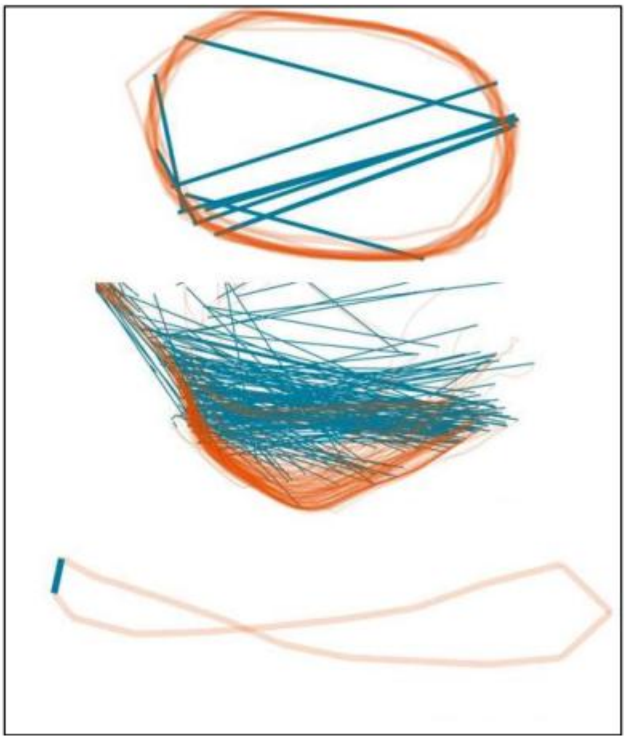


Figure 17: (taken from MacGibbon & Mules 2023): A selection of trawl paths created using GPR data (orange lines) and the corresponding tows created using the 'traditional ERS straight-line' method (green lines).

The footprints are also larger in every year for the hybrid data set when compared with the straight-line data set but the ratios are lower than for the aggregate area, ranging between 103.8–107% (differences of between 2664 and 4787 km^2) for the time series, meaning that the hybrid data footprint ranged between 4 and 7% larger than the straight-line equivalents. This difference arises because tows mapped using GPR data can follow irregular trawl paths, which—when forming the outer boundary of the footprint—can extend beyond the limits defined by straight-line approximations. Take for example, the bottom example in Figure 17. If this green tow (straight-line footprint) represents the right hand extreme of an overall footprint, then the orange line (hybrid footprint) shows the potential for the edge of the footprint to extend beyond where the straight-line method defines the footprint's edge. In some areas however, it is possible that if curved trawl tracks curved inwards from a straight-line between two points, the footprint could be lower for the hybrid data. For some of the individual target species examined this is the case with hybrid footprints smaller than the equivalent straight line footprint in some instances (see section 10 and Appendices E–H). Figure 18 demonstrates this, where the hybrid data set shows the hybrid footprint around a contour, and the equivalent straight-line footprint traversing the top of the contour and covering more area. The nature of the seabed contours, foul ground that can't be towed on, and fisher behaviour will likely determine which applies to a given area and/or target fishery.

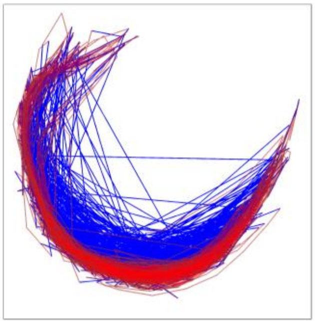


Figure 18: The straight-line footprint for a selected area and target fishery (blue lines) and the equivalent hybrid footprint (red lines) plotted over the top of the straight-line footprint.

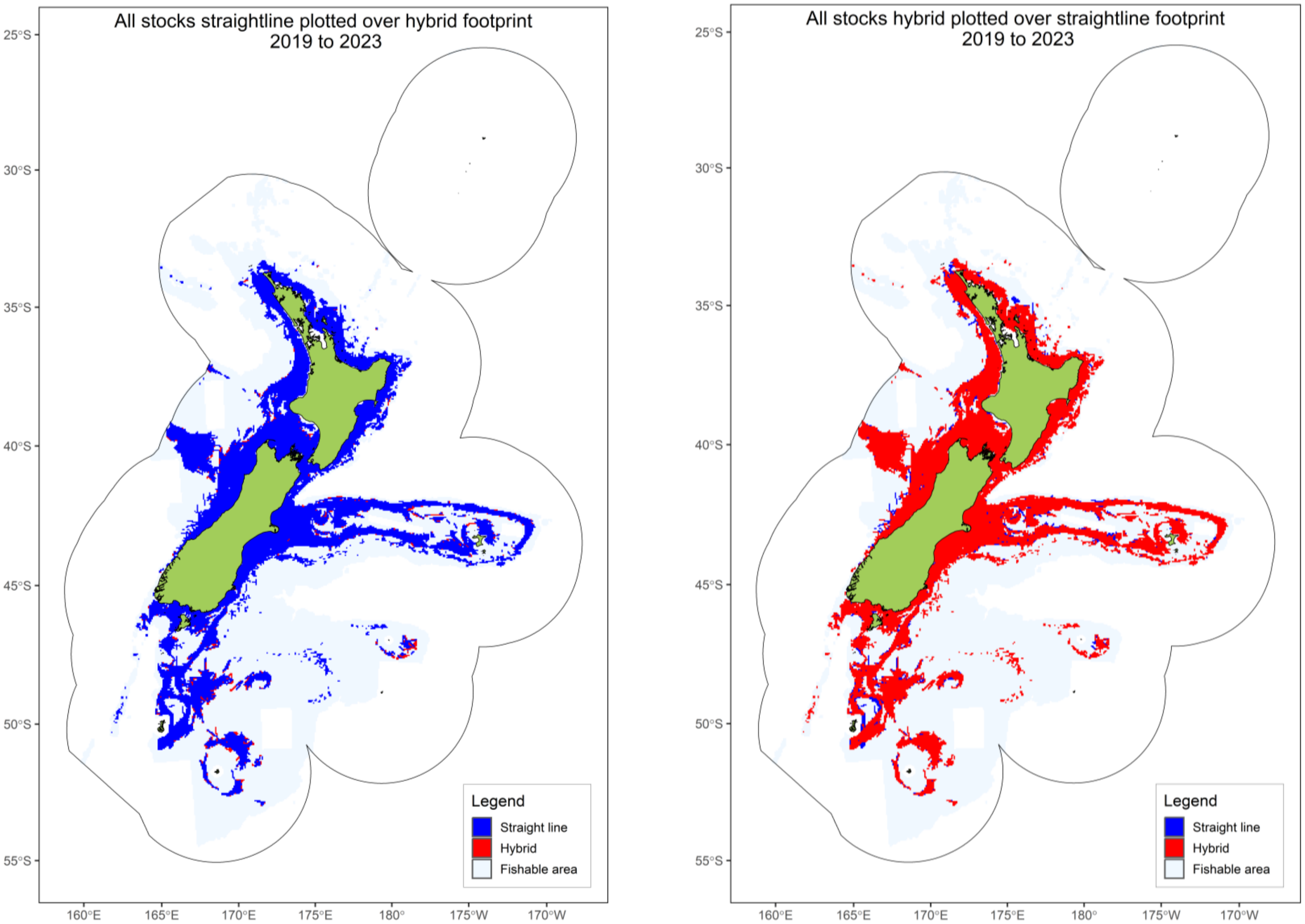


Figure 19: The straight-line footprint superimposed over the hybrid footprint (left plot) and vice versa (right plot) for 2019 to 2023.

Figure 19 shows the straight-line footprint superimposed over the hybrid footprint (left plot). It can be seen that the hybrid footprint extends from the edges of the straight-line footprint in a number of places, though not extensively. The right-hand plot, where the hybrid footprint is superimposed over the straight-line footprint, shows that the straight-line footprint also has some areas that are exclusive to it. Figure 20 shows the spatial distribution of the hybrid and straight-line footprints by degree of contact. At this resolution, there is little difference that can be seen between the two data sets.

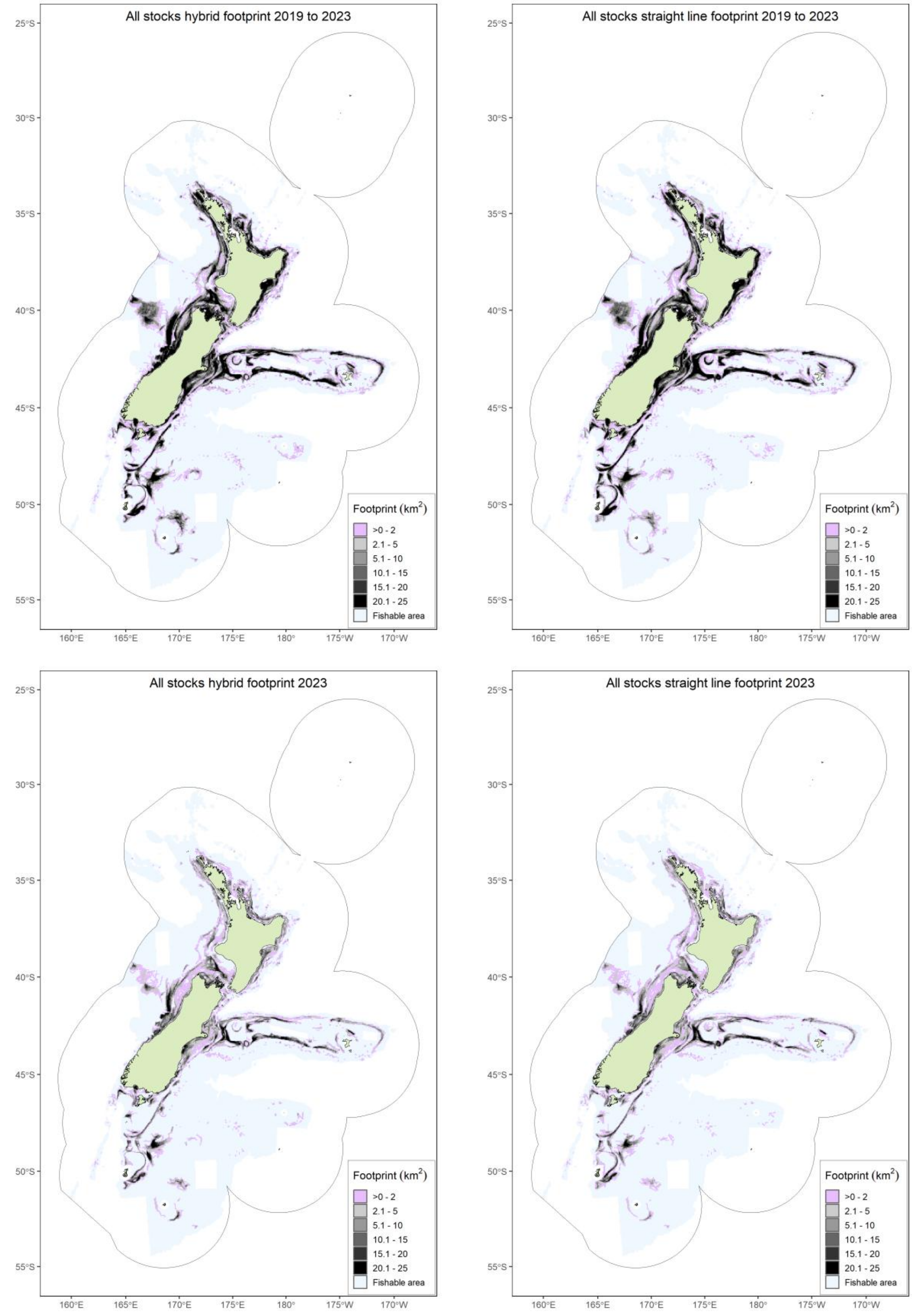


Figure 20: Distribution of the All Stocks footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

7.2 All Stocks hybrid and straight-line comparison: Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table 19 where the base footprint was created for 2008–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 107.5% to 282.3%, representing differences of between 18 and 268 cells. The increasing trend in the number of new cells contacted by the hybrid data set is interesting, particularly as it appears to be the opposite to the straight-line method. The likely explanation for this is that the base number of cells consists of those contacted by the straight-line approach using years 2008–2018. That is all that is available over a reasonable period of time to create a base because there is only GPR data from 2019 and even then coverage was low. The sudden inclusion of GPR data and its ability to capture locations that may always have been contacted results in more 'new' cells being contacted using the hybrid approach. Given that the number of vessels with GPR devices *and* the ping rate has increased over the last five years (see Appendix D), the number of new cells according to the hybrid data set has been increasing. Really, all that has likely changed is our ability to capture more accurately where vessels have probably always gone.

Ratios for the aggregate area were higher for the hybrid data set in all years, ranging between 116.7% and 897.6%, representing differences of between 43 and 1306 km^2. While these are substantially different ratios and differences between the two data sets, in the context of the overall All Stocks aggregate areas each year, the differences are relatively small.

For the footprint, the ratio ranged between 113.8% and 759.4% representing differences of between 34 and 1149 km^2. Again, while these are relatively large differences between the two data sets in terms of the ratios, in the context of the overall footprint, the differences are relatively small.

When considering the footprint as a percentage of the aggregate area, each data set has a relatively close match, between 81.3% and 96.2% for the hybrid data set and 94.8 and 98.1% for the straight-line data set. This suggests that for both, the aggregate areas are not much larger than the footprints, resulting in the ratio between the two data sets for this measure being fairly close at between 84.6% and 100.1%. This suggests that most of the fishing in 'new' areas is likely to be minor exploratory fishing or fishing on the margins of already established areas.

Table 19: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the All Stocks hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	258	240	107.5	299.7	256.8	116.7	281.7	247.5	113.8	94.0	96.4	97.5
2020	250	221	113.1	434.0	341.3	127.2	417.6	328.1	127.3	96.2	96.1	100.1
2021	354	146	242.5	903.6	185.3	487.6	774.6	175.7	440.9	85.7	94.8	90.4
2022	447	190	235.3	1 503.8	198.1	759.1	1 343.3	194.4	691.0	89.3	98.1	91.0
2023	415	147	282.3	1 325.7	147.7	897.6	1 078.3	142.0	759.4	81.3	96.1	84.6

7.3 All Stocks hybrid and straight-line comparison: Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table 20). The ratio between the two data sets for the median number of tows that contacted a cell was 113.6% but this was for a difference of just three tows. The ratio for the mean number was 114.9% and this represented a difference of 13 tows. The ratio for the maximum number of tows was 124.7% and represented a more substantial difference of 634 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 119%, though there is little actual difference (9.4 vs 7.9 km^2). The mean is again higher for the hybrid data (ratio of 134%, or 43 vs 32.1 km^2). The most substantial difference is for the maximum (ratio of 272% or 3601.6 vs 1322.5 km^2).

The spatial distribution of the aggregate area for both data types is shown in Figure 21 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference. There is, however, a need to have different categories with substantially higher upper ranges for the hybrid data set for all years combined. The overall spatial location of intensity is much the same however, even if the values of intensity may differ.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 105.2%, which represents a difference of just 0.3 km^2, 6.1 vs 5.8 km^2. The mean footprint has a ratio of 100%, with both data sets having a mean footprint of 8.9 km^2. The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table 21. The annual ratio for the median number of tows that contacted a cell ranged from 110–120%, or 1–2 tows each year. For the mean, the ratio ranged from 109.7–118.6% or a maximum difference of 4.2 tows in any one year. For the maximum, the annual ratio ranged from 101.1–113.5%, representing differences of between 7 and 83 tows.

The annual median ratios for the aggregate area in a cell ranged from 109.7–122.6% but in no year did the actual difference in square kilometres exceed 0.7. The ratio for the mean aggregate area was very close in each year, ranging from 126.4–142.4%, and represented a difference between data types of no more than 3.6 km^2 in any one year. The ratios for the maximum aggregate area were more substantial, ranging from 156.9–396.3% or between 254 and 857 km^2.

The annual median ratios for the footprint in a cell ranged from 106.5–111.1% (a maximum difference of 0.3 km^2), and the means from 103.6–108.3% (a maximum difference of 0.4 km^2). The maximum footprint for both data types in all years is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100% in all years.

Table 20: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for All Stocks, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1	1	100.0	4.0	4.0	100.0	25.0	22.0	113.6
Aggregate area	<0.1	<0.1	–	1.2	1.1	109.1	9.4	7.9	119.0
Footprint	<0.1	<0.1	–	1.1	1.0	110.0	6.1	5.8	105.2
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	100.1	87.1	114.9	114.0	98.0	116.3	3199.0	2565.0	124.7
Aggregate area	43.0	32.1	134.0	42.1	34.9	120.6	3601.6	1322.5	272.3
Footprint	8.9	8.9	100.0	16.0	16.2	98.8	25.0	25.0	100.0

Table 21: Annual summary data for the number of tows that contact each cell, the aggregate area, and the footprint for All Stocks, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	3.0	2.0	150.0	10.0	9.0	111.1	27.2	24.8	109.7	32.0	29.0	110.3	699.0	616.0	113.5
2020	3.0	3.0	100.0	11.0	10.0	110.0	29.7	25.5	116.5	34.0	30.0	113.3	792.0	724.0	109.4
2021	3.0	3.0	100.0	11.0	10.0	110.0	28.2	24.6	114.6	34.0	29.2	116.4	629.0	594.0	105.9
2022	3.0	3.0	100.0	12.0	10.0	120.0	28.1	24.2	116.1	33.0	29.0	113.8	657.0	650.0	101.1
2023	3.0	2.0	150.0	10.0	9.0	111.1	26.8	22.6	118.6	32.0	26.0	123.1	638.0	563.0	113.3
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.8	0.8	100.0	3.4	3.1	109.7	11.5	9.1	126.4	12.1	10.5	115.2	828.8	296.9	279.2
2020	1.0	0.9	111.1	4.0	3.4	117.6	12.5	9.3	134.4	12.5	10.1	123.8	700.4	446.4	156.9
2021	1.0	0.9	111.1	4.2	3.6	116.7	11.8	9.0	131.1	12.4	10.4	119.2	754.2	225.7	334.2
2022	1.0	0.9	111.1	4.1	3.5	117.1	12.2	9.0	135.6	12.4	10.2	121.6	778.0	210.9	368.9
2023	1.0	0.8	125.0	3.8	3.1	122.6	12.1	8.5	142.4	12.3	9.5	129.5	1145.6	289.1	396.3
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.8	0.8	100.0	3.0	2.8	107.1	5.4	5.1	105.9	8.4	7.9	106.3	25.0	25.0	100.0
2020	0.9	0.8	112.5	3.2	2.9	110.3	5.3	5.0	106.0	8.0	7.5	106.7	25.0	25.0	100.0
2021	0.9	0.8	112.5	3.3	3.1	106.5	5.4	5.1	105.9	8.1	7.7	105.2	25.0	25.0	100.0
2022	0.9	0.8	112.5	3.3	3.1	106.5	5.3	5.1	103.9	7.9	7.6	103.9	25.0	25.0	100.0
2023	0.9	0.8	112.5	3.0	2.7	111.1	5.2	4.8	108.3	7.9	7.2	109.7	25.0	25.0	100.0

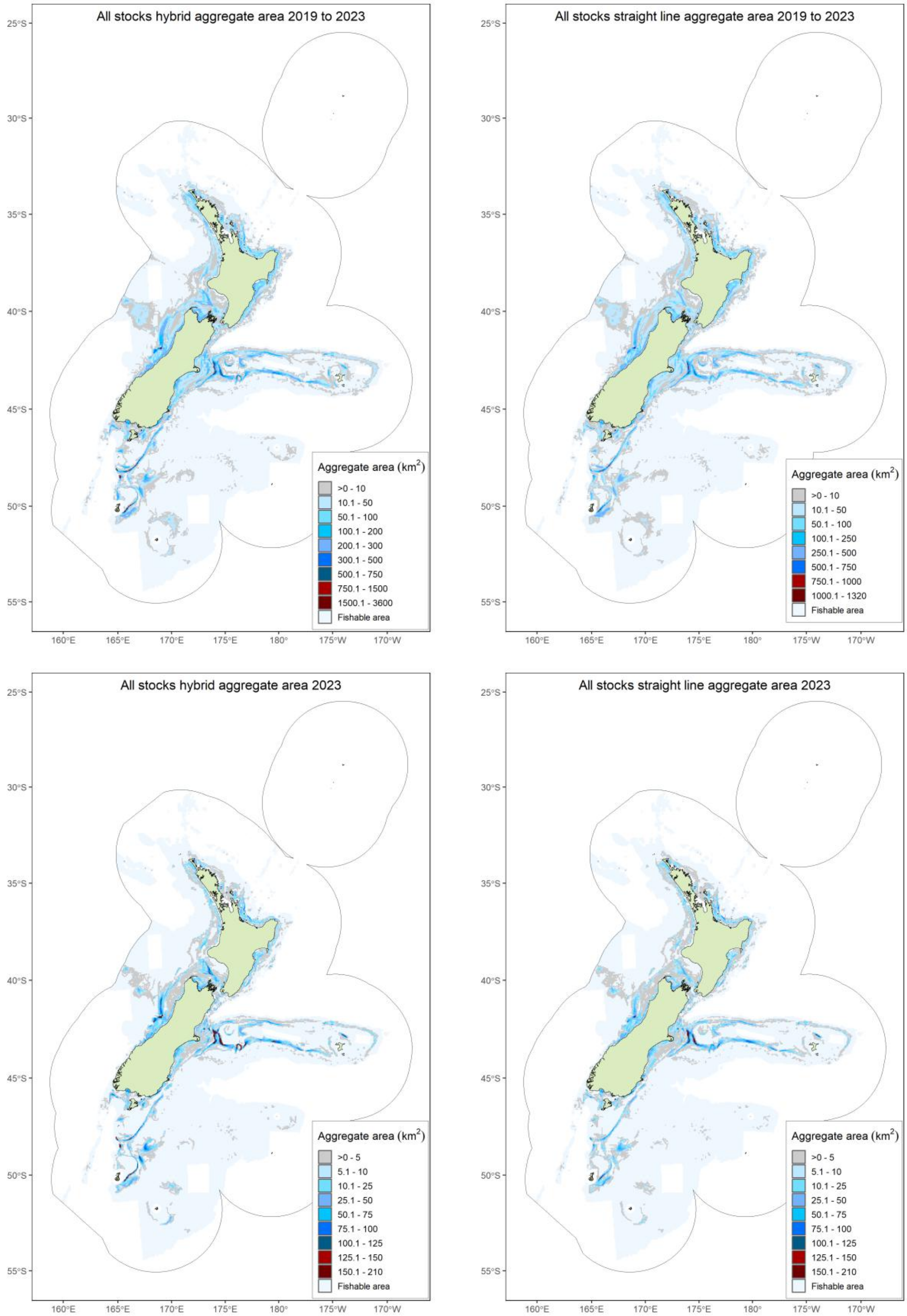


Figure 21: Distribution of the All Stocks aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

7.4 All Stocks hybrid and straight-line comparison: Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure 22, upper two plots). Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted overall (Figure 22, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure 23 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen spatially.

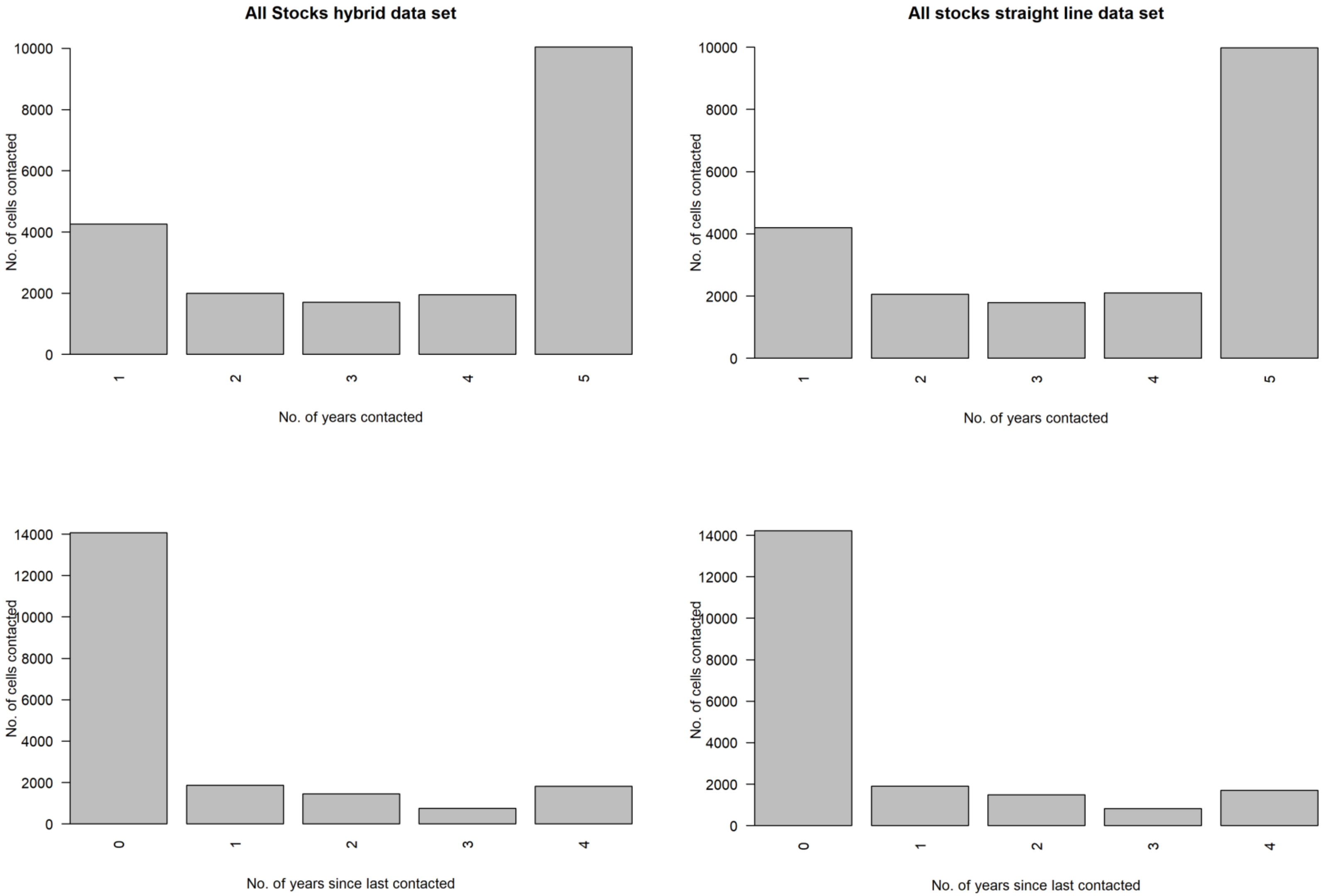


Figure 22: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the All Stocks data set.

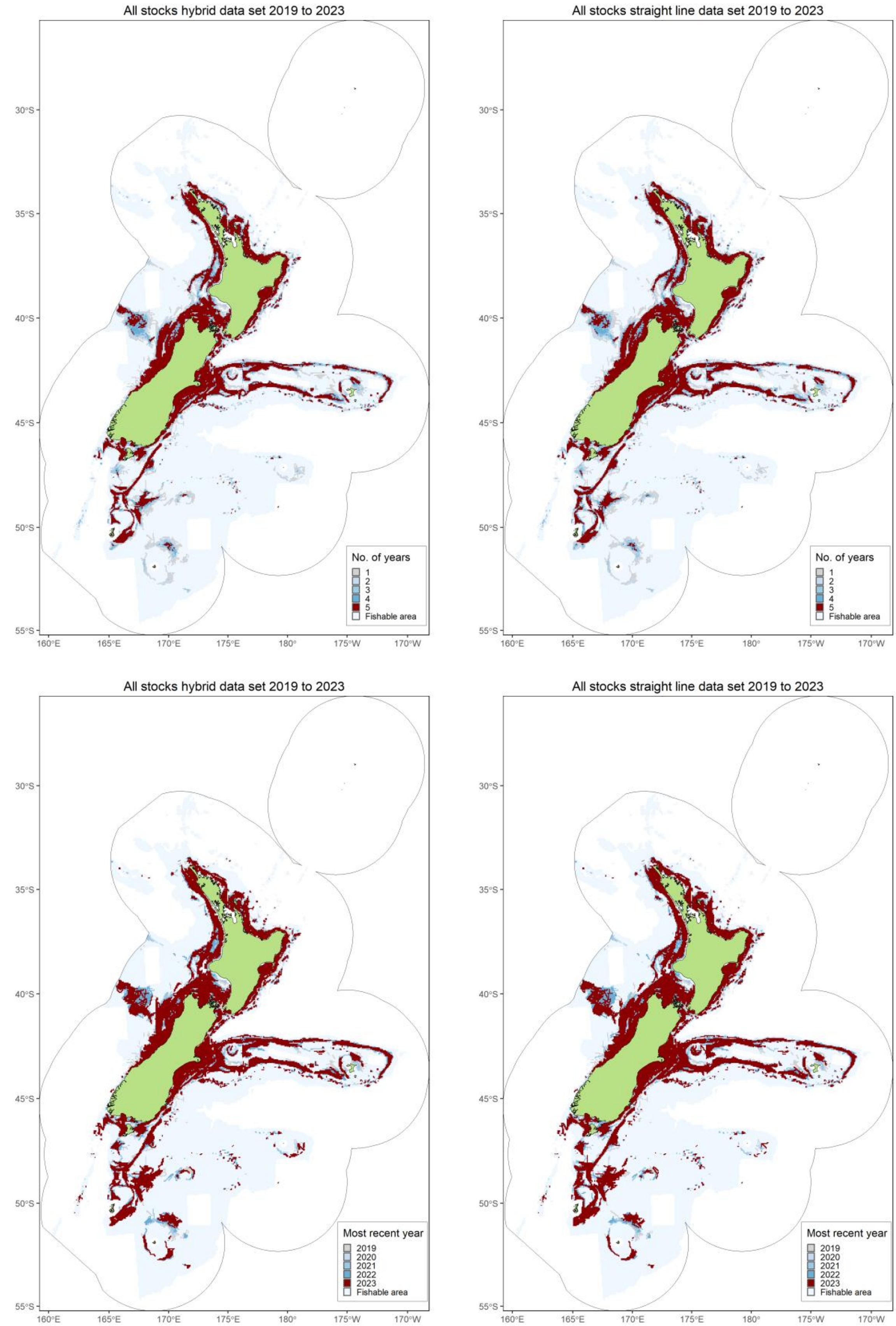


Figure 23: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right) for the All Stocks data set.

8. RESULTS: DEEPWATER, COMPARISONS OF THE STRAIGHT-LINE AND HYBRID METHODS (2019–2023)

As with the All Stocks data set, for the purposes of hybrid data, we are reporting from the 2019 fishing year onwards, when GPR devices were first introduced onto some fishing vessels. While coverage was low in this year, there is GPR data available and as it is considered to provide a better representation of trawl paths than the straight-line method, we will begin hybrid analyses that make use of GPR data from 2019, even if the improvements are only to a relatively small number of fishing events. For each measure of contact the ratio is expressed as a percentage of the hybrid value to the straight-line value. Where values are below 100%, this means that the hybrid value is smaller than the corresponding straight-line value, and where greater than 100% the hybrid value is larger than the straight-line value.

The total number of tows, number of straight-line tows (for which there is no corresponding GPR data), number of tows with GPR data, and the percentage of total tows that had GPR data is given by fishing year in Appendix D in Table D3. Compared with the All Stocks, coverage was much better for deepwater on its own (low coverage in 2019 in the inshore fleet lowered the average for All Stocks). In 2019, 82.2% of all deepwater tows had at least one GPR ping occurring between the start and end positions given in the ERS reporting forms. This increased to 90.3% in 2020, then 91.9%, 94.7%, and 96.1% in each of the last three years respectively. While all vessels are supposed to have GPR devices fitted, there will always be some tows without GPR data for a variety of reasons including equipment failure, and tows that begun and ended before GPR devices could ping. The latter reason can affect some deepwater fisheries in particular such as target fisheries for orange roughy, oreo dory species, black cardinalfish, and alfonsino, where tows are of a short duration on underwater topographic features.

The median GPR ping rate of vessels in the deepwater data set that ping at least once every 11 minutes, and those that ping once every 11 minutes or longer is given in Table D4. Compared with the All Stocks data set (which as mentioned, is influenced by its inshore component), the ping rates are more infrequent. Only a minority of vessels pinged more frequently than once every 11 minutes for the first three years with values of between 39.5% and 45.5%. Overall though the ping rate has improved over time and in 2022 and 2023 the percentage of vessels pinging more frequently than once every 11 minutes was 52.4% and 66.2% respectively.

8.1 Deepwater hybrid and straight-line comparison: spatial extent

The number of cells contacted, aggregate area, and footprint for the deepwater hybrid and straight-line data sets are given in Table 22. The ratios for the number of cells contacted ranged between 99.3% and 100.6%, representing a close match between the two data sets in all five years covered, with the hybrid data set sometimes contacting fewer cells than the straight-line data set, and sometimes contacting more. In terms of numbers of cells, the difference between the hybrid and straight-line data sets represented between -62 and 58 cells, a relatively small number as a proportion of total cells contacted.

Table 22: The number of cells, aggregate area (km^2), and footprint (km^2) for the Deepwater hybrid and straight-line data sets. The ratio for each measure of contact is expressed as a percentage of the hybrid value to the straight-line value.

	Cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	10 007	9 981	100.3	120 531.1	85 204.7	141.5	46 336.7	43 027.4	107.7
2020	9 144	9 206	99.3	114 706.4	80 936.9	141.7	42 371.9	39 649.3	106.9
2021	9 821	9 763	100.6	112 155.4	80 058.5	140.1	46 283.0	43 054.1	107.5
2022	9 423	9428	99.9	115 178.8	79 730.4	144.5	45 614.2	42 950.8	106.2
2023	9 582	9 610	99.7	122 110.2	79 905.8	152.8	46 657.0	42 158.3	110.7

For the aggregate area, the ratios are substantially higher than for the number of cells contacted, ranging between 140.1% and 152.8% (differences of between 32 097 and 42 204 km^2), meaning that in all years, the hybrid data set gave higher aggregate areas than the straight-line data set.

The footprints are also larger in every year for the hybrid data set when compared with the straight-line data set but the ratios are lower than for the aggregate area, ranging between 106.2–110.7% (differences of between 2663 and 4499 km^2) for the time series, meaning that the hybrid data footprint ranged between 6% and 7% larger than the straight-line equivalents.

Figure 24 shows the spatial distribution of the hybrid and straight-line footprints by degree of contact. At this resolution, there is little difference that can be seen between the two data sets.

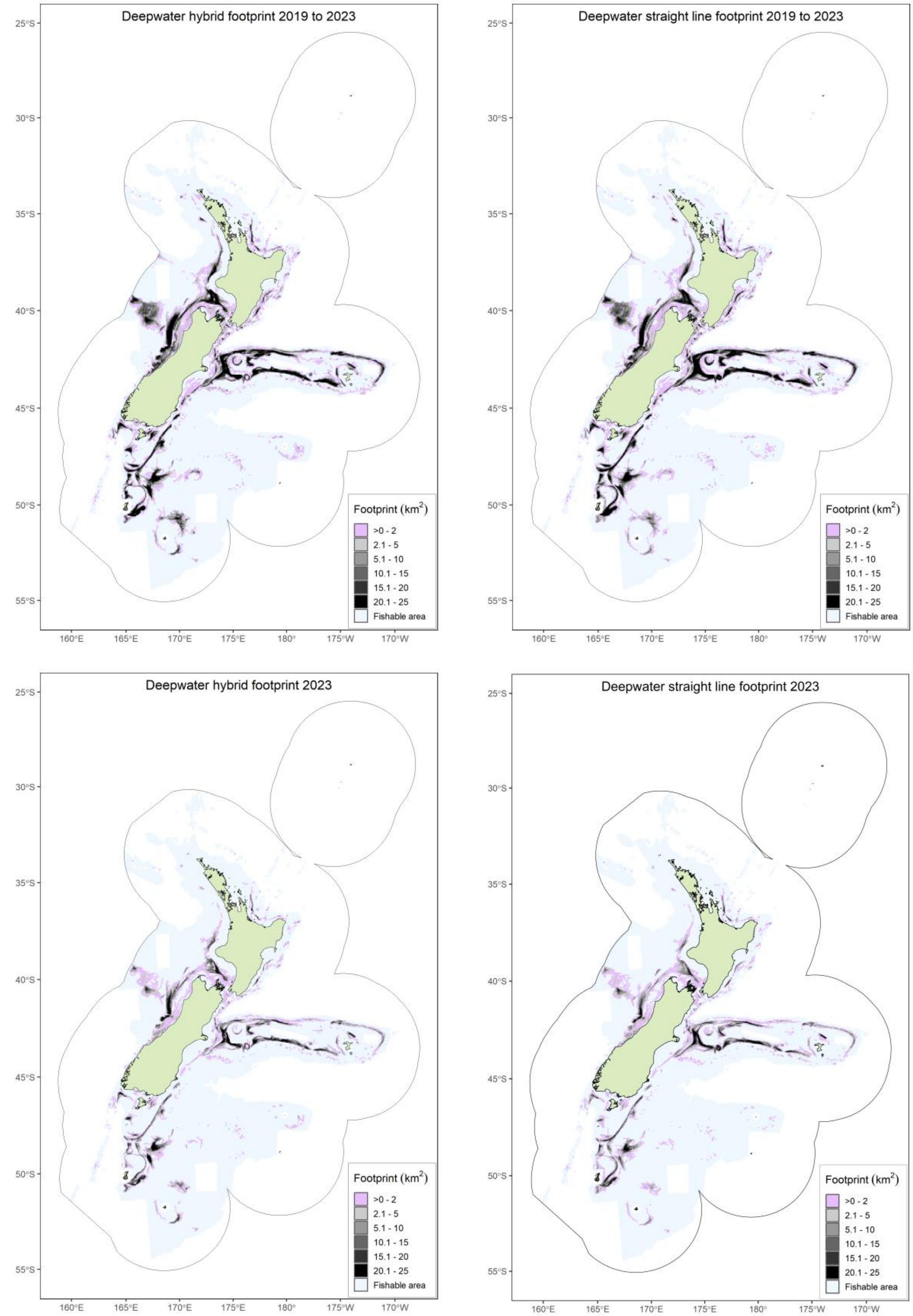


Figure 24: Distribution of the deepwater footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

8.2 Deepwater hybrid and straight-line comparison: Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table 23 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 90% to 137.5%, representing differences of between -7 and 3 cells.

Ratios for the aggregate area of these new cells were higher for the hybrid data set in all years, ranging between 99.6% and 120.9%, representing differences of between -0.3 and 17 km^2.

For the footprint, the ratio ranged between 100% and 120.9% representing differences of between 0 and 14.9 km^2. These are similar values to the aggregate area because in terms of area, the two measures are very similar within data sets. When considering the footprint as a percentage of the aggregate area, each data set has a relatively close match, between 95% and 100% for the hybrid data set and 95.1% and 100% for the straight-line data set. This suggests that for both, the aggregate areas are not much larger than the footprints, resulting in the ratio between the two data sets for this measure being fairly close at between 97.1% and 100.4%. This suggests that most of the fishing in 'new' areas is likely to be minor exploratory fishing or fishing on the margins of already established area, and either data set will show this.

Table 23: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the deepwater hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells contacted			Aggregate area (km^2)			Footprint (km^2)			Footprint as a % of agg area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	69	68	101.5	95.4	92.1	103.6	90.6	87.6	103.4	95.0	95.1	99.9
2020	54	54	100.0	43.2	40.7	106.1	43.1	40.5	106.4	99.8	99.5	100.3
2021	63	70	90.0	71.9	72.2	99.6	69.9	69.9	100.0	97.2	96.8	100.4
2022	54	57	94.7	70.2	53.2	132.0	68.0	53.1	128.1	96.9	99.8	97.1
2023	11	8	137.5	5.2	4.3	120.9	5.2	4.3	120.9	100.0	100.0	100.0

8.3 Deepwater hybrid and straight-line comparison: Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table 24). The ratio between the two data sets for the median number of tows that contacted a cell was a match between the two data sets 100%, or 10 km tows each. The ratio for the mean number was 122% and this represented a difference of 11.8 tows. The ratio for the maximum number of tows was 124.8% and represented a more substantial difference of 636 tows. This is almost identical to the All Stocks data set, suggesting that the maximum is driven mainly by the deepwater component rather than inshore.

For the aggregate area the minimum area was essentially the same for both data types, at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 117.1%, though there is little actual difference (4.1 vs 3.5 km^2). The mean is again higher for the hybrid data (ratio of 144.7%, or 38.5 vs 26.6 km^2). The most substantial difference is for the maximum (ratio of 272.6% or 3601.6 vs 1321 km^2). Again, these maximum values are almost the same as those for the All Stocks data set, suggesting that the maximum for All Stocks is driven by the deepwater component rather than the inshore.

The spatial distribution of the aggregate area for both data types is shown in Figure 25 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference. There is, however, a need to have different categories with substantially higher upper ranges for the hybrid data set for all years combined and the 2023 fishing year. The overall spatial location of intensity is much the same however, even if the values of intensity may differ.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 106.7%, which represents a difference of just 0.2 km^2, 3.2 vs 3 km^2. The mean footprint has a ratio of 102.9%, or 7.1 vs 6.9 km^2. The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table 25. The annual ratio for the median number of tows that contacted a cell ranged from 100–120%, or 0–1 tow each year. For the mean, the ratio ranged from 118.3–126.7% or a maximum difference of 4.4 tows in any one year. For the maximum, the annual ratio ranged from 109.4–135.7%, representing differences of between 68 and 168 tows.

The annual median ratios for the aggregate area in a cell ranged from 113–125% but in no year did the actual difference in square kilometres exceed 0.5. The ratio for the mean aggregate area was very close in each year, ranging from 139–153%, and represented a difference between data types of no more than 4.4 km^2 in any one year. The ratios for the maximum aggregate area were more substantial, ranging from 156.9–396.4% or between 254 and 857 km^2. These are the same maximum values as seen for the All Stocks data set, showing that the deepwater component of the All Stocks data set drives its maximum values.

The annual median ratios for the footprint in a cell ranged from 105–115.8% (a maximum difference of 0.3 km^2), and the means from 104.3–111.4% (a maximum difference of 0.5 km^2). The maximum footprint for both data types in all years is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100% in all years.

Table 24: Summary data for the number of tows that contact a cell, the footprint, and the aggregate area by 25-km^2 cell for deepwater, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100	2.0	2.0	100	10.0	10.0	100.0
Aggregate area	<0.1	<0.1	–	0.8	0.8	100	4.1	3.5	117.1
Footprint	<0.1	<0.1	–	0.8	0.8	100	3.2	3.0	106.7
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	65.5	53.7	122.0	46.0	40.0	115.0	3 196.0	2 560.0	124.8
Aggregate area	38.5	26.6	144.7	23.6	19.0	124.2	3 601.6	1 321.0	272.6
Footprint	7.1	6.9	102.9	11.9	11.4	104.4	25.0	25.0	100.0

Table 25: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for deepwater, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019.0	1.0	1.0	100.0	4.0	4.0	100.0	20.0	16.8	119.0	16.0	14.0	114.3	696.0	568.0	122.5
2020.0	2.0	2.0	100.0	5.0	5.0	100.0	22.2	18.3	121.3	18.0	16.0	112.5	792.0	724.0	109.4
2021.0	2.0	2.0	100.0	6.0	5.0	120.0	20.0	16.9	118.3	18.0	15.0	120.0	573.0	483.0	118.6
2022.0	2.0	2.0	100.0	6.0	5.0	120.0	20.6	16.9	121.9	19.0	17.0	111.8	515.0	440.0	117.0
2023.0	2.0	2.0	100.0	6.0	5.0	120.0	20.9	16.5	126.7	20.0	15.0	133.3	638.0	470.0	135.7
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019.0	0.5	0.5	100.0	2.0	1.7	117.6	12.0	8.5	141.2	9.3	7.1	131.0	828.8	296.9	279.2
2020.0	0.7	0.6	116.7	2.3	2.0	115.0	12.5	8.8	142.0	9.3	7.4	125.7	700.4	446.4	156.9
2021.0	0.7	0.6	116.7	2.5	2.1	119.0	11.4	8.2	139.0	9.4	7.6	123.7	754.2	225.4	334.6
2022.0	0.7	0.6	116.7	2.6	2.3	113.0	12.2	8.5	143.5	10.1	8.0	126.2	778.0	210.9	368.9
2023.0	0.7	0.6	116.7	2.5	2.0	125.0	12.7	8.3	153.0	10.9	7.6	143.4	1145.6	289.1	396.3
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019.0	0.5	0.5	100.0	1.8	1.6	112.5	4.6	4.3	107.0	6.4	5.7	112.3	25.0	25.0	100.0
2020.0	0.6	0.6	100.0	2.0	1.8	111.1	4.6	4.3	107.0	6.4	5.8	110.3	25.0	25.0	100.0
2021.0	0.6	0.6	100.0	2.1	2.0	105.0	4.7	4.4	106.8	6.6	6.1	108.2	25.0	25.0	100.0
2022.0	0.7	0.6	116.7	2.3	2.1	109.5	4.8	4.6	104.3	6.7	6.4	104.7	25.0	25.0	100.0
2023.0	0.7	0.6	116.7	2.2	1.9	115.8	4.9	4.4	111.4	7.2	6.1	118.0	25.0	25.0	100.0

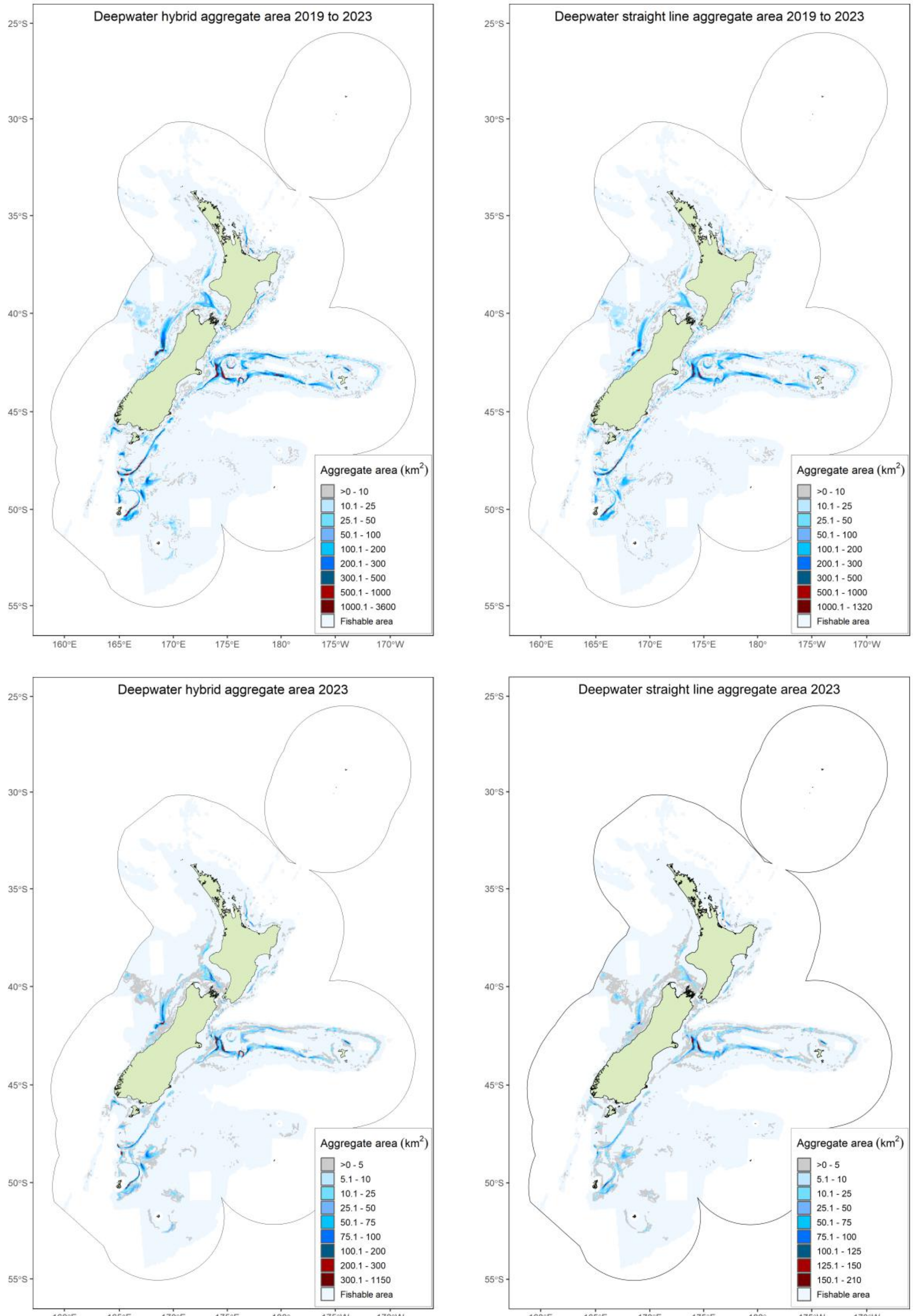


Figure 25: Distribution of the deepwater aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

8.4 Deepwater hybrid and straight-line comparison: Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure 26, upper two plots). Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted overall (Figure 26, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure 27 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen spatially at this resolution.

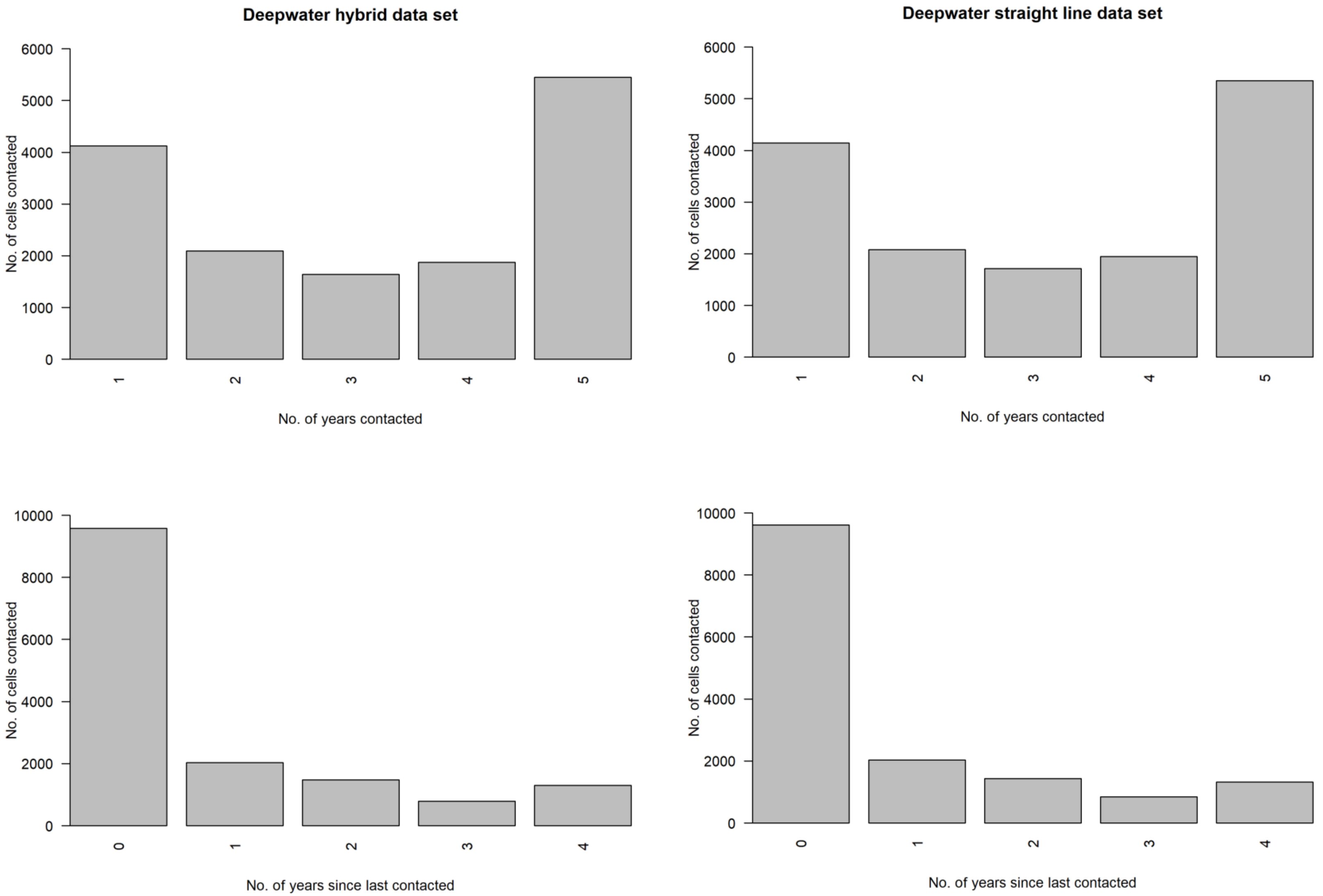


Figure 26: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the deepwater data set.

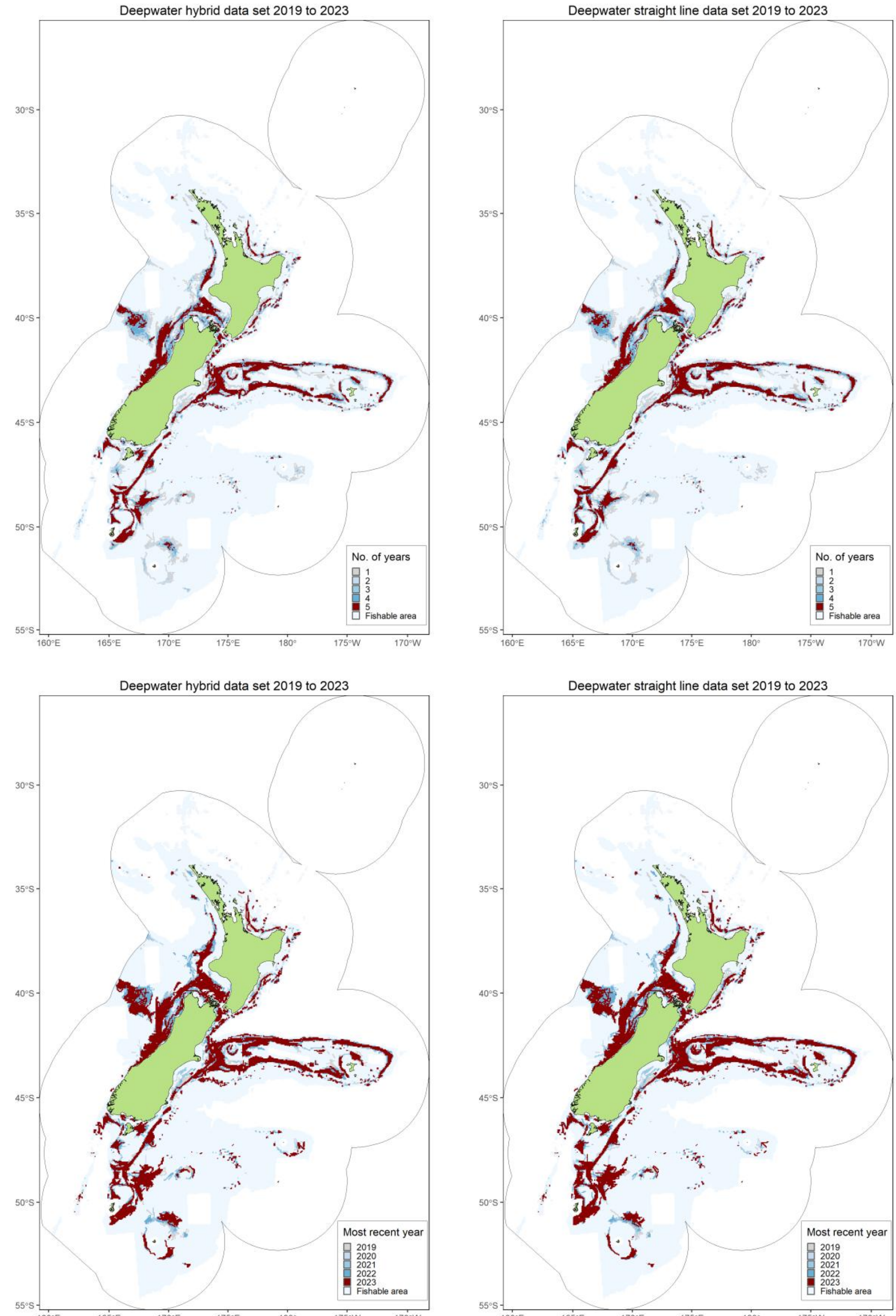


Figure 27: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right) for the deepwater data set.

9. RESULTS: INSHORE, COMPARISONS OF THE STRAIGHT-LINE AND HYBRID METHODS (2019–2023)

As with the All Stocks and deepwater data sets, for the purposes of hybrid data, we are reporting from the 2019 fishing year onwards, when GPR devices were first introduced onto some fishing vessels. While coverage was low in this year, there is GPR data available and as it is considered to provide a better representation of trawl paths than the straight-line method, we will begin hybrid analyses that make use of GPR data from 2019, even if the improvements are only to a relatively small number of fishing events. For each measure of contact the ratio is expressed as a percentage of the hybrid value to the straight-line value. Where values are below 100%, this means the hybrid value is smaller than the corresponding straight-line value, and where greater than 100% the hybrid value is larger than the straight-line value.

The total number of tows, number of straight-line tows (for which there is no corresponding GPR data), number of tows with GPR data, and the percentage of total tows that had GPR data is given by fishing year in Appendix D in Table D5. Coverage for inshore was low in 2019, with just 26.6% of tows having corresponding GPR pings. However, this improved dramatically from 2020 onwards, with values of between 93.2 and 97.7% thereafter.

The median GPR ping rate of vessels in the inshore data set that ping at least once every 11 minutes, and those that ping once every 11 minutes or longer is given in Table D6. While overall coverage of inshore was low in the beginning of the time period, the rate at which inshore vessels pinged has always been higher than for the deepwater fleet. 78.2% pinged more frequently than once every 11 minutes in 2019, and the rate has increased over time to 87% in 2023.

9.1 Inshore hybrid and straight-line comparison: spatial extent

The number of cells contacted, aggregate area, and footprint for the inshore hybrid and straight-line data sets are given in Table 26. The ratios for the number of cells contacted ranged between 97.4% and 99.7%, representing a close match between the two data sets in all five years covered, but the hybrid data set contacting slightly fewer cells in all years. In terms of numbers of cells, the difference between the hybrid and straight-line data sets represented between -28 and -181 cells, a relatively small number as a proportion of total cells contacted.

Table 26: The number of cells, aggregate area (km^2), and footprint (km^2) for the inshore hybrid and straight-line data sets. The ratio for each measure of contact is expressed as a percentage of the hybrid value to the straight-line value.

	Cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	8 584	8 612	99.7	59 527.1	56 964.0	104.5	38 414.3	38 098.0	100.8
2020	6 911	7 040	98.2	55 990.3	47 915.3	116.9	31 974.1	31 455.7	101.6
2021	6 893	7 074	97.4	57 270.0	48 967.9	117.0	32 184.2	32 064.4	100.4
2022	6 416	6 497	98.8	51 531.5	44 256.1	116.4	29 071.8	28 718.9	101.2
2023	8 584	8 612	99.7	59 527.1	56 964.0	104.5	38 414.3	38 098.0	100.8

For the aggregate area, the ratios are all above 100%, indicating that the hybrid data set had higher aggregate areas in all years compared with the straight-line data set. The ratios ranged from 104.5% to 117.5%, representing difference in area of between 2563 and 8302 km^2.

The footprints are also larger in every year for the hybrid data set when compared with the straight-line data, albeit only slightly, with ratios ranging from 100.4–102.5%. This represents differences in area of between 120 and 684 km^2.

Figure 28 shows the spatial distribution of the hybrid and straight-line footprints by degree of contact. At this resolution, there is little difference that can be seen between the two data sets.

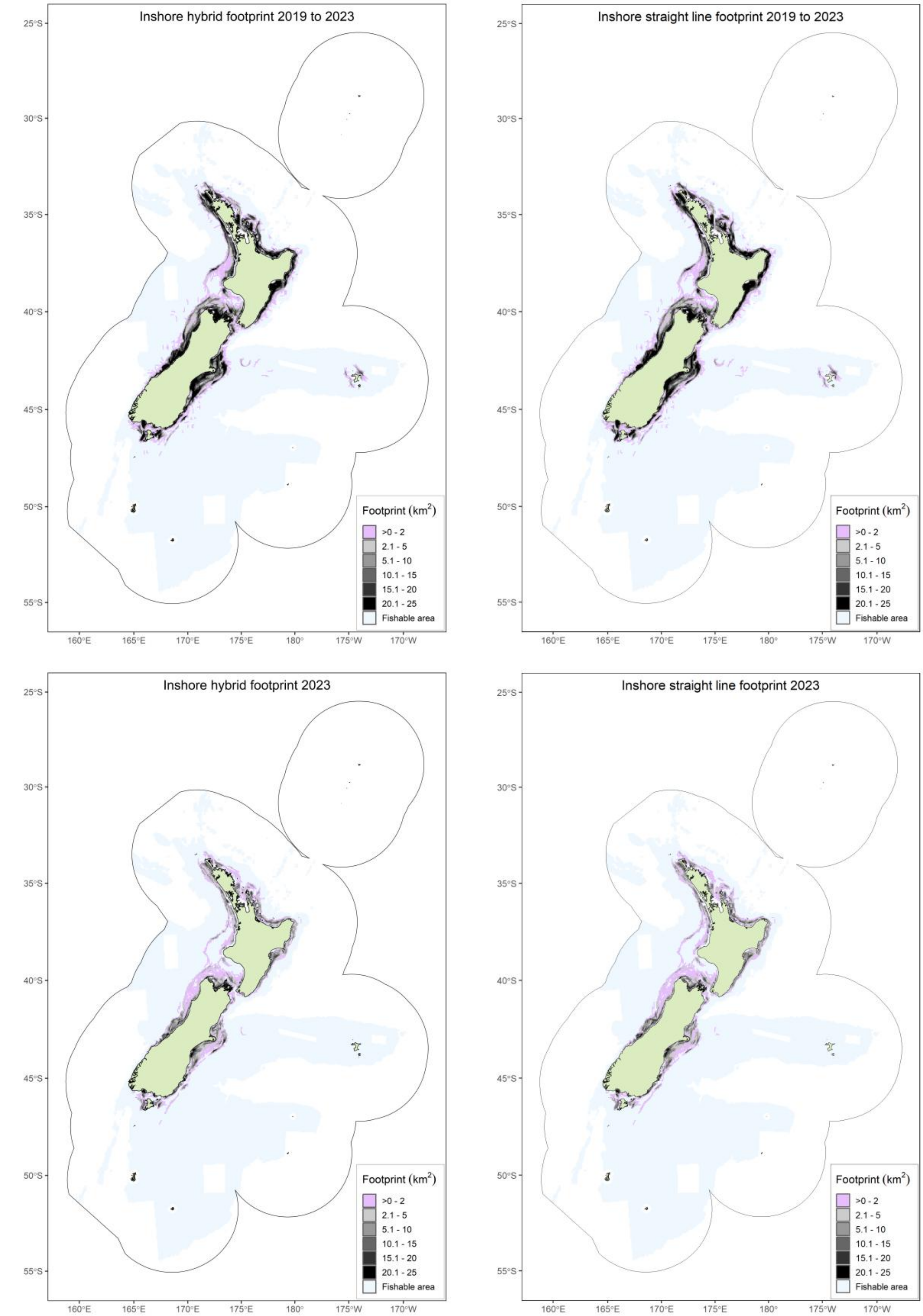


Figure 28: Distribution of the inshore footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

9.2 Inshore hybrid and straight-line comparison: Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table 27 where the base footprint was created for 2008–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 43.5% to 100%, representing differences of between -39 and 0 cells.

Ratios for the aggregate area of these new cells were higher for the hybrid data set in all years, ranging between 30.6% and 125.6%. While the ratios suggest big disparities between the two data sets, in terms of area, the differences are relatively small, between -12.9 and 1.1 km^2.

For the footprint, the ratio ranged between 30.6% and 118.9% representing differences of between 0 and 14.9 km^2. These are similar values to the aggregate area because in terms of area, the two measures are very similar within data sets. When considering the footprint as a percentage of the aggregate area, each data set has a relatively close match, between 81.5% and 100% for the hybrid data set and 86% and 100% for the straight-line data set. This suggests that for both, the aggregate areas are not much larger than the footprints, resulting in the ratio between the two data sets for this measure being fairly close at between 94.8% and 100%. This suggests that most of the fishing in ‘new’ areas is likely to be minor exploratory fishing or fishing on the margins of already established area, and either data set will show this.

Table 27: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the deepwater inshore and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	Cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of agg area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	125	125	100.0	37.5	38.4	97.7	36.7	37.6	97.6	97.9	97.9	100.0
2020	30	69	43.5	11.1	24.0	46.2	11.1	24.0	46.2	100.0	100.0	100.0
2021	5	7	71.4	5.4	4.3	125.6	4.4	3.7	118.9	81.5	86.0	94.8
2022	6	10	60.0	1.1	3.6	30.6	1.1	3.6	30.6	100.0	100.0	100.0
2023	11	14	78.6	3.5	3.6	97.2	3.5	3.6	97.2	100.0	100.0	100.0

9.3 Inshore hybrid and straight-line comparison: Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table 28). The ratio between the two data sets for the median number of tows that contacted a cell was a match between the two data sets 112.1%, or a difference of four tows. The ratio for the mean number was 109.1% and this represented a difference of 8.8 tows. The ratio for the maximum number of tows was 102.7%, and represented a more difference of 66 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 118.4%, though there is little actual difference (9 vs 7.6 km^2). The mean is again higher for the hybrid data (ratio of 116.2%, or 28.7 vs 24.7 km^2). The most substantial difference is for the maximum (ratio of 109.3% or 535.5 vs 489.8 km^2).

The spatial distribution of the aggregate area for both data types is shown in Figure 29 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference. There is, however, a need to have different categories with substantially higher upper ranges for the hybrid data set for all years combined. The overall spatial location of intensity is much the same however, even if the values of intensity may differ.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 107.1%, which represents a difference of just 0.4 km^2, or 6 vs 5.6 km^2. The mean footprint has a ratio of 93%, or 8 vs 8.6 km^2. The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table 29. The annual ratio for the median number of tows that contacted a cell ranged from 110–116.7%, or 1–2 tows each year. For the mean, the ratio ranged from 102.7–111.9% or a maximum difference of 3.2 tows in any one year. For the maximum, the annual ratio ranged from 101.1–105.9%, representing differences of between 7 and 70 tows.

The annual median ratios for the aggregate area in a cell ranged from 104–120.7% but in no year did the actual difference in square kilometres exceed 0.6. The ratio for the mean aggregate area was very close in each year, ranging from 104.5–120.3%, and represented a difference between data types of no more than 1.4 km^2 in any one year. The ratios for the maximum aggregate area were more substantial in comparison, ranging from 102.7–145% or between 2.9 and 51.5 km^2.

The annual median ratios for the footprint in a cell ranged from 104.3–107.7% (a maximum difference of 0.2 km^2), and the means from 102.2–104.8% (also a maximum difference of 0.2 km^2). The ratios for the maximum footprint ranged from 98.4 to 103.4, representing a maximum difference of 0.8 km^2 for any one year. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible area of a cell.

Table 28: **Summary data for the number of tows that contact a cell, the footprint, and the aggregate area by 25-km2 cell for inshore, for the combined fishing years 2019–2023, for the inshore hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.**

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	5.0	4.0	125	37	33.0	112.1
Aggregate area	<0.1	<0.1	–	0.9	0.9	100	9	7.6	118.4
Footprint	<0.1	<0.1	–	1.0	0.8	125	6	5.6	107.1
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	105.2	96.4	109.1	137.0	125.0	109.6	2525.0	2459.0	102.7
Aggregate area	28.7	24.7	116.2	37.6	33.1	113.6	535.5	489.8	109.3
Footprint	8.0	8.6	93.0	15.0	15.8	94.9	25.0	25.0	100.0

Table 29: **Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for inshore, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.**

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	3.0	3.0	100.0	11.0	10.0	110.0	26.3	25.6	102.7	34.0	33.0	103.0	623.0	616.0	101.1
2020	4.0	4.0	100.0	15.0	13.0	115.4	29.3	26.3	111.4	37.0	33.0	112.1	428.0	403.0	106.2
2021	4.0	4.0	100.0	16.0	14.0	114.3	30.1	26.9	111.9	38.0	34.0	111.8	627.0	592.0	105.9
2022	4.0	4.0	100.0	15.0	13.0	115.4	29.5	26.9	109.7	38.0	34.0	111.8	656.0	649.0	101.1
2023	4.0	4.0	100.0	14.0	12.0	116.7	27.1	24.5	110.6	35.0	31.0	112.9	633.0	563.0	112.4
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.6	0.6	100.0	2.6	2.5	104.0	6.9	6.6	104.5	9.4	8.7	108.0	110.0	107.1	102.7
2020	0.9	0.8	112.5	3.8	3.2	118.7	8.1	6.8	119.1	10.6	8.8	120.5	136.3	95.9	142.1
2021	0.9	0.8	112.5	4.0	3.4	117.6	8.3	6.9	120.3	10.7	9.2	116.3	157.3	132.5	118.7
2022	0.9	0.8	112.5	3.7	3.1	119.4	8.0	6.8	117.6	10.1	8.8	114.8	160.9	112.0	143.7
2023	0.9	0.8	112.5	3.5	2.9	120.7	7.5	6.3	119.0	9.6	8.3	115.7	166.0	114.5	145.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.6	0.5	120.0	2.4	2.3	104.3	4.5	4.4	102.3	7.1	6.9	102.9	24.0	24.4	98.4
2020	0.8	0.8	100.0	3.0	2.8	107.1	4.6	4.5	102.2	7.1	6.8	104.4	24.3	24.0	101.2
2021	0.8	0.8	100.0	3.1	2.9	106.9	4.7	4.5	104.4	7.2	7.1	101.4	24.3	23.8	102.1
2022	0.8	0.8	100.0	2.9	2.7	107.4	4.5	4.4	102.3	6.9	6.7	103.0	24.4	23.6	103.4
2023	0.8	0.7	114.3	2.8	2.6	107.7	4.4	4.2	104.8	6.7	6.5	103.1	24.4	24.1	101.2

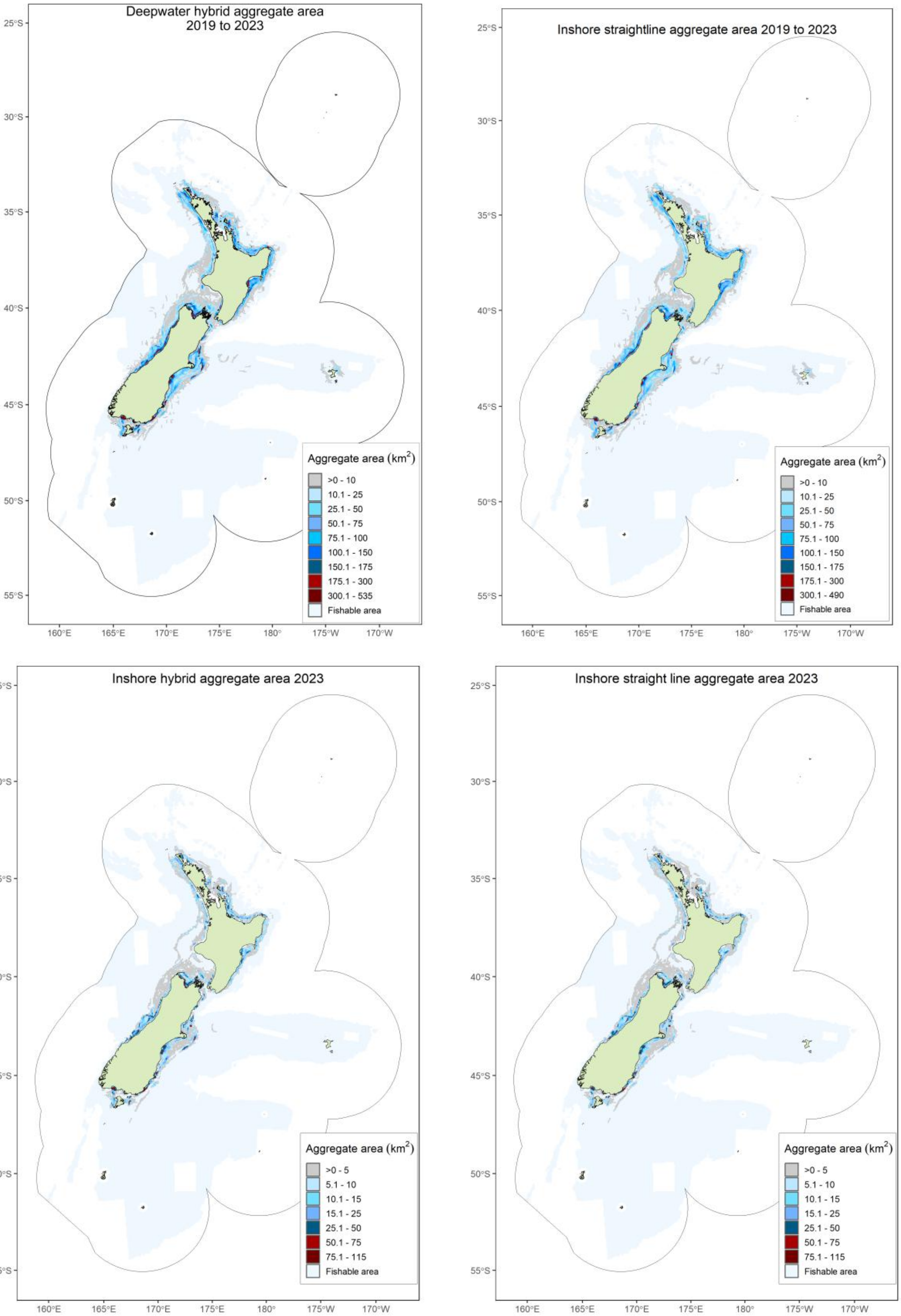


Figure 29: Distribution of the inshore aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

9.4 Inshore hybrid and straight-line comparison: Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure 30, upper two plots). Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted overall (Figure 30, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure 31 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen spatially at this resolution.

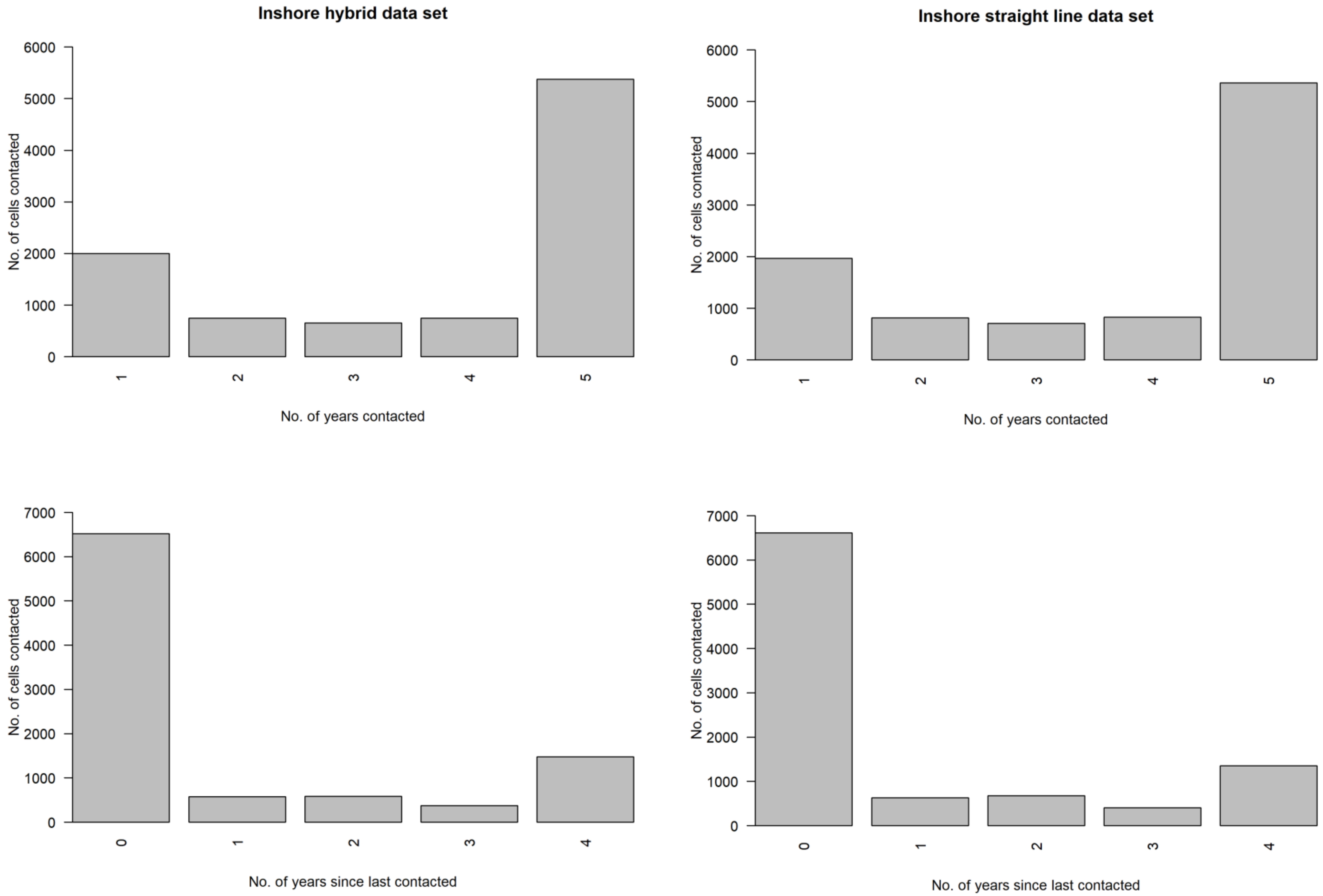


Figure 30: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the inshore data set.

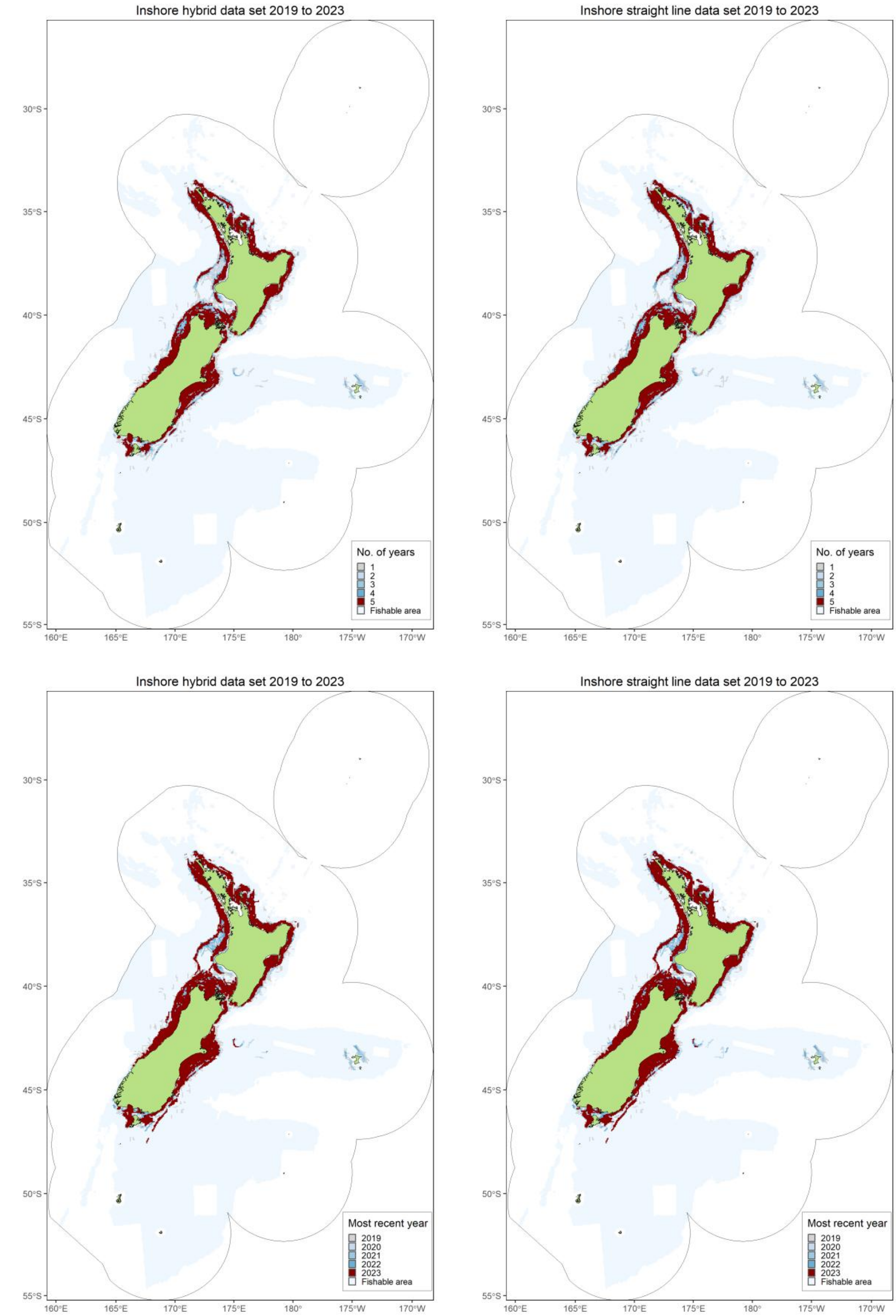


Figure 31: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right) for the inshore data set.

10. RESULTS: HYBRID AND STRAIGHT-LINE COMPARISONS FOR INDIVIDUAL TARGETS OR TARGET GROUPS

Fisheries New Zealand requested that specific target fisheries or fisheries groups be investigated to see if differences exist between hybrid and straight-line approaches to estimating the footprints and other summary statistics at the level of individual targets or target groups.

The results are summarised here with respect to the aggregate areas and footprints and broadly discussed in Section 11. Comparisons are made by comparing the ratios between the hybrid and straight-line estimates. They are expressed for each measure as a percentage of the hybrid:straight-line value. Ratios of less than 100% indicate that the hybrid value was lower than the straight-line value, 100% indicates an exact match, and values over 100% indicate that the hybrid value was larger than the straight-line value. The range of ratios seen across the years are presented here, along with the corresponding area in square kilometres for each ratio. Note that the difference in area for the lower value in the ratio range can sometimes be higher in terms of square kilometres than the difference in the area for the upper value of the range (e.g. arrow squid). This can occur when the lower value in the range of ratios comes from large hybrid and straight-line values that are a close match. For example a hybrid:straight-line ratio of 150% is achieved for areas of 100 and 150 km^2, a difference of 50 km^2. But for areas of 0.2 and 0.1 km^2 the resulting ratio is 200% for a difference of just 0.1 km^2. It is for this reason that the difference in area for the given ratios is also reported, so that large ratios can be put in the context of the area it represents. A ratio of 200% sounds substantial but may only be a very small area.

More detailed results for individual targets or target groups can be found for selected tier one deepwater fisheries, inshore target fisheries, orange roughy/oreo dory Marine Stewardship Council (MSC) areas, and for hoki/hake/ling bycatch assessment areas in Appendices E, F, G, and H respectively. The more detailed appendices include results and discussions for the spatial extent, new cells contacted, intensity, and the number of years cells are contacted and the number of years since cells were contacted.

10.1 Hybrid and straight-line comparisons for selected tier one deepwater species

For all selected tier one deepwater target species, the hybrid method produced larger aggregate areas than the straight-line method, in all years (Table 30). For some species the range of hybrid:straight-line ratios seen is relatively small, for example ESCR orange roughy where the ratio ranged between 100.6 and 111.8%. For other target species the differences were more substantial for example southern blue whiting which ranged from 202.7–260.8%, indicating that the hybrid aggregate area was at least double that of the straight-line estimate every year. The wide area covered by some targets means that substantial differences in the ratio can represent hundreds or even thousands of square kilometres in a given year.

More variation is seen in the footprints of each target. Larger hybrid footprints are seen in all years for Jack mackerel, southern blue whiting, and orange roughy in areas 7A and ESCR. Arrow squid had *lower* footprints in all years for the hybrid method. Scampi and orange roughy in NWCR showed a mix where the hybrid footprint was higher in some years but lower in others compared with the straight-line method. For a given species, the footprints were a closer match than the aggregate areas between the two methods, reflected in the lower and upper ranges of the ratios for the footprint compared with the aggregate area.

Table 30: The range of ratios (expressed as a percentage) for the hybrid:straight-line aggregate areas and footprints for selected tier one deepwater target fisheries between the 2019 and 2023 fishing years. Values in parentheses represent the corresponding difference in km² between the hybrid and straight-line estimates for those corresponding ratios. Cells coloured green are for measures where the hybrid value was higher than the straight-line value in all years, cells in red are for measures where the hybrid value was lower than the straight-line values in all years, and clear cells are for measures where the hybrid value was sometimes higher and sometimes lower than the straight line value.

Target	Aggregate area ratio (difference in km²)	Footprint ratio (difference in km²)
JMA	166.6 (2478.7) – 197.7 (4704.0)	137.2 (1215.3) – 145.7 (1284.6)
SCI	108.2 (672.3) – 112.4 (1145.1)	96.6 (-157) – 100.3 (14.4)
SQU	153.5 (7565.3) – 181.7 (6175.6)	73.8 (-934.9) – 83.8 (-631.8)
SBW	202.7 (872.1) – 260.8 (1256.8)	166.8 (500.4) – 215.7 (412.1)
ORH - 7A	103.0 (82.9) – 112.7 (266.5)	101.5 (20) – 108.7 (128.5)
ORH - NWCR	104.9 (23.0) – 121.1 (101.0)	97.2 (-11.5) – 106.8 (23.7)
ORH - ESCR	100.6 (6.5) – 111.8 (217.1)	100.2 (1.7) – 107.0 (98.7)

10.2 Hybrid and straight-line comparisons for selected inshore target species/groups

Hybrid aggregate areas were higher in all years for all targets groups except for one year in TAR 4 (Table 31). The lower hybrid aggregate area for TAR 4 was in 2022, on the back of rapidly declining aggregate areas before there was no targeting of tarakihi in TAR 4 at all in 2023. The variation seen across targets could be relatively narrow (e.g. 101.7–104.5% for TAR 8), or relatively large (e.g. 137.8–220.7% for BAR 4). The magnitude of difference in ratio doesn't necessarily correspond to large differences in terms of square kilometres. For example, the upper ratio of 136.9% for TAR 5 represented a difference of 24 km² in that year, but for WCNI mixed targets the upper ratio of 107.2% represented a difference of 352.5 km².

For the footprint, the selected targets showed more variation. The hybrid footprint was larger in all years for just over half of the 20 different inshore groups investigated: FMA 2 mixed targets, BAR 1, BAR 5, BAR 7, TAR 5, ECSI flatfish, ECSI mixed targets, SCSI STA, TBGB FLA, and both mixed target combinations investigated in TBGB. The footprint was lower in all years for the hybrid method for four groups: FMA 1 mixed targets, TAR 2, TAR 4, and TAR 8. BAR 4, TAR 1, TAR 3, TAR 7, and WCNI mixed all had a mix where the hybrid footprint was sometimes higher and sometimes lower than the straight-line estimate. For a given species, the footprints were a closer match than the aggregate areas were between the two methods, reflected in the lower and upper ranges of the ratios for the footprint compared with the aggregate area.

Table 31: The range of ratios (expressed as a percentage) for the hybrid:straight-line aggregate areas and footprints for selected inshore target/target group fisheries between the 2019 and 2023 fishing years. Values in parentheses represent the corresponding difference in km^2 between the hybrid and straight-line estimates for those corresponding ratios. Cells coloured green are for measures where the hybrid value was higher than the straight-line value in all years, cells in red are for measures where the hybrid value was lower than the straight-line values in all years, and clear cells are for measures where the hybrid value was sometimes higher and sometimes lower than the straight line value.

Target/target group	Aggregate area ratio (difference in km^2)	Footprint ratio (difference in km^2)
FMA 1 mixed	103.3 (185.1) – 115.0 (683.3)	96.8 (-104.0) – 99.9 (-5.1)
FMA 2 mixed	104.4 (183.5) – 129.8 (549.3)	101.9 (56.4) – 115.5 (228.8)
BAR 1	113.5 (346.8) – 146.1 (1294.6)	105.8 (131.3) – 120.9 (449.8)
BAR 4	137.8 (264.1) – 220.7 (812)	84.3 (-52.1) – 170.5 (73)
BAR 5	146.2 (598.2) – 185.2 (675.7)	111.2 (84.3) – 143.9 (295.7)
BAR 7	114.3 (346.0) – 135.4 (1117.6)	103.5 (71.8) – 116.2 (433.9)
TAR 1	102.6 (94.5) – 112.5 (314.1)	96.6 (-87.1) – 100.5 (11.5)
TAR 2	104.2 (194.4) – 112.8 (476.6)	98.5 (-49.2) – 90.5 (-160.4)
TAR 3	107.6 (164.4) – 125.1 (213.5)	98.1 (-11.7) – 107.1 (57.2)
TAR 4	95.5 (-5.6) – 107.9 (69.0)	90.4 (-9.3) – 97.3 (-1.2)
TAR 5	103.6 (1.1) – 136.9 (24.0)	102.7 (0.8) – 123.6 (14.8)
TAR 7	101.8 (76.6) – 113.6 (389.4)	97.8 (-74.9) – 103.9 (92.6)
TAR 8	101.7 (7.2) – 104.5 (19.3)	-87.1 (-43.8) – 99.5 (-2.6)
ECSI - FLA	104.4 (145.4) – 125.8 (718.7)	101.4 (11.4) – 106.7 (90.8)
ECSI mixed	104.7 (264.7) – 119.5 (855.3)	102.9 (124.3) – 109.6 (309)
SCSI - STA	104.1 (33.6) – 123.1 (223.8)	102.0 (13.4) – 110.8 (75.4)
TBGB - FLA	114.8 (226.7) – 137.2 (155.4)	107.4 (76.5) – 130.3 (83.7)
TBGB mixed	109.1 (268.0) – 135.9 (861.9)	103.8 (69.1) – 114.4 (191.9)
TBGB mixed 2	103.0 (41.4) – 130.5 (599.7)	101.4 (14.9) – 116 (165.6)
WCNI mixed	102.3 (116.7) – 107.2 (352.5)	99.0 (-44.4) – 101.0 (38.9)

10.3 Hybrid and straight-line comparisons for orange roughy/oreo dory Marine Stewardship Council (MSC) Areas

Hybrid aggregate areas were higher in all years for all three of the orange roughy/oreo dory MSC areas (Table 32). As seen with the tier one deepwater and inshore targets, the magnitude of difference in ratio doesn't necessarily correspond to large differences in terms of square kilometres. For example, the upper ratio of 121.1% for NWCR represented a difference of 101 km^2 in that year, but the ESCR upper ratio of 111.4% represented a difference of 218.4 km^2.

The footprints were higher in every year for areas ESCR and 7A but the ratios were still relatively low with a minimum of 100.1% (ESCR) to a maximum of 108.7% (7A). NWCR had a mix of the hybrid footprint being lower (97.2%) and higher than the straight-line estimate (by up to 106.8%). As seen for the tier one deepwater and inshore targets, the footprints were a closer match than the aggregate areas were between the two methods, reflected in the lower and upper ranges of the ratios for the footprint compared with the aggregate area.

Table 32: The range of ratios (expressed as a percentage) for the hybrid:straight-line aggregate areas and footprints for orange rough/oreo dory Marine Stewardship Council Areas between the 2019 and 2023 fishing years. Values in parentheses represent the corresponding difference in km² between the hybrid and straight-line estimates for those corresponding ratios. Cells coloured green are for measures where the hybrid value was higher than the straight-line value in all years, cells in red are for measures where the hybrid value was lower than the straight-line values in all years, and clear cells are for measures where the hybrid value was sometimes higher and sometimes lower than the straight line value.

Target/target group	Aggregate area ratio (difference in km²)	Footprint ratio (difference in km²)
OEO/ORH - ESCR	100.7 (7.6) – 111.4 (218.4)	100.1 (0.5) – 106.2 (90.6)
OEO/ORH - NWCR	104.9 (23.0) – 121.1 (101.0)	97.2 (-11.5) – 106.8 (23.7)
OEO/ORH - 7A	103.0 (82.9) – 112.7 (266.5)	101.5 (20) – 108.7 (128.5)

10.4 Hybrid and straight-line comparisons for hoki/hake/ling bycatch assessment areas

The aggregate area was higher for the hybrid method than the straight-line in all years in all bycatch assessment areas except for WCNI 9 (Table 33). WCNI 9 had two years in which the hybrid aggregate area was higher and three years in which it was lower. For areas such as EAST 2 and NORTH 1 where fisheries for hoki, hake, and ling are minor, the range of ratios seen is relatively small. But for areas where there are significant fisheries for these species the range of ratios is large in comparison e.g. WCSI 7, SUBA 6, and CHAT 4. For some of these areas the hybrid aggregate is more than double that of the straight-line estimate and equates to differences of thousands of square kilometres (up to 9615.3 km² more for a ratio of 130.5% in CHAT 4).

Less than half (four of nine) of the areas had larger hybrid footprints in every year (WCSI 7, PUYS 5, STEW 5, and SUBA 6). Two areas had smaller hybrid footprints in all years (COOK 8 and EAST 2), and three areas had a mix of smaller and larger hybrid footprints in some years (WCNI 9, SQUAK 6, CHAT 4, and NORTH 1). As with the other targets or target groups looked at in this study, the footprints were a closer match than the aggregate areas were between the two methods, reflected in the lower and upper ranges of the ratios for the footprint compared with the aggregate area.

Table 33: The range of ratios (expressed as a percentage) for the hybrid:straight-line aggregate areas and footprints for hoki/hake/ling bycatch assessment areas between the 2019 and 2023 fishing years. Values in parentheses represent the corresponding difference in km² between the hybrid and straight-line estimates for those corresponding ratios. Cells coloured green are for measures where the hybrid value was higher than the straight-line value in all years, cells in red are for measures where the hybrid value was lower than the straight-line values in all years, and clear cells are for measures where the hybrid value was sometimes higher and sometimes lower than the straight line value.

Target/target group	Aggregate area ratio (difference in km²)	Footprint ratio (difference in km²)
HOK/HAK/LIN - WCNI 9	97.9 (-0.7) – 103.2 (1.8)	91.8 (-4.4) – 99.8 (-0.2)
HOK/HAK/LIN - WCSI 7	161.8 (4769.0) – 235.4 (8122.7)	123.2 (994.5) – 147.5 (1528.2)
HOK/HAK/LIN - PUYS 5	135.7 (218.4) – 199.4 (660.0)	112.4 (50.2) – 139.6 (177.3)
HOK/HAK/LIN - STEW 5	178.1 (5460.0) – 210.1 (4963.8)	109.6 (344.2) – 115.3 (438.0)
HOK/HAK/LIN - SQUAK 6	108.7 (42.8) – 142.7 (253.3)	87.3 (-46.6) – 114.8 (75.1)
HOK/HAK/LIN - SUBA 6	161.8 (982.4) – 284.8 (2146.0)	136.8 (299.2) – 172.3 (665.1)
HOK/HAK/LIN - CHAT 4	123.4 (6323.3) – 130.5 (9615.3)	96.9 (-407.0) – 101.7 (209.2)
HOK/HAK/LIN - COOK 8	109.3 (52.1) – 133.6 (147.5)	86.7 (-23.7) – 95.1 (-6.7)
HOK/HAK/LIN - EAST 2	101.1 (2.0) – 120.4 (21.7)	93.4 (-33.3) – 99.7 (-0.3)
HOK/HAK/LIN - NORTH 1	101.0 (13.7) – 104.0 (34.2)	78.9 (-120.2) – 100.9 (6.0)

11. DISCUSSION

The analyses presented here represent estimates of swept areas for bottom-contacting trawling within the EEZ+TS, with the main analyses restricted to the ‘fishable area’; that is, a seafloor area that is open to trawling, to a maximum depth of 1600 m, that provides a comparable seafloor area across all years. Interpretation of relative measures depends on the fitness of the data and the relevance of the underlying assumptions.

In some early years, particularly in the deepwater data, some legitimate effort is not included because the trawling took place before a closure was implemented (for example, closure of seamounts took place from 2001). In total, the retained data represented 97.6% of the All Stocks total aggregate area, and 96.9% of the footprint for all tows, including those totally in closed areas, on land, in depths over 1600 m, or portions of tows that crossed into closed areas or onto land (see Appendix B). For much of the non-retained portion, it is highly unlikely that the location data are correct, for either the whole tow or for either the start or end position; there is no way of knowing where this effort should be located and its exclusion from analyses is the best course of action.

Table A2 indicates that while there was a lot of inshore trawl effort reported on CELR forms prior to 2008 (53 620–98 389 tows), the nature of this form means that data cannot be included in an analysis that requires tow-by-tow data. The TCER form was introduced in 2008, allowing for tow-by-tow reporting of trawl effort and it is from then that the All Stocks data are presented so that both inshore and deepwater effort can be included together. Prior to 2008, any analyses of All Stocks data are almost entirely deepwater effort. Some CELR data continued to be collected between 2008 and 2019, but only a very small amount (4862 tows, or 0.4% of CELR tows for the 34-year time period).

For the deepwater fleet, trawl contact is represented mainly by TCEPR, a small amount on TCER during 2008–2020, then mainly by ERS from 2018. The inshore component is represented by the TCER form in most years except for a small amount of effort during 2018–2020 as the ERS form was being phased in, but from 2018 most effort has been recorded by ERS. The ERS data are comparable to the TCEPR other than the increased precision of the resolution of the start and end positions of the former. The TCER data are comparable with the TCEPR data except the former reports only the start of tow data, and the estimated swept area of each TCER tow is developed using a tow distance calculated from the reported duration × speed that is then represented as a straight-line to generate a potential tow endpoint (see Methods); whereas the TCEPR tow is represented by a straight-line distance between reported start and end positions.

As previously noted by Baird & Mules (2021a, b), this method of track line creation inevitably creates a disparity in the swept areas and a straight-line may be more relevant for some trawl tows than others. The duration × speed distance may take into account the track line that follows contours (a more realistic track), but when applied as a straight-line the spatial representation may place parts of the tow in unlikely depths. Similarly, the straight-line representation of TCEPR and ERS data does not account for any trawling that includes U-turns or other trawl paths that deviate from a straight-line. MacGibbon & Mules (2023) developed methods under project BEN2020-01 to use Geospatial Position Reporting (GPR) data as a first step towards addressing this issue. These methods were expanded on in this study and applied to a variety of specific target fisheries to investigate potential differences between the traditional straight-line methodology used in the past and methods that use GPR data. It also sought to investigate the feasibility of retrospectively inferring track lines of tows where GPR data is not available, using more recent GPR data as the basis. These aspects of the study are discussed below.

The development of the footprint would also be enhanced by a better representation of the likely width of the trawl gear on the seafloor. Doorspread data by tow are not collected; only wingspread data are reported. The use of electronic gear providing doorspread by tow is not universal, although most deepwater fleet vessels are likely to have this capability. When observers have been on commercial trawlers, the doorspread data they report generally is the same for every tow. An approach was made to the deepwater and inshore industry prior to work commencing on footprint project BEN2020-01 in an attempt to improve the doorspread values that had been applied in the past. This would have been especially valuable for the inshore data where the vessel size and potentially gears used vary between areas and target fisheries. However, it was agreed by the Aquatic Environment Working Group (which included industry representatives), that the previously used values for the different vessel length categories would be adequate and were still used in the previous two projects (BEN2020-01 and BEN2022-01) and in this study here.

Swept area analysis summary
All summaries here for the swept area analysis are referring to the straight-line data set that spans the full range of years for the respective areas (2008–2023 for All Stocks and inshore, 1990–2023 for deepwater).

The All Stocks footprint for 2008–2023 was estimated to be between about 68 780 and 94 500 km^2 each year, decreasing over the 16 years, with the lowest value estimated for 2023. These data reflect the decreasing amount of bottom-contacting trawl effort during these years; the numbers of tows in the TCEPR, TCER, and ERS data steadily dropped from 91 920 in 2010 to 59 963 in 2023. The annual aggregate areas for All Stocks decreased overall from a peak of 162 870 km^2 in 2010 to the nadir of 121 374 km^2 in 2023. The number of cells contacted was more variable during this time period although, predictably, the years with the lowest footprint and aggregate areas (2020–2023) also have the lowest numbers of cells contacted. The All Stocks footprint contacted between 1.7% and 2.3% of the EEZ+TS seafloor and between 5.0% and 6.8% of the fishable area each year. One notable limitation of the All Stocks data set is that in order for the inshore and deepwater components it is comprised of to be comparable, the time period covered needs to be truncated to 2008 onwards when inshore fisheries can be adequately represented. This means that there is a long period of deepwater data excluded and inshore data for which we have no information. This is highlighted by the larger numbers of new cells contacted by the All Stocks data set each year compared with the deepwater data set.

In the 34-year time series for deepwater data, there was a steady increase in the footprint from under 48 000 km^2 in 1990 to a sustained period of contact during 1998 to 2003 (range 72 001 to 80 545 km^2), followed by a steady decrease to 39 649 km^2 in 2020 (the lowest of the 34-year time series), with a slight increase to around 42 000–43 000 km^2 over the last three years. Declines have been seen for most deepwater targets and the swept area data reflect the drop in effort. The annual aggregate areas have decreased from around 150 000–171 200 km^2 during 1997–2003 to under 100 000 km^2 from 2006 on, with a nadir in 2009 (78 924 km^2), between about 79 500 and 88 700 km^2 during 2010–2017, before another peak at 95 600 km^2 in 2018, before dropping again thereafter. The 2023 estimate of 79 906 km^2 is the third lowest aggregate area in the time series. In total, the deepwater analysis estimated a 34-year total of 3 773 288 km^2 aggregate area and 357 847 km^2 footprint, representing 8.7% of the EEZ+TS and 25.9% of the fishable area. Between 1990 and 2007, the annual footprint contacted between 1.2% and 2.0% of the EEZ+TS and 3.4% and 5.8% of the fishable area (peaks in 2002 and 2003); whereas, between 2008 and 2022, the annual footprint contacted 1.0–1.2% and 2.9–3.7% of the fishable area (lowest value in 2020).

The 2008–2023 inshore footprint also decreased, from a peak of about 46 680 km^2 in 2010 to a nadir of 27 843 km^2 in 2023. This contact was equivalent to 0.7–1.1% of the EEZ+TS seafloor area and 2.1–3.4% of the fishable area, with the lowest value from 2023. The aggregate areas during these years ranged between the low in 2023 (41 394 km^2) and the peak in 2010 (75 857 km^2).

New cells contacted
New cells contacted are identified as a way to assess if new areas are being trawled and see if fisheries may be expanding into new territory. There are some limitations to this approach that need to be discussed here. The different time periods of the three main data sets mean that what are apparently new areas may not actually be new. For example, of All Stocks, deepwater, and inshore; deepwater has the earliest start with the 1990 fishing year and the base on which new cells are then identified covers the longest period (1990–1994). However, deepwater fishing had been carried out for many years prior to this and it is possible that cells identified as 'new' may have been contacted before but there is no way of knowing this. Likewise, the All Stocks and inshore data sets begin in 2008 and each take that year as their base, due to the limitations of the time period of comparable reporting that is available.

The deepwater and inshore footprints also overlap with one another. A cell that may be new to one data set might not be new to the other. This is also true of any analyses that look at the new areas trawled by individual target species as many fisheries, especially inshore ones, overlap with one another and effectively operate as mixed target fisheries. Target-level analyses may be useful to see if new areas are being trawled when certain species are targeted but are not likely to be useful when looking at new areas as a whole.

New areas trawled are also based on determining what cells have never been contacted previously without any consideration for the extent of the contact. But in some cases new areas may be trawled within a portion of a cell that has been contacted before. In such cases, the new *area* trawled will not be identified because it is not a new *cell*.

The number of new cells contacted each year has the potential to be of value and should continue to be summarised. Whether or not it is useful will depend on the questions managers are seeking to answer. Where managers do think that it would be useful, the best option is likely to be looking at new cells contacted by All Stocks as a whole, and if appropriate, conducting more detailed subsequent analyses to determine what particular target species may be involved. Preferably, this should be done using a hybrid approach as this gives a more realistic representation of trawl paths taken. The straight-line approach may miss cells that have been contacted or possibly misidentify cells as having been contacted that weren't, particularly for fisheries that may follow curved areas around contours such as arrow squid (see Appendix E).

While some cells may be incorrectly identified as new because they haven't been contacted since data collection methods allowed, this is not likely to be a problem long term. They will increasingly likely be identified as contacted in the following years as data collection has improved, even more so via accurate mapping using GPR data. With time, any cells identified as being new are more likely to be legitimately so or have not been contacted in so long that they are potentially noteworthy.

For data prior to 2019, the straight-line method is all there is to go on. While not ideal, it may still provide some indication as to whether new areas are being fished or not. If the straight-line approach is used in the future, it may still provide some indication that fishing is occurring in new areas. While the straight-line method may not always create the most realistic trawl tracks, if it identifies new areas this still suggests some change *may* be occurring in fishing patterns, even if further work may be needed to build up an accurate picture of that change. If this appears to be happening increasingly for a given area and is for some reason of interest or concern, discussions between fisheries managers and the fishing companies involved could clarify what is occurring if a truly accurate picture is needed.

Retrospectively applying GPR data to infer more realistic trawl track lines

This component of the study showed promise that it could be achieved but was not pursued further after the initial analyses showed it was feasible. After a presentation of the progress on this component of the project given to the Aquatic Environment Working Group on 18 November 2024, it was agreed by members that it was not worth pursuing further.

The reasons for this were that while it might be possible to produce standard tows from existing GPR data and retrospectively apply this to historical straight-line data, there are also potential issues. Using present day fishing patterns to infer past fishing patterns is quite possibly fraught with problems. Fishing behaviour may have changed over time for a variety of reasons including shortened tow times to improve catch quality in some fisheries. Catch sensors may also have changed tow times. Fish abundance and distributions may have changed, and a succession of different skippers over times also might cause overall fishery characteristics to have changed. Also, this exercise applied more widely to historical data would require very large computational power, quite likely an Artificial Intelligence approach.

Even if the exercise was successful, it may be of limited value to present management needs anyway. We now have GPR data going back to the 2019 fishing year, and almost complete coverage from the 2020 fishing year on (more than 90% of tows). Assuming that the GPR methods produce a more realistic representation of actual trawl paths (which is likely), with several years of data and with this increasing, the information will be there for managers to use and answer *current* management questions. These questions could be "is trawling occurring in an area where an application for a marine farm or reserve has been made", or "how intense is current trawling in a given area and how long may recovery of sensitive benthic habitats take given the current level of trawling?". The second question *may* benefit from as long a time series as possible (in which retrospective data might be useful) but the first question is less likely to, and the current (and ongoing) collection of GPR data should be sufficient to meet management needs.

Comparison of the hybrid and straight-line method

Comparison of the hybrid and straight-line methods for the All Stocks, deepwater, and inshore data sets showed that the number of cells contacted was lower in all years for All Stocks and inshore for the hybrid method, overall. For deepwater, some years had higher numbers of cells contacted and some years lower. The differences however were generally small, especially in the context of the total number of cells contacted.

All three data sets showed larger overall aggregate areas in all years for the hybrid data. Given how far hybrid tow lines can deviate from the equivalent straight tow lines (see Figure 17), this is not surprising. Summaries for aggregate area and the number of tows for contacted cells also showed higher numbers for both measured for the hybrid data set compared with the straight-line. This is likely to be because tows derived from GPR data are longer than the straight-line equivalents which increases the likelihood that a cell is contacted. Increased numbers of tows in a cell will logically increase the aggregate area in a cell.

All three data sets also showed larger overall footprints in all years for the hybrid data, although the ratios are typically smaller for the footprints than they are for the aggregate areas. It is not surprising that aggregate ratios tend to be bigger. For the footprint, once the tows that define the spatial extent of a footprint have been established, further tows cannot add to the total footprint. Whether using straight-line or hybrid methods, the margins of a trawl footprint are likely to be defined by variables such as topography and species distribution, even though tows inside of the outer margins may be quite different for the two methods. But the aggregate area is added to within the footprint by every successive tow. This allows the hybrid aggregate area to be substantially larger as hybrid tows will only ever be longer than their straight-line equivalents (or the same where a tow really is a straight-line).

Comparisons were also made between the two methods for a variety of inshore and deepwater target/target groups. Most groups had some years where more cells overall were contacted by the hybrid method and others where more cells were contacted by the straight-line method. Generally, the differences for the number of cells contacted between the two methods for a group, these were small. Larger differences were seen for scampi and squid though, and this appears to be a result of fishing areas such as the Veryan and Mernoo Banks, and other areas where contours are followed. Trawl lines derived from GPR data are likely to show a more realistic path around a contour, as vessels maintain appropriate depths for the species being targeted. But assuming a straight-line between end points can give the appearance of having towed directly through an area rather than around the edges of it, which 'allows' straight-line tows to potentially contact more cells than the GPR tows.

As for the All Stocks, deepwater, and inshore groups overall, the various target groups also had larger overall aggregate areas each year except for some years for the HOK/HAK/LIN bycatch assessment area WCNI 9 and one year for TAR 4. It is interesting that any hybrid aggregate area could be smaller than the equivalent straight-line estimate, given that an individual trawl track derived from GPR data should be the same distance or longer. More investigation would need to be done to determine why but the two most likely reasons are that the GPR track 'shifts' some portion of a tow outside of the defined area of a subarea being analysed into a neighbouring one, or into an area closed to trawling. Either scenario would result in some portion of a tow being excluded. If the estimates between the two methods would otherwise have been close, the hybrid estimate now has the potential to be slightly smaller than the straight-line estimate. In the four instances where the hybrid aggregate areas were smaller than their straight-line equivalents, the values were indeed close. For WCNI 9, the largest disparity was the hybrid aggregate area being 2.1% or 0.7 km^2 smaller. For TAR 4, the difference for the one year where the hybrid aggregate area was smaller was small at 4.5% or 5.6 km^2. For all other target species, though, the hybrid aggregate area was always larger as expected. For some of the larger volume fisheries such as arrow squid, jack mackerel, and hoki, the aggregate areas were substantially larger for the hybrid data set.

Footprints for the various target groups showed a wide range of differences between the hybrid and straight-line methods. Some species had higher hybrid footprints in all years, some showed a mix of higher and lower estimates, and a few had lower hybrid footprints in all years. Overall, the footprint was usually larger for the hybrid data. A single tow derived from GPR data will always be longer than the equivalent tow that assumes a straight-line, or at least the same length if the tow was a perfect straight-line. This means that individual GPR tows will have larger footprints than their straight-line equivalents, but when considering the *overall* extent of the footprint from *all* tows, the straight-line can potentially be larger if it artificially makes tows traverse areas such as foul ground or go through bottom depths not appropriate for a particular target species. GPR tows are less likely to do this and thus are not ‘allowed’ to go into some areas, resulting in a smaller footprint in some areas or target fisheries.

Given the resolution at which the footprint and aggregate areas can be plotted and the wide area covered, the plots for the various groups were not very informative. However, it can be seen in Figures 16 and 17 (see Sections 6 and 7.1) that the trawl paths can differ greatly between the two methods. The ability to plot tows using GPR data would still be invaluable at small spatial scales, particularly when trying to map as accurately as possible the fishing activity in an area that is, for example, being proposed as a marine reserve, or an aquaculture farm.

It should be kept in mind that many of the individual targets or target groups that were examined are likely to have significant overlap with other fisheries operating in the same geographic area, particularly (but not only) for inshore fisheries. The extent and intensity of other overlapping fisheries needs to be considered when assessing another fishery for various management purposes. In particular, the new cells contacted by one target fishery might not be new to another target fishery. Or one target fishery may have contacted a previously untouched *portion* of a previously contacted cell. This was not done here for individual fisheries. To do so would require comparing the footprint of a given individual fishery of interest with all other fisheries in the area, *minus* the fishery of interest to see where overlap may have occurred. This was not done in this project as the budget did not allow it but is possible and may be useful for any analyses that may occur on a smaller geographic scale if relevant for the particular management objectives being investigated.

While the utility of retrospectively applying the method (if possible) to data that pre-dates GPR is likely to be of limited utility, hybrid data should be used going forward as it is likely to provide a more realistic representation of the trawl footprint and the aggregate area. While analyses involving GPR data are more time consuming and complicated, they are not massively so since processing times have been exponentially reduced since BEN2020-01 when it was first investigated. The data are available and coverage is now widespread across the New Zealand fleet. The advantages are sufficient that the hybrid method is preferable. The more realistic trawl paths created will provide a more accurate representation of the footprint, especially its extent. The aggregate area is often substantially increased which is important for estimating the intensity of fishing – an important metric for identifying the degree of fishing effort and also for assessing benthic impacts and possible recovery times. Accurate portrayal of the paths tows take will also help to assess how the establishment of reserves, marine farms etc. may impact fishing activity in an area. It will also decrease the possibility that some tows will incorrectly be placed in closed areas, again resulting in a better estimation of the footprint and aggregate areas. Finally, for any analyses where correcting for the position of the net is likely to be useful, the use of GPR data will probably improve this, particularly for tows where the path taken deviates substantially from a straight line between the start and end positions.

There will still be a need however to include the straight-line methods as there will be times when individual tows have no associated GPR data due to, for example, equipment failure or tows beginning and ending in between pings. Prior to the introduction of GPR devices during the 2019 fishing year, the straight-line method is all that is available and so this approach should continue to be taken for this time period. As such, going forward, the approach would need to remain a *hybrid* one, where GPR data is used when available, and a straight-line approach taken when it is not. The majority of events have associated GPR data, and when available, should be used.

12. POTENTIAL RESEARCH

The development of methods to retrospectively apply standard tows developed from GPR data to past data that pre-dated GPR data was halted due to the lack of computational power and lack of AI ability to apply the data over historical data sets. Despite this, it was found that there is still the *potential* that standard tows could be detected widely through all effort data once this problem has been solved. The detection of vessel behavioural patterns could enable analysts to tell the difference between steaming, searching, and active fishing behaviour in the fleet which could then be quantified for use in catch-per-unit-effort analyses. It could also potentially be used to detect the likely direction of tows used in historical TCER data where only start positions were reported, thus enabling more accurate footprints and aggregate areas to be estimated.

13. FULFILMENT OF BROADER OUTCOMES

The development of methods to retrospectively apply standard tows developed from GPR data to past data that pre-dated GPR data was halted due to the lack of computational power and lack of AI ability to apply the data over historical data sets. However, the remaining budget on this component of the project was utilised to support the investigation of a further ten target/target groups than had originally been planned for the comparisons between the hybrid and straight-line methods.

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15. REFERENCES

Baird, S.J.; Hewitt, J.E.; Wood, B.A. (2015). Benthic habitat classes and trawl fishing disturbance in New Zealand waters shallower than 250 m. *New Zealand Aquatic Environment and Biodiversity Report No. 144*. 184 p.

Baird, S.J.; Mules, R. (2019). Extent of bottom contact by New Zealand commercial trawl fishing for deepwater Tier 1 and Tier 2 target species determined using CatchMapper software, fishing years 2008–18. *New Zealand Aquatic Environment and Biodiversity Report No. 229*. 106 p.

Baird, S.J.; Mules, R. (2021a). Extent of bottom contact by commercial fishing activity in New Zealand waters, 1989–90 to 2017–18. *New Zealand Aquatic Environment and Biodiversity Report No. 259*. 143 p.

Baird, S.J.; Mules, R. (2021b). Extent of bottom contact by commercial trawling and dredging in New Zealand waters1989–90 to 2018–19. *New Zealand Aquatic Environment and Biodiversity Report No. 260*. 157 p.

Baird, S.J.; Wood, B.A. (2018). Extent of bottom contact by New Zealand commercial trawl fishing for deepwater Tier 1 and Tier 2 target fishstocks, 1989–90 to 2015–16. *New Zealand Aquatic Environment and Biodiversity Report No. 193*. 102 p.

Baird, S.J.; Wood, B.A.; Bagley, N.W. (2011). Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989–90 to 2004–05. *New Zealand Aquatic Environment and Biodiversity Report No. 73*. 143 p.

Black, J.; Tilney, R. (2017). Monitoring New Zealand's trawl footprint for deepwater fisheries: 1989–90 to 2012–13. *New Zealand Aquatic Environment and Biodiversity Report No. 176*. 65 p.

Black, J.; Wood, R.; Berthelsen, T.; Tilney, R. (2013). Monitoring New Zealand's trawl footprint for deepwater fisheries: 1989–1990 to 2009–2010. *New Zealand Aquatic Environment and Biodiversity Report No. 110*. 57 p.

Fisheries New Zealand (2019). National Fisheries Plan for Deepwater and Middle-depth Fisheries 2019. Fisheries New Zealand Technical Paper No: 2019/03. 34 p.

Fisheries New Zealand (2020). Fisheries Assessment Plenary, May 2020: stock assessments and stock status. Compiled by the Fisheries Science Group, Fisheries New Zealand, Wellington, New Zealand.

Fisheries New Zealand (2022). National Inshore Finfish Fisheries Plan October 2022. 41 p. https://www.mpi.govt.nz/dmsdocument/54529-National-Inshore-Finfish-October-2022.

MacGibbon, D.J.; Mules, R. (2023). Extent and intensity of bottom contact by commercial trawling and shellfish dredging in New Zealand waters, 1990–2021. *New Zealand Aquatic Environment and Biodiversity Report No. 316*. 174 p.

MacGibbon, D.J.; Mules, R.; Goode, S. (2024). Extent and intensity of bottom contact by commercial trawling in New Zealand waters, 1990–2022. *New Zealand Aquatic Environment and Biodiversity Report No. 344*. 80 p.

Osborne, T.A. (2018). Forecasting quantity of displaced fishing Part 2: CatchMapper – Mapping EEZ catch and effort. *New Zealand Aquatic Environment and Biodiversity Report No. 200*. 168 p.

R Core Team (2024). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. http://www.R-project.org.

APPENDIX A

Table A1: Number of bottom-contacting tows in the 1990–2023 TCER/TCEPR/ERS data set retained for the spatial analysis, by form type. 'NA' means not assigned to a stock.

Form type	Deepwater	Inshore	NA	Total
ERS - Trawl	143 020	148 299	285	291 604
TCE	30 974	503 853	1 163	535 990
TCP	1 130 832	320 233	735	1 451 800
All	1 304 826	972 385	2 183	2 279 394

Table A2: Number of records and number of tows reported as trawl tows on CELRs, and the number of tows in the raw data set prior to grooming, number of tows retained and the percentage of the trawl retained for analysis TCER/TCEPR/ERS data, for 1990–2023. NB: 'Retained' tows are those tows that survive the grooming process (i.e. have acceptable fishing effort values) and that were inside the fishable area.

	CELR		TCER/TCEPR/ERS		
Fishing year	Number of records	Number of tows	Number of tows	Retained	% retained
1990	27 106	80 031	45 406	37 719	83.1
1991	29 923	93 390	54 539	45 545	83.5
1992	30 123	98 389	59 205	50 634	85.5
1993	32 140	96 538	63 876	53 365	83.5
1994	29 610	87 153	65 708	53 295	81.1
1995	28 640	88 076	74 060	59 072	79.8
1996	25 296	78 522	83 427	68 434	82.0
1997	26 437	87 479	86 985	72 684	83.6
1998	24 557	88 391	90 250	78 807	87.3
1999	25 322	79 415	84 891	71 354	84.1
2000	22 854	64 840	76 695	66 541	86.8
2001	21 094	60 938	73 973	64 612	87.3
2002	19 657	55 833	72 483	65 774	90.7
2003	20 759	59 472	70 990	64 734	91.2
2004	20 346	57 425	64 258	58 888	91.6
2005	21 182	59 618	60 842	55 755	91.6
2006	19 910	56 014	54 412	50 664	93.1
2007	19 098	53 620	50 028	46 164	92.3
2008	477	1 282	87 831	84 657	96.4
2009	622	1 766	85 428	82 292	96.3
2010	167	437	91 920	88 744	96.5
2011	58	157	85 556	81 595	95.4
2012	63	195	84 204	80 043	95.1
2013	63	173	83 574	79 249	94.8

	CELR		TCER/TCEPR/ERS		
Fishing year	Number of records	Number of tows	Number of tows	Retained	% retained
2014	74	268	84 830	79 756	94.0
2015	38	103	78 570	73 372	93.4
2016	87	306	77 639	72 950	94.0
2017	39	154	77 754	73 259	94.2
2018	-	-	75 121	69 640	92.7
2019	5	21	71 428	65 594	91.8
2020	-	-	66 346	61 841	93.2
2021	-	-	64 777	61 413	94.8
2022	-	-	59 963	56 792	94.7
2023	-	-	57 819	54 733	94.7
All	445 747	1 350 006	2 464 788	2 229 971	90.5

APPENDIX B

Table B1: Reasons for tows from the All Stocks data set not being included in the fishable area analysis because they were inside closed areas, on the land, or beyond 1600 m, by form type for 2008–2023. Note that some tows may be in more than one category (e.g., part of a tow was on land and also in a closed area), hence totals are greater than the sum of the individual categories for exclusion.

	On land			In closed area			>1600m			Outside fishable area		
Fishing year	ERS - Trawl	TCE	TCP	ERS - Trawl	TCE	TCP	ERS - Trawl	TCE	TCP	ERS - Trawl	TCE	TCP
2008	0	189	0	0	201	78	0	21	93	0	497	177
2009	0	100	1	0	130	55	0	17	62	0	329	121
2010	0	113	2	0	193	107	0	9	49	0	400	163
2011	0	115	0	0	160	86	0	18	45	0	347	130
2012	0	102	2	0	336	64	0	13	40	0	536	106
2013	0	67	9	0	323	52	0	19	25	0	476	88
2014	0	81	3	0	366	48	0	14	60	0	558	107
2015	0	63	0	0	313	32	0	20	43	0	435	75
2016	0	66	0	0	268	61	0	25	40	0	390	104
2017	0	84	5	0	180	41	0	15	47	0	324	90
2018	0	53	1	18	147	5	5	17	1	23	250	8
2019	10	89	1	40	149	1	12	11	1	69	278	3
2020	18	1	0	260	0	0	14	0	0	301	1	0
2021	65	0	0	17	0	0	7	0	0	101	0	0
2022	16	0	0	10	0	0	8	0	0	36	0	0
2023	12	0	0	5	0	0	14	0	0	34	0	0
All	121	1 123	24	350	2 766	630	60	199	506	564	4 821	1 172

Table B2: Swept areas for TCER, TCEPR, and ERS data that were inside the EEZ outer boundary and the percentage retained for the 'fishable' area summaries for All Stocks, by fishing year, where 'Out' gives the swept area not included in the final spatial analysis (outside the fishable area), 'Inside' gives the estimated swept area within the fishable area, and '% kept' gives the percent retained in the 'fishable' area analyses.

	Aggregate area (km^2)			Footprint (km^2)		
Fishing year	Outside	Inside	% kept	Outside	Inside	% kept
2008	5 430.0	154 219.6	96.6	4 250.6	92 148.1	95.6
2009	4 954.0	151 961.1	96.8	3 851.2	90 060.5	95.9
2010	5 594.7	162 870.6	96.7	4 306.9	94 536.1	95.6
2011	4 988.3	156 172.6	96.9	3 935.2	91 584.1	95.9
2012	5 100.6	152 278.4	96.8	3 923.8	88 006.0	95.7
2013	4 897.0	146 203.1	96.8	3 757.6	85 794.1	95.8
2014	4 918.6	151 882.2	96.9	3 728.2	90 360.1	96.0
2015	3 919.2	149 183.0	97.4	3 086.3	89 084.7	96.7
2016	4 017.3	146 385.9	97.3	3 109.0	86 314.8	96.5
2017	4 032.3	154 371.7	97.5	3 178.3	88 093.4	96.5
2018	3 536.9	158 128.4	97.8	2 800.6	88 413.4	96.9
2019	2 837.2	142 230.7	98.0	2 329.7	80 235.5	97.2
2020	931.0	128 893.7	99.3	652.9	69 784.2	99.1
2021	479.1	129 285.7	99.6	432.5	73 996.4	99.4
2022	247.4	124 125.7	99.8	213.7	70 566.3	99.7
2023	257.1	121 374.1	99.8	216.0	68 779.6	99.7
All	56 140.9	2 329 566.6	97.6	43 772.3	1 347 757.2	96.9

APPENDIX C

Table C1: Percent of deepwater tows by data collection form type, the number of tows, and number of vessels (based on unique vessel key) by fishing year for 1990–2023. ERS is Electronic Reporting System, TCE is Trawl Catch Effort Return, and TCP is Trawl Catch Effort Processing Return.

Year	ERS (%)	TCE (%)	TCP (%)	Total	Vessel count
1990	–	–	100.0	34 179	127
1991	–	–	100.0	42 310	148
1992	–	–	100.0	45 488	150
1993	–	–	100.0	46 570	137
1994	–	–	100.0	46 792	148
1995	–	–	100.0	49 175	157
1996	–	–	100.0	50 366	153
1997	–	–	100.0	53 570	165
1998	–	–	100.0	58 242	149
1999	–	–	100.0	53 557	136
2000	–	–	100.0	50 676	109
2001	–	–	100.0	48 631	101
2002	–	–	100.0	50 123	103
2003	–	–	100.0	49 301	101
2004	–	–	100.0	42 400	95
2005	–	–	100.0	39 878	87
2006	–	–	100.0	36 943	80
2007	–	–	100.0	33 349	72
2008	–	9.0	91.0	33 899	112
2009	–	7.7	92.3	29 715	107
2010	–	8.9	91.1	30 580	116
2011	–	8.6	91.4	28 290	115
2012	–	9.1	90.9	27 216	105
2013	–	11.5	88.5	25 906	101
2014	–	11.8	88.2	26 916	106
2015	–	10.7	89.3	26 692	104
2016	–	10.3	89.7	27 117	105
2017	–	8.7	91.3	26 409	99
2018	73.7	8.8	17.6	26 622	96
2019	84.4	5.7	9.9	26 134	89
2020	99.9	–	–	26 415	89
2021	100.0	–	–	25 438	81
2022	100.0	–	–	24 042	82
2023	100.0	–	–	23 821	71
Total	11.2	2.4	86.4	1 266 762	–
Total unique vessels					569

APPENDIX D

Table D1: Total number of tows by year for the All Stocks data set, number of straight-line tows (tows for which there was no corresponding GPR data), number of GPR tows, and the % of total tows made up of GPR tows by fishing years 2019–2023.

Fishing year	Total tows	Straight-line tows	GPR tows	% GPR
2019	65 536	33 603	31 933	48.7
2020	61 827	4 962	56 865	92.0
2021	61 481	3 061	58 420	95.0
2022	56 771	2 484	54 287	95.6
2023	54 710	1 630	53 080	97.0

Table D2: The number of vessels with median GPR ping rates under 11 minutes, the number of vessels with median GPR ping rates greater than or equal to once every 11 minutes, and the corresponding percentage of total vessels with those ping rates for the All Stocks data set.

Fishing year	N vessels with median GPR rate <11 mins	N vessels with median GPR rate >=11 mins	Total	% <11 mins	% >=11 mins
2019	93	53	146	63.7	36.3
2020	118	49	167	70.7	29.3
2021	117	45	162	72.2	27.8
2022	111	40	151	73.5	26.5
2023	115	25	140	82.1	17.9

Table D3: Total number of tows by year for the deepwater data set, number of straight-line tows (tows for which there was no corresponding GPR data), number of GPR tows, and the % of total tows made up of GPR tows by fishing years 2019–2023.

Fishing year	Total tows	Straight-line tows	GPR tows	% GPR
2019	4 641	21 454	26 095	82.2
2020	2 560	23 833	26 393	90.3
2021	2 057	23 362	25 419	91.9
2022	1 274	22 750	24 024	94.7
2023	924	22 882	23 806	96.1

Table D4: The number of vessels with median GPR ping rates under 11 minutes, the number of vessels with median GPR ping rates greater than or equal to once every 11 minutes, and the corresponding percentage of total vessels with those ping rates for the deepwater data set.

Fishing year	N vessels with median GPR rate <11 mins	N vessels with median GPR rate >=11 mins	Total	% <11 mins	% >=11 mins
2019	32	49	81	39.5	60.5
2020	40	48	88	45.5	54.5
2021	36	45	81	44.4	55.6
2022	43	39	82	52.4	47.6
2023	47	24	71	66.2	33.8

Table D5: Total number of tows by year for the inshore data set, number of straight-line tows (tows for which there was no corresponding GPR data), number of GPR tows, and the % of total tows made up of GPR tows by fishing years 2019–2023.

Fishing year	Total tows	Straight-line tows	GPR tows	% GPR
2019	28 916	10 471	39 387	26.6
2020	2 400	33 005	35 405	93.2
2021	1 001	34 951	35 952	97.2
2022	1 210	31 497	32 707	96.3
2023	706	30 178	30 884	97.7

Table D6: The number of vessels with median GPR ping rates under 11 minutes, the number of vessels with median GPR ping rates greater than or equal to once every 11 minutes, and the corresponding percentage of total vessels with those ping rates for the inshore data set.

Fishing year	N vessels with median GPR rate <11 mins	N vessels with median GPR rate >=11 mins	Total	% <11 mins	% >=11 mins
2019	93	26	119	78.2	21.8
2020	116	24	140	82.9	17.1
2021	115	23	138	83.3	16.7
2022	105	22	127	82.7	17.3
2023	100	15	115	87.0	13.0

APPENDIX E

COMPARISONS BETWEEN THE HYBRID AND STRAIGHT-LINE METHODS FOR SELECTED DEEPWATER LAYERS

JMA – Spatial extent

The summaries in this section are for all tows targeting jack mackerel throughout the EEZ.

The annual total numbers of cells, aggregate swept area, and footprint for all JMA fishstocks are given in Table E1. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 106.6% and 110.3%, or a difference of between 78 and 141 cells.

The ratio for the aggregate area was between 166.6% and 197.7%, or a difference of between 2479 and 4704 km^2.

The ratio for the footprint was between 137.2% and 145.7% or a difference of between 1285 and 1592 km^2.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure E1. At this resolution, there is no appreciable difference.

JMA – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table E2 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 100% (an exact match) to 287.5% This apparent disparity is at the upper end of the scale, however, it shows that there is little difference between the two data sets as the total is just 15 cells (23 vs 8 cells in 2019).

Higher ratios are seen for the aggregate area, ranging between 107.1% and 666.7%. Again, the apparent large disparity is only due to the values in each data set being so low that any departure is large when expressed as a proportion. In fact, the largest ratio of 666.7% is a difference of 2.0 vs 0.3 km^2 and is for the 2022 fishing year when the number of new cells contacted was the same for the two data sets.

For the footprint, the ratio ranged between 107.1% and 633.3% but as for the aggregate area, while the ratios may appear high, the actual differences are low (between -1.4 and 6.6 km^2.)

When comparing the footprint as a percentage of the aggregate area, there was almost an exact match between the two data sets (95–100%). This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

JMA – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table E3). The ratio between the two data sets for the median number of tows that contacted a cell was 120% but this was for a difference of just one tow. The ratio for the mean number was 138% and this represented a difference of 7.2 tows. The ratio for the maximum number of tows was 160 and represented a more substantial difference of 161 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 142%, though there is little actual difference (3.4 vs 2.4 km^2). The mean is again higher for the hybrid data (ratio of 170%, or 16.4 vs 9.6 km^2). The most substantial difference is for the maximum (197%) or 295.5 vs 150.4 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure E2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference. There is however, a need to have different categories with higher upper ranges for the hybrid data set for all years combined. The overall spatial location of intensity is much the same however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 150%, which represents a difference of just 1 km^2, 3 vs 2 km^2. The mean footprint has a ratio of 120%, or 6 vs 5 km^2. The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table E4. The annual ratio for the median number of tows that contacted a cell ranged from 100–150%, or 0–1 tows. For the mean, the ratio ranged from 126–145% or a maximum difference of 3.6 tows. For the maximum, the annual ratio ranged from 131–177%, or a maximum difference of 72 tows.

The annual median ratios for the aggregate areas in a cell ranged from 127–146%, and the means from 156–182%. In terms of km^2, the differences are low, no more than 3.3 km^2. The maximum aggregate area shows more substantial differences, with ratios ranging from 186–258% or 27.4–81.3 km^2.

The annual median ratios for the footprint in a cell ranged from 121–142% but in no year did the actual difference in square kilometres exceed 0.5. The ratio for the mean footprint varied little each year, ranging from 128–133%, and represented a difference between data types of no more than 1 km^2. The ratios for the maximum footprint ranged from 112–151%. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and they were generally fairly close to one another for both data types, but always slightly larger for the hybrid data.

JMA – Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure E3, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted, though the hybrid data set tends to have higher number of cells contacted overall (Figure E3, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure E4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen spatially.

Table E1: Number of cells contacted, aggregate area, and footprint for JMA for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1 230	1 115	110.3	5 767.7	3 289.0	166.6	4 097.8	2 813.2	145.7
2020	1 103	1 017	108.5	6 250.5	3 633.3	172.0	4 072.3	2 902.2	140.3
2021	1 301	1 160	112.2	6 356.8	3 528.4	175.4	4 102.1	2 818.5	145.5
2022	1 262	1 184	106.6	6 737.9	4 044.6	180.2	4 482.0	3 266.7	137.2
2023	1 299	1 205	107.8	9 520.4	4 816.4	197.7	5 239.0	3 647.5	143.6

Table E2: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for JMA. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	23	8	287.5	9.7	3.2	303.1	9.7	3.2	303.1	100.0	100.0	100.0
2020	5	4	125.0	1.5	1.4	107.1	1.5	1.4	107.1	100.0	100.0	100.0
2021	9	5	180.0	5.6	3.5	160.0	5.6	3.5	160.0	100.0	100.0	100.0
2022	2	2	100.0	2.0	0.3	666.7	1.9	0.3	633.3	95.0	100.0	95.0
2023	8	7	114.3	3.4	2.7	125.9	3.4	2.7	125.9	100.0	100.0	100.0

Table E3: **Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for JMA, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.**

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	6.0	5.0	120.0
Aggregate area	<0.1	<0.1	–	0.9	0.8	113.0	3.4	2.4	142.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	3.0	2.0	150.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	26.4	19.2	138.0	24.0	19.0	126.0	428	267	160.0
Aggregate area	16.4	9.6	171.0	14.4	9.3	155.0	295.5	150.4	197.0
Footprint	6.0	5.0	120.0	9.0	7.0	129.0	25.0	25.0	100.0

Table E4: **Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for JMA, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.**

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	3.0	3.0	100.0	7.6	5.9	129.0	9.0	7.5	120.0	62.0	39.0	159.0
2020	1.0	1.0	100.0	4.0	3.0	133.0	9.1	7.2	126.0	10.0	9.0	111.0	84.0	64.0	131.0
2021	1.0	1.0	100.0	3.0	2.0	150.0	8.1	6.2	131.0	7.0	6.0	117.0	102.0	68.0	150.0
2022	1.0	1.0	100.0	4.0	3.0	133.0	8.6	6.5	132.0	10.0	8.0	125.0	116.0	78.0	149.0
2023	1.0	1.0	100.0	3.0	3.0	100.0	11.6	8.0	145.0	12.0	10.0	120.0	166.0	94.0	177.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.5	140.0	1.6	1.2	133.0	4.7	2.9	162.0	5.6	4.0	140.0	47.8	20.4	234.0
2020	0.7	0.5	140.0	1.9	1.5	127.0	5.7	3.6	158.0	6.0	4.4	136.0	63.5	34.1	186.0
2021	0.6	0.5	120.0	1.5	1.1	136.0	4.9	3.0	163.0	4.3	3.1	139.0	80.8	37.1	218.0
2022	0.8	0.6	133.0	1.9	1.4	136.0	5.3	3.4	156.0	5.9	4.0	148.0	87.3	39.4	222.0
2023	0.7	0.6	117.0	1.9	1.3	146.0	7.3	4.0	182.0	7.4	4.5	164.0	132.8	51.5	258.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.5	140.0	1.5	1.2	125.0	3.3	2.5	132.0	4.5	3.6	125.0	20.8	13.8	151.0
2020	0.7	0.5	140.0	1.7	1.4	121.0	3.7	2.9	128.0	4.8	4.0	120.0	22.3	18.4	121.0
2021	0.6	0.5	120.0	1.4	1.1	127.0	3.2	2.4	133.0	3.7	2.8	132.0	23.0	20.1	114.0
2022	0.8	0.6	133.0	1.8	1.4	129.0	3.6	2.8	129.0	4.6	3.7	124.0	23.4	19.7	119.0
2023	0.7	0.6	117.0	1.7	1.2	142.0	4.0	3.0	133.0	5.5	4.0	138.0	24.7	22.0	112.0

Plots removed for data confidentiality reasons.

Figure E1: Distribution of the JMA footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure E2: Distribution of the JMA aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

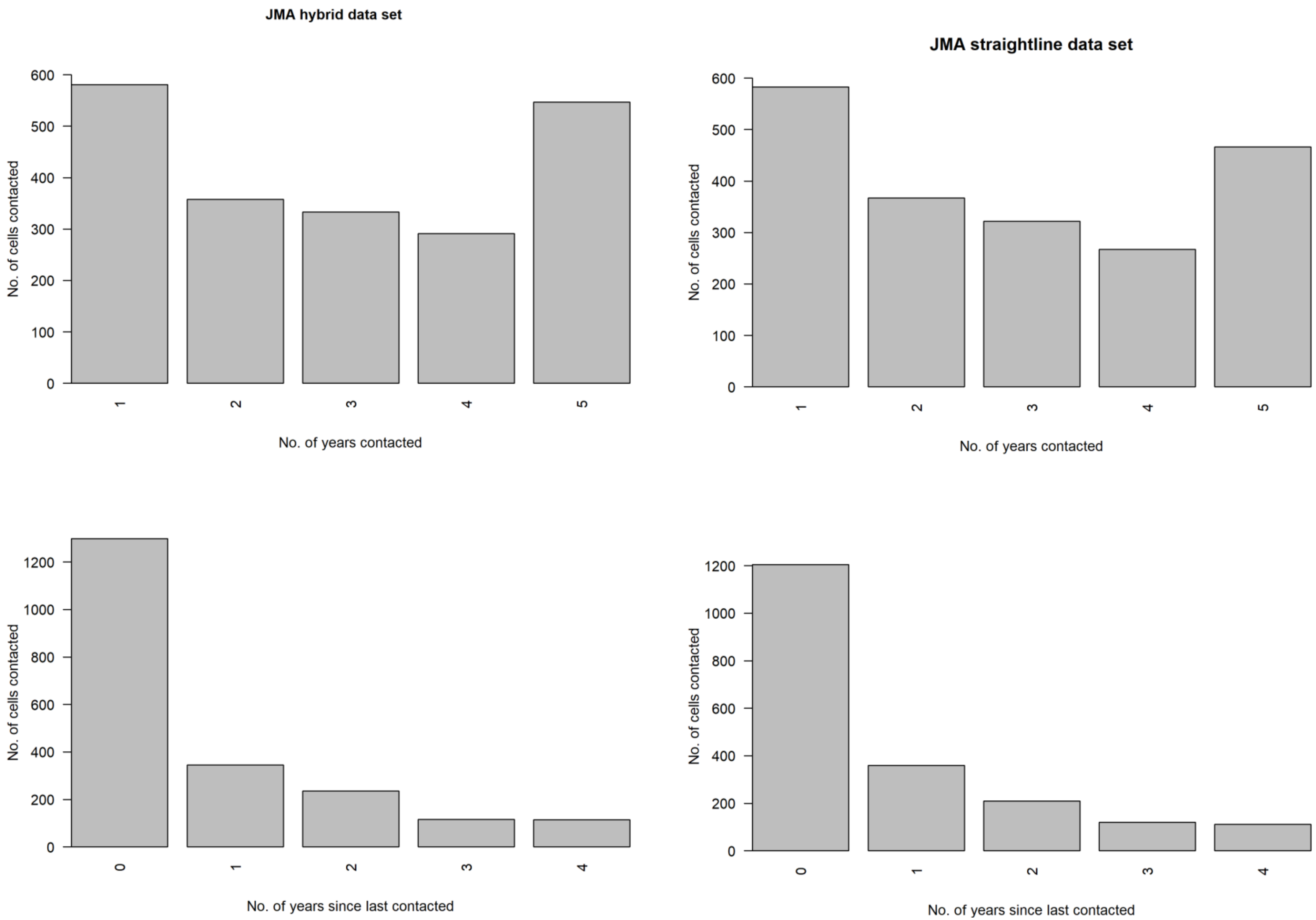

Figure E3: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure E4: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

SCI – Spatial extent

The summaries in this section consist of all tows targeting scampi throughout the EEZ.

The annual total numbers of cells, aggregate swept area, and footprint for all scampi fishstocks are given in Table E5. For the five-year period the hybrid:straight-line ratio of cells contacted ranged from 87.1–94.3%, or a difference of between -129 and -37 cells.

The ratios for the aggregate area however were above 100% each year, indicating that the hybrid aggregate area each year is higher than the straight-line area, even if fewer cells have been contacted. Ratios ranged from 108.2–112.4%, or a difference of between 672 and 11 145 km^2. While the straight-line data set has a smaller aggregate area than the hybrid data set, it is still possible for it to have contacted more cells than the hybrid data set. Straight-line tows can appear to have crossed through areas where the equivalent curved line derived from GPR data has not. Assuming the GPR data is a better representation of reality, GPR tows may have gone around a feature – perhaps to avoid foul ground, or to maintain the appropriate depth around a contour to best catch the target species. The equivalent straight-line tow will appear to have gone through the middle of what is being avoided (see for example the right hand plot in Figure 16).

The ratio for the footprint was between 96.6% and 100.3% or a difference of between -157 and 14.4 km^2. This suggests that the majority of tows targeting scampi are in fact relatively straight-lines; the ratios are all close to 100%.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure E5. At this resolution, no difference can be seen between the two.

SCI – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table E6 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 0 (in 2022 when the hybrid data set contacted no new cells and the straight-line contacted three) to 123.5%. While this is a wide range in ratios, the differences between the number of cells between the hybrid and straight-line data sets is actually very low, ranging from 1–5.

Ratios for the aggregate area of new cells contacted ranged between 0% and 108.1%. As for the number of cells contacted, the aggregate area values are very low, ranging from -0.7 to 1.4 km^2.

For the footprint, the ratio was the same in every year as for the aggregate area, except slightly higher in 2023. This is because so few new cells were contacted between the two years, and these most likely represented the very edges of established areas, and the footprint and aggregate area are nearly identical.

When comparing the footprint as a percentage of the aggregate area, the ratios were 100% or close to in every year. This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the outer edges of established areas.

SCI – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table E7). The ratio between the two data sets for the median number of tows that contacted a cell was 175% but this was for a difference of just six tows. The ratio for the mean number was 122% and this represented a more substantial difference 33.1 tows. The ratio for the maximum number of tows was 108%, or a difference of 119 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are still not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 180%, though there is little actual difference (2.0 vs 1.1 km^2). The mean is slightly higher for the hybrid data (ratio of 120%, or 41.1 vs 32.9 km^2). There is almost no difference between the two data sets for the maximum values, with a ratio of 104%, or 433.1 vs 417.9 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure E6 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). For all years combined, there is almost no difference that can be seen in either the spatial distribution or the intensity of fishing therein. When looking at just the most recent fishing year, the spatial distribution is again almost identical between the two data sets but the intensity is higher for the hybrid data with more cells coloured red (higher intensity) in most of the main fishing areas.

As with the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 200%, but this represents a difference of just 1 km^2, 2 vs 1 km^2. The mean footprint has a ratio of 100%, an exact match with 7 km^2 for each data type. Both data sets contains cells that have been completely contacted, with footprints equal to 25 km^2, hence the ratio of the maximum footprint is a perfect match of 100%.

The same summary information by year is given in Table E8. The annual ratio for the median number of tows that contacted a cell ranged from 122–225%, or 7.5–11.5 tows. For the mean, the ratio ranged from 113–122% or a maximum difference of 9.8 tows. For the maximum, the annual ratio ranged from 104–116%, or a maximum difference of 45 tows in any one year.

The annual median ratios for the aggregate area in a cell ranged from 126–229%, but none of the differences represent more than 2.3 km^2. The ratios for the mean range from 115–124%, but represent no more than 2.5 km^2. The ratios for the maximum aggregate area range from 96–113%, and represents a maximum difference of 12.3 km^2.

The annual median ratios for the footprint in a cell range from 111–186% but in no year did the actual difference in square kilometres exceed 1.2. Ratios for the mean footprint ranged from 103–113%, but this represents a maximum difference of only 0.6 km^2. The ratios for the maximum footprint ranged from 100–103%, but both datasets had maximum footprint values very close to 25 km^2, the maximum possible so the resulting ratios were very close.

SCI – Number of years contacted

There is little difference in the distribution between the two data sets when comparing the number of years cells were contacted, but the hybrid data set did have close to 100 fewer cells that were contacted in just one year of the time period, and 100 fewer cells that were contacted in every year (Figure E7, upper two plots). Numbers of cells are similar between the two data sets for 2–4 years of contact.

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted, although the hybrid data set tends to have fewer cells contacted overall (Figure E7, lower two plots). For both, the most recent fishing year had the largest number of cells at about 750 for the hybrid and just over 800 for the straight-line data set. The numbers were similar between the two data sets for those that had been contacted between 1 and 4 years ago at around 50, 70, 50, and 300 cells respectively.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure E8 (upper two plots) and for the most recent year contacted (lower two plots). At this resolution, there is little difference that can be seen between the two data sets.

Table E5: Number of cells contacted, aggregate area, and footprint for SCI for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	870	999	87.1	8 899.1	8 226.8	108.2	4 426.9	4 506.0	98.2
2020	668	726	92.0	9 312.0	8 436.0	110.4	4 367.5	4 485.1	97.4
2021	624	668	93.4	10 509.3	9 574.9	109.8	4 456.3	4 613.3	96.6
2022	616	653	94.3	9 755.8	8 915.5	109.4	4 502.2	4 535.0	99.3
2023	748	805	92.9	10 354.9	9 209.8	112.4	4 820.5	4 806.1	100.3

Table E6: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for SCI. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	82	80	102.5	18.7	17.3	108.1	18.6	17.2	108.1	99.5	99.4	100.1
2020	1	6	16.7	0.3	1.0	30.0	0.3	1.0	30.0	100.0	100.0	100.0
2021	21	17	123.5	6.6	6.2	106.5	6.6	6.2	106.5	100.0	100.0	100.0
2022	0	3	0.0	0.0	0.7	0.0	0.0	0.7	0.0	–	100.0	–
2023	8	9	88.9	4.2	7.4	56.8	4.0	7.2	55.6	95.2	97.3	97.8

Table E7: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for SCI, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.	100.0	1.0	1.0	100.0	14.0	8.0	175.0
Aggregate area	<0.1	<0.1	–	0.3	0.3	100.0	2.0	1.1	181.8
Footprint	<0.1	<0.1	–	0.0	0.0	–	2.0	1.0	200.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	184.0	150.9	121.9	293.2	209.8	139.8	1710.0	1591.0	107.5
Aggregate area	41.1	32.9	124.9	54.7	36.1	151.5	433.1	417.9	103.6
Footprint	7.0	7.0	100.0	13.0	13.0	100.0	25.0	25.0	100.0

Table E8: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for SCI, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	13.5	6.0	225.0	46.9	38.6	122.0	77.0	61.5	125.0	326.0	302.0	108.0
2020	6.0	4.0	150.0	38.0	27.0	141.0	62.4	53.1	118.0	102.0	88.0	116.0	334.0	289.0	116.0
2021	7.0	5.0	140.0	42.0	34.5	122.0	74.2	64.4	115.0	119.2	106.2	112.0	444.0	427.0	104.0
2022	7.8	5.0	156.0	50.5	39.0	129.0	70.4	62.3	113.0	108.0	102.0	106.0	429.0	389.0	110.0
2023	5.0	3.0	167.0	39.0	28.0	139.0	62.1	53.4	116.0	95.2	75.0	127.0	490.0	470.0	104.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	1.6	0.7	229.0	10.2	8.2	124.0	16.0	11.6	138.0	70.2	69.8	101.0
2020	0.9	0.6	150.0	6.5	4.2	155.0	13.9	11.6	120.0	22.1	19.1	116.0	87.5	77.3	113.0
2021	0.8	0.6	133.0	7.3	5.8	126.0	16.8	14.3	117.0	27.0	23.4	115.0	123.9	111.6	111.0
2022	0.9	0.6	150.0	8.7	6.9	126.0	15.8	13.7	115.0	25.3	20.5	123.0	105.2	101.0	104.0
2023	0.6	0.4	150.0	6.4	4.6	139.0	13.8	11.4	121.0	21.3	16.4	130.0	137.5	143.6	96.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	1.3	0.7	186.0	5.1	4.5	113.0	9.3	7.7	121.0	23.5	23.5	100.0
2020	0.8	0.5	160.0	4.3	3.1	139.0	6.5	6.2	105.0	10.9	10.9	100.0	23.8	23.1	103.0
2021	0.8	0.6	133.0	4.7	4.1	115.0	7.1	6.9	103.0	12.4	12.6	98.0	24.7	24.7	100.0
2022	0.8	0.6	133.0	5.4	4.8	113.0	7.3	6.9	106.0	12.7	12.6	101.0	24.6	24.4	101.0
2023	0.6	0.4	150.0	4.0	3.6	111.0	6.4	6.0	107.0	10.9	10.1	108.0	24.9	24.6	101.0

Plots removed for data confidentiality reasons.

Figure E5: Distribution of the SCI footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure E6: Distribution of the SCI aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

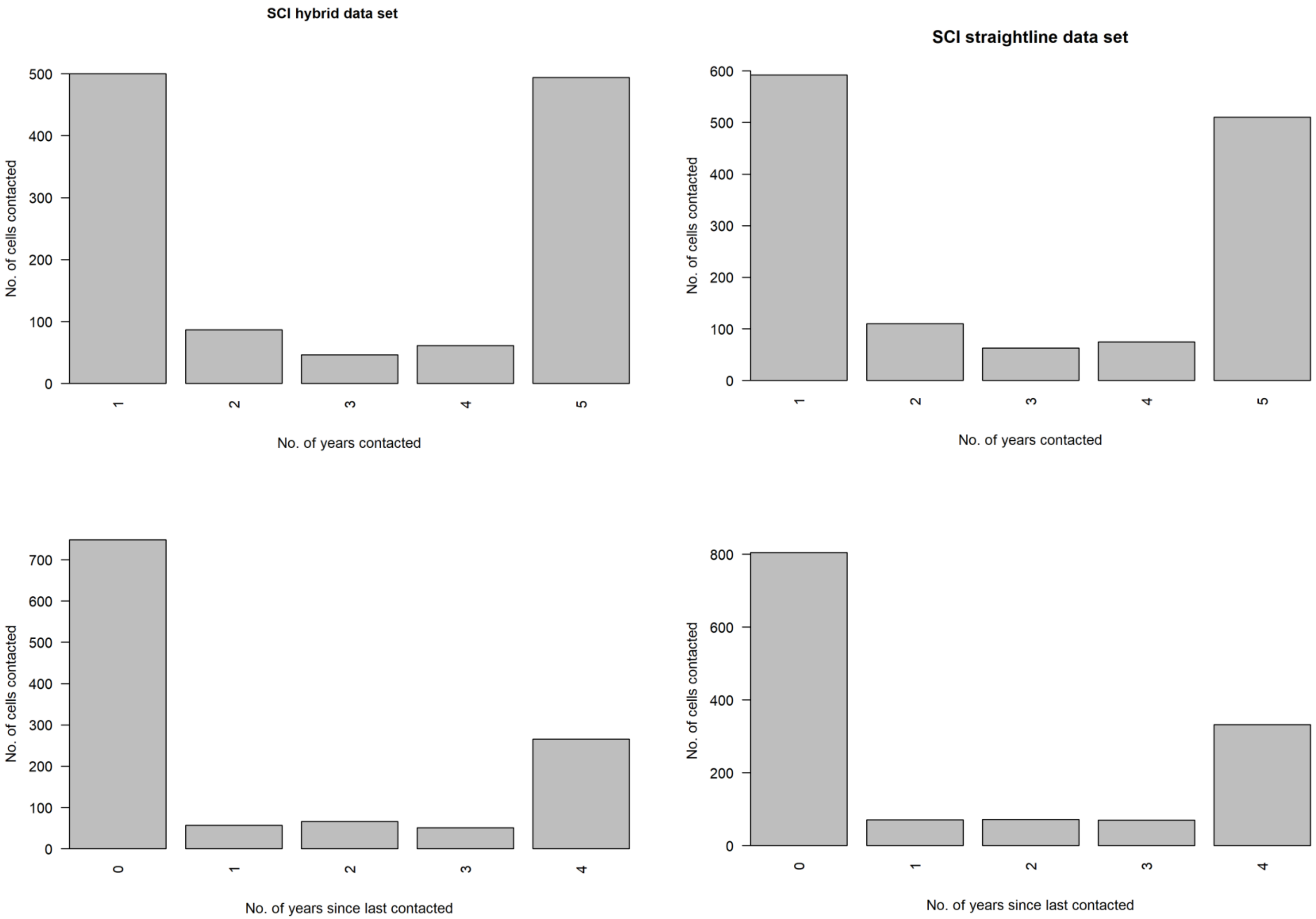

Figure E7: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure E8: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left_ and the straight-line data (right).

SQU – Spatial extent

The summaries in this section consist of all tows targeting arrow squid throughout the EEZ.

The annual total numbers of cells, aggregate swept area, and footprint for all arrow squid fishstocks are given in Table E9. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 79.5% and 92.1%, or a difference of between -187 and -73 cells which indicates that the hybrid data set contacted fewer cells than the straight-line data set in all years.

The ratio for the aggregate area was between 153.5% and 181.7%, or a difference of between 6176 and 9418 km^2. For the number of cells contacted to be lower but the aggregate area substantially higher for the hybrid data presents a puzzle. The scampi fishery (see previous section) also showed lower numbers of cells contacted by the hybrid data but higher aggregate areas, but the disparity between the aggregate areas was much less for scampi than what is seen here for squid. As mentioned above for scampi, it is possible for the hybrid data set to have contacted fewer cells than the straight-line data set. Straight-line tows can appear to have crossed through areas where the equivalent curved line tows derived from GPR data never have. Assuming the GPR data is a better representation of reality, GPR tows may have gone around a feature – perhaps to avoid foul ground, or perhaps to maintain the appropriate depth around a contour to best catch the target species. The equivalent straight-line tow will appear to have gone through the middle of what is being avoided (see for example the far right plot in Figure 16).

As for the number of cells, the ratios for the footprint were lower for the hybrid data and were between 73.8% and 83.8% or a difference of between -632 and -935 km^2. The swept area of a single trawling event calculated using the hybrid method will always be higher than that of the same event calculated using the straight-line method, or at a minimum, equal to it if the true path of the trawl was an exact straight-line. So, at first it might seem impossible that the footprint of the hybrid data in this case is smaller than it is for the straight-line data set. However, Table E9 considers the footprint of the overall fishery, not a single event. Figure E9 shows the spatial distribution of the squid footprint. Most of it is associated with contours around circular shaped areas such as the Mernoo and Veryan Banks on the Chatham Rise, the Stewart-Snares Shelf, and around the Auckland Island Shelf. If most tows targeting squid are following a curved path, the overall footprint calculated from these tows will be smaller than the same footprint calculated assuming tows are a straight-line. A single tow derived from GPR data will always be longer than the equivalent tow that assumes a straight-line, or at least the same length if the tow was a perfect straight-line. This means that individual GPR tows will have larger footprints than their straight-line equivalents, but when considering the *overall* extent of the footprint from *all* tows, the straight-line can potentially be larger if it artificially makes tows traverse areas such as foul ground, or go through bottom depths not appropriate for the targeting of a species. GPR tows are less likely to do this, and thus are not ‘allowed’ to go into some areas, resulting in a smaller footprint.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure E9. The straight-line plots appear to cover a wider area around the contours. This is particularly noticeable for example around the Veryan Bank on the Chatham Rise which is roughly circular in shape when looking at a contour plot. It appears to have been completely contacted when looking at the straight-line plot for all years combined. This has likely occurred as a result of straight-lines going from the one side of the bank to the other side. This gives the appearance of the tow having gone over the top of the bank, which is unlikely. Aside from the potential of encountering foul ground on the top of the Veryan Bank, there would be a large change in depth which might not be suitable for targeting squid at an optimal depth. The hybrid plot shows a different story: the edges of it are fished, making it appear as a ring shape which is more likely – fishing around the edges, avoiding foul and maintaining depths favourable to targeting squid. This pattern explains why the hybrid data set has contacted fewer cells, has a smaller footprint, but a larger aggregate area, when compared with the straight-line data set.

SQU – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table E10 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 73.9% to 103.4%. This represents a difference of between -8 and 1 cell.

Aside from the 2019 fishing year, ratios are less than 100% for both the aggregate area and footprint suggesting that the areas for each measure are lower for the hybrid data. This will likely be for the same reason as described above for the overall footprint. The ratio values for the footprint are almost identical to those for the aggregate area, because the swept areas are almost identical. This is most likely because the new areas fished are on the margins of previously established areas, or possibly minor exploratory fishing.

When comparing the footprint as a percentage of the aggregate area, there was almost an exact match in the ratio between the two data sets (95.7–100%). This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

SQU – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table E11). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (four tows each). The ratio for the mean number was 142% and this represented a more substantial difference (99 vs 69.5 tows). The ratio for the maximum number of tows was 135% and represented a substantial difference of 472 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 70%, though there is little actual difference (1.2 vs 1.6 km^2). The mean is higher for the hybrid data (ratio of 180%, or 59.8 vs 32.7 km^2). The most substantial difference is for the maximum (210%) or 1904.5 vs 895.9 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure E10 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution is similar, although there appears to be a slightly wider area covered by the straight-line data set, likely for the reasons discussed above. The overall areas of highest intensity though are essentially the same.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 100%, which represents an exact match with 1 km^2. The mean footprint has a ratio of 80%, but this represents a difference of just 1 km^2, 4 vs 5 km^2. The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is an exact match of 100%.

The same summary information by year is given in Table E12. The annual ratio for the median number of tows that contacted a cell ranged from 100–200%, or 0–3 tows. For the mean, the ratio ranged from 134–172% or a maximum difference of 15.2 tows. For the maximum, the annual ratio ranged from 116–161%, or a maximum difference of 131 tows in any one year.

The annual median ratios for the aggregate areas in a cell ranged from 112–125%, and the means from 166–228%. In terms of square kilometres the differences are low. The maximum aggregate area ratios range from 138–262%.

The annual median ratios for the footprint in a cell ranged from 93–114% but in no year did the actual difference in square kilometres exceed 0.2. The ratio for the mean footprint ranged from 90–95%. The ratios for the maximum footprint ranged from 84–102%. There was generally a close match between the two data types because the maximum possible footprint for a cell is 25 km^2 (the total area of a cell) and both data types had maximum footprints close to the maximum possible.

SQU – Number of years contacted

The distribution for the number of years a cell is contacted is similar between the two data sets, although the hybrid data set has a higher number of cells that were contacted in one year only, and the straight-line data set has more cells that were contacted in 2–5 years (Figure E11, upper two plots).

The distribution was also quite similar between the two data sets for the number of years since a cell was last contacted (Figure E11, lower two plots). There are however slightly more cells contacted by the straight-line data set, most noticeably for the cells contacted in the most recent fishing year (zero years since last contact) with around 900 cells contacted compared with just over 700 for the hybrid data set.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure E12 (upper two plots) and for the most recent year contacted (lower two plots). The two data sets are broadly similar, but there is some difference with the straight-line data set covering a broader area due to the nature of the fishery fishing around contours so much. In terms of the number of years contacted and the most recent year contacted for a cell, the two data sets are broadly similar.

Table E9: Number of cells contacted, aggregate area, and footprint for SQU for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	846	919	92.1	21 693.3	14 128.0	153.5	3 276.7	3 908.5	83.8
2020	930	1088	85.5	26 005.2	16 587.3	156.8	3 441.8	4 291.4	80.2
2021	907	1019	89.0	19 902.0	11 823.6	168.3	3 396.9	4 157.1	81.7
2022	850	986	86.2	16 753.6	9 329.2	179.6	3 307.2	4 208.7	78.6
2023	725	912	79.5	13 736.0	7 560.4	181.7	2 629.4	3 564.3	73.8

Table E10: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for SQU. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	30	29	103.4	13.5	11.7	115.4	13.4	11.7	114.5	99.3	100.0	99.3
2020	63	71	88.7	41.7	50.0	83.4	39.3	48.2	81.5	94.2	96.4	97.7
2021	17	23	73.9	8.0	9.3	86.0	7.9	9.3	84.9	98.8	100.0	98.8
2022	6	6	100.0	2.3	2.5	92.0	2.2	2.5	88.0	95.7	100.0	95.7
2023	14	17	82.4	7.4	7.9	93.7	7.4	7.9	93.7	100.0	100.0	100.0

Table E11: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for SQU, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	4.0	4.0	100.0
Aggregate area	<0.1	<0.1	–	0.4	0.5	80.0	1.2	1.6	75.0
Footprint	<0.1	<0.1	–	0.0	0.0	–	1.0	1.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	99.0	69.5	142.4	48.0	41.0	117.1	1825.0	1353.0	134.9
Aggregate area	59.8	32.7	182.9	17.7	14.8	119.6	1904.5	895.9	212.6
Footprint	4.0	5.0	80.0	6.0	8.0	75.0	25.0	25.0	100.0

Table E12: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for SQU, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	6.0	5.0	120.0	44.1	33.0	134.0	36.0	28.5	126.0	495.0	414.0	120.0
2020	1.0	1.0	100.0	4.0	4.0	100.0	47.4	32.2	147.0	31.0	20.0	155.0	744.0	644.0	116.0
2021	1.0	1.0	100.0	5.0	4.0	125.0	36.2	25.0	145.0	33.0	24.0	138.0	432.0	301.0	144.0
2022	1.0	1.0	100.0	5.0	5.0	100.0	31.4	19.9	158.0	28.8	19.0	152.0	297.0	185.0	161.0
2023	1.0	1.0	100.0	6.0	3.0	200.0	29.7	17.3	172.0	28.0	17.0	165.0	281.0	191.0	147.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	2.0	1.6	125.0	25.6	15.4	166.0	13.9	9.8	142.0	484.4	278.3	174.0
2020	0.4	0.5	80.0	1.6	1.4	114.0	28.0	15.2	184.0	10.7	7.2	149.0	562.4	406.6	138.0
2021	0.5	0.5	100.0	1.6	1.4	114.0	21.9	11.6	189.0	12.5	8.7	144.0	445.2	202.6	220.0
2022	0.5	0.5	100.0	1.8	1.6	112.0	19.7	9.5	207.0	12.7	7.5	169.0	304.5	116.4	262.0
2023	0.5	0.6	83.0	1.8	1.5	120.0	18.9	8.3	228.0	12.3	6.9	178.0	309.1	128.5	241.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.6	1.4	114.0	3.9	4.3	91.0	5.4	5.7	95.0	24.3	24.7	98.0
2020	0.4	0.5	80.0	1.3	1.3	100.0	3.7	3.9	95.0	4.4	4.7	94.0	25.0	24.9	100.0
2021	0.5	0.5	100.0	1.3	1.2	108.0	3.7	4.1	90.0	4.8	4.7	102.0	24.9	24.7	101.0
2022	0.5	0.5	100.0	1.4	1.5	93.0	3.9	4.3	91.0	5.4	5.5	98.0	25.0	24.6	102.0
2023	0.5	0.5	100.0	1.5	1.4	107.0	3.6	3.9	92.0	5.0	4.8	104.0	20.3	24.2	84.0

Plots removed for data confidentiality reasons.

Figure E9: Distribution of the SQU footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure E10: Distribution of the SQU aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

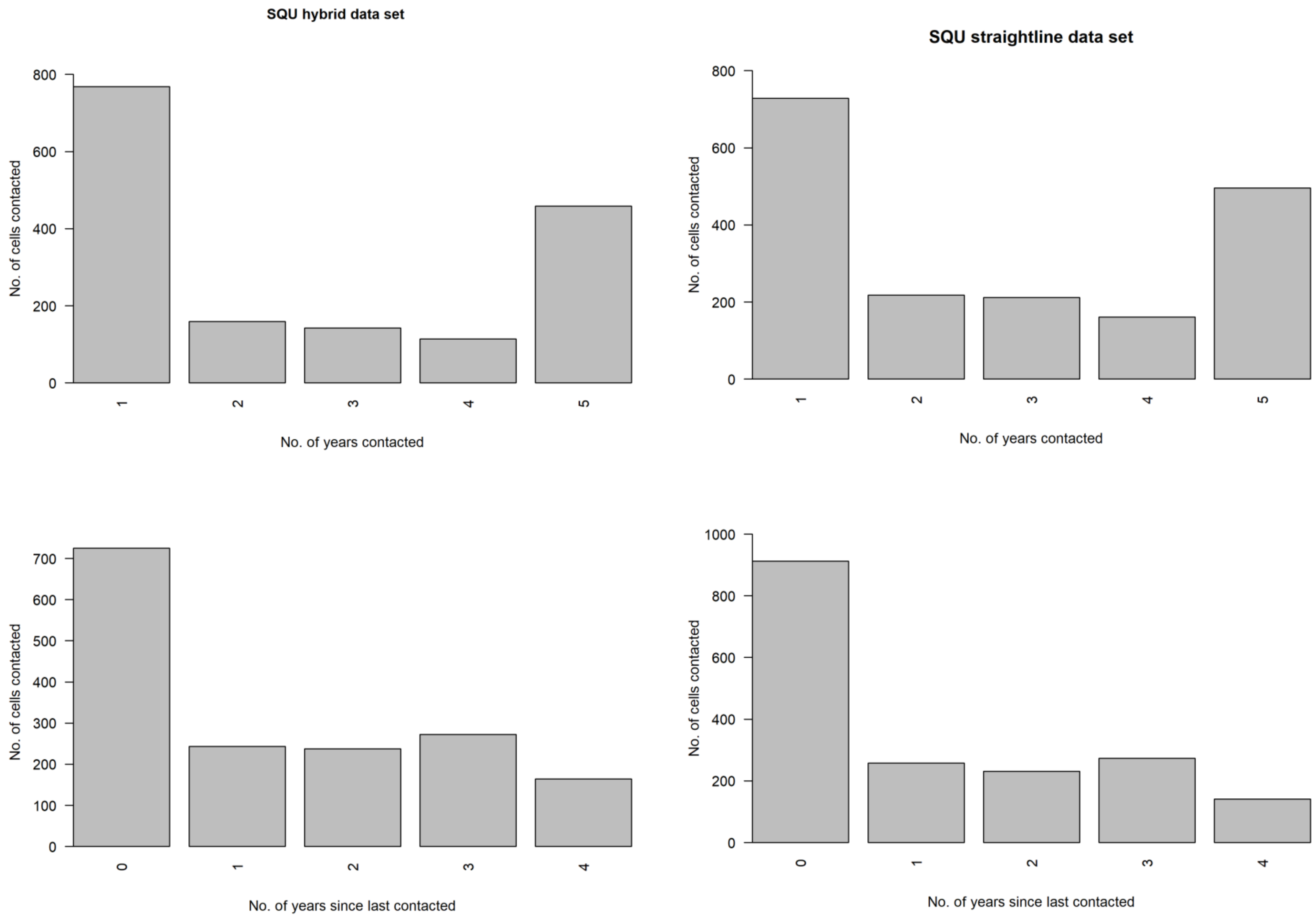

Figure E11: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure E12: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

SBW – Spatial extent

The summaries in this section consist of all tows targeting southern blue whiting.

The annual total numbers of cells, aggregate swept area, and footprint for all southern blue whiting are given in Table E13. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 105.7% and 126.5%, or a difference of between 10 and 91 cells.

The ratio for the aggregate area was between 202.7 and 260.8%, or a difference of between 355 and 1257 km^2.

The ratio for the footprint was between 166.8 and 215.7% or a difference of between 230 and 786 km^2.

The spatial extent of the footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure E13. There is little difference in the spatial distribution at this resolution, but it can be seen that the footprint is higher for the hybrid data set with some cells having been completely contacted (25 km^2 coverage) whereas for the straight-line data set this shows no cells having complete coverage.

SBW – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table E14 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 71.4% to 150% (although there was an exact match in 2020 with no new cells contacted by either data set). The differences between the number of cells between the hybrid and straight-line data sets are low, ranging from -2 to 12.

Higher ratios are seen for the aggregate area, ranging between 116.3% and 275.6%. As for the number of cells, the numbers are low, with the aggregate areas generally fairly close, ranging from 0–72 km^2. While the number of cells contacted was higher for the straight-line data set than the hybrid, in 2023, the aggregate area was slightly higher for the former.

For the footprint, the ratio ranged between 114% and 248.4% but as for the aggregate area, while the ratios may appear high, the actual differences are low (between 0 and 57.3 km^2.)

When comparing the footprint as a percentage of the aggregate area, the ratios were close between the two data sets (81.2–101.4%). This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

SBW – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table E15). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (four tows each) and for the mean it was 134 tows (a difference of 2.7 tows). For the maximum number of tows that contacted a cell, the ratio was 169%, or a difference of 46 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 170%, although there is little actual difference (2.4 vs 1.4 km^2). The mean is again higher for the hybrid data (ratio of 200%, or 17.2 vs 3.6 km^2). The most substantial difference is for the maximum (220%) or 75.9 vs 33.9 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure E14 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). For all years combined, there is not much difference in the spatial distribution, the 'hot spots' are essentially the same but it can be seen that the hybrid data set has higher values for its categories than the straight-line data set. For the most recent fishing year, the overall spatial distribution appears the same at the resolution displayed, but the values of the aggregate area are noticeably different. The hybrid data has a larger extent of the most intensely fished cells, both south and north of Campbell Island.

As with the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 200%, but this represents a difference of just 1 km^2, 2 vs 1 km^2. The mean footprint has a ratio of 170%, or 5 vs 3 km^2. The maximum footprint ratio is 130%, or 24 vs 19 km^2.

The same summary information by year is given in Table E16. The annual ratio for the median number of tows that contacted a cell ranged from 100–150%, or 0–1 tows. For the mean, the ratio ranged from 125–139% or a maximum difference of 1.7 tows. For the maximum, the annual ratio ranged from 128–188%, or a maximum difference of 16 tows.

The annual median ratios for the aggregate areas in a cell ranged from 108–200%, but all of the differences between the two data sets represent less than 1 km^2. The ratios for the mean range from 177–236%, but the actual values are close, with the largest difference being just 2.4 km^2 in 2023. The ratios for the maximum aggregate area show more substantial differences, with ratios ranging from 217–282%, representing differences of between 16 and 29 km^2.

The annual median ratios for the footprint in a cell ranged from 100–189% but in no year did the actual difference in square kilometres exceed 0.8. Ratios for the mean footprint ranged from 143–192%, but the differences between the two data sets were at most only 1.2 km^2. The ratios for the maximum footprint ranged from 141–190%, representing a difference of between just 6 and 8 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

SBW – Number of years contacted

There is little difference in the distribution between the two data sets when comparing the number of years cells were contacted, but the hybrid data set did have close to 100 more cells that were contacted in just one year of the time period (Figure E15, upper two plots). Numbers of cells are similar between the two data sets for 2–5 years of contact.

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted, though the hybrid data set tends to have a higher number of cells contacted overall (Figure E15, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure E16 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is little difference that can be seen spatially, but it can be seen that the hybrid data set has a greater extent of cells that have been contacted in the most recent fishing year, as was also illustrated in the bar plot of Figure E15.

Table E13: Number of cells contacted, aggregate area, and footprint for SBW for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	375	328	114.3	1 721.4	849.3	202.7	1 249.0	748.6	166.8
2020	184	174	105.7	602.7	247.3	243.7	462.9	232.6	199.0
2021	293	246	119.1	1 308.4	609.9	214.5	989.9	546.5	181.1
2022	310	261	118.8	914.6	378.3	241.8	768.4	356.3	215.7
2023	434	343	126.5	2 038.3	781.5	260.8	1 472.1	686.5	214.4

Table E14: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for SBW. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	11	10	110.0	16.8	14.1	119.1	16.3	13.5	120.7	97.0	95.7	101.4
2020	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2021	25	18	138.9	73.8	31.3	235.8	55.6	29.0	191.7	75.3	92.7	81.2
2022	36	24	150.0	112.7	40.9	275.6	95.9	38.6	248.4	85.1	94.4	90.1
2023	5	7	71.4	5.0	4.3	116.3	4.9	4.3	114.0	98.0	100.0	98.0

Table E15: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for SBW, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	4.0	4.0	100.0
Aggregate area	<0.1	<0.1	–	0.8	0.6	133.0	2.4	1.4	171.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	1.0	200.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	10.7	8.0	134.0	14.0	11.0	127.0	113.0	67.0	169.0
Aggregate area	7.2	3.6	200.0	9.5	5.1	186.0	75.9	33.9	224.0
Footprint	5.0	3.0	167.0	7.0	5.0	140.0	24.0	19.0	126.0

Table E16: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for SBW, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	3.0	3.0	100.0	7.1	5.7	125.0	10.0	8.0	125.0	48.0	32.0	150.0
2020	1.0	1.0	100.0	3.0	2.0	150.0	4.8	3.1	155.0	6.0	4.0	150.0	32.0	17.0	188.0
2021	1.0	1.0	100.0	3.0	3.0	100.0	6.9	5.4	128.0	10.0	8.0	125.0	38.0	27.0	141.0
2022	1.0	1.0	100.0	2.0	2.0	100.0	4.6	3.3	139.0	7.0	5.0	140.0	23.0	16.0	144.0
2023	1.0	1.0	100.0	2.0	2.0	100.0	6.5	5.0	130.0	8.0	6.0	133.0	50.0	39.0	128.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.6	0.5	120.0	1.3	1.2	108.0	4.6	2.6	177.0	5.9	4.0	148.0	44.9	15.9	282.0
2020	0.6	0.5	120.0	1.6	0.8	200.0	3.3	1.4	236.0	4.1	1.7	241.0	25.5	9.5	268.0
2021	0.7	0.5	140.0	1.6	1.2	133.0	4.5	2.5	180.0	5.9	3.3	179.0	38.8	15.2	255.0
2022	0.6	0.4	150.0	1.4	0.8	175.0	3.0	1.4	214.0	3.9	2.1	186.0	21.0	9.1	231.0
2023	0.8	0.5	160.0	1.7	0.9	189.0	4.7	2.3	204.0	5.6	2.8	200.0	49.1	22.6	217.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.6	0.5	120.0	1.2	1.2	100.0	3.3	2.3	143.0	4.9	3.7	132.0	19.6	11.9	165.0
2020	0.6	0.5	120.0	1.4	0.8	175.0	2.5	1.3	192.0	3.5	1.7	206.0	15.0	7.9	190.0
2021	0.7	0.5	140.0	1.5	1.2	125.0	3.4	2.2	155.0	5.3	3.1	171.0	18.2	11.3	161.0
2022	0.6	0.4	150.0	1.4	0.8	175.0	2.5	1.4	179.0	3.5	1.9	184.0	13.7	7.9	173.0
2023	0.8	0.5	160.0	1.7	0.9	189.0	3.4	2.0	170.0	4.8	2.7	178.0	20.8	14.8	141.0

Plots removed for data confidentiality reasons.

Figure E13: Distribution of the SBW footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure E14: Distribution of the SBW aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

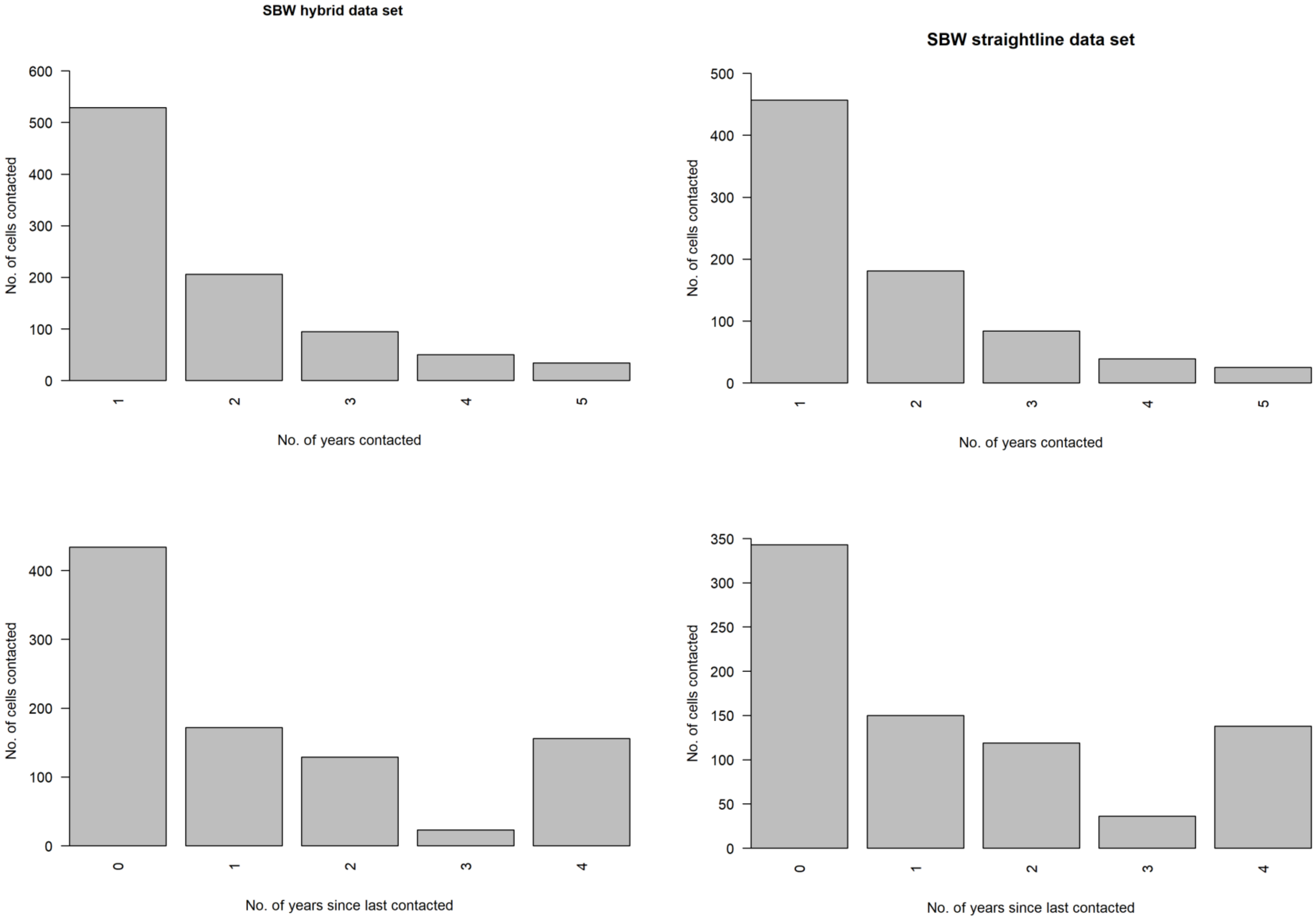

Figure E15: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure E16: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

Orange roughy – ORH 7A – Spatial extent

The summaries in this section are for all tows targeting orange roughy in Marine Stewardship Council area ORH 7A (Challenger Plateau).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table E17. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 98.7% and 103%, or a difference of between -11 and 15 cells.

The ratio for the aggregate area was between 103 and 112.7%, or a difference of between 45.9 and 266.5 km^2.

The ratio for the footprint was between 101.5 and 108.7% or a difference of between 20 and 134.3 km^2.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing year is shown in Figure E17. At this resolution, there is no appreciable difference, although in 2023 the footprint is slightly more intense in the far west of the region.

Orange roughy – ORH 7A – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table E18 where the base footprint was created for 1990–2018 using the straight-line data set. Ratios for the number of new cells contacted each year ranged between 90.2% and 333.3%. Overall numbers are low though, with the actual values ranging from -7–7 new cells each year.

The ratios for the aggregate area ranged between 100.3% and 390.9%. The actual differences are small however, the largest being by just 4.6 km^2.

Ratios for the footprint are similar to the aggregate area (99.8–390.9%), because the values for the footprint are almost the same.

As a result, when comparing the footprint as a percentage of the aggregate area, ratios were close to 100% between the two data sets (99.2–100%). This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

Orange roughy – ORH 7A – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table E19). The ratio between the two data sets for the median number of tows that contacted a cell was 100% with 15 tows each. The ratio for the mean number was 102.8% and represented a difference of just 0.6 tows. The ratio for the maximum number of tows was 132.4%, representing a more substantial difference of 68 tows between the hybrid and straight-line data sets.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 100% (7.3 km^2 for each data set). The mean is higher for the hybrid data (ratio of

104.8%, or 10.9 vs 10.4 km^2). The most substantial difference is for the maximum with a ratio of 149.1%, or 150.6 vs 101 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure E18 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference. There is, however, a need to have a higher upper range in the categories for the hybrid data set for all years combined. The overall spatial location of intensity is much the same however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 116.7%, a difference of just 1 km^2. The ratios for the mean is 100% (7 km^2 for each data set), and for the maximum, the ratio is 104.2%, a difference of just 1 km^2. The maximum footprint for the hybrid data set was equal to the area of a cell, which cannot exceed 25 km^2, but is slightly smaller for the straight-line data set.

The same summary information by year is given in Table E20. The annual median ratio for the number of tows in a cell was 100% in all years except 2019 (125%, a difference of just one tow). The ratio for the mean number of tows ranged from 99–106, which represented a maximum difference of 0.3 tows. The ratio for the maximum ranged from 88–126%, a maximum difference of 13 tows.

The annual median ratios for the aggregate areas in a cell ranged from 93–111%, representing a difference of no more than 0.2 km^2. Ratios for the mean ranged from 100–112%, or a maximum difference of 0.3 km^2. The ratios for the maximum aggregate area ranged from 101–198% or 0.4–19.1 km^2.

The annual median ratios for the footprint in a cell ranged from 93–111% but in no year did the actual difference in square kilometres exceed 0.2. The ratio for the mean footprint was very close in each year, ranging from 100–109%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 98–141%, which represented a maximum difference of 5.5 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

Orange roughy – ORH 7A – Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure E19, upper two plots) nor was there for the number of years since a cell was last contacted (Figure E19, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure E20 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen spatially.

Table E17: Number of cells contacted, aggregate area, and footprint for ORH-ORH 7A for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	475	475	100.0	1 528.5	1 482.6	103.1	1 336.2	1 316.2	101.5
2020	674	665	101.4	1 855.4	1 659.2	111.8	1 602.2	1 473.7	108.7
2021	751	729	103.0	2 804.6	2 721.7	103.0	2 492.4	2 426.8	102.7
2022	841	852	98.7	3 530.3	3 382.0	104.4	3 141.2	3 060.0	102.7
2023	686	671	102.2	2 363.8	2 097.3	112.7	1 880.7	1 746.4	107.7

Table E18: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for ORH 7A. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	32	31	103.2	98.7	94.1	104.9	93.3	89.2	104.6	94.5	94.8	99.7
2020	47	47	100.0	41.9	38.7	108.3	41.7	38.5	108.3	99.5	99.5	100.0
2021	42	38	110.5	59.3	54.3	109.2	57.0	52.6	108.4	96.1	96.9	99.2
2022	46	51	90.2	57.5	57.3	100.3	57.2	57.3	99.8	99.5	100.0	99.5
2023	10	3	333.3	4.3	1.1	390.9	4.3	1.1	390.9	100.0	100.0	100.0

Table E19: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for ORH-ORH 7A, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	4.0	75.0	15.0	15.0	100.0
Aggregate area	<0.1	<0.1	–	1.5	1.6	93.8	7.3	7.3	100.0
Footprint	<0.1	<0.1	–	2.0	2.0	100.0	7.0	6.0	116.7
	Mean			**3rd quartile**			**Maximum**		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	21.8	21.2	102.8	30.0	30.0	100.0	278	210.0	132.4
Aggregate area	10.9	10.4	104.8	15.2	15.0	101.3	150.6	101.0	149.1
Footprint	7.0	7.0	100.0	12.0	11.0	109.1	25.0	24.0	104.2

Table E20: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for ORH-ORH 7A, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	5.0	4.0	125.0	6.8	6.6	103.0	9.0	9.0	100.0	90.0	77.0	117.0
2020	1.0	2.0	50.0	3.0	3.0	100.0	5.6	5.3	106.0	6.0	6.0	100.0	63.0	64.0	98.0
2021	2.0	2.0	100.0	6.0	6.0	100.0	7.1	7.2	99.0	10.0	10.0	100.0	49.0	41.0	120.0
2022	3.0	3.0	100.0	7.0	7.0	100.0	8.4	8.1	104.0	11.0	11.0	100.0	54.0	43.0	126.0
2023	1.0	1.0	100.0	3.0	3.0	100.0	6.8	6.5	105.0	6.0	7.0	86.0	76.0	86.0	88.0
	Aggregate area 1st Quartile			**Aggregate area median**			**Aggregate area mean**			**Aggregate area 3rd Quartile**			**Aggregate area maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.7	100.0	2.1	1.9	111.0	3.2	3.1	103.0	4.3	4.3	100.0	47.1	37.4	126.0
2020	0.8	0.7	114.0	1.5	1.5	100.0	2.8	2.5	112.0	3.3	3.1	106.0	33.2	28.2	118.0
2021	0.8	0.8	100.0	2.9	3.0	97.0	3.7	3.7	100.0	5.7	5.6	102.0	30.5	20.4	150.0
2022	1.5	1.2	125.0	3.3	3.2	103.0	4.2	4.0	105.0	5.8	5.6	104.0	38.6	19.5	198.0
2023	0.7	0.6	117.0	1.3	1.4	93.0	3.4	3.1	110.0	3.5	3.4	103.0	45.0	44.6	101.0
	Footprint 1st Quartile			**Footprint median**			**Footprint mean**			**Footprint 3rd Quartile**			**Footprint maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.7	100.0	2.1	1.9	111.0	2.8	2.8	100.0	4.1	4.1	100.0	20.2	18.6	109.0
2020	0.8	0.7	114.0	1.5	1.4	107.0	2.4	2.2	109.0	3.2	3.1	103.0	18.3	16.3	112.0
2021	0.8	0.8	100.0	2.7	2.9	93.0	3.3	3.3	100.0	5.3	5.2	102.0	17.5	13.2	133.0
2022	1.5	1.2	125.0	3.2	3.1	103.0	3.7	3.6	103.0	5.3	5.2	102.0	19.0	13.5	141.0
2023	0.7	0.6	117.0	1.3	1.3	100.0	2.7	2.6	104.0	3.3	3.3	100.0	20.7	21.2	98.0

Plots removed for data confidentiality reasons.

Figure E17: Distribution of the ORH-ORH 7A footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure E18: Distribution of the ORH-ORH 7A aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

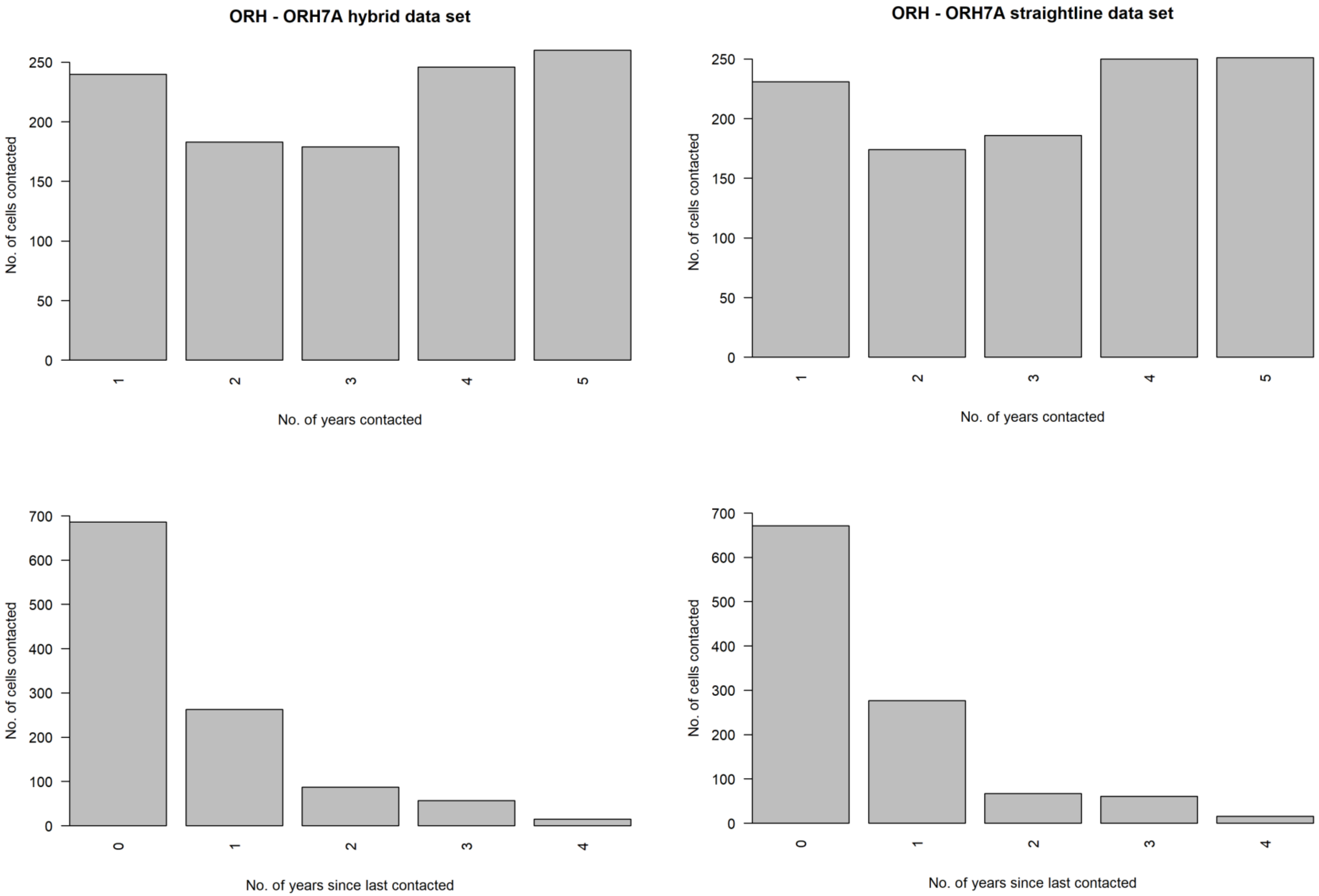

Figure E19: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure E20: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

Orange roughy NWCR – Spatial extent

The summaries in this section are for all tows targeting orange roughy in Marine Stewardship Council area NWCR (North West Chatham Rise).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table E21. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 92.9% and 104.6%, or a difference of between -15 and 11 cells.

The ratio for the aggregate area was between 104.9 and 121.1%, or a difference of between 23 and 101 km^2.

The ratio for the footprint was between 97.2 and 106.8% or a difference of between -0.9 and 23.7 km^2.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing year is shown in Figure E21. At this resolution, there is no appreciable difference.

Orange roughy NWCR – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table E22 where the base footprint was created for 1990–2018 using the straight-line data set. New cells were contacted in just 2019 and 2020, with ratios 200% and 60%, but this represented a difference of just -1 and 2 cells respectively.

The ratios for the aggregate area were vastly different between the two data sets in both years with 216.7% and 9.1% for 2019 and 2020 respectively, but the overall areas were small (0.7 and 1 km^2).

Ratios for the footprint are identical to the aggregate area, because the values for the footprint are the same.

As a result, when comparing the footprint as a percentage of the aggregate area, there was an exact match between the two data sets (100% each year). This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

Orange roughy NWCR – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table E23). The ratio between the two data sets for the median number of tows that contacted a cell was 100% with four tows each. The ratio for the mean number was 105.9% and represented a difference of just 0.7 tows. The ratio for the maximum number of tows was 119.3%, representing a difference of 23 tows between the hybrid and straight-line data sets.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 95.5%, a difference of -0.1 km^2. The ratio for the mean is higher for the hybrid data (ratio of 108.3%, 0.5 km^2). The most substantial difference is for the maximum with a ratio of 125.7%, or 52.9 vs 42.1 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure E22 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference. There is, however, a need to have different categories with higher upper ranges for the hybrid data set for all years combined. The overall spatial location of intensity is much the same however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets that the ratio is essentially meaningless. The ratios for the median and mean are both 100%, with values of 2 and 4 km^2 respectively. The ratio for the maximum footprint was 95.2%, or a difference of -1 km^2.

The same summary information by year is given in Table E24. The annual median ratio for the number of tows in a cell was 100% in all years except 2020 (150%, a difference of one tow). The ratio for the mean number of tows ranged from 100–117, which represented a maximum difference of 0.7 tows. The ratio for the maximum ranged from 100–142%, a maximum difference of 17 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–112%, representing a difference of no more than 0.1 km^2. Ratios for the mean ranged from 100–125%, or a maximum difference of 0.5 km^2. The maximum aggregate area shows more variable ratios, with values ranging from 89–224% or -0.9–14.3 km^2.

The annual median ratios for the footprint in a cell was 100% in all years except 2020 when it was 108%, a difference of just 0.1 km^2. The ratio for the mean footprint ranged from 96–112%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 77–127%, but the maximum difference this represents is just 2.2 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types, but always slightly larger for the hybrid data.

Orange roughy NWCR – Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted although the hybrid data set contains slightly more cells contacted in just one year and slightly fewer contacted in five years (Figure E23, upper two plots). For the number of years since a cell was last contacted, the hybrid data set had slightly more cells contacted within 0 and 2 years, and slightly fewer contacted within 1, 3, and 4 years (Figure E23, lower two plots). The overall distributions are much the same between the two data sets however.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure E24 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen spatially.

Table E21: Number of cells contacted, aggregate area, and footprint for ORH-NWCR for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	230	242	95.0	580.4	479.4	121.1	429.0	411.9	104.2
2020	196	211	92.9	490.4	467.4	104.9	397.3	408.8	97.2
2021	211	204	103.4	633.3	599.6	105.6	484.2	485.1	99.8
2022	190	196	96.9	330.1	300.9	109.7	263.9	257.9	102.3
2023	249	238	104.6	403.3	373.8	107.9	371.8	348.1	106.8

Table E22: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for ORH -NWCR. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	2	1	200.0	1.3	0.6	216.7	1.3	0.6	216.7	100.0	100.0	100.0
2020	3	5	60.0	0.1	1.1	9.1	0.1	1.1	9.1	100.0	100.0	100.0
2021	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table E23: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for ORH-NWCR, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	4.0	4.0	100.0
Aggregate area	<0.1	<0.1	–	0.8	0.8	100.0	2.1	2.2	95.5
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	2.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	12.6	11.9	105.9	14.5	14.0	103.6	142.0	119.0	119.3
Aggregate area	6.5	6.0	108.3	7.3	7.4	98.6	52.9	42.1	125.7
Footprint	4.0	4.0	100.0	6.0	6.0	100.0	20.0	21.0	95.2

Table E24: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for ORH-NWCR, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	2.0	2.0	100.0	4.9	4.2	117.0	5.8	5.8	100.0	57.0	40.0	142.0
2020	1.0	1.0	100.0	3.0	2.0	150.0	4.8	4.3	112.0	7.0	6.0	117.0	30.0	28.0	107.0
2021	1.0	1.0	100.0	3.0	3.0	100.0	5.7	5.6	102.0	6.0	6.0	100.0	38.0	35.0	109.0
2022	1.0	1.0	100.0	2.0	2.0	100.0	3.6	3.2	112.0	3.0	3.0	100.0	32.0	32.0	100.0
2023	1.0	1.0	100.0	2.0	2.0	100.0	3.0	3.0	100.0	4.0	4.0	100.0	16.0	15.0	107.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	0.9	0.8	112.0	2.5	2.0	125.0	2.8	2.5	112.0	25.8	11.5	224.0
2020	0.6	0.6	100.0	1.3	1.2	108.0	2.5	2.2	114.0	3.7	3.1	119.0	13.1	14.1	93.0
2021	0.7	0.8	87.0	1.7	1.6	106.0	3.0	2.9	103.0	3.2	3.2	100.0	23.5	23.7	99.0
2022	0.7	0.7	100.0	0.9	0.9	100.0	1.7	1.5	113.0	1.8	1.5	120.0	13.9	12.8	109.0
2023	0.5	0.5	100.0	0.8	0.8	100.0	1.6	1.6	100.0	2.1	1.9	111.0	7.5	8.4	89.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	0.8	0.8	100.0	1.9	1.7	112.0	2.4	2.2	109.0	10.2	8.0	127.0
2020	0.6	0.6	100.0	1.3	1.2	108.0	2.0	1.9	105.0	2.8	2.7	104.0	8.4	9.2	91.0
2021	0.7	0.7	100.0	1.6	1.6	100.0	2.3	2.4	96.0	2.9	2.9	100.0	14.6	15.8	92.0
2022	0.7	0.7	100.0	0.9	0.9	100.0	1.4	1.3	108.0	1.6	1.5	107.0	7.1	9.2	77.0
2023	0.5	0.5	100.0	0.8	0.8	100.0	1.5	1.5	100.0	2.0	1.9	105.0	7.2	7.3	99.0

Plots removed for data confidentiality reasons.

Figure E21: Distribution of the ORH-NWCR footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure E22: Distribution of the ORH-NWCR aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

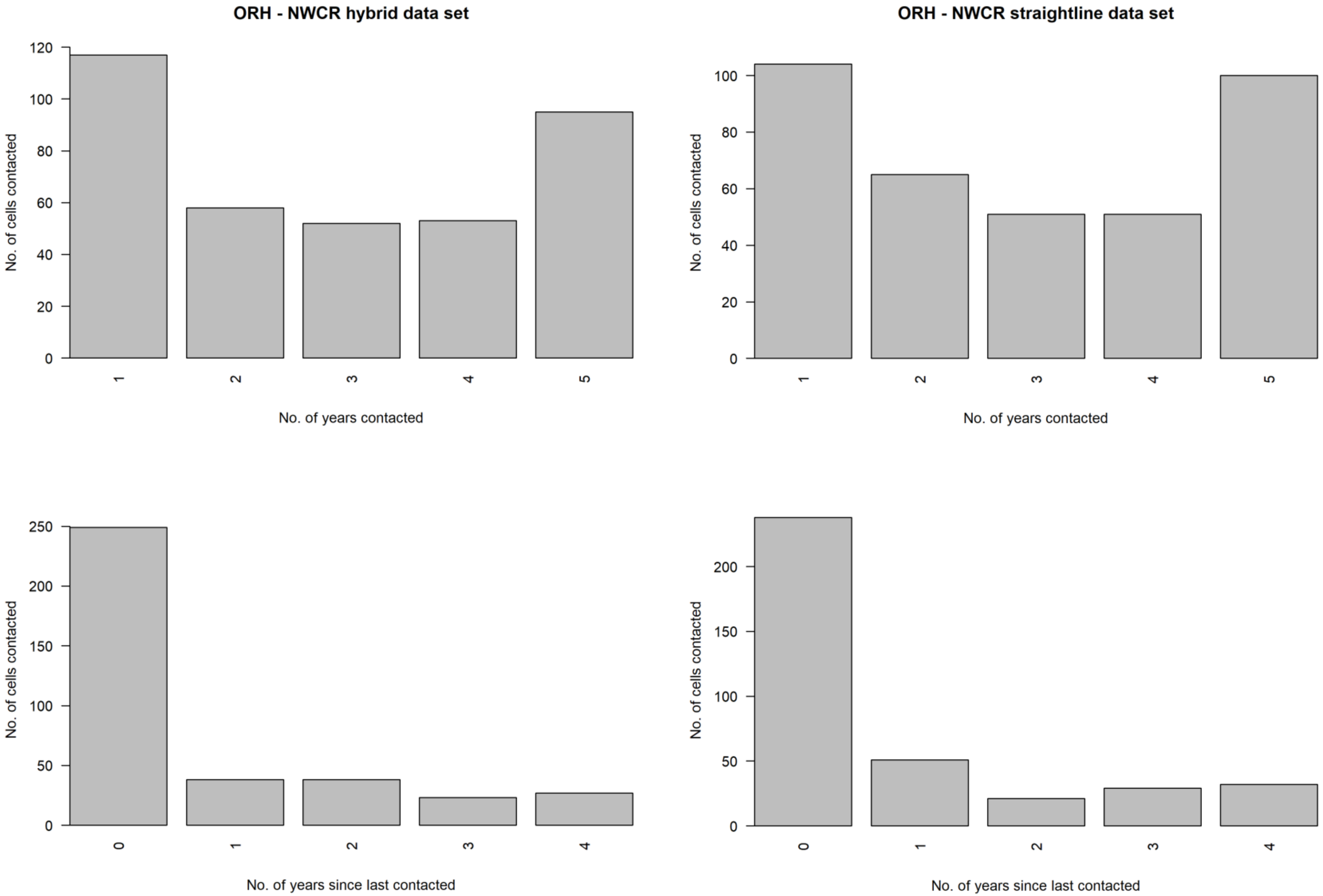

Figure E23: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure E24: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

Orange roughy ESCR – Spatial extent

The summaries in this section are for all tows targeting orange roughy in Marine Stewardship Council area ESCR (South East Chatham Rise).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table E25. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 99.4% and 102.9%, or a difference of between -2 and 12 cells.

The ratio for the aggregate area was between 100.6 and 111.8%, or a difference of between 7 and 217.1 km^2.

The ratio for the footprint was between 100.2% and 107% or a difference of between 1.7 and 98.7 km^2. The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing year is shown in Figure E25. At this resolution, there is no appreciable difference.

Orange roughy ESCR – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table E26 where the base footprint was created for 1990–2018 using the straight-line data set. Neither data set recorded any new cells being contacted in 2019. The ratio was 66.7% in 2020, but this represented a difference of just one more cell being contacted by the straight-line data set (three cells in the straight-line vs two cells in the hybrid data set). For the remaining three years in the time period each data set recorded one new cell contacted each year so the corresponding ratios were 100%.

The ratios for the aggregate area ranged between 14.3% and 175%. The actual differences are small however, the largest being by just 0.6 km^2. Ratios for the footprint are identical to the aggregate area, because the values for the footprint are the same.

As a result, when comparing the footprint as a percentage of the aggregate area, there was an exact match between the two data sets (100% each year). This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

Orange roughy ESCR – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table E27). The ratio between the two data sets for the median number of tows that contacted a cell was 100% with 15 tows each. The ratio for the mean number was 102.5% and represented a difference of just 0.9 tows. The ratio for the maximum number of tows was 104.9%, representing a difference of 33 tows between the hybrid and straight-line data sets.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 101.8%, a difference of 0.1 km^2. The mean is again higher for the hybrid data (ratio of 105.6%, or 17 vs 16.1 km^2). The most substantial difference is for the maximum (with a ratio of 105.9%, or 399.5 vs 377.4 km^2).

The spatial distribution of the aggregate area for both data types is shown in Figure E26 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference. There is, however, a need to have different categories with higher upper ranges for the hybrid data set for all years combined. The overall spatial location of intensity is much the same.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratios for the median, mean, and maximum are all 100%, with values of 4, 7, and 25 km^2 respectively. The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2.

The same summary information by year is given in Table E28. The annual median ratio for the number of tows in a cell was 100%, with the values each year ranging from 3–8 tows. The ratio for the mean number of tows ranged from 101–105%, which represented a maximum difference of 0.5 tows. The ratio for the maximum ranged from 97–108%, a maximum difference of 13 tows.

The annual median ratios for the aggregate areas in a cell ranged from 92–100%, representing a difference of no more than -0.1 km^2. Ratios for the mean ranged from 100–113%, or a maximum difference of 0.6 km^2. The maximum aggregate area shows more substantial differences, with ratios ranging from 96–120% or -2–13.3 km^2.

The annual median ratios for the footprint in a cell ranged from 90–105% but in no year did the actual difference exceed 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 100–105%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 95–105%. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types, but always slightly larger for the hybrid data.

Orange roughy ESCR – Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure E27, upper two plots) nor was there for the number of years since a cell was last contacted (Figure E27, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure E28 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen spatially.

Table E25: Number of cells contacted, aggregate area, and footprint for ORH-ESCR for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	357	359	99.4	1 036.8	1 030.3	100.6	713.4	711.7	100.2
2020	429	430	99.8	1 970.8	1 876.0	105.1	1 344.6	1 294.2	103.9
2021	435	426	102.1	2 871.6	2 679.1	107.2	1 925.2	1 846.8	104.2
2022	430	418	102.9	2 283.2	2 152.7	106.1	1 550.6	1 517.0	102.2
2023	385	381	101.0	2 061.9	1 844.8	111.8	1 501.1	1 402.4	107.0

Table E26: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for ORH-ESCR. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2020	2	3	66.7	0.1	0.7	14.3	0.1	0.7	14.3	100.0	100.0	100.0
2021	1	1	100.0	0.6	0.6	100.0	0.6	0.6	100.0	100.0	100.0	100.0
2022	1	1	100.0	0.7	0.4	175.0	0.7	0.4	175.0	100.0	100.0	100.0
2023	1	1	100.0	0.6	0.6	100.0	0.6	0.6	100.0	100.0	100.0	100.0

Table E27: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for ORH-ESCR, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	3.0	100.0	15.0	15.0	100.0
Aggregate area	<0.1	<0.1	–	0.8	0.8	100.0	5.8	5.7	101.8
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	4.0	4.0	100.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	37.1	36.2	102.5	46.0	47.0	97.9	700.0	667.0	104.9
Aggregate area	17.0	16.1	105.6	21.9	21.7	100.9	399.5	377.4	105.9
Footprint	7.0	7.0	100.0	13.0	13.0	100.0	25.0	25.0	100.0

Table E28: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for ORH-ESCR, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	1.5	133.0	3.0	3.0	100.0	8.5	8.4	101.0	7.0	7.0	100.0	107.0	110.0	97.0
2020	2.0	2.0	100.0	5.0	5.0	100.0	10.9	10.6	103.0	12.0	11.0	109.0	185.0	172.0	108.0
2021	2.0	3.0	67.0	8.0	8.0	100.0	13.5	13.3	102.0	17.0	17.0	100.0	158.0	151.0	105.0
2022	2.0	2.0	100.0	5.0	5.0	100.0	10.8	10.8	100.0	14.0	14.0	100.0	137.0	129.0	106.0
2023	2.0	2.0	100.0	6.0	6.0	100.0	10.5	10.0	105.0	14.0	13.0	108.0	116.0	114.0	102.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.2	1.3	92.0	2.9	2.9	100.0	3.0	3.0	100.0	50.4	52.4	96.0
2020	0.8	0.8	100.0	2.3	2.3	100.0	4.6	4.4	105.0	4.9	4.7	104.0	104.6	96.5	108.0
2021	0.8	0.8	100.0	3.4	3.5	97.0	6.6	6.3	105.0	8.6	8.2	105.0	96.0	90.3	106.0
2022	0.8	0.7	114.0	2.0	2.0	100.0	5.3	5.1	104.0	6.8	6.6	103.0	81.4	68.1	120.0
2023	0.8	0.8	100.0	3.0	3.0	100.0	5.4	4.8	113.0	6.9	6.7	103.0	73.1	70.1	104.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.4	75.0	1.0	1.0	100.0	2.0	2.0	100.0	2.4	2.7	89.0	17.3	18.2	95.0
2020	0.7	0.8	87.0	2.0	1.9	105.0	3.1	3.0	103.0	4.2	4.1	102.0	24.2	23.8	102.0
2021	0.8	0.8	100.0	2.7	2.8	96.0	4.4	4.3	102.0	6.9	6.7	103.0	23.8	23.3	102.0
2022	0.7	0.7	100.0	1.8	2.0	90.0	3.6	3.6	100.0	5.4	5.5	98.0	23.1	22.1	105.0
2023	0.8	0.8	100.0	2.7	2.6	104.0	3.9	3.7	105.0	5.9	5.6	105.0	21.5	21.6	100.0

Plots removed for data confidentiality reasons.

Figure E25: Distribution of the ORH-ESCR footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Figure E26: Distribution of the ORH-ESCR aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

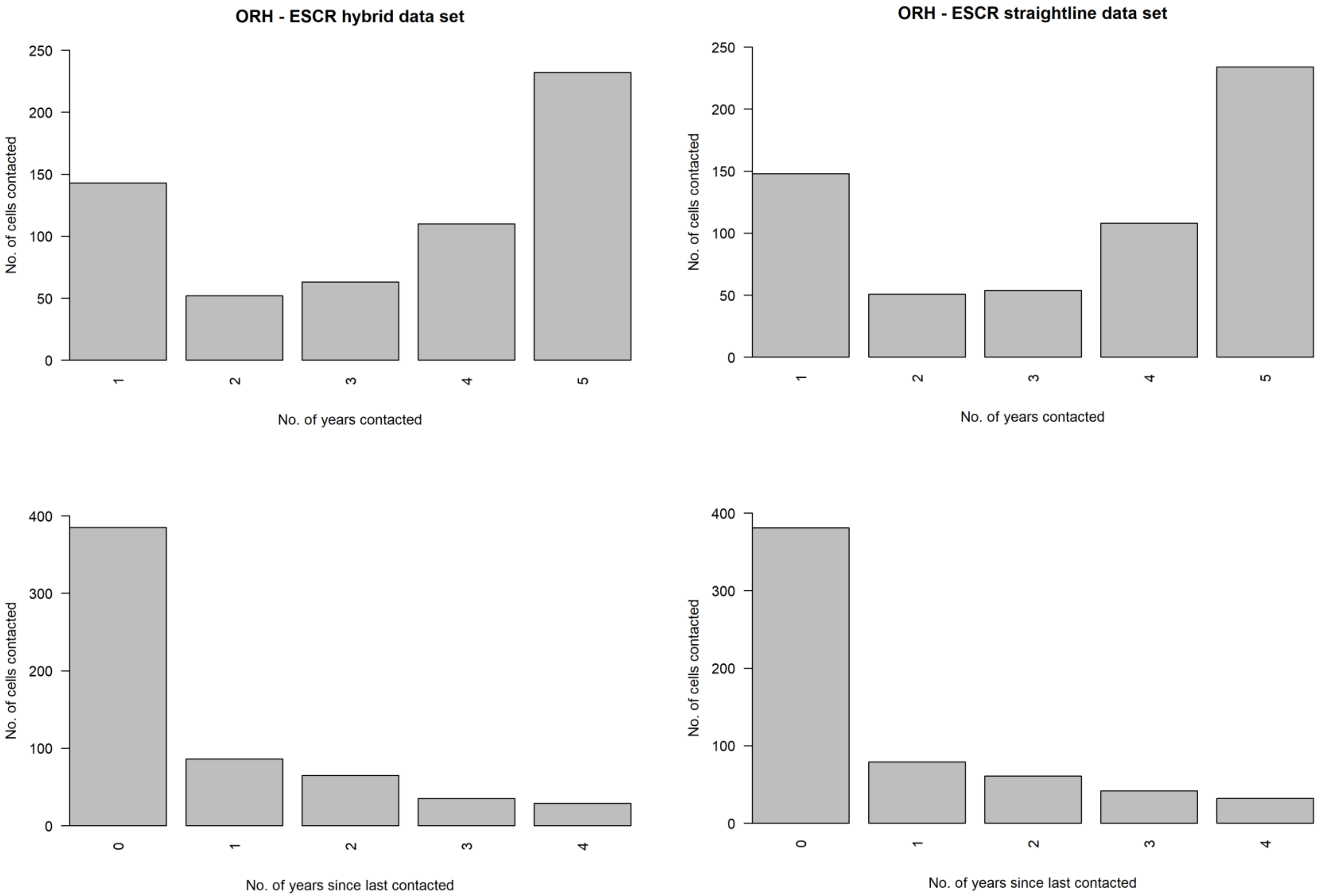

Figure E27: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure E28: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

APPENDIX F

COMPARISONS BETWEEN THE HYBRID AND STRAIGHT-LINE METHODS FOR SELECT INSHORE LAYERS

FMA 1 mixed – Spatial extent

This layer consists of all tows that targeted snapper, trevally, red gurnard, or John dory in Fisheries Management Area 1 (FMA 1).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F1. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 97.5% and 101.6%, or a difference of between -19 and 12 cells. This indicates that the hybrid data set sometimes contacted more cells than the straight-line data set, and sometimes fewer. The difference is however low, especially in the context of the total number of cells contacted.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 103.3–115%, or a difference of between 185 and 683 km^2.

The footprint was slightly smaller for the hybrid data set in all years with ratios ranging from 96.8–99.9% or a difference of between -104 and -5 km^2, which is close in the context of the total area of the footprint.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F1. At this resolution, there is little difference between the two data sets.

FMA 1 mixed – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F2 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 85.7–133.3%. In terms of the difference in the numbers of new cells contacted however, the maximum value was just two cells in 2019, and in 2021 neither data set contacted any new cells.

Ratios for the aggregate areas compared with the straight-line data set for those new cells contacted ranged from 81.8–173%. In terms of area, this represents a maximum difference of just 4.6 km^2.

Ratios for the footprint ranged from 81.8–155.6%, the maximum difference this represents is just 3.5 km^2.

When considering the footprint as a percentage of the aggregate area, the ratio ranged from 89.9–100%. This closeness demonstrates that irrespective of which data set is used, the ‘new’ areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing.

FMA 1 mixed – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F3). The ratio between the two data sets for the median number of tows that contacted a cell was 200% but this was for a difference of just two tows. The ratio for the mean number was 44% and this represented a more substantial difference (92 vs 211.4 tows). The ratio for the maximum was 40% and again represented a relatively substantial difference (750 vs 1895 tows).

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 167%, representing a difference of just 2.8 km^2. The ratio for the mean is 51%, representing a more substantial difference at -24.7 km^2. The ratio for the maximum also suggests a substantial difference at 55%, or -224.2 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little, and the most intensely fished areas are the same for both data sets. However, the hybrid data sets require higher categories than the straight-line data set to span the full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 133% (1 km^2). For the mean, the ratio is 89%, but this represents a difference of just 1 km^2 between the two data sets. Both data sets have a maximum footprint of 25 km^2 (the maximum possible, complete coverage in a cell), hence the ratio is 100%, a perfect match.

The same summary information by year is given in Table F4. The median ratio for the number of tows that contacted a cell ranged from 100–108%, or a difference of no more than one tow. The ratio for the mean ranged from 103–112%, representing a difference of no more than 2.5 tows. The ratio for the maximum ranged from 95–136%, or a maximum difference of 54 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–121%, which represented an actual difference of no more than 0.6 km^2 in any one year. The ratios for the means ranged from 105–116%, which represented an actual difference of no more than 0.6 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 106–158% or -4–29.4 km^2.

The annual median ratios for the footprint in a cell ranged from 93–108%, but this represented a difference of no more than 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 98–100%, and represented a difference between data types of no more than 0.1 km^2. The ratios for the maximum footprint ranged from 96–107%, representing a maximum difference of 0.1 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

FMA 1 mixed – Number of years contacted

There is little difference between the two data sets when comparing the number of years that cells were contacted (Figure F3, upper two plots) nor for number of years since a cell was last contacted (Figure F3, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F1: Number of cells contacted, aggregate area, and footprint for FMA 1 mixed for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	936	942	99.4	5 871.5	5 686.4	103.3	4 042.8	4 047.9	99.9
2020	821	821	100.0	5 779.4	5 252.3	110.0	3 465.6	3 545.2	97.8
2021	770	758	101.6	5 712.2	5 118.7	111.6	3 353.5	3 425.0	97.9
2022	737	756	97.5	5 227.9	4 636.9	112.7	3 189.5	3 293.5	96.8
2023	777	791	98.2	5 242.2	4 558.9	115.0	3 139.6	3 204.6	98.0

Table F2: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for FMA 1 mixed. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	12	14	85.7	2.4	2.9	82.8	2.4	2.9	82.8	100.0	100.0	100.0
2020	14	13	107.7	10.9	6.3	173.0	9.8	6.3	155.6	89.9	100.0	89.9
2021	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2022	4	3	133.3	0.9	1.1	81.8	0.9	1.1	81.8	100.0	100.0	100.0
2023	5	5	100.0	1.4	1.4	100.0	1.4	1.4	100.0	100.0	100.0	100.0

Table F3: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for FMA 1 mixed, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	4.0	2.0	200.0	34.0	20.5	166.0
Aggregate area	<0.1	0.1	–	0.9	0.5	180.0	7.0	4.2	167.0
Footprint	<0.1	0.1	–	1.0	1.0	100.0	4.0	3.0	133.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	92.0	211.4	44.0	149.8	303.2	49.0	750.0	1895.0	40.0
Aggregate area	25.5	50.2	51.0	37.4	64.7	58.0	275.3	499.5	55.0
Footprint	8.0	9.0	89.0	14.0	18.0	78.0	25.0	25.0	100.0

Table F4: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for FMA 1 mixed, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	3.0	2.0	150.0	11.0	11.0	100.0	24.3	23.6	103.0	37.0	35.0	106.0	164.0	154.0	106.0
2020	3.0	3.0	100.0	13.0	13.0	100.0	25.0	23.2	108.0	37.0	33.0	112.0	244.0	229.0	107.0
2021	3.2	4.0	80.0	15.0	15.0	100.0	26.3	24.8	106.0	39.0	37.0	105.0	175.0	150.0	117.0
2022	5.0	5.0	100.0	17.0	16.0	106.0	25.1	22.6	111.0	37.0	34.0	109.0	202.0	148.0	136.0
2023	4.0	4.0	100.0	14.0	13.0	108.0	23.5	21.0	112.0	35.0	31.0	113.0	126.0	132.0	95.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	2.5	2.5	100.0	6.3	6.0	105.0	9.4	8.9	106.0	59.3	53.8	110.0
2020	0.6	0.7	86.0	3.1	2.9	107.0	7.0	6.4	109.0	8.7	8.2	106.0	67.0	63.0	106.0
2021	0.7	0.8	87.0	3.4	3.0	113.0	7.4	6.8	109.0	10.3	9.3	111.0	65.9	52.0	127.0
2022	0.9	0.8	112.0	4.1	3.6	114.0	7.1	6.1	116.0	9.5	8.5	112.0	80.5	51.1	158.0
2023	0.8	0.7	114.0	3.5	2.9	121.0	6.7	5.8	116.0	9.1	7.6	120.0	52.1	41.2	126.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	2.3	2.3	100.0	4.3	4.3	100.0	7.1	7.0	101.0	21.2	21.6	98.0
2020	0.6	0.6	100.0	2.5	2.5	100.0	4.2	4.3	98.0	6.2	6.7	93.0	19.8	20.6	96.0
2021	0.6	0.7	86.0	2.5	2.7	93.0	4.4	4.5	98.0	6.9	7.1	97.0	21.6	20.8	104.0
2022	0.8	0.8	100.0	3.1	3.1	100.0	4.3	4.4	98.0	6.4	6.7	96.0	23.4	21.8	107.0
2023	0.8	0.7	114.0	2.7	2.5	108.0	4.0	4.1	98.0	6.2	6.3	98.0	20.0	19.8	101.0

Plots removed for data confidentiality reasons.

Figure F1: Distribution of the FMA 1 mixed footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F2: Distribution of the FMA 1 mixed aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

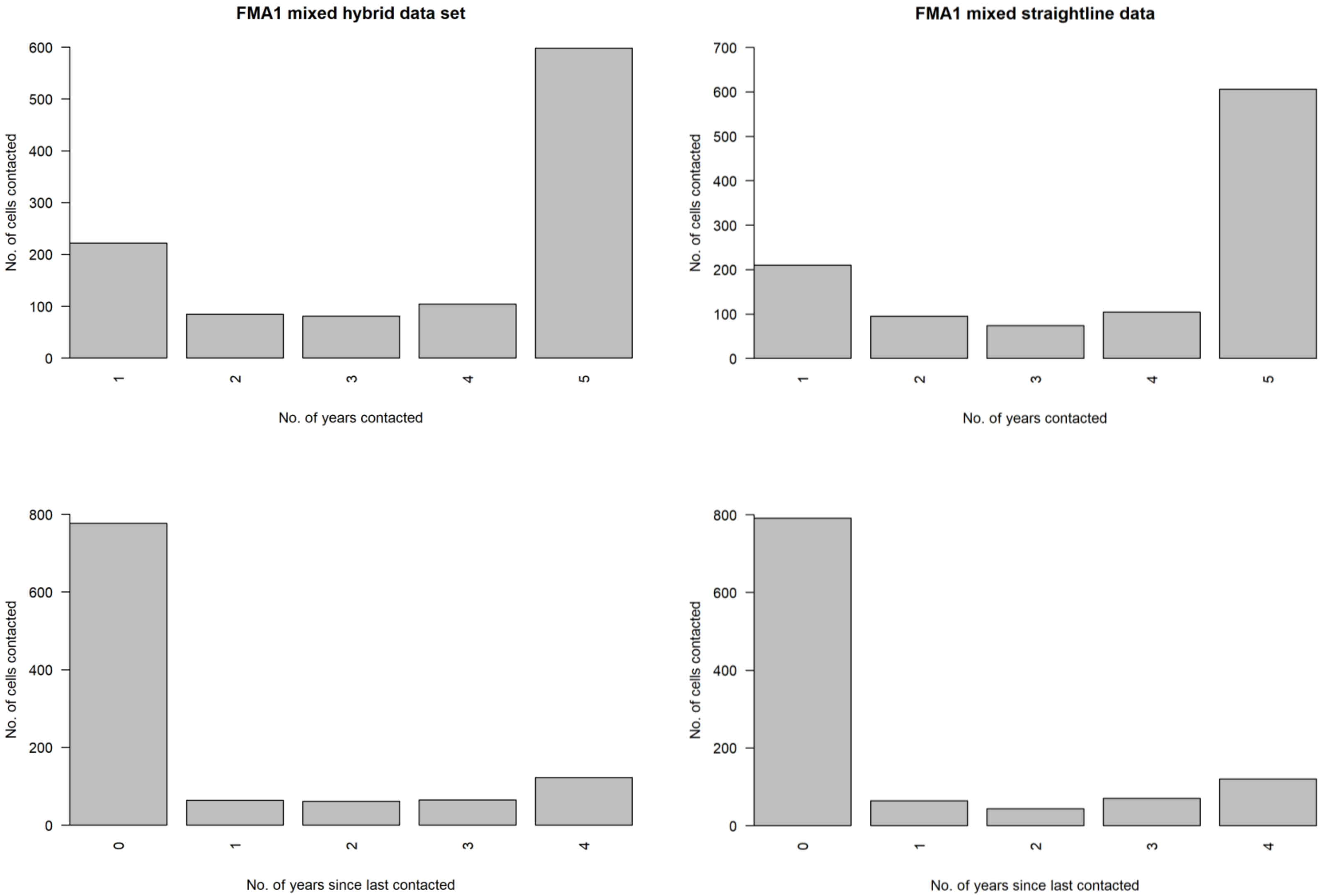

Figure F3: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F4: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

FMA 2 mixed – Spatial extent

The summaries in 'FMA2 mixed' consist of all tows that targeted snapper, red gurnard, trevally, red cod, or blue moki in Fisheries Management Area 2 (FMA 2).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F5. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 98.9% and 100.9%, or a difference of between -5 and 1 cells. This indicates that the hybrid data set sometimes contacted more cells than the straight-line data set, and sometimes fewer. The difference is however low, especially in the context of the total number of cells contacted.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 104.4–129.8%, or a difference of between 184 and 728 km^2.

The footprint was slightly smaller for the hybrid data set in all years with ratios ranging from 101.9–115.1% or a difference of between 56 and 229 km^2, which is close in the context of the total area of the footprint.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years are shown in Figure F5. At this resolution, there is little difference between the two data sets.

FMA 2 mixed – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F6 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 0 (when there were no new cells contacted by the hybrid data set and 1 cell in the straight-line) and 125% (when 5 cells were contacted by the hybrid and 4 by the straight-line data set). Neither data set contacted new cells in the 2022 or 2023.

Only in 2019 and 2020 were there new cells contacted by both data sets, and for both data sets the aggregate areas were the same, resulting in ratios of 100%. The corresponding footprints were the same as the aggregate areas so the ratios were again 100%, hence the ratios resulting from the footprint as a percentage of the aggregate area were also 100%. This closeness demonstrates that irrespective of which data set is used, the 'new' areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing.

FMA 2 mixed – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F7). The ratio between the two data sets for the median number of tows that contacted a cell was 200% but this was for a difference of just two tows. The ratio for the mean number was 123%, representing a difference of 17.3 tows. For the maximum, the ratio was 101%, a difference of 11 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 114%, representing a difference of just 0.5 km^2. The ratio for the mean is 119%, representing difference of 3.3 km^2. The ratio for the maximum is more substantial at 137%, 65.7 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F6 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little, and the most intensely fished areas are the same for both data sets, showing Hawke Bay as the most intensely fished area. However, the hybrid data sets require higher categories than the straight-line data set in order to span the full range of data because overall, the aggregate area is higher for the former than it is for the latter.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 100% (3 km^2 for both) as it is for the mean (7 km^2). Both data sets have a maximum footprint of 25 km^2 (the maximum possible, complete coverage in a cell), hence the ratio is 100%, a perfect match.

The same summary information by year is given in Table F8. For the annual median number of tows that contacted a cell, the ratio ranged from 130–155%, representing a difference of no more than six tows. The annual mean ratio ranged from 101–130%, representing a maximum difference of six tows. For the maximum number of tows, the annual ratio ranged from 83–124%, which represented a maximum difference of 48 tows between the two data sets.

The annual median ratios for the aggregate areas in a cell ranged from 113–139%, which represented an actual difference of no more than 0.7 km^2 in any one year. The ratios for the means ranged from 104–132%, which represented an actual difference of no more than 6.4 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 96–193% or -1.9–37.8 km^2.

The annual median ratios for the footprint in a cell ranged from 105–118%, but this represented a difference of no more than 0.3 km^2. The ratio for the mean footprint was very close in each year, ranging from 103–119%, and represented a difference between data types of no more than 0.6 km^2. The ratios for the maximum footprint ranged from 100–120%, representing a maximum difference of 3.9 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close to one another for both data types.

FMA 2 mixed – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted (Figure F7, upper two plots) nor for number of years since a cell was last contacted (Figure F7, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F8 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F5: Number of cells contacted, aggregate area, and footprint for FMA 2 mixed for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	785	784	100.1	4 341.4	4 157.9	104.4	3 038.6	2 982.2	101.9
2020	585	581	100.7	4 197.4	3 530.0	118.9	2 698.9	2 551.6	105.8
2021	549	544	100.9	3 163.4	2 456.3	128.8	2 087.4	1 900.3	109.8
2022	556	560	99.3	3 560.2	2 832.2	125.7	2 338.1	2 144.8	109.0
2023	452	457	98.9	2 392.4	1 843.1	129.8	1 706.8	1 478.0	115.5

Table F6: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	19	19	100.0	4.5	4.5	100.0	4.5	4.5	100.0	100.0	100.0	100.0
2020	5	4	125.0	1.3	1.3	100.0	1.3	1.3	100.0	100.0	100.0	100.0
2021	0	1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	–	100.0	–
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table F7: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km² cell for FMA 2 mixed, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	4.0	2.0	200.0	34.0	20.0	170.0
Aggregate area	<0.1	0.1	–	0.4	0.4	100.0	4.2	3.7	114.0
Footprint	<0.1	0.1	–	<0.1	0.1	–	3.0	3.0	100.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	92.0	74.7	123.0	149.8	94.0	159.0	750.0	739.0	101.0
Aggregate area	20.5	17.2	119.0	26.2	20.3	129.0	244.7	179.0	137.0
Footprint	7.0	7.0	100.0	12.0	13.0	92.0	25.0	25.0	100.0

Table F8: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for FMA 2 mixed, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	3.0	2.0	150.0	11.0	8.0	138.0	24.3	22.1	110.0	37.0	34.2	108.0	164.0	189.0	87.0
2020	3.0	3.0	100.0	13.0	10.0	130.0	25.0	24.7	101.0	37.0	37.0	100.0	244.0	196.0	124.0
2021	3.2	3.0	107.0	15.0	11.0	136.0	26.3	20.3	130.0	39.0	27.0	144.0	175.0	179.0	98.0
2022	5.0	3.0	167.0	17.0	11.0	155.0	25.1	23.2	108.0	37.0	31.0	119.0	202.0	244.0	83.0
2023	4.0	2.0	200.0	14.0	10.0	140.0	23.5	18.5	127.0	35.0	29.0	121.0	126.0	104.0	121.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.7	1.5	113.0	5.5	5.3	104.0	7.9	7.6	104.0	46.2	48.1	96.0
2020	0.6	0.6	100.0	2.5	2.1	119.0	7.2	6.1	118.0	10.3	9.6	107.0	71.0	47.5	149.0
2021	0.6	0.5	120.0	2.6	2.2	118.0	5.8	4.5	129.0	7.1	6.4	111.0	61.9	45.0	138.0
2022	0.7	0.5	140.0	2.8	2.2	127.0	6.4	5.1	125.0	7.6	6.9	110.0	78.5	40.7	193.0
2023	0.5	0.4	125.0	2.5	1.8	139.0	5.3	4.0	132.0	7.9	6.5	122.0	34.6	22.9	151.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.6	1.4	114.0	3.9	3.8	103.0	6.3	6.2	102.0	20.5	20.5	100.0
2020	0.6	0.5	120.0	2.0	1.9	105.0	4.6	4.4	105.0	7.3	7.4	99.0	23.1	21.3	108.0
2021	0.5	0.5	100.0	2.2	2.0	110.0	3.8	3.5	109.0	5.7	5.3	108.0	20.9	20.0	104.0
2022	0.6	0.5	120.0	2.4	2.1	114.0	4.2	3.8	111.0	6.1	5.8	105.0	23.6	19.7	120.0
2023	0.5	0.4	125.0	2.0	1.7	118.0	3.8	3.2	119.0	6.0	5.5	109.0	17.4	14.6	119.0

Plots removed for data confidentiality reasons.

Figure F5: Distribution of the FMA 2 mixed footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F6: Distribution of the FMA 2 mixed aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

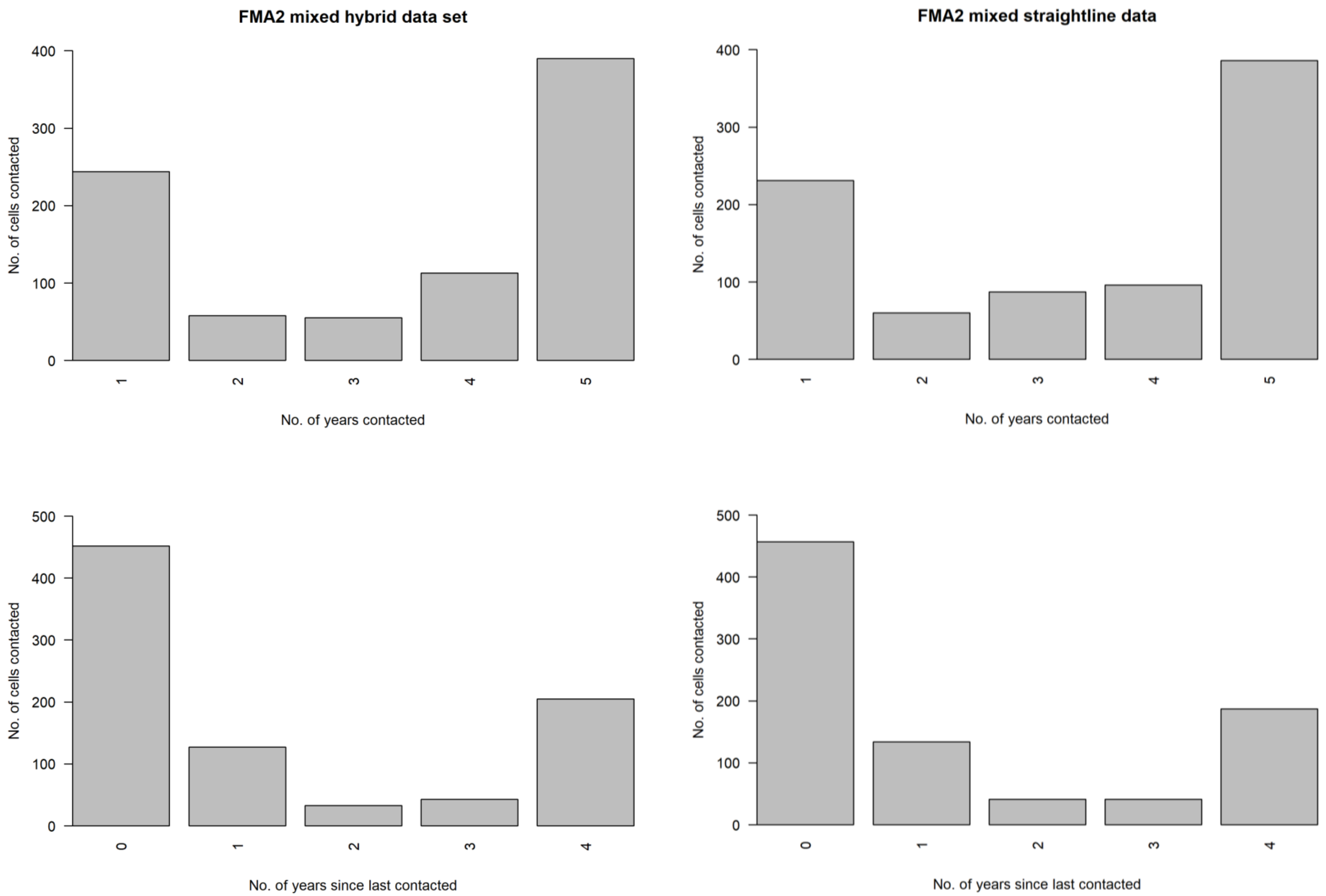

Figure F7: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Figure F8: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

BAR 1 – Spatial extent

The summaries in this section consist of all tows targeting barracouta in Quota Management Area BAR 1.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F9. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 98.3% and 101.4%, or a difference of between -19 and -3 cells.

While fewer cells were contacted by the hybrid data set, the aggregate area was larger than the straight-line data set with ratios ranging from 113.5–146.1%, or a difference of between 347 and 1407 km^2. The footprint was also larger for the hybrid data set with ratios of between 105.8% and 120.9% or a difference of between 131 and 450 km^2.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F9. At this resolution, there is no appreciable difference.

BAR 1 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F10 where the base footprint was created for 2008–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 93.3% (hybrid data set contacting fewer new cells) to 106.7% (hybrid data set contacting more cells). The closeness of the ratios to 100%, a perfect match, is reflected in the difference in the number of cells contacted, which ranged from -2 and 1 cell.

The aggregate area of the new cells contacted shows generally similar ratios, ranging from 88.9% to 108%, with the differences in area ranging from just -0.5–0.9 km^2.

For the footprint, the ratios were slightly more wide ranging, being between 76.5% and 103.6%, but the actual differences were no more than 0.5 km^2 in any one year.

When comparing the footprint as a percentage of the aggregate area, the ratios were close in all years except 2022 between the two data sets (76.5–100%). While the disparity in 2022 seems large, this is due only to a difference of 0.4 km^2 between the aggregate area and footprint for the hybrid data, whereas the straight-line data set had an exact match in the same year. These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

BAR 1 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F11). The ratio between the two data sets for the median number of tows that contacted a cell was 120% but this represented a difference of just two tows. The ratio for the mean number was 114% and represented a difference of four tows. The ratio for the maximum number of tows was 154% and represented a more substantial difference of 161 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 107%, representing a difference of just 0.2 km^2. The ratio for the mean is 133%, but again, the actual difference is small at just 3 km^2. The most substantial difference is for the maximum (243%) or 386 vs 159 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F10 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity. There is however, a need to have different categories with higher upper ranges for the hybrid data set. The overall spatial location of intensity is much the same however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (3 km^2). The mean footprint is also an exact match with a ratio of 100% (5 km^2). The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table F12. The annual median for the number of tows that contacted a cell ranged from 100–133%, representing a difference of no more than 1.6 tows. The ratio for the mean number of tows ranged from 104–117%, representing a difference of no more than 1.6 tows. For the maximum, the ratio ranged from 97–156%, representing a maximum difference of 61 tows.

The annual median ratios for the aggregate areas in a cell ranged from 110–120%, which represented an actual difference of no more than 0.3 km^2 in any one year. The ratios for the means ranged from 115–150%, which represented an actual difference of no more than 1.4 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 159–248% or 18–94 km^2.

The annual median ratios for the footprint are in a cell range from 106–120% but in no year did the actual difference in square kilometres exceed 0.2. The ratio for the mean footprint was very close in each year, ranging from 107–120%, and represented a difference between data types of no more than 0.4 km^2. The ratios for the maximum footprint ranged from 104–139%, representing a maximum difference of 6.2 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types, but always slightly larger for the hybrid data.

BAR 1 – Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure F11, upper two plots). For both, almost 450 cells were contacted in one year, between about 200 were contacted in 2–4 years. The largest category was for cells contacted in all five years, with just over 600 cells for each data type.

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure F11, lower two plots). For both, the most recent fishing year had the largest number of cells at just over 1000. Around 200 cells were contacted in each of the categories for 2–4 years since last contacted.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F12 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table F9: Number of cells contacted, aggregate area, and footprint for BAR 1 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1257	1260	99.8	2 917.3	2 570.5	113.5	2 402.8	2 271.5	105.8
2020	1093	1112	98.3	4 332.9	3 323.3	130.4	2 995.8	2 649.0	113.1
2021	1185	1201	98.7	5 713.9	4 307.2	132.7	3 456.7	3 219.7	107.4
2022	981	987	99.4	4 101.3	2 806.7	146.1	2 415.0	2 122.2	113.8
2023	1079	1064	101.4	3 602.2	2 567.5	140.3	2 606.3	2 156.5	120.9

Table F10: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for BAR 1. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	45	44	102.3	12.1	11.2	108.0	11.6	11.2	103.6	95.9	100.0	95.9
2020	14	15	93.3	3.9	3.8	102.6	3.8	3.8	100.0	97.4	100.0	97.4
2021	31	33	93.9	9.6	10.1	95.0	9.6	10.1	95.0	100.0	100.0	100.0
2022	4	4	100.0	1.7	1.7	100.0	1.3	1.7	76.5	76.5	100.0	76.5
2023	16	15	106.7	4.0	4.5	88.9	4.0	4.5	88.9	100.0	100.0	100.0

Table F11: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for BAR 1, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	12.0	10.0	120.0
Aggregate area	<0.1	<0.1	–	0.6	0.5	120.0	3.0	2.8	107.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	3.0	3.0	100.0
	Mean			**3rd quartile**			**Maximum**		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	32.6	28.6	114.0	44.0	40.0	110.0	460.0	299.0	154.0
Aggregate area	12.0	9.0	133.0	12.6	11.0	115.0	385.9	159.0	243.0
Footprint	5.0	5.0	100.0	9.0	8.0	112.0	25.0	25.0	100.0

Table F12: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for BAR 1, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	4.0	4.0	100.0	7.2	6.9	104.0	10.0	9.0	111.0	52.0	52.0	100.0
2020	2.0	2.0	100.0	6.0	5.0	120.0	11.3	9.7	116.0	16.0	13.0	123.0	79.0	76.0	104.0
2021	2.0	2.0	100.0	6.0	6.0	100.0	12.7	11.2	113.0	16.0	15.0	107.0	133.0	101.0	132.0
2022	2.0	2.0	100.0	5.0	5.0	100.0	10.5	9.0	117.0	11.0	10.0	110.0	170.0	109.0	156.0
2023	2.0	1.0	200.0	4.0	3.0	133.0	8.5	7.4	115.0	10.5	9.0	117.0	69.0	71.0	97.0
	Aggregate area 1st Quartile			**Aggregate area median**			**Aggregate area mean**			**Aggregate area 3rd Quartile**			**Aggregate area maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.1	1.0	110.0	2.3	2.0	115.0	2.9	2.6	112.0	34.6	17.0	204.0
2020	0.4	0.4	100.0	1.6	1.3	120.0	4.0	3.0	133.0	4.7	3.8	124.0	50.5	31.7	159.0
2021	0.5	0.5	100.0	1.7	1.5	110.0	4.8	3.6	133.0	5.2	4.3	121.0	119.6	59.0	203.0
2022	0.4	0.4	100.0	1.2	1.1	110.0	4.2	2.8	150.0	3.4	2.9	117.0	158.0	63.8	248.0
2023	0.4	0.4	100.0	1.0	0.9	110.0	3.3	2.4	138.0	3.6	2.7	133.0	57.4	26.8	214.0
	Footprint 1st Quartile			**Footprint median**			**Footprint mean**			**Footprint 3rd Quartile**			**Footprint maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.0	1.0	100.0	1.9	1.8	106.0	2.7	2.4	113.0	14.6	11.2	130.0
2020	0.4	0.4	100.0	1.4	1.3	108.0	2.7	2.4	113.0	4.0	3.4	118.0	20.5	16.9	121.0
2021	0.5	0.5	100.0	1.6	1.4	114.0	2.9	2.7	107.0	4.1	3.8	108.0	23.6	20.5	115.0
2022	0.4	0.4	100.0	1.1	1.0	110.0	2.5	2.2	114.0	3.0	2.6	115.0	23.8	22.9	104.0
2023	0.4	0.4	100.0	1.0	0.9	111.0	2.4	2.0	120.0	3.1	2.5	124.0	22.3	16.1	139.0

Plots removed for data confidentiality reasons.

Figure F9: Distribution of the BAR 1 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F10: Distribution of the BAR 1 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

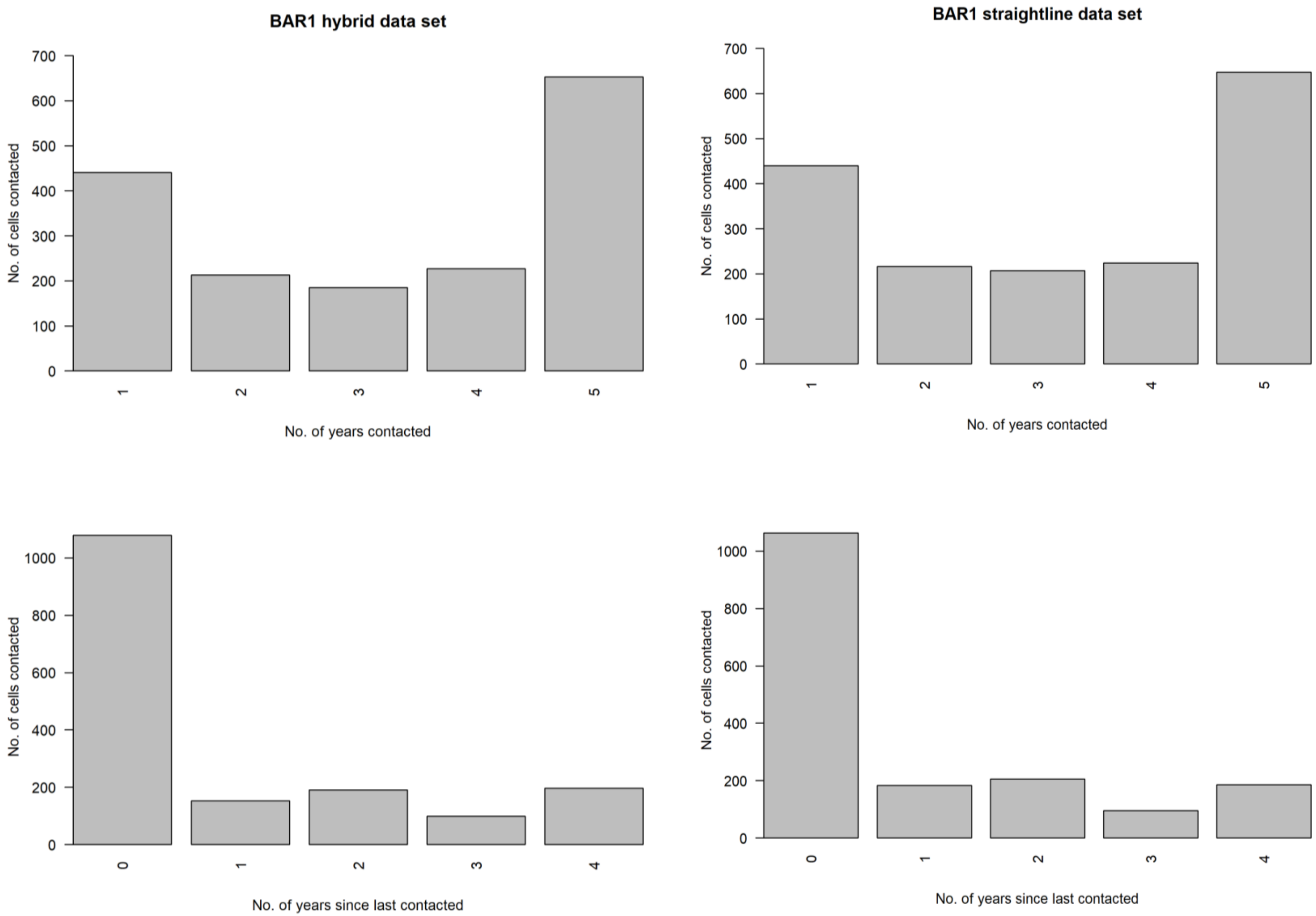

Figure F11: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F12: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

BAR 4 – Spatial extent

The summaries in this section consist of all tows targeting barracouta in Quota Management Area BAR 4.

The annual total number of cells, aggregate swept area, and footprint for BAR 4 are given in Table F13. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 105.5% and 124.7%, or a difference of between 4 and 18 cells, indicating that the hybrid data set contacted more cells than the straight-line data set, albeit only a few more.

The aggregate area was larger for the hybrid data set with ratios ranging from 137.8–220.7%, or a difference of between 102 and 812 km^2.

The footprint was larger for the hybrid data set in some years, but smaller in other years with ratios ranging from 84.3–170.5% or a difference of between -52 and 105 km^2.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F13. At this resolution, there is little difference but it can be seen that the hybrid data set has a slightly more extensive area with the highest footprints.

BAR 4 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F14 where the base footprint was created for 2008–2018 using the straight-line data set.

In four of the five years, new cells were contacted by one data set but not the other. Only in one year were there new cells contacted by both data sets (2021) and the ratio was 225%, or a difference of five cells. The ratio for the aggregate area in 2021 was 317.6%, or 5.4 vs 1.7 km^2. For both data sets, the footprint is equal to the aggregate area, meaning that none of the new areas were contacted more than once.

BAR 4 – Intensity

For the combined 2019–2023 data, the minimum number of tows that contact cells was one for both data types (Table F15). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (6 tows each). The ratio for the mean number was 117% (46 vs 39.3 tows). The ratio for the maximum number of tows was more substantial at 152 tows (330 vs 217 tows).

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 115%, representing a difference of just 0.3 km^2. The ratio for the mean is 154%, but again, the actual difference is relatively small at just 10.7 km^2. The most substantial difference is for the maximum (231%) or 305 vs 131.8 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F14 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is little difference with respect to the distribution of intensity. There is however, a need to have different categories with higher upper ranges for the hybrid data set. The overall spatial location of intensity is much the same however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (2 km^2) and also for the mean (5 km^2). The maximum footprint is slightly lower for the hybrid data set at 23 km^2 vs 25 km^2 (the latter being the maximum possible footprint within a cell), giving a ratio of 92%.

The same summary information by year is given in Table F16. For the number of tows that contacted a cell the annual median ranged from 62–104%, representing a difference of no more than 10 tows. The annual mean ranged from 114–137%, a difference of no more than 10.6 tows. The ratio for the maximum number of tows ranged from 100–164%, a maximum difference of 47 tows.

The annual median ratios for the aggregate areas in a cell ranged from 110–120%, which represented an actual difference of no more than 0.3 km^2 in any one year. The ratios for the means ranged from 130–205%, which represented an actual difference of no more than 1.4 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 159–248% or 4.6–97.3 km^2.

The annual median ratios for the footprint in a cell ranged from 67–118%, or from -1.3 km^2 to 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 107–120%, and represented a difference between data types of between -0.9 and 0.7 km^2. The ratios for the maximum footprint ranged from 89–124%, representing a maximum difference of 2.4 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

BAR 4 – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although slightly more cells were contacted in just one year for the hybrid data set (Figure F15, upper two plots).

For the number of years since a cell was last contacted, there were more cells contacted in the most recent fishing year (zero years since last contacted) for the hybrid data set (Figure F15, lower two plots). There were similar numbers contacted one, two, and four years ago, but only the hybrid data set had cells that were contacted three years ago.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F16 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution, other than the hybrid data set having a slightly more extensive area where there was contact in the most recent fishing year.

Table F13: Number of cells contacted, aggregate area, and footprint for BAR 4 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	77	73	105.5	963.5	699.4	137.8	279.5	331.6	84.3
2020	58	51	113.7	707.3	418.8	168.9	268.9	251.3	107.0
2021	91	73	124.7	400.2	212.0	188.8	283.2	178.1	159.0
2022	54	50	108.0	1 484.5	672.5	220.7	273.7	280.1	97.7
2023	87	71	122.5	222.8	121.0	184.1	176.5	103.5	170.5

Table F14: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for BAR 4. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	2	<0.1	–	1.9	0.0	–	1.9	0.0	–	100.0	–	–
2020	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2021	9	4	225.0	5.4	1.7	317.6	5.4	1.7	317.6	100.0	100.0	100.0
2022	0	1	0.0	0.0	0.4	0.0	0.0	0.4	0.0	–	100.0	–
2023	0	5	0.0	0.0	1.0	0.0	0.0	1.0	0.0	–	100.0	–

Table F15: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km² cell for BAR 4, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.5	1.0	150.0	6.0	6.0	100.0
Aggregate area	<0.1	<0.1	–	0.7	0.7	100.0	2.3	2.0	115.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	2.0	100.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	46.0	39.3	117.0	69.5	77.8	89.0	330.0	217.0	152.0
Aggregate area	30.7	20.0	154.0	23.8	23.5	101.0	305.0	131.8	231.0
Footprint	5.0	5.0	100.0	8.0	8.0	100.0	23.0	25.0	92.0

Table F16: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for BAR 4, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	6.0	7.0	86.0	20.2	17.4	116.0	27.0	22.0	123.0	103.0	66.0	156.0
2020	1.0	4.0	25.0	13.5	13.0	104.0	18.4	16.0	115.0	24.5	25.5	96.0	71.0	51.0	139.0
2021	1.0	1.0	100.0	2.0	3.0	67.0	6.5	5.6	116.0	8.0	7.0	114.0	35.0	32.0	109.0
2022	3.2	5.0	64.0	16.0	26.0	62.0	38.9	28.3	137.0	75.8	45.8	166.0	121.0	74.0	164.0
2023	1.0	1.0	100.0	2.0	2.0	100.0	4.0	3.5	114.0	6.0	4.0	150.0	18.0	18.0	100.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.6	83.0	1.7	1.6	106.0	12.5	9.6	130.0	12.9	15.6	83.0	85.1	42.4	201.0
2020	0.7	1.5	47.0	4.2	5.6	75.0	12.2	8.2	149.0	17.4	13.0	134.0	67.8	27.5	247.0
2021	0.5	0.6	83.0	1.2	1.1	109.0	4.4	2.9	152.0	4.5	3.3	136.0	30.1	20.5	147.0
2022	1.1	0.9	122.0	4.3	8.4	51.0	27.5	13.4	205.0	39.3	23.1	170.0	143.0	45.7	313.0
2023	0.3	0.3	100.0	0.9	0.7	129.0	2.6	1.7	153.0	3.3	1.6	206.0	15.5	10.9	142.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.6	67.0	1.3	1.1	118.0	3.6	4.5	80.0	6.9	8.2	84.0	17.5	19.7	89.0
2020	0.7	1.3	54.0	2.6	3.0	87.0	4.6	4.9	94.0	7.2	7.3	99.0	20.2	17.8	113.0
2021	0.5	0.5	100.0	1.2	1.1	109.0	3.1	2.4	129.0	3.6	3.0	120.0	17.4	15.3	114.0
2022	0.9	0.8	112.0	2.6	3.9	67.0	5.1	5.6	91.0	8.2	10.3	80.0	17.6	19.3	91.0
2023	0.3	0.3	100.0	0.8	0.7	114.0	2.0	1.5	133.0	2.8	1.5	187.0	9.3	7.5	124.0

Plots removed for data confidentiality reasons.

Figure F13: Distribution of the BAR 4 footprint for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F14: Distribution of the BAR 4 aggregate area for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

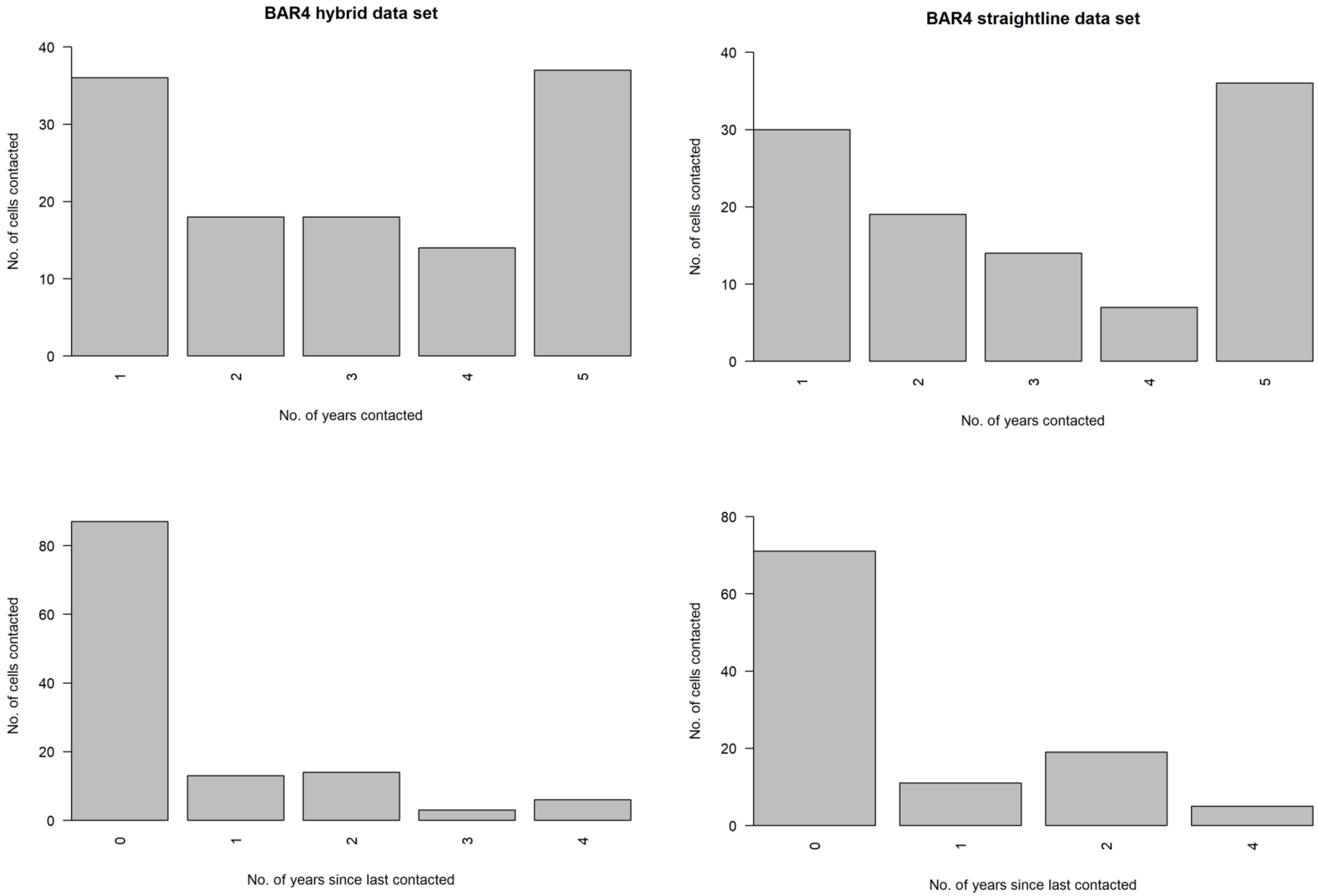

Figure F15: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for BAR 4.

Plots removed for data confidentiality reasons.

Figure F16: Distribution of cells, by the number of years contacted (top two plots), and by the most recent year fished (bottom two plots) between 2019 and 2023 for the hybrid data and the straight-line data.

BAR 5 – Spatial extent

The summaries in this section consist of all tows targeting barracouta in Quota Management Area BAR 5.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F17. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 99.6% and 112.1%, or a difference of between -1 and 37 cells, indicating that the hybrid data set usually contacted more cells than the straight-line data set, albeit only a few more.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 146.2–185.2%, or a difference of between 598 and 789 km^2.

The footprint was larger for the hybrid data set in all years with ratios ranging from 111.2–143.9% or a difference of between 84 and 296 km^2.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F17. At this resolution, there is little difference but it can be seen that the hybrid data set has a slightly more extensive area with the highest footprints.

BAR 5 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F18 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 77.4–157.9%, indicating that in some years the hybrid data set contacted more new cells than the straight-line data set, and in some years the reverse was true. In terms of the numbers of new cells contacted however, the values themselves were low, ranging from -11–7.

In some years the hybrid data set had higher aggregate areas compared with the straight-line data set for those new cells contacted and in other years it was lower, with ratios ranging from 94.5–184.7 km^2. In terms of area, the differences are very low however, ranging from -0.7–3.7 km^2.

As for the number of cells and aggregate area, the footprint was also higher in some years for the hybrid data set, and higher in some years for the straight-line data set, with ratios ranging from 95.2–198.5%. Again, in terms of area, the differences are very low however, ranging from -0.6–6.6 km^2.

BAR 5 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F19). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (two tows each) The ratio for the mean number of tows was 132% and this represented 6.2 tows. The ratio for the maximum number of tows that contacted a cell was 143%, representing a more substantial difference of 114 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 116%, representing a difference of just 0.3 km^2. The ratio for the mean is 159%, but again, the actual difference is relatively small at just 5.6 km^2. The most substantial difference is for the maximum (183%) or 305 vs 166.6 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F18 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is little difference with respect to the distribution of intensity. There is however, a need to have different categories with higher upper ranges for the hybrid data set. The overall spatial location of intensity is much the same however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (2 km^2). For the mean, the ratio is 125%, but this represents a difference of just 1 km^2 between the two data sets. Both data sets have a maximum footprint of 25 km^2, meaning total coverage of a cell, hence the ratio is 100%, a perfect match.

The same summary information by year is given in Table F20. The ratio for the annual median number of tows was 100% in all years. The ratio for the annual mean number of tows ranged from 124–136%, representing a maximum difference of 3.2 tows. For the maximum, the ratio ranged from 111–160%, representing a maximum difference of 50 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–158%, which represented an actual difference of no more than 0.7 km^2 in any one year. The ratios for the means ranged from 140–168%, which represented an actual difference of no more than 2.9 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 146–213% or 15.3–51.6 km^2.

The annual median ratios for the footprint in a cell ranged from 100–144%, but this represented a difference of no more than 0.4 km^2. The ratio for the mean footprint was very close in each year, ranging from 107–127%, and represented a difference between data types of no more than 0.7 km^2. The ratios for the maximum footprint ranged from 103–137%, representing a maximum difference of 5.8 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

BAR 5 – Number of years contacted

There is almost no difference between the two data sets when comparing the number of years cells were contacted (Figure F19, upper two plots) nor for number of years since a cell was last contacted (Figure F19, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F20 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table F17: Number of cells contacted, aggregate area, and footprint for BAR 5 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	271	260	104.2	1 892.5	1 294.3	146.2	834.2	749.9	111.2
2020	273	274	99.6	2 045.8	1 256.9	162.8	996.2	795.3	125.3
2021	342	305	112.1	1 469.0	793.3	185.2	969.6	673.9	143.9
2022	324	308	105.2	1 738.9	1 060.7	163.9	982.2	774.4	126.8
2023	386	379	101.8	1 798.3	1 060.5	169.6	1 051.3	822.1	127.9

Table F18: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for BAR 5. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	16	14	114.3	6.2	5.2	119.2	5.6	5.2	107.7	90.3	100	90.3
2020	24	31	77.4	12.0	12.7	94.5	11.9	12.5	95.2	99.2	98.4	100.8
2021	30	19	157.9	13.6	9.9	137.4	13.6	9.9	137.4	100.0	100	100.0
2022	27	29	93.1	14.9	15.3	97.4	14.5	14.7	98.6	97.3	96.1	101.2
2023	12	9	133.3	13.3	7.2	184.7	13.3	6.7	198.5	100.0	93.1	107.4

Table F19: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for BAR 5, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	6.0	6.0	100.0
Aggregate area	<0.1	<0.1	–	0.6	0.6	100.0	2.2	1.9	116.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	2.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	25.8	19.6	132.0	26.0	20.0	130.0	381.0	267.0	143.0
Aggregate area	15.1	9.5	159.0	12.1	8.9	136.0	305.0	166.6	183.0
Footprint	5.0	4.0	125.0	6.0	6.0	100.0	25.0	25.0	100.0

Table F20: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for BAR 5, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	2.0	2.0	100.0	11.3	9.1	124.0	7.0	7.0	100.0	150.0	116.0	129.0
2020	1.0	1.0	100.0	3.0	3.0	100.0	12.2	9.0	136.0	11.0	8.0	138.0	140.0	90.0	156.0
2021	1.0	1.0	100.0	3.0	3.0	100.0	7.3	5.6	130.0	8.0	7.0	114.0	75.0	47.0	160.0
2022	1.0	1.0	100.0	3.0	3.0	100.0	9.5	7.5	127.0	10.0	8.0	125.0	66.0	54.0	122.0
2023	2.0	1.0	200.0	4.0	4.0	100.0	8.5	6.4	133.0	13.0	9.0	144.0	49.0	44.0	111.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.4	75.0	0.8	0.8	100.0	7.0	5.0	140.0	3.8	3.3	115.0	122.8	76.2	161.0
2020	0.5	0.5	100.0	1.4	1.0	140.0	7.5	4.6	163.0	5.7	3.5	163.0	106.5	54.9	194.0
2021	0.5	0.5	100.0	1.1	1.1	100.0	4.3	2.6	165.0	4.0	3.1	129.0	55.0	25.8	213.0
2022	0.5	0.4	125.0	1.4	1.1	127.0	5.4	3.4	159.0	4.2	2.7	156.0	62.0	42.6	146.0
2023	0.6	0.5	120.0	1.9	1.2	158.0	4.7	2.8	168.0	5.4	3.7	146.0	46.0	30.7	150.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.4	75.0	0.8	0.8	100.0	3.1	2.9	107.0	3.0	2.9	103.0	24.0	23.3	103.0
2020	0.5	0.4	125.0	1.3	0.9	144.0	3.6	2.9	124.0	3.7	3.0	123.0	24.8	22.2	112.0
2021	0.5	0.5	100.0	1.1	1.1	100.0	2.8	2.2	127.0	3.5	2.9	121.0	21.3	15.5	137.0
2022	0.5	0.4	125.0	1.3	1.0	130.0	3.0	2.5	120.0	3.6	2.6	138.0	21.0	18.4	114.0
2023	0.6	0.5	120.0	1.6	1.2	133.0	2.7	2.2	123.0	3.7	3.0	123.0	15.7	15.2	103.0

Plots removed for data confidentiality reasons.

Figure F17: Distribution of the BAR 5 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F18: Distribution of the BAR 5 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

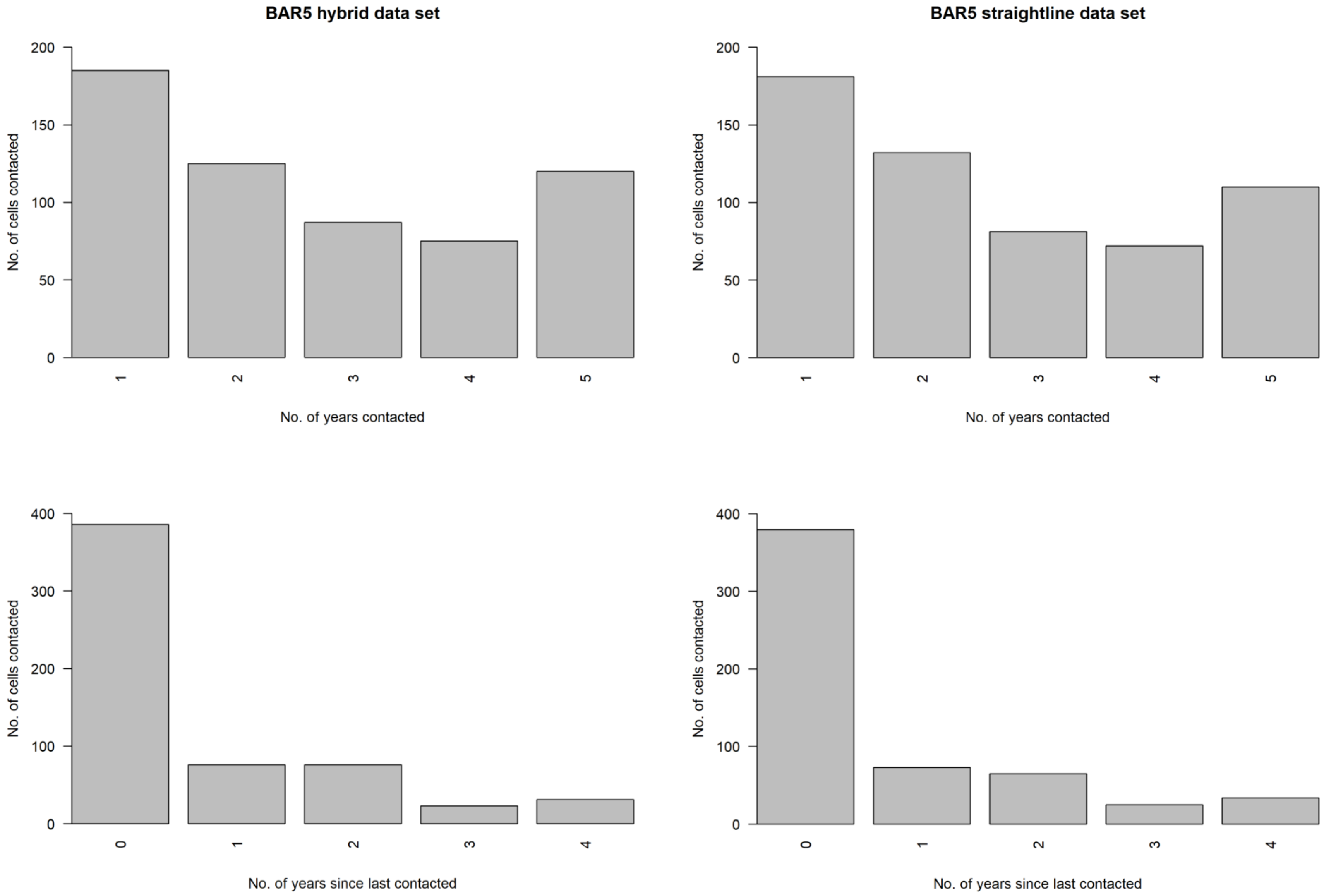

Figure F19: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F20: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

BAR 7 Spatial extent

The summaries contained in this section consist of all tows targeting barracouta in Quota Management Area BAR 7.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F21. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 98.8% and 102.2%, or a difference of between -17 and 24 cells. This indicates that the hybrid data set sometimes contacted more cells than the straight-line data set, and sometimes fewer. The difference is however low, especially in the context of the total number of cells contacted.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 114.3–135.4%, or a difference of between 217 and 1118 km^2.

The footprint was larger for the hybrid data set in all years with ratios ranging from 103.5–116.2% or a difference of between 72 and 434 km^2.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F21. At this resolution, there is little difference between the two data sets.

BAR 7 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F22 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 79.1–125%, indicating that in some years the hybrid data set contacted more new cells than the straight-line data set, and in some years the reverse was true. In terms of the numbers of new cells contacted however, the values themselves were low, ranging from -14–3.

In some years the hybrid data set had higher aggregate areas compared with the straight-line data set for those new cells contacted and in other years it was lower, with ratios ranging from 89.5–159 km^2. In terms of area, the differences are very low however, ranging from -2.6–4.6 km^2.

As for the number of cells and aggregate area, the footprint was also higher in some years for the hybrid data set, and higher in some years for the straight-line data set, with ratios ranging from 89.4–161%. Again, in terms of area, the differences are very low however, ranging from -2.9–4.7 km^2.

BAR 7 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F23). The ratio between the two data sets for the median number of tows that contacted a cell was 114% representing a difference of just one tow. The ratio for the mean number was 113% and this represented a difference of two tows. The ratio for the maximum number of tows was 105%, and represented a difference of 14 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 114%, representing a difference of just 0.3 km^2. The ratio for the mean is 124%, but again, the actual difference is relatively small at just 1.2 km^2. The ratio for the maximum is also low, at 104%, 91.4 vs 88 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F22 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is little difference with respect to the distribution of intensity.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (2 km^2). For the mean, the ratio is 133%, but this represents a difference of just 1 km^2 between the two data sets. Both data sets have a maximum footprint of 22 km^2 (close to the maximum possible of 25 km^2), hence the ratio is 100%, a perfect match.

The same summary information by year is given in Table F24. The ratio for the median number of tows that contacted a cell ranged from 100–150%, representing a difference of no more than one tow. The ratio for the mean ranged from 106–117%, representing a difference of no more than 1.1 tows. For the maximum, the ratio ranged from 100–138%, or a maximum difference of 24 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–117%, which represented an actual difference of no more than 0.1 km^2 in any one year. The ratios for the means ranged from 115–138%, which represented an actual difference of no more than 0.8 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 100–278% or 0–49.2 km^2.

The annual median ratios for the footprint in a cell ranged from 100–117%, but this represented a difference of no more than 0.1 km^2. The ratio for the mean footprint was very close in each year, ranging from 100–117%, and represented a difference between data types of no more than 0.3 km^2. The ratios for the maximum footprint ranged from 103–131%, representing a maximum difference of 5 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

BAR 7 Number of years contacted

There is almost no difference between the two data sets when comparing the number of years cells were contacted (Figure F23, upper two plots) nor for number of years since a cell was last contacted (Figure F23, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F24 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table F21: Number of cells contacted, aggregate area, and footprint for BAR 7 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1016	1006	101.0	1 286.5	1 069.4	120.3	1 114.4	989.1	112.7
2020	1455	1472	98.8	4 276.9	3 159.3	135.4	3 108.9	2 675.0	116.2
2021	1339	1330	100.7	2 765.0	2 419.0	114.3	2 150.7	2 078.9	103.5
2022	1322	1332	99.2	2 742.2	2 267.6	120.9	2 092.0	1 931.9	108.3
2023	1138	1114	102.2	1 677.9	1 445.8	116.1	1 400.3	1 314.7	106.5

Table F22: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for BAR 7. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	23	25	92.0	6.8	7.6	89.5	6.8	7.6	89.5	100.0	100	100.0
2020	53	67	79.1	24.8	27.4	90.5	24.4	27.3	89.4	98.4	99.6	98.8
2021	21	20	105.0	12.4	7.8	159.0	12.4	7.7	161.0	100.0	98.7	101.3
2022	19	20	95.0	9.3	8.8	105.7	9.3	8.6	108.1	100.0	97.7	102.4
2023	15	12	125.0	15.1	13.2	114.4	14.7	12.7	115.7	97.4	96.2	101.2

Table F23: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for BAR 7, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	2.0	150.0	8.0	7.0	114.0
Aggregate area	<0.1	<0.1	–	0.8	0.7	114.0	2.4	2.1	114.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	2.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	17.9	15.9	113.0	20.0	18.0	111.0	317.0	303.0	105.0
Aggregate area	6.2	5.0	124.0	6.6	5.5	120.0	91.4	88.0	104.0
Footprint	4.0	3.0	133.0	5.0	5.0	100.0	22.0	22.0	100.0

Table F24: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for BAR 7, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	2.0	2.0	100.0	3.5	3.2	109.0	4.0	4.0	100.0	45.0	45.0	100.0
2020	2.0	1.0	200.0	4.0	3.0	133.0	7.6	6.5	117.0	9.0	8.0	112.0	78.0	71.0	110.0
2021	1.0	1.0	100.0	3.0	3.0	100.0	6.7	6.3	106.0	8.0	7.8	103.0	87.0	63.0	138.0
2022	1.0	1.0	100.0	3.0	2.0	150.0	6.2	5.6	111.0	7.0	6.0	117.0	92.0	88.0	105.0
2023	1.0	1.0	100.0	2.0	2.0	100.0	4.6	4.3	107.0	5.0	5.0	100.0	50.0	49.0	102.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.5	0.5	100.0	1.3	1.1	118.0	1.2	1.2	100.0	18.3	18.3	100.0
2020	0.4	0.4	100.0	1.1	1.0	110.0	2.9	2.1	138.0	3.3	2.4	138.0	76.9	27.7	278.0
2021	0.4	0.4	100.0	0.9	0.9	100.0	2.1	1.8	117.0	2.3	2.2	105.0	38.8	25.2	154.0
2022	0.3	0.3	100.0	0.8	0.7	114.0	2.1	1.7	124.0	2.1	1.9	111.0	26.0	21.0	124.0
2023	0.3	0.3	100.0	0.7	0.6	117.0	1.5	1.3	115.0	1.7	1.6	106.0	16.5	13.8	120.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.5	0.5	100.0	1.1	1.0	110.0	1.2	1.2	100.0	12.7	11.9	107.0
2020	0.4	0.4	100.0	1.1	1.0	110.0	2.1	1.8	117.0	2.8	2.3	122.0	21.2	16.2	131.0
2021	0.4	0.4	100.0	0.9	0.8	112.0	1.6	1.6	100.0	2.1	2.0	105.0	15.4	14.9	103.0
2022	0.3	0.3	100.0	0.7	0.7	100.0	1.6	1.5	107.0	1.9	1.7	112.0	13.0	12.5	104.0
2023	0.3	0.3	100.0	0.7	0.6	117.0	1.2	1.2	100.0	1.5	1.5	100.0	10.1	8.9	113.0

Plots removed for data confidentiality reasons.

Figure F21: Distribution of the BAR 7 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F22: Distribution of the BAR 7 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

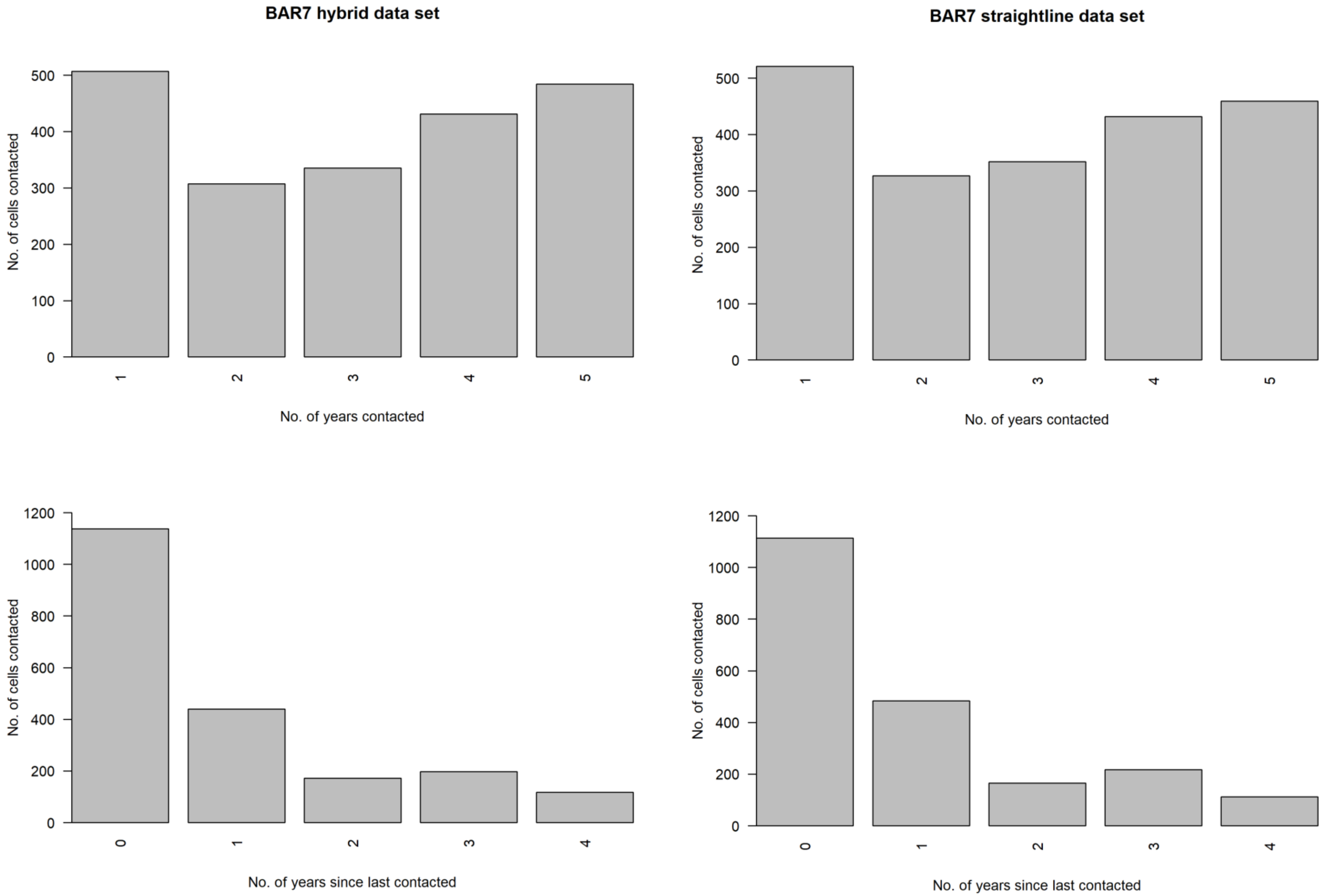

Figure F23: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F24: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

TAR 1 – Spatial extent

The summaries in this section consist of all tows targeting tarakihi in Quota Management Area TAR 1. The annual total numbers of cells, aggregate swept area, and footprint are given in Table F25. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 94.3% and 99.8%, or a difference of between -66 and -3 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 102.6–112.5%, or a difference of between 95 and 392 km^2.

The footprint was slightly lower for the hybrid data set in all years except 2023 with ratios ranging from 96.6–100.5% or a difference of between -87 and 12 km^2, which is close in the context of the total area of the footprint.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F25. At this resolution, there is little difference between the two data sets.

TAR 1 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F26 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 40.9–112.5%. While it might seem that there is a large disparity, the ratio represents differences of between just -13 and 1 cell.

The ratio for the aggregate area for new cells contacted ranged from 50–126.5%, but this represented a difference of no more than 2.4 km^2.

For the footprint of new cells contacted, the ratios ranged from 50–123.5%, representing a difference of no more than 2.4 km^2. These values are almost identical to those for the aggregate area, because the aggregate area and footprint are almost identical. Because of this, the ratio for the footprint as a percentage of the aggregate area is, or is close to, 100% in all years (range 94.4–100%). This closeness demonstrates that irrespective of which data set is used, the 'new' areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing.

TAR 1 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F27). The ratio between the two data sets for the median number of tows that contacted a cell was 112%, a difference of just one tow. The ratio for the mean number was 111% and represented a difference of 3.4 tows. The maximum number of tows had a ratio of 110%, a difference of 25 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 115%, representing a difference of just 0.3 km^2. The ratio for the mean is 113%, representing a difference of 1.3 km^2. The ratio for the maximum is more substantial at 93%, a difference of -10.4 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F26 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little. However, the straight-line data sets require higher categories for all years combined than the hybrid data set in order to span the full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 100% (2 km^2) The ratio for the mean is a also a perfect match at 100% (5 km^2), as is the maximum is (24 km^2).

The same summary information by year is given in Table F28. The annual ratio for the median number of tows that contacted a cell ranged from 100–140%, representing a difference of no more than two tows. For the mean, the annual ratio ranged from 102–116%, which represented a difference of no more than 1.5 tows. The maximum annual ratio ranged from 100–108%, representing a maximum difference of five tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–129%, which represented an actual difference of no more than 0.5 km^2 in any one year. The ratios for the means ranged from 104–119%, which represented an actual difference of no more than 0.6 km^2 in any one year. Ratios for the maximum aggregate area ranged from 84–101% or -6.9–0.3 km^2.

The annual median ratios for the footprint in a cell ranged from 100–115%, representing a difference of no more than 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 96–104%, and represented a difference between data types of no more than 0.1 km^2. The ratios for the maximum footprint ranged from 85–100%, representing a maximum difference of 2.4 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close to one another for both data types.

TAR 1 – Number of years contacted

There is little difference between the two data sets when comparing the number of years in which cells were contacted (Figure F27, upper two plots) nor for number of years since a cell was last contacted (Figure F27, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F28 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F25: Number of cells contacted, aggregate area, and footprint for TAR 1 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1267	1270	99.8	3 675.0	3 580.5	102.6	2 841.7	2 883.4	98.6
2020	1095	1161	94.3	4 131.4	3 739.1	110.5	2 944.7	3 001.0	98.1
2021	967	994	97.3	3 537.5	3 199.2	110.6	2 446.9	2 534.0	96.6
2022	858	901	95.2	3 479.3	3 137.0	110.9	2 380.4	2 446.7	97.3
2023	889	920	96.6	2 826.5	2 512.4	112.5	2 138.9	2 127.4	100.5

Table F26: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TAR 1. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km2)			Footprint (km2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	30	31	96.8	8.0	8.3	96.4	8.0	8.3	96.4	100.0	100.0	100.0
2020	9	22	40.9	2.8	5.2	53.8	2.8	5.2	53.8	100.0	100.0	100.0
2021	9	8	112.5	4.3	3.4	126.5	4.2	3.4	123.5	97.7	100.0	97.7
2022	6	6	100.0	1.8	1.6	112.5	1.7	1.6	106.2	94.4	100.0	94.4
2023	6	10	60.0	1.3	2.6	50.0	1.3	2.6	50.0	100.0	100.0	100.0

Table F27: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TAR 1, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	9.0	8.0	112.0
Aggregate area	<0.1	<0.1	–	0.5	0.5	100.0	2.3	2.0	115.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	2.0	2.0	100.0
	Mean			**3rd quartile**			**Maximum**		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	33.4	30.1	111.0	51.0	46.0	111.0	276.0	251.0	110.0
Aggregate area	11.2	9.9	113.0	15.9	13.2	120.0	140.6	151.0	93.0
Footprint	5.0	5.0	100.0	8.0	9.0	89.0	23.0	23.0	100.0

Table F28: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TAR 1, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.5	1.0	150.0	4.0	4.0	100.0	8.7	8.5	102.0	12.0	12.0	100.0	84.0	80.0	105.0
2020	2.0	2.0	100.0	7.0	5.0	140.0	11.1	9.6	116.0	17.0	15.0	113.0	74.0	69.0	107.0
2021	2.0	1.0	200.0	6.0	5.0	120.0	10.9	9.8	111.0	16.0	14.0	114.0	74.0	72.0	103.0
2022	3.0	2.0	150.0	8.5	7.0	121.0	12.1	10.7	113.0	18.0	17.0	106.0	71.0	66.0	108.0
2023	2.0	2.0	100.0	7.0	5.0	140.0	9.7	8.6	113.0	15.0	13.0	115.0	54.0	54.0	100.0
	Aggregate area 1st Quartile			**Aggregate area median**			**Aggregate area mean**			**Aggregate area 3rd Quartile**			**Aggregate area maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.2	1.2	100.0	2.9	2.8	104.0	3.8	3.7	103.0	37.1	44.0	84.0
2020	0.5	0.4	125.0	1.7	1.4	121.0	3.8	3.2	119.0	5.5	4.9	112.0	32.3	32.0	101.0
2021	0.4	0.4	100.0	1.5	1.4	107.0	3.7	3.2	116.0	4.8	4.5	107.0	31.2	31.3	100.0
2022	0.5	0.5	100.0	2.2	1.7	129.0	4.1	3.5	117.0	5.9	4.9	120.0	29.9	30.5	98.0
2023	0.4	0.4	100.0	1.8	1.5	120.0	3.2	2.7	119.0	5.0	4.1	122.0	19.3	20.1	96.0
	Footprint 1st Quartile			**Footprint median**			**Footprint mean**			**Footprint 3rd Quartile**			**Footprint maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.1	1.1	100.0	2.2	2.3	96.0	3.3	3.3	100.0	13.9	14.6	95.0
2020	0.4	0.4	100.0	1.5	1.3	115.0	2.7	2.6	104.0	4.3	4.1	105.0	13.9	14.0	99.0
2021	0.4	0.4	100.0	1.3	1.3	100.0	2.5	2.5	100.0	3.8	3.8	100.0	15.3	15.3	100.0
2022	0.5	0.5	100.0	1.7	1.6	106.0	2.8	2.7	104.0	4.5	4.2	107.0	13.1	15.5	85.0
2023	0.4	0.4	100.0	1.6	1.4	114.0	2.4	2.3	104.0	3.8	3.6	106.0	13.3	13.3	100.0

Plots removed for data confidentiality reasons.

Figure F25: Distribution of the TAR 1 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

F26: Distribution of the TAR 1 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

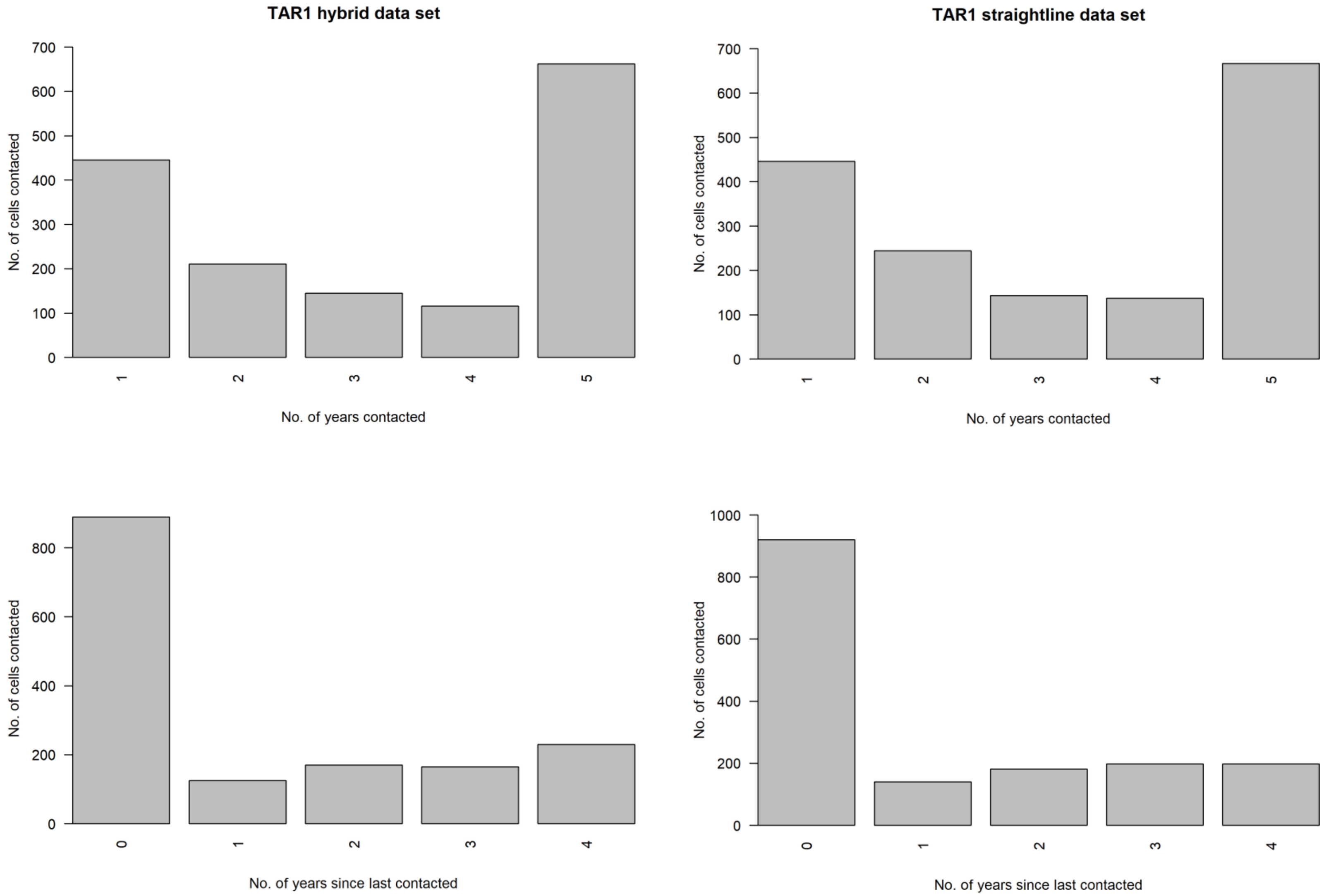

Figure F27: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons. **Figure F28: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).**

TAR 2 – Spatial extent

The summaries in this section consist of all tows targeting tarakihi in Quota Management Area TAR 2.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F29. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 93.1% and 99%, or a difference of between -47 and -9 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 104.2–112.8%, or a difference of between 194 and 477 km^2.

The footprint was slightly lower for the hybrid data set in all years with ratios ranging from 90.5–98.5% or a difference of between -222 and -49 km^2, which is relatively close in the context of the total area of the footprint.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F29. At this resolution, there is little difference between the two data sets.

TAR 2 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F30 where the base footprint was created for 2008–2018 using the straight-line data set.

There was almost no difference in the number of new cells contacted by each data set. There were 17 new cells contacted by both in 2019, after which the number contacted by each ranged between 0 and 1. The corresponding aggregate areas and footprints were essentially identical where there was data. This closeness demonstrates that irrespective of which data set is used, the 'new' areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing, for the few instances where there were new cells contacted in either data set.

TAR 2 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F31). The ratio between the two data sets for the median number of tows that contacted a cell was 121% a difference of three tows. The ratio for the mean was 108%, a difference of five tows. The maximum number of tows had a ratio of 118%, which represented a more substantial difference of 136 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 118%, representing a difference of just 0.5 km^2. The ratio for the mean is 112%, representing a difference of 2 km^2. The ratio for the maximum is more substantial at 125%, a difference of 53 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F30 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little. However, the hybrid data sets require higher categories for all years combined than the straight-line data set to span the full range of data because overall, the aggregate area is higher for the former than it is for the latter.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 67% representing a difference of just 1 km^2. The ratio for the mean is 86%, representing a difference of just 1 km^2. The ratio for the maximum is 96%, and this also represents a difference of just 1 km^2. Only the hybrid data set gives a maximum footprint of 25 km^2, the maximum possible in a cell.

The same summary information by year is given in Table F32. For the number of tows that contacted a cell, the median ratio ranged from 100–126%, which represented no more than three tows in any one year. The annual ratio for the mean ranged from 104–114%, which represented a difference of no more than 3.1 tows. For the maximum number of tows, the ratio ranged from 107–129%, which represented a maximum of 44 tows in any one year.

The annual median ratios for the aggregate areas in a cell ranged from 100–138%, which represented an actual difference of no more than 0.5 km^2 in any one year. The ratios for the means ranged from 104–121%, which represented an actual difference of no more than 1.1 km^2 in any one year. Ratios for the maximum aggregate area ranged from 107–129% or 3.2–13.4 km^2.

The annual median ratios for the footprint in a cell ranged from 96–109%, representing a difference of no more than 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 93–100%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 78–105%, representing a maximum difference of -4.2 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

TAR 2 – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted (Figure F31, upper two plots) nor for number of years since a cell was last contacted (Figure F31, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F32 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F29: Number of cells contacted, aggregate area, and footprint for TAR 2 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km²)			Footprint (km²)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	929	938	99.0	4 773.3	4 578.9	104.2	3 270.2	3 319.4	98.5
2020	653	667	97.9	4 210.0	3 733.4	112.8	2 405.1	2 627.2	91.5
2021	637	684	93.1	4 021.2	3 587.5	112.1	2 383.4	2 548.8	93.5
2022	553	566	97.7	2 610.3	2 348.0	111.2	1 536.2	1 696.6	90.5
2023	549	559	98.2	2 613.5	2 384.5	109.6	1 663.9	1 770.0	94.0

Table F30: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TAR 2. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km²)			Footprint (km²)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	17	17	100.0	2.9	2.9	100.0	2.9	2.9	100.0	100.0	100.0	100.0
2020	1	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2021	0	1	0.0	0.0	0.2	0.0	0.0	0.2	0.0	–	100.0	–
2022	1	0	–	0.1	0.0	–	0.1	0.0	–	100.0	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table F31: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TAR 2, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	17.0	14.0	121.0
Aggregate area	<0.1	<0.1	–	0.5	0.5	100.0	3.3	2.8	118.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	2.0	3.0	67.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	70.2	65.2	108.0	115.0	110.0	105.0	875.0	739.0	118.0
Aggregate area	18.2	16.2	112.0	27.6	24.1	115.0	265.0	212.4	125.0
Footprint	6.0	7.0	86.0	12.0	12.0	100.0	24.0	25.0	96.0

Table F32: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TAR 2, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	7.0	7.0	100.0	19.7	19.0	104.0	33.0	32.0	103.0	176.0	160.0	110.0
2020	3.0	3.0	100.0	15.0	13.0	115.0	23.8	21.7	110.0	35.0	32.5	108.0	197.0	153.0	129.0
2021	4.0	3.0	133.0	16.0	13.0	123.0	24.6	21.5	114.0	35.0	31.2	112.0	218.0	177.0	123.0
2022	3.0	3.0	100.0	12.0	9.5	126.0	19.0	17.4	109.0	26.0	24.0	108.0	136.0	111.0	123.0
2023	4.0	3.0	133.0	14.0	13.0	108.0	18.9	17.6	107.0	28.0	27.0	104.0	148.0	138.0	107.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.4	1.4	100.0	5.1	4.9	104.0	8.4	7.3	100.0	50.5	47.3	107.0
2020	0.7	0.6	117.0	3.3	2.9	114.0	6.4	5.6	114.0	9.5	8.4	114.0	60.0	46.6	129.0
2021	0.7	0.5	140.0	3.6	2.6	138.0	6.3	5.2	121.0	9.2	8.0	138.0	67.7	58.6	116.0
2022	0.6	0.4	150.0	2.4	1.9	126.0	4.7	4.1	115.0	6.1	5.5	126.0	42.0	33.8	124.0
2023	0.7	0.6	117.0	2.9	2.4	121.0	4.8	4.3	112.0	7.2	6.6	121.0	53.9	47.4	114.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.4	1.4	100.0	3.5	3.5	100.0	6.3	6.1	103.0	18.1	21.1	86.0
2020	0.6	0.6	100.0	2.3	2.4	96.0	3.7	3.9	95.0	6.2	6.7	93.0	19.3	18.3	105.0
2021	0.6	0.5	120.0	2.4	2.2	109.0	3.7	3.7	100.0	5.9	6.1	97.0	17.9	20.2	89.0
2022	0.5	0.4	125.0	1.8	1.7	106.0	2.8	3.0	93.0	4.3	4.6	93.0	14.8	17.0	87.0
2023	0.6	0.5	120.0	2.1	2.1	100.0	3.0	3.2	94.0	5.1	5.3	96.0	15.3	19.5	78.0

Plots removed for data confidentiality reasons.

Figure F29: Distribution of the TAR 2 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F30: Distribution of the TAR 2 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

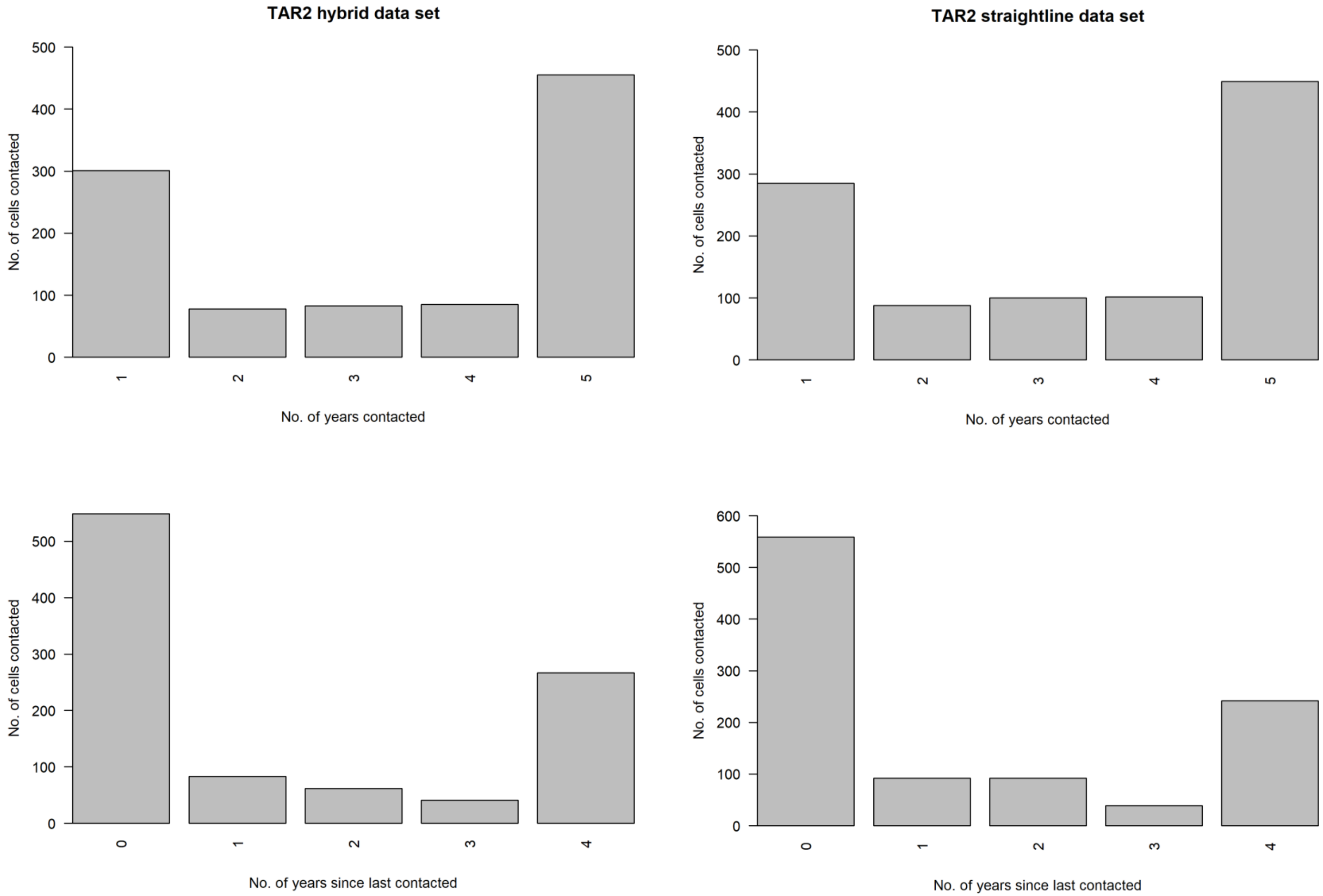

Figure F31: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F32: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

TAR 3 – Spatial extent

The summaries in this section consist of all tows targeting tarakihi in Quota Management Area TAR 3.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F33. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 95% and 100.8%, or a difference of between -27 and 7 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 107.6–125.1%, or a difference of between 130 and 216 km^2.

The footprint was slightly higher for the hybrid data set in all years except 2022 with ratios ranging from 98.1–107.1% or a difference of between -11.7 and 58.9 km^2, which is relatively close in the context of the total area of the footprint.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F33. At this resolution, there is little difference between the two data sets.

TAR 3 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F34 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratio for the number of new cells contacted ranged from 50–100% but represented a difference of no more than one cell in any one year.

The ratios for the aggregate areas ranged from 50–260% but again, the actual differences were small, representing a difference of no more than 0.6km^2.

Ratios for the footprint ranged from 50–200% but represented a difference of no more than 0.6 km^2.

When considering the footprint as a percentage of the aggregate area, both data sets were generally very close, hence the ratios between the two are 100%, or close to. The ratio of 61.5% in 2021 is because there is more difference between the aggregate area and corresponding footprint for the hybrid data set than usual, but this is an actual difference of only 1 km^2, but as a proportion this is relatively high, and the same values for the straight-line footprint are identical to one another.

The overall closeness demonstrates that irrespective of which data set is used, the ‘new’ areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing, for the few instances where there were new cells contacted in either data set.

TAR 3 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F35). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (six tows each). The ratio for the mean number was 108%, a difference of 1.9 tows. The ratio for the maximum number of tows in a cell was 101%, a difference of three tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 100%, a perfect match between the two data sets. The ratio for the mean is 116%, representing a difference of 0.9 km^2. The ratio for the maximum is also close at 102%, a difference of 3.7 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F34 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little and the same ranges are used for the different categories of intensity.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is a perfect match at 100% (1 km^2) as is the ratio for the mean (3 km^2). The ratio for the maximum is 105%, representing a difference of just 1 km^2. Neither data set gives a maximum footprint of 25 km^2, the maximum possible in a cell.

The same summary information by year is given in Table F36. For the number of tows that contacted a cell, the annual ratio for the median was 100% in all years. For the mean, the ratio ranged from 103–118%, representing a difference of no more than 1.2 tows in any one year. The maximum annual ratio ranged from 98–136%, which represented a maximum difference of 27 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–120%, which represented an actual difference of no more than 0.1 km^2 in any one year. The ratios for the means ranged from 108–131%, which represented an actual difference of no more than 0.5 km^2 in any one year. Ratios for the maximum aggregate area ranged from 96–149% or -1.9–11.8 km^2.

The annual median ratios for the footprint in a cell ranged from 100–120%, representing a difference of no more than 0.1 km^2. The ratio for the mean footprint was close in each year, ranging from 93–117%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 89–119%, representing a maximum difference of 2.1 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

TAR 3 – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although there are slightly more cells in the hybrid data set that have just one year of contact (Figure F35, upper two plots). There is little difference in the number of years since a cell was last contacted between the two data sets, although they hybrid data set has slightly fewer cells contacted in the most recent fishing year (zero years since contact) (Figure F35, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F36 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F33: Number of cells contacted, aggregate area, and footprint for TAR 3 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	876	869	100.8	2 344.1	2 179.5	107.6	1 792.2	1 733.3	103.4
2020	576	583	98.8	1 213.7	998.1	121.6	858.0	800.8	107.1
2021	517	544	95.0	1 064.3	850.8	125.1	698.8	680.0	102.8
2022	427	427	100.0	1 156.9	966.1	119.7	608.8	620.5	98.1
2023	477	496	96.2	1 050.7	920.3	114.2	696.0	671.1	103.7

Table F34: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TAR 3. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	10	11	90.9	1.0	1.1	90.9	1.0	1.1	90.9	100.0	100.0	100.0
2020	5	6	83.3	1.5	1.5	100.0	1.4	1.5	93.3	93.3	100.0	93.3
2021	5	5	100.0	2.6	1.0	260.0	1.6	1.0	160.0	61.5	100.0	61.5
2022	1	1	100.0	0.4	0.2	200.0	0.4	0.2	200.0	100.0	100.0	100.0
2023	1	2	50.0	0.2	0.4	50.0	0.2	0.4	50.0	100.0	100.0	100.0

Table F35: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km2 cell for TAR 3, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	6.0	6.0	100.0
Aggregate area	<0.1	<0.1	–	0.4	0.4	100.0	1.3	1.3	100.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0
	Mean			**3rd quartile**			**Maximum**		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	25.4	23.5	108.0	22.0	20.0	110.0	480.0	477.0	101.0
Aggregate area	6.5	5.6	116.0	5.1	4.5	113.0	170.9	167.2	102.0
Footprint	3.0	3.0	100.0	4.0	4.0	100.0	23.0	22.0	105.0

Table F36: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TAR 3, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	3.0	3.0	100.0	10.9	10.6	103.0	11.2	11.0	102.0	120.0	120.0	100.0
2020	1.0	1.0	100.0	3.0	3.0	100.0	8.1	7.3	111.0	8.0	7.0	114.0	103.0	76.0	136.0
2021	1.0	1.0	100.0	3.0	3.0	100.0	7.9	6.7	118.0	8.0	7.0	114.0	73.0	69.0	106.0
2022	1.0	1.0	100.0	3.0	3.0	100.0	10.3	9.2	112.0	9.0	8.0	112.0	126.0	126.0	100.0
2023	1.0	1.0	100.0	3.0	3.0	100.0	8.2	7.2	114.0	10.0	8.0	125.0	110.0	112.0	98.0
	Aggregate area 1st Quartile			**Aggregate area median**			**Aggregate area mean**			**Aggregate area 3rd Quartile**			**Aggregate area maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.8	0.8	100.0	2.7	2.5	108.0	2.6	2.6	100.0	36.2	36.1	100.0
2020	0.3	0.2	150.0	0.6	0.6	100.0	2.1	1.7	124.0	1.7	1.6	106.0	35.9	24.1	149.0
2021	0.3	0.3	100.0	0.6	0.5	120.0	2.1	1.6	131.0	1.8	1.5	120.0	27.8	24.0	116.0
2022	0.3	0.2	150.0	0.7	0.6	117.0	2.7	2.3	117.0	2.1	1.9	111.0	52.7	48.8	108.0
2023	0.3	0.3	100.0	0.8	0.7	114.0	2.2	1.9	116.0	2.2	1.8	122.0	42.9	44.8	96.0
	Footprint 1st Quartile			**Footprint median**			**Footprint mean**			**Footprint 3rd Quartile**			**Footprint maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.8	0.8	100.0	2.0	2.0	100.0	2.4	2.4	100.0	17.4	17.6	99.0
2020	0.3	0.2	150.0	0.6	0.5	120.0	1.5	1.4	107.0	1.5	1.5	100.0	16.3	14.5	112.0
2021	0.2	0.2	100.0	0.6	0.5	120.0	1.4	1.2	117.0	1.5	1.4	107.0	10.1	10.8	94.0
2022	0.3	0.2	150.0	0.6	0.6	100.0	1.4	1.5	93.0	1.8	1.7	106.0	12.8	14.4	89.0
2023	0.3	0.3	100.0	0.7	0.7	100.0	1.5	1.4	107.0	1.9	1.7	112.0	13.2	11.1	119.0

Plots removed for data confidentiality reasons.

Figure F33: Distribution of the TAR 3 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F34: Distribution of the TAR 3 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

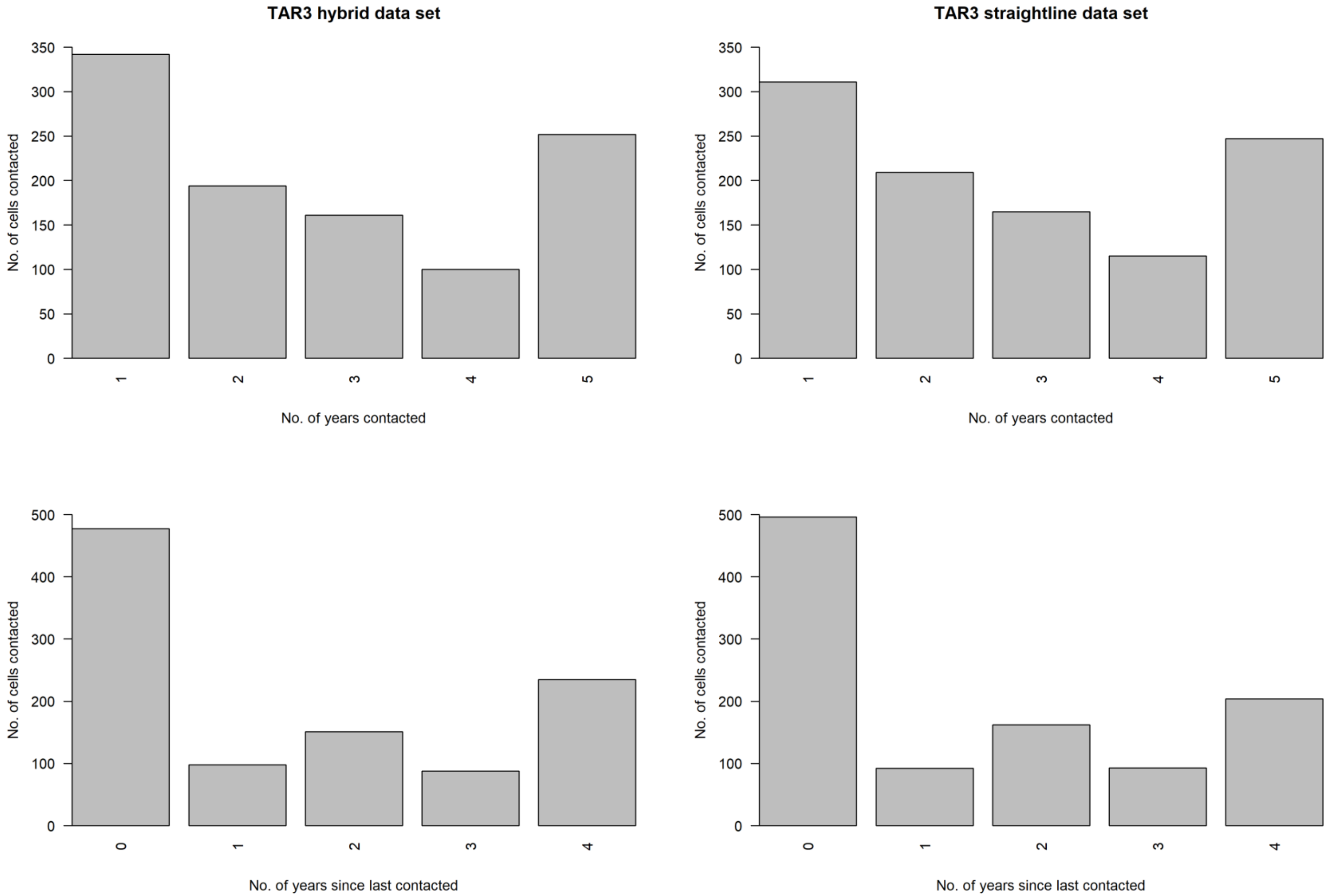

Figure F35: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F36: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

TAR 4 – Spatial extent

The summaries in this section consist of all tows targeting tarakihi in Quota Management Area TAR 4.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F37. For the four-year period (note that there was no target fishing reported in 2023) the hybrid:straight-line ratio number of cells contacted ranged between 82.9 and 109.3%, or a difference of between -9 and 8 cells.

The aggregate area was larger for the hybrid data set in all years except 2021 with ratios ranging from 95.5–107.9%, or a difference of between 130 and 216 km^2.

The footprint was lower for the hybrid data set in all years with ratios ranging from 90.4–97.3% or a difference of between -27.2 and -1.2 km^2, which is relatively close in the context of the total area of the footprint.

For all measures of contact and for both data sets, there is a rapid decline each year before there being no reported target fishing of tarakihi in TAR 4 in 2023.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F37. At this resolution, there is little difference between the two data sets.

TAR 4 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F38 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratio for the number of new cells contacted ranged from 37.5–200% but represented a difference of no more than -17 cells in any one year.

The ratios for the aggregate areas ranged from 14.3–94.9% but again, the actual differences were small, representing a difference of no more than -7.1 km^2.

Ratios for the footprint ranged from 14.3–96.6%, representing a maximum difference of -7.1 km^2. These values are almost identical to the aggregate area because the new areas contacted were almost all contacted only once.

When considering the footprint as a percentage of the aggregate area, both data sets were generally very close, hence the ratios between the two are 100%, or close to. The overall closeness demonstrates that irrespective of which data set is used, the ‘new’ areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing.

TAR 4 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F39). The ratio between the two data sets for the median number of tows that contacted a cell was 150% but this was for a difference of just one tow. The ratio for the mean was 109% which represented a difference of 1.3 tows. (41.8 vs 19.2 tows). The maximum number of tows had a ratio of 75%, or a difference of -33 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 150% but represents a difference of just 0.3 km^2. The ratio for the mean is 114%, representing a difference of 0.7 km^2. The ratio for the maximum is 83%, or a difference of -9.8 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F38 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). At first glance, the hybrid data set appears to have a greater area of more intense contact but the difference in spread between the two data sets means that they have different ranges. But overall, the spatial distribution of intensity is very similar.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is a perfect match at 100% (1 km^2) as is the ratio for the mean (3 km^2). The ratio for the maximum is 105%, representing a difference of just 1 km^2. Neither data set gives a maximum footprint of 25 km^2, the maximum possible in a cell.

The same summary information by year is given in Table F40. For the number of tows that contacted a cell, the annual median ratio ranged from 100–150%, which represented a difference of no more than 1.5 tows in any one year. The ratio for the mean ranged from 89–124%, which represented a difference of no more than 1.2 tows. For the maximum number of tows in a cell, the annual ratio ranged from 82–120%, or a maximum difference of -10 cells.

The annual median ratios for the aggregate areas in a cell ranged from 87–157%, which represented an actual difference of no more than 0.4 km^2 in any one year. The ratios for the means ranged from 93–124%, which represented an actual difference of no more than 0.4 km^2 in any one year. Ratios for the maximum aggregate area ranged from 86–117% or -4.6–1.6 km^2.

The annual median ratios for the footprint in a cell ranged from 75–129%, representing a difference of no more than 0.2 km^2. The ratio for the mean footprint was close in each year, ranging from 82–115%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 77–115%, representing a maximum difference of -2.3 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

TAR 4 – Number of years contacted

The bar plots of the numbers of years a cell was contacted, and the number of years since a cell was last contacted, show that the overall distribution is similar. For both measures however, the straight-line data set contacts more cells overall. (Figure F39).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F40 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution, but the straight-line data set shows an area with a larger extent of contact to the west.

Table F37: Number of cells contacted, aggregate area, and footprint for TAR 4 for fishing years 2019 to 2022 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	214	214	100.0	946.3	877.3	107.9	522.4	549.6	95.1
2020	139	148	93.9	370.2	355.5	104.1	237.1	260.1	91.2
2021	94	86	109.3	117.7	123.3	95.5	87.2	96.5	90.4
2022	29	35	82.9	60.3	59.3	101.7	43.7	44.9	97.3

Table F38: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2022, for the hybrid and straight-line data sets for TAR 4. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	43	43	100.0	20.3	21.4	94.9	19.9	20.6	96.6	98.0	96.3	101.8
2020	29	46	63.0	10.2	17.3	59.0	10.2	17.3	59.0	100.0	100.0	100.0
2021	2	1	200.0	0.6	0.0	–	0.5	0.0	–	83.3	–	–
2022	3	8	37.5	0.4	2.8	14.3	0.4	2.8	14.3	100.0	100.0	100.0

Table F39: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TAR 4, for the combined fishing years 2019–2022, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	3.0	2.0	150.0
Aggregate area	<0.1	<0.1	–	0.3	0.3	100.0	0.9	0.6	150.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	15.1	13.8	109.0	25.0	18.2	137.0	99.0	132.0	75.0
Aggregate area	5.8	5.1	114.0	6.6	4.9	135.0	49.3	59.1	83.0
Footprint	3.0	3.0	100.0	4.0	4.0	100.0	20.0	19.0	105.0

Table F40: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TAR 4, 2019–2022, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	3.0	3.0	100.0	11.1	10.6	105.0	14.0	12.8	109.0	72.0	82.0	88.0
2020	1.0	1.0	100.0	5.0	3.5	143.0	6.9	6.5	106.0	9.5	9.0	106.0	33.0	40.0	82.0
2021	1.0	2.0	50.0	3.0	3.0	100.0	4.0	4.5	89.0	5.0	6.0	83.0	19.0	22.0	86.0
2022	1.0	1.0	100.0	3.0	2.0	150.0	6.1	4.9	124.0	9.0	4.0	225.0	24.0	20.0	120.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.0	1.0	100.0	4.4	4.1	107.0	4.6	3.9	118.0	37.9	42.5	89.0
2020	0.4	0.5	80.0	1.1	0.7	157.0	2.7	2.4	113.0	3.8	3.1	123.0	18.7	21.8	86.0
2021	0.3	0.5	60.0	0.7	0.8	87.0	1.3	1.4	93.0	1.4	1.9	74.0	9.2	9.4	98.0
2022	0.2	0.3	67.0	0.5	0.5	100.0	2.1	1.7	124.0	1.5	1.4	107.0	11.0	9.4	117.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.0	1.0	100.0	2.4	2.6	92.0	3.5	3.3	106.0	18.0	17.6	102.0
2020	0.4	0.4	100.0	0.9	0.7	129.0	1.7	1.8	94.0	2.7	2.7	100.0	7.9	10.2	77.0
2021	0.3	0.5	60.0	0.6	0.8	75.0	0.9	1.1	82.0	1.2	1.6	75.0	5.1	4.8	106.0
2022	0.2	0.3	67.0	0.5	0.5	100.0	1.5	1.3	115.0	1.4	1.3	108.0	7.7	6.7	115.0

Plots removed for data confidentiality reasons.

Figure F37: Distribution of the TAR 4 footprint for the 2019–2022 fishing years combined (top two plots) and 2022 (bottom two plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F38: Distribution of the TAR 4 aggregate area for the 2019–2022 fishing years combined (top two plots) and 2022 (bottom two plots) for the hybrid and straight-line data sets.

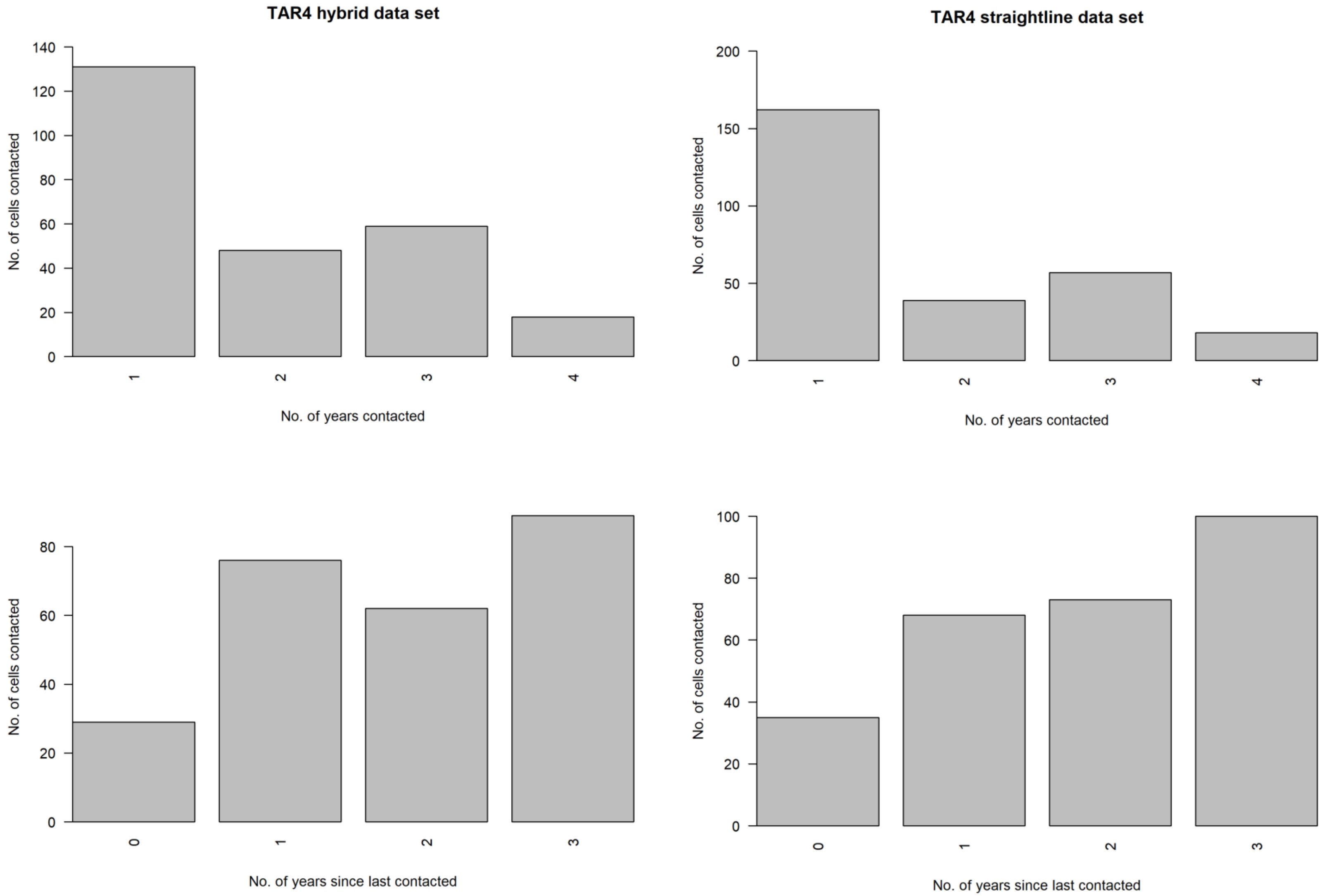

Figure F39: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2022 for the hybrid data (left) and straight-line data (right) for TAR 4.

Plots removed for data confidentiality reasons.

Figure F40: Distribution of cells, by the number of years contacted (top two plots), and by the most recent year fished (bottom two plots) between 2019 and 2023 for the hybrid data and the straight-line data.

TAR 5 – Spatial extent

The summaries in this section consist of all tows targeting tarakihi in Quota Management Area TAR 5.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F41. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 100% and 110.5%, or a difference of between 0 and 8 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 103.6–136.9%, or a difference of between 1.1 and 24 km^2.

The footprint was higher for the hybrid data set in all years with ratios ranging from 102.7–123.6% or a difference of between 0.8 and 14.8 km^2.

The spatial distribution of the footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F41. At this resolution, there is little difference between the two data sets.

TAR 5 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F42 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratio for the number of new cells contacted ranged from 83.3–111.1% but represented a difference of no more than one cell in any one year.

The ratios for the aggregate areas ranged from 84–433.3%. While the upper range may seem very large, this represents a difference of just 1 km^2 (1.3 vs 1).

Ratios for the footprint also ranged from 84–433.3% because the footprint and the aggregate area were identical in every year.

When considering the footprint as a percentage of the aggregate area, the ratios are 100% in every case because for both measures in every year, the aggregate areas and footprint are the same. This is most likely because the 'new' areas contacted were just fishing activity on the margins of established areas, rather than any new or exploratory fishing, for the few instances where there were new cells contacted in either data set.

TAR 5 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F43). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (two tows each). The ratio for the mean number was 108% and this represented a difference of 0.4 tows. The maximum number of tows that contacted a cell had a ratio of 112%, or a difference of three tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 87%, but this represents a difference of just -0.1km^2. The ratio for the mean is 111%, representing a difference of 0.2 km^2. The ratio for the maximum is 90%, a difference of -1.8 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F42 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little, but the straight-line data set requires a slightly higher upper range for the most intensely fished cells to cover the full range.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is a perfect match at 100% (1 km^2) as is the ratio for the mean (2 km^2). The ratio for the maximum is 120%, representing a difference of just 2 km^2. Neither data set gives a maximum footprint of 25 km^2, the maximum possible in a cell.

The same summary information by year is given in Table F44. For the number of tows that contacted a cell, the annual ratio for the median ranged from 100–200%, which represented a maximum difference of one tow. The annual mean ranged from 94–116%, which represented a difference of no more than 0.5 tows in any one year. For the maximum number of tows that contacted a cell, the ratio ranged from 100–138%, which represented a maximum difference of just three tows.

The annual median ratios for the aggregate areas in a cell ranged from 83–133%, which represented an actual difference of no more than 0.2 km^2 in any one year. The ratios for the means ranged from 100–140%, which represented an actual difference of no more than 0.4 km^2 in any one year. Ratios for the maximum aggregate area ranged from 70–164% or -2–1.8 km^2.

The annual median ratios for the footprint in a cell ranged from 83–133%, representing a difference of no more than 0.1 km^2. The ratio for the mean footprint was close in each year, ranging from 100–120%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 75–154%, representing a maximum difference of 1.3 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

TAR 5 – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although there are slightly more cells in the hybrid data set that have just one year of contact (Figure F43, upper two plots). There is little difference in the number of years since a cell was last contacted between the two data sets, although they hybrid data set has slightly fewer cells contacted in the most recent fishing year (zero years since contact) (Figure F43, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F44 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F41: Number of cells contacted, aggregate area, and footprint for TAR 5 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	91	90	101.1	56.9	47.7	119.3	53.5	46.5	115.1
2020	64	63	101.6	89	65.0	136.9	77.6	62.8	123.6
2021	116	116	100.0	119.6	111.1	107.7	109.1	104.7	104.2
2022	45	42	107.1	31.9	30.8	103.6	30.8	30.0	102.7
2023	84	76	110.5	102.7	93.5	109.8	90.0	78.3	114.9

Table F42: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TAR 5. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	5	6	83.3	1.0	1.3	76.9	1.0	1.3	76.9	100.0	100.0	100.0
2020	1	1	100.0	1.3	0.3	433.3	1.3	0.3	433.3	100.0	100.0	100.0
2021	2	2	100.0	2.1	2.5	84.0	2.1	2.5	84.0	100.0	100.0	100.0
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	10	9	111.1	2.8	3.0	93.3	2.8	3.0	93.3	100.0	100.0	100.0

Table F43: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TAR 5, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	2.0	2.0	100.0
Aggregate area	<0.1	<0.1	–	0.3	0.3	100.0	0.7	0.8	87.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	5.5	5.1	108.0	7.0	6.0	117.0	28.0	25.0	112.0
Aggregate area	2.1	1.9	111.0	2.8	2.2	127.0	15.5	17.3	90.0
Footprint	2.0	2.0	100.0	2.0	2.0	100.0	12.0	10.0	120.0

Table F44: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TAR 5, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	1.0	1.0	100.0	1.9	1.9	100.0	2.0	2.0	100.0	10.0	9.0	111.0
2020	1.0	1.0	100.0	2.0	2.0	100.0	3.6	3.1	116.0	5.0	5.0	100.0	11.0	8.0	138.0
2021	1.0	1.0	100.0	2.0	1.0	200.0	2.7	2.5	108.0	3.0	3.0	100.0	11.0	11.0	100.0
2022	1.0	1.0	100.0	1.0	1.0	100.0	1.7	1.8	94.0	2.0	2.0	100.0	4.0	4.0	100.0
2023	1.0	1.0	100.0	1.0	1.0	100.0	2.9	2.9	100.0	2.2	2.2	100.0	14.0	14.0	100.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.2	0.2	100.0	0.4	0.3	133.0	0.6	0.5	120.0	0.7	0.6	117.0	4.6	2.8	164.0
2020	0.3	0.2	150.0	0.8	0.6	133.0	1.4	1.0	140.0	1.7	1.6	106.0	5.9	4.3	137.0
2021	0.1	0.2	50.0	0.5	0.6	83.0	1.0	1.0	100.0	1.7	1.4	121.0	4.6	6.6	70.0
2022	0.2	0.2	100.0	0.5	0.4	125.0	0.7	0.7	100.0	0.9	0.8	112.0	2.9	3.3	88.0
2023	0.3	0.2	150.0	0.6	0.6	100.0	1.2	1.2	100.0	1.0	1.0	100.0	9.8	9.8	100.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.2	0.2	100.0	0.4	0.3	133.0	0.6	0.5	120.0	0.7	0.6	117.0	3.7	2.4	154.0
2020	0.3	0.2	150.0	0.7	0.6	117.0	1.2	1.0	120.0	1.7	1.6	106.0	5.4	4.3	126.0
2021	0.1	0.2	50.0	0.5	0.6	83.0	0.9	0.9	100.0	1.5	1.4	107.0	4.0	5.3	75.0
2022	0.2	0.2	100.0	0.5	0.4	125.0	0.7	0.7	100.0	0.8	0.8	100.0	2.8	2.9	97.0
2023	0.3	0.2	150.0	0.6	0.6	100.0	1.1	1.0	110.0	1.0	1.0	100.0	7.8	7.3	107.0

Plots removed for data confidentiality reasons.

Figure F41: Distribution of the TAR 5 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F42: Distribution of the TAR 5 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

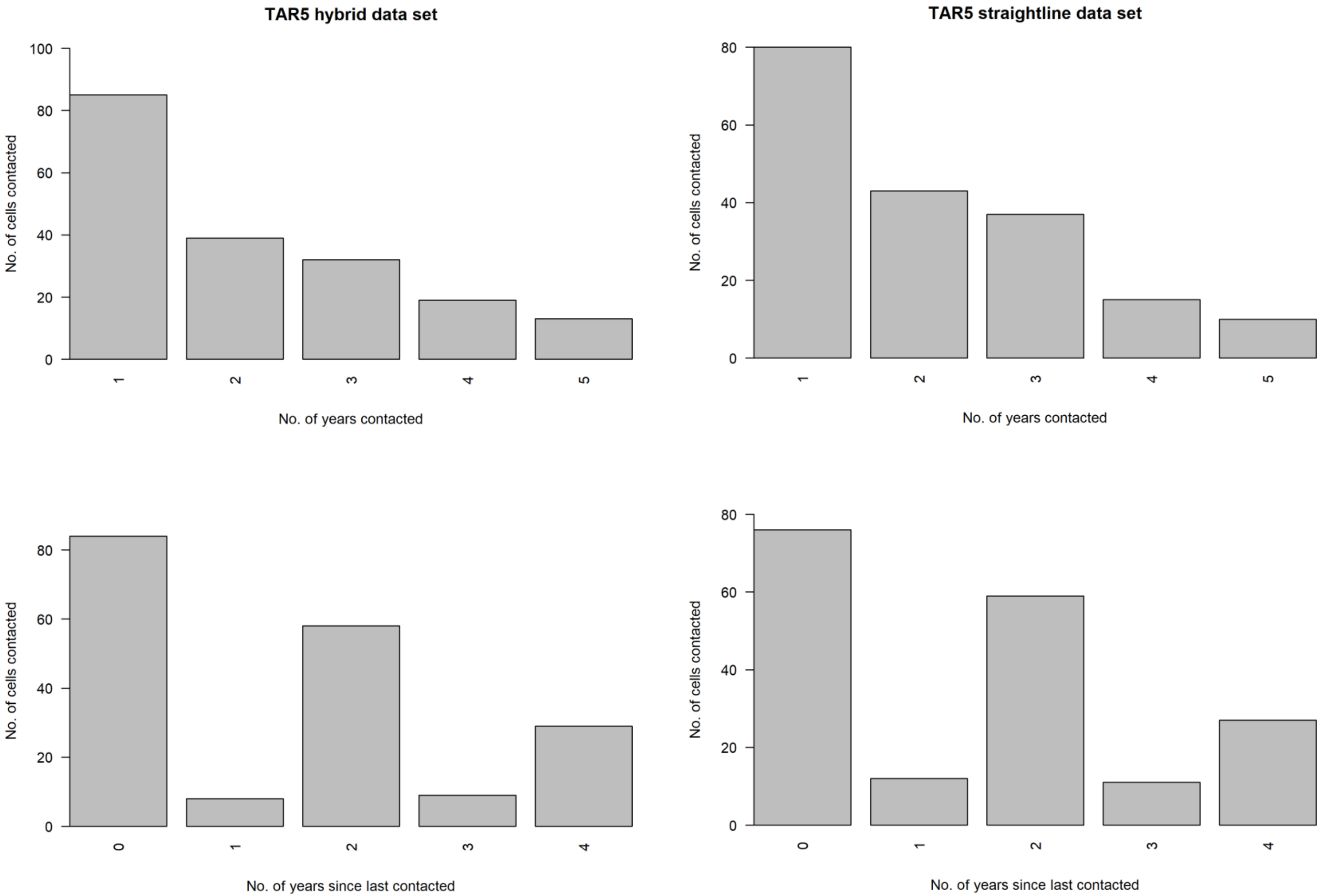

Figure F43: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F44: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

TAR 7 Spatial extent

The summaries in this section consist of all tows targeting tarakihi in Quota Management Area TAR 7.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F45. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 97% and 101.8%, or a difference of between -39 and 15 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 101.8–113.6%, or a difference of between 76.6 and 389.4 km^2.

The footprint was higher for the hybrid data set in all but one year with ratios ranging from 97.8–103.9% or a difference of between -74.9 and 92.6km^2.

The spatial distribution of the footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F45. At this resolution, there is little difference between the two data sets.

TAR 7 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F46 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratio for the number of new cells contacted ranged from 83.3–200% but represented a difference of no more than three cells in any one year

The ratios for the aggregate areas ranged from 100–200% but this represented a difference of no more than 3.1 km^2 in any one year.

Ratios for the footprint also ranged from 100–200% and for both data sets in most years the aggregate area and footprint were identical, with the maximum difference being 2.5 km^2.

When considering the footprint as a percentage of the aggregate area, the ratios are ranged from 94.6–103.2%. This is because for both data sets the aggregate areas and footprints were the same, so the resulting ratios are usually 100% or close to. This is most likely because the ‘new’ areas contacted were just fishing activity on the margins of established areas, rather than any new or exploratory fishing, for the few instances where there were new cells contacted in either data set.

TAR 7 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F47). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (10 tows each). The ratio for the mean number was 106% which represented a difference of just 1.5 tows. The maximum number of tows had a ratio of 108% or 27 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is a perfect match at 100% (2.7 km^2). The ratio for the mean is 109%, representing a difference of 0.7 km^2. The ratio for the maximum is 119%, a difference of 18.9 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F46 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little, but the hybrid data set requires a slightly higher upper range for the most intensely fished cells to cover the full range and shows a few more areas with highest intensity on the west coast compared with the straight-line data set.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is a perfect match at 100% (2 km^2) as is the ratio for the mean (5 km^2) and the maximum (24 km^2). Neither data set gives a maximum footprint of 25 km^2, the maximum possible in a cell.

The same summary information by year is given in Table F48. For the number of tows that contacted a cell, the annual ratio for the median was 100% (a perfect match) in every year. The annual ratio for the mean ranged from 101–108%, which represented a difference of no more than 0.6 tows. For the maximum number of tows that contacted a cell, the ratio ranged from 100–114%, which represented no more than ten tows in any one year.

The annual median ratios for the aggregate areas in a cell ranged from 100–111%, which represented an actual difference of no more than 0.1 km^2 in any one year. The ratios for the means ranged from 100–114%, which represented an actual difference of no more than 0.3 km^2 in any one year. Ratios for the maximum aggregate area ranged from 100–128% or 0–6.6 km^2.

The annual median ratios for the footprint in a cell ranged from 92–110%, representing a difference of no more than 0.1 km^2. The ratio for the mean footprint was a perfect match at 100% in each year. The ratios for the maximum footprint ranged from 95–108%, representing a maximum difference of -1.4 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

TAR 7 Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although there are slightly more cells in the hybrid data set that have five years of contact (Figure F47, upper two plots). There is little difference in the number of years since a cell was last contacted between the two data sets (Figure F47, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F48 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F45: Number of cells contacted, aggregate area, and footprint area for TAR 7 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1508	1509	99.9	4 278.0	4 201.4	101.8	3 293.4	3 368.3	97.8
2020	1162	1147	101.3	2 618.3	2 385.7	109.7	1 998.3	1 981.6	100.8
2021	1278	1317	97.0	3 144.1	2 874.5	109.4	2 488.5	2 462.8	101.0
2022	1087	1094	99.4	2 365.5	2 177.1	108.7	1 864.7	1 836.1	101.6
2023	1214	1193	101.8	3 245.7	2 856.3	113.6	2 468.6	2 376.0	103.9

Table F46: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TAR 7. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	23	23	100.0	4.4	4.4	100.0	4.4	4.4	100.0	100.0	100.0	100.0
2020	2	1	200.0	0.2	0.1	200.0	0.2	0.1	200.0	100.0	100.0	100.0
2021	10	12	83.3	6.7	6.7	100.0	6.5	6.3	103.2	97.0	94.0	103.2
2022	1	1	100.0	0.4	0.0	–	0.4	0.0	–	100.0	–	–
2023	16	13	123.1	10.6	7.5	141.3	9.9	7.4	133.8	93.4	98.7	94.6

Table F47: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TAR 7, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	3.0	100.0	10.0	10.0	100.0
Aggregate area	<0.1	<0.1	–	0.7	0.6	117.0	2.7	2.7	100.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	2.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	28.1	26.6	106.0	35.0	34.0	103.0	384.0	357.0	108.0
Aggregate area	8.3	7.6	109.0	9.8	9.2	107.0	119.9	101.0	119.0
Footprint	5.0	5.0	100.0	7.0	7.0	100.0	24.0	24.0	100.0

Table F48: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TAR 7, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	5.0	5.0	100.0	9.6	9.5	101.0	12.0	12.0	100.0	111.0	111.0	100.0
2020	2.0	2.0	100.0	4.0	4.0	100.0	7.8	7.5	104.0	10.0	10.0	100.0	84.0	74.0	114.0
2021	2.0	2.0	100.0	4.0	4.0	100.0	8.0	7.4	108.0	11.0	10.0	110.0	69.0	62.0	111.0
2022	1.0	1.0	100.0	4.0	4.0	100.0	7.7	7.3	105.0	10.0	9.0	111.0	96.0	88.0	109.0
2023	2.0	2.0	100.0	4.0	4.0	100.0	8.9	8.4	106.0	10.0	10.0	100.0	98.0	90.0	109.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.3	1.3	100.0	2.8	2.8	100.0	3.4	3.4	100.0	39.5	39.5	100.0
2020	0.4	0.4	100.0	1.0	0.9	111.0	2.3	2.1	110.0	2.7	2.5	108.0	26.8	23.9	112.0
2021	0.5	0.4	125.0	1.1	1.1	100.0	2.5	2.2	114.0	3.0	2.7	111.0	25.6	20.0	128.0
2022	0.4	0.4	100.0	1.0	0.9	111.0	2.2	2.0	110.0	2.6	2.4	108.0	32.0	25.4	126.0
2023	0.4	0.4	100.0	1.0	1.0	100.0	2.7	2.4	113.0	2.7	2.7	100.0	36.1	32.8	110.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.2	1.3	92.0	2.2	2.2	100.0	3.0	3.1	97.0	18.8	18.8	100.0
2020	0.4	0.4	100.0	0.9	0.9	100.0	1.7	1.7	100.0	2.3	2.2	105.0	12.9	14.3	90.0
2021	0.4	0.4	100.0	1.1	1.0	110.0	1.9	1.9	100.0	2.5	2.4	104.0	13.3	14.0	95.0
2022	0.4	0.4	100.0	0.9	0.9	100.0	1.7	1.7	100.0	2.3	2.2	105.0	13.6	12.6	108.0
2023	0.4	0.4	100.0	1.0	1.0	100.0	2.0	2.0	100.0	2.4	2.5	96.0	18.2	17.1	106.0

Plots removed for data confidentiality reasons.

Figure F45: Distribution of the TAR 7 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F46: Distribution of the TAR 7 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

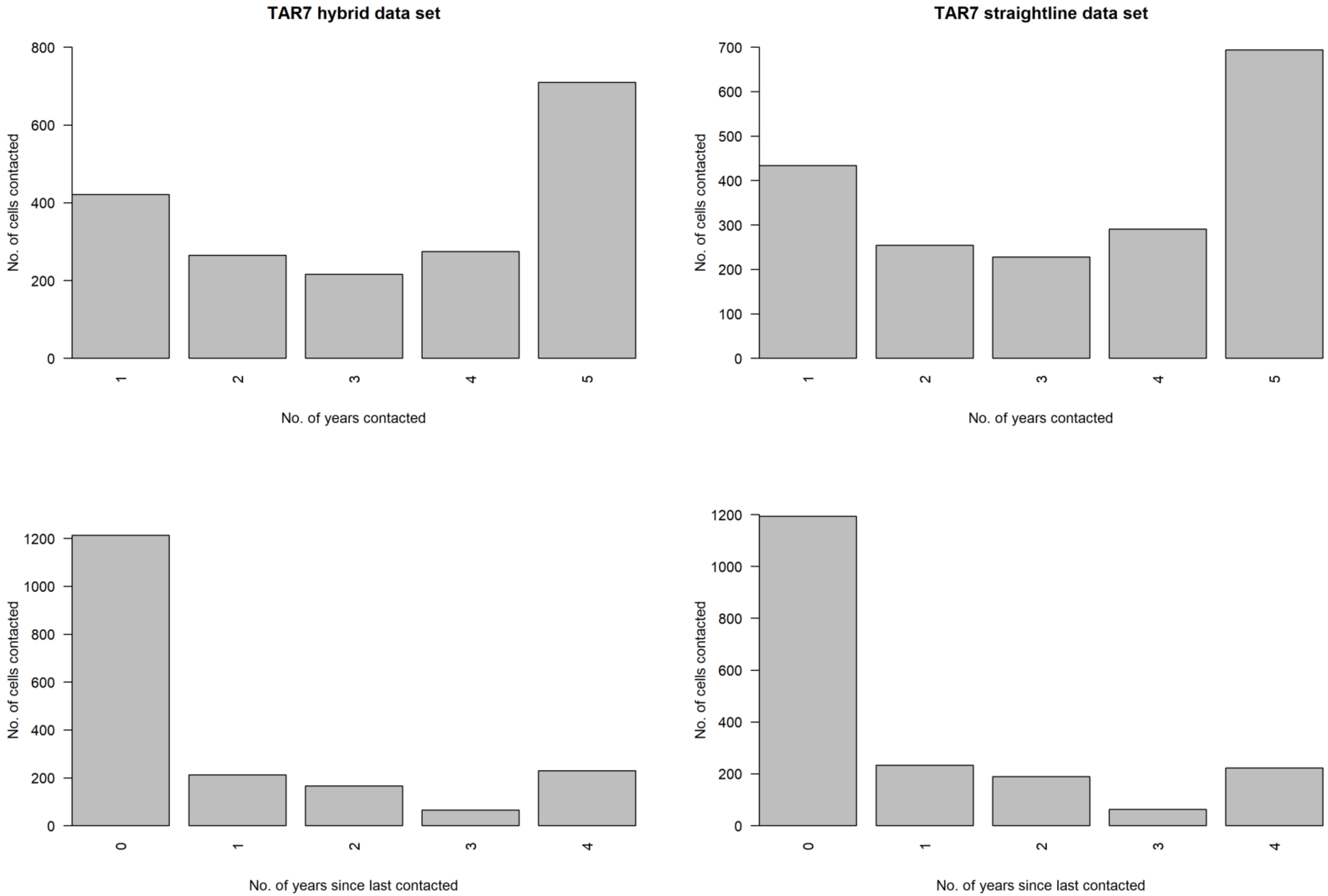

Figure F47: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F48: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

TAR 8 – Spatial extent

The summaries in this section consist of all tows targeting tarakihi in Quota Management Area TAR 8.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F49. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 96.6% and 102.8%, or a difference of between -7 and 9 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 101.7–104.5%, or a difference of between 7.2 and 21.9 km^2.

The footprint was lower for the hybrid data set in all years with ratios ranging from 87.1–99.5% or a difference of between -43.8 and -2.6 km^2.

The spatial distribution of the footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F49. At this resolution, there is little difference between the two data sets.

TAR 8 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F50 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratio for the number of new cells contacted ranged from 83.3–100% but represented a difference of no more than one cell in any one year.

The ratios for the aggregate areas ranged from 59.1–130.8% but this represented a difference of no more than -0.9 km^2 in any one year.

Ratios for the footprint also ranged from 61.9–130.8%, representing a maximum difference of -0.8 km^2.

When considering the footprint as a percentage of the aggregate area, the ratios were 100% in all years except 2019 (104.7%). This is because for both data sets the aggregate areas and footprints were the same, so the resulting ratios are usually 100% or close to. This is most likely because the 'new' areas contacted were just fishing activity on the margins of established areas, rather than any new or exploratory fishing, for the few instances where there were new cells contacted in either data set.

TAR 8 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F51). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (three tows for each data set). The ratio for the mean number was 99%, a difference of -0.1 tows. For the maximum number of tows that contacted a cell, the ratio was 92%, or -34 cells.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is a perfect match at 100% (0.7 km^2). The ratio for the mean is 102%, representing a difference of 0.1 km^2. The ratio for the maximum is 102%, a difference of 1.9 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F50 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution differs little, and unlike most other target fisheries in this report, there is no difference in the ranges of the categories in the legends for each data set.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is a perfect match at 100% (1 km^2). The ratio for the mean is 67%, or a difference of 1 km^2. The ratio for the maximum is 102%, representing a difference of 1 km^2. Neither data set gives a maximum footprint of 25 km^2, the maximum possible in a cell.

The same summary information by year is given in Table F52. For the number of tows that contacted a cell, the median ratio was 100% in each year. For the mean number of tows that contacted a cell, the annual ratio ranged from 99–105%, which represented a difference of no more than 0.4 tows in any one year. The annual ratio for the maximum ranged from 83–103%, which represented a maximum difference of -17 tows.

The annual median ratios for the aggregate areas in a cell ranged from 87–117%, which represented an actual difference of no more than 0.1 km^2 in any one year. The ratios for the means ranged from 100–106%, which represented an actual difference of no more than 0.1 km^2 in any one year. Ratios for the maximum aggregate area ranged from 94–104% or -1.6–1.2 km^2.

The annual median ratios for the footprint in a cell ranged from 80–117%, representing a difference of no more than 0.1 km^2. The ratio for the mean footprint ranged from 85–100% in each year, representing a difference of no more than -0.2 km^2. The ratios for the maximum footprint ranged from 76–104%, representing a maximum difference of -0.8 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

TAR 8 – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although there are slightly more cells in the hybrid data set that have one year of contact (Figure F51, upper two plots). There is little difference in the number of years since a cell was last contacted between the two data sets (Figure F51, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F52 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F49: Number of cells contacted, aggregate area, and footprint for TAR 8 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	333	324	102.8	729.5	713.2	102.3	492.7	495.3	99.5
2020	253	254	99.6	598.5	576.6	103.8	417.1	427.5	97.6
2021	269	276	97.5	452.9	433.6	104.5	294.8	338.6	87.1
2022	242	246	98.4	441.1	433.9	101.7	275.0	310.3	88.6
2023	171	177	96.6	400.7	387.3	103.5	249.4	268.1	93.0

Table F50: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TAR 8. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	5	6	83.3	1.3	2.2	59.1	1.3	2.1	61.9	100.0	95.5	104.7
2020	9	9	100.0	1.7	1.3	130.8	1.7	1.3	130.8	100.0	100.0	100.0
2021	5	6	83.3	1.2	1.4	85.7	1.2	1.4	85.7	100.0	100.0	100.0
2022	6	6	100.0	1.6	1.6	100.0	1.6	1.6	100.0	100.0	100.0	100.0
2023	2	2	100.0	0.5	0.5	100.0	0.5	0.5	100.0	100.0	100.0	100.0

Table F51: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TAR 8, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	3.0	3.0	100.0
Aggregate area	<0.1	<0.1	–	0.3	0.3	100.0	0.7	0.7	100.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	17.8	17.9	99.0	14.0	15.0	93.0	367.0	401.0	92.0
Aggregate area	5.2	5.1	102.0	3.5	3.7	95.0	90.5	88.6	102.0
Footprint	2.0	3.0	67.0	3.0	3.0	100.0	21.0	22.0	95.0

Table F52: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TAR 8, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	3.0	3.0	100.0	7.3	7.4	99.0	9.0	9.0	100.0	79.0	78.0	101.0
2020	1.0	1.0	100.0	3.0	3.0	100.0	7.4	7.3	101.0	8.0	8.0	100.0	59.0	59.0	100.0
2021	1.0	1.0	100.0	2.0	2.0	100.0	5.8	5.5	105.0	5.0	5.0	100.0	75.0	73.0	103.0
2022	1.0	1.0	100.0	2.0	2.0	100.0	6.8	6.6	103.0	6.8	6.0	113.0	100.0	111.0	90.0
2023	1.0	1.0	100.0	3.0	3.0	100.0	8.7	8.3	105.0	9.0	8.0	112.0	86.0	103.0	83.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.7	0.8	87.0	2.2	2.2	100.0	2.1	2.2	95.0	43.8	42.6	103.0
2020	0.3	0.3	100.0	0.7	0.7	100.0	2.4	2.3	104.0	2.3	2.3	100.0	23.6	25.2	94.0
2021	0.2	0.2	100.0	0.4	0.4	100.0	1.7	1.6	106.0	1.2	1.0	120.0	21.4	20.6	104.0
2022	0.3	0.2	150.0	0.5	0.5	100.0	1.8	1.8	100.0	1.6	1.8	89.0	25.8	25.5	101.0
2023	0.3	0.2	150.0	0.7	0.6	117.0	2.3	2.2	105.0	2.4	2.1	114.0	24.6	24.8	99.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.7	0.8	87.0	1.5	1.5	100.0	1.8	2.0	90.0	13.1	13.7	96.0
2020	0.3	0.3	100.0	0.7	0.7	100.0	1.6	1.7	94.0	2.1	2.1	100.0	12.6	13.4	94.0
2021	0.2	0.2	100.0	0.4	0.4	100.0	1.1	1.2	92.0	0.8	1.0	80.0	11.4	11.0	104.0
2022	0.2	0.2	100.0	0.4	0.5	80.0	1.1	1.3	85.0	1.3	1.7	76.0	7.8	10.2	76.0
2023	0.3	0.2	150.0	0.7	0.6	117.0	1.5	1.5	100.0	1.8	1.8	100.0	9.6	10.6	91.0

Plots removed for data confidentiality reasons.

Figure F49: Distribution of the TAR 8 footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F50: Distribution of the TAR 8 aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

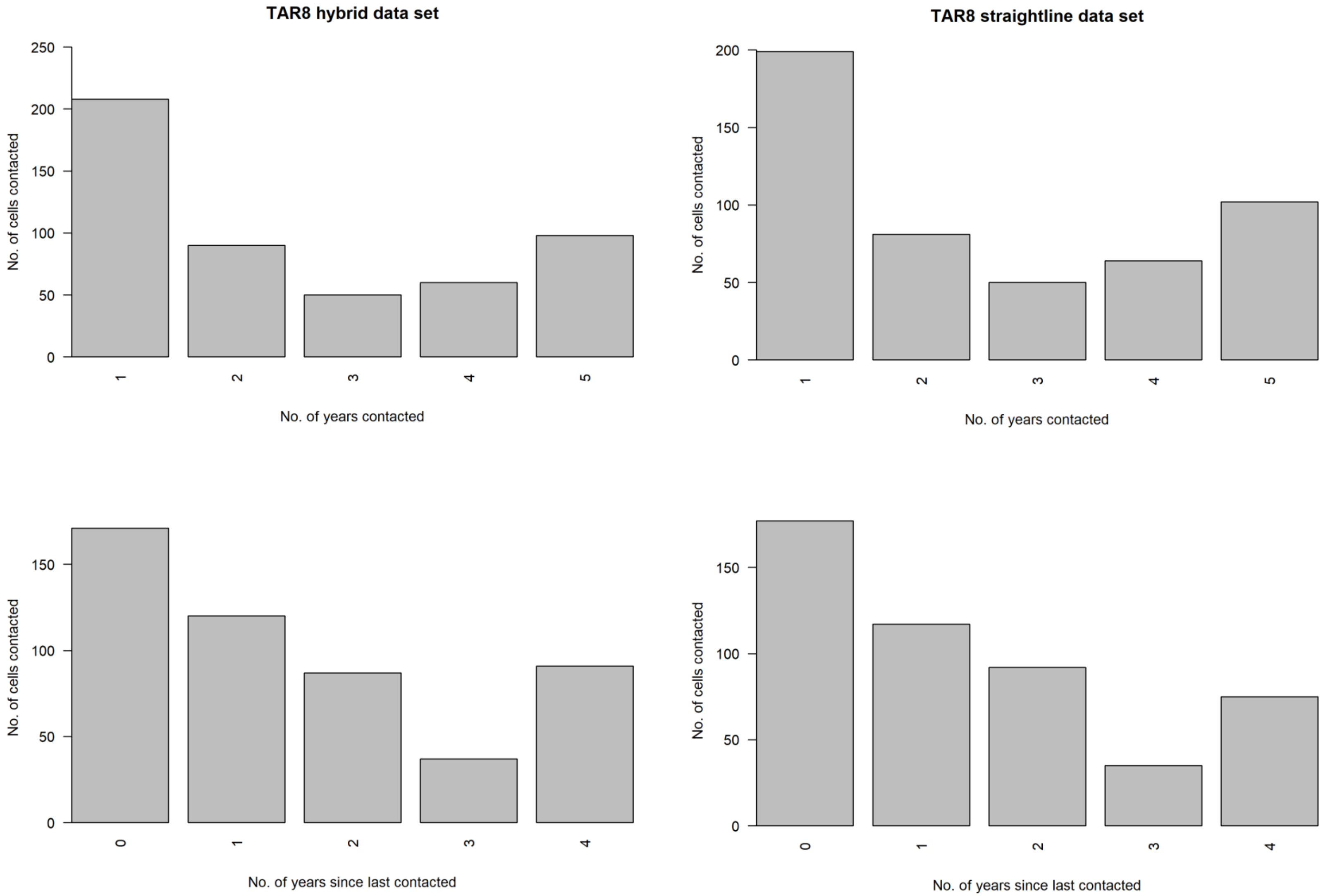

Figure F51: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F52: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

ECSI FLA – Spatial extent

The summaries in this section consist of all tows targeting flatfish in Fisheries Management Area FMA 3.

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F53. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 97.7% and 104%, or a difference of between -9 and 11 cells. This indicates that the hybrid data set sometimes contacted more cells than the straight-line data set, and sometimes fewer. The difference is however low, especially in the context of the total number of cells contacted.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 104.4–125.8%, or a difference of between 145 and 719 km^2.

The footprint was also larger for the hybrid data set in all years with ratios ranging from 101.4–106.7% or a difference of between 11 and 91 km^2, which is close in the context of the total area.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F53. At this resolution, there is little difference between the two data sets.

ECSI FLA – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F54 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 100–107.7%. In terms of the difference in the numbers of new cells contacted however, the maximum value was just one cell, and in 2023, neither data set contacted any new cells.

In all years where there was a difference, the hybrid data set had higher aggregate areas compared with the straight-line data set for those new cells contacted ranging from 100–166.7 km^2. In terms of area, this represents a maximum difference of 30.4 km^2.

As for the number of cells and aggregate area, the footprint was also higher for the hybrid data set in years where there was a difference, with ratios ranging from 101.8–162.5%, with the maximum difference this represents being just 9 km^2.

When considering the footprint as a percentage of the aggregate area, the ratios ranged from 85.4–100%. This indicates that the footprints are a closer match to the aggregate area for the straight-line data set than they are for the straight-line data set, but both data sets are close. This closeness demonstrates that the ‘new’ areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing.

ECSI FLA – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F55). The ratio between the two data sets for the median number of tows that contacted a cell was 133% but this was for a difference of just two tows. The ratio for the mean number was 108% and this represented a difference of 7.1 tows. The maximum number of tows had a ratio of 103%, a difference of 67 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 120%, representing a difference of just 0.2 km^2. The ratio for the mean is 117%, but again, the actual difference is relatively small at just 2.9 km^2. The ratio for the maximum is 96%, a difference of -20.3 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F54 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is little difference with respect to the spatial distribution of intensity. The straight-line data set however, needs a slightly higher upper limit for all years combined to cover the full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median was 120%, representing a difference of just 0.2 km^2. For the mean, the ratio was 117%, but this represents a difference of just 2.9 km^2 between the two data sets. Both data sets have a maximum footprint of 25 km^2 (the maximum possible, complete coverage in a cell), hence the ratio is 100%, a perfect match.

The same summary information by year is given in Table F56. For the number of tows that contacted a cell the median annual ratio ranged from 100–140%, representing a difference of no more than three tows in a given year. For the mean number of tows, the annual ratio ranged from 101–112%, which represented a maximum difference of 4.5 tows. The annual ratio for the maximum number of tows that contacted a cell ranged from 100–106%, representing a difference of no more than 23 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–145%, which represented an actual difference of no more than 0.5 km^2 in any one year. The ratios for the means ranged from 102–124%, which represented an actual difference of no more than 1.7 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 98–105% or -10–18.1 km^2.

The annual median ratios for the footprint in a cell ranged from 100–133%, but this represented a difference of no more than 0.3 km^2. The ratio for the mean footprint was very close in each year, ranging from 97–107%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 98–105%, representing a maximum difference of 0.4 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

ECSI FLA – Number of years contacted

There is almost no difference between the two data sets when comparing the number of years cells were contacted (Figure F55, upper two plots) nor for number of years since a cell was last contacted (Figure F55, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F56 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table F53: Number of cells contacted, aggregate area, footprint, footprint as a percentage of the EEZ, and footprint as a percentage of the fishable area for ECSI FLA for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	655	650	100.8	3 435.7	3 290.3	104.4	1 964.9	1 909.0	102.9
2020	453	447	101.3	3 500.1	2 781.4	125.8	1 451.3	1 360.5	106.7
2021	389	398	97.7	3 501.3	2 908.0	120.4	1 266.1	1 214.6	104.2
2022	288	277	104.0	2 304.7	1 989.0	115.9	845.7	834.3	101.4
2023	227	225	100.9	2 344.6	2 006.9	116.8	879.9	841.3	104.6

Table F54: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for ECSI FLA. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	88	88	100.0	137.3	106.9	128.4	102.4	93.4	109.6	74.6	87.4	85.4
2020	14	13	107.7	6.1	5.6	108.9	5.7	5.6	101.8	93.4	100.0	93.4
2021	5	5	100.0	1.4	0.8	175.0	1.3	0.8	162.5	92.9	100.0	92.9
2022	5	5	100.0	1.7	1.5	113.3	1.7	1.5	113.3	100.0	100.0	100.0
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table F55: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for ECSI FLA, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	8.0	6.0	133.0
Aggregate area	<0.1	<0.1	–	0.4	0.3	133.0	1.2	1.0	120.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	95.5	88.4	108.0	57.2	51.0	112.0	2460.0	2393.0	103.0
Aggregate area	19.9	17.0	117.0	10.5	8.8	119.0	458.2	478.5	96.0
Footprint	4.0	4.0	100.0	6.0	6.0	100.0	25.0	25.0	100.0

Table F56: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for ECSI FLA, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	5.0	5.0	100.0	25.9	25.7	101.0	25.9	25.7	101.0	404.0	403.0	100.0
2020	2.0	1.0	200.0	7.0	5.0	140.0	36.0	32.8	110.0	36.0	32.8	110.0	423.0	400.0	106.0
2021	2.0	2.0	100.0	11.0	8.0	138.0	43.4	38.9	112.0	43.4	38.9	112.0	597.0	577.0	103.0
2022	2.0	1.0	200.0	5.0	5.0	100.0	38.4	37.2	103.0	38.4	37.2	103.0	509.0	497.0	102.0
2023	3.0	2.0	150.0	14.0	12.0	117.0	49.8	46.8	106.0	49.8	46.8	106.0	527.0	516.0	102.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.9	0.9	100.0	5.2	5.1	102.0	4.4	4.3	102.0	94.3	94.3	100.0
2020	0.3	0.3	100.0	1.0	0.8	125.0	7.7	6.2	124.0	7.1	4.6	154.0	97.4	80.4	121.0
2021	0.4	0.4	100.0	1.6	1.1	145.0	9.0	7.3	123.0	8.0	5.5	145.0	135.5	117.4	115.0
2022	0.3	0.2	150.0	0.8	0.7	114.0	8.0	7.2	111.0	5.5	5.0	110.0	87.8	86.3	102.0
2023	0.5	0.4	125.0	2.1	1.8	117.0	10.3	8.9	116.0	12.9	8.9	145.0	102.0	112.0	91.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.9	0.8	112.0	3.0	2.9	103.0	3.8	3.7	103.0	23.3	23.3	100.0
2020	0.3	0.3	100.0	0.9	0.8	112.0	3.2	3.0	107.0	4.6	3.9	118.0	22.4	21.4	105.0
2021	0.4	0.4	100.0	1.2	0.9	133.0	3.3	3.1	106.0	4.6	4.0	115.0	22.5	22.4	100.0
2022	0.2	0.2	100.0	0.7	0.7	100.0	2.9	3.0	97.0	3.7	3.8	97.0	21.4	21.8	98.0
2023	0.4	0.4	100.0	1.6	1.5	107.0	3.9	3.7	105.0	6.2	5.4	115.0	18.5	18.2	102.0

Plots removed for data confidentiality reasons.

Figure F53: Distribution of the ECSI FLA footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F54: Distribution of the ECSI FLA aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

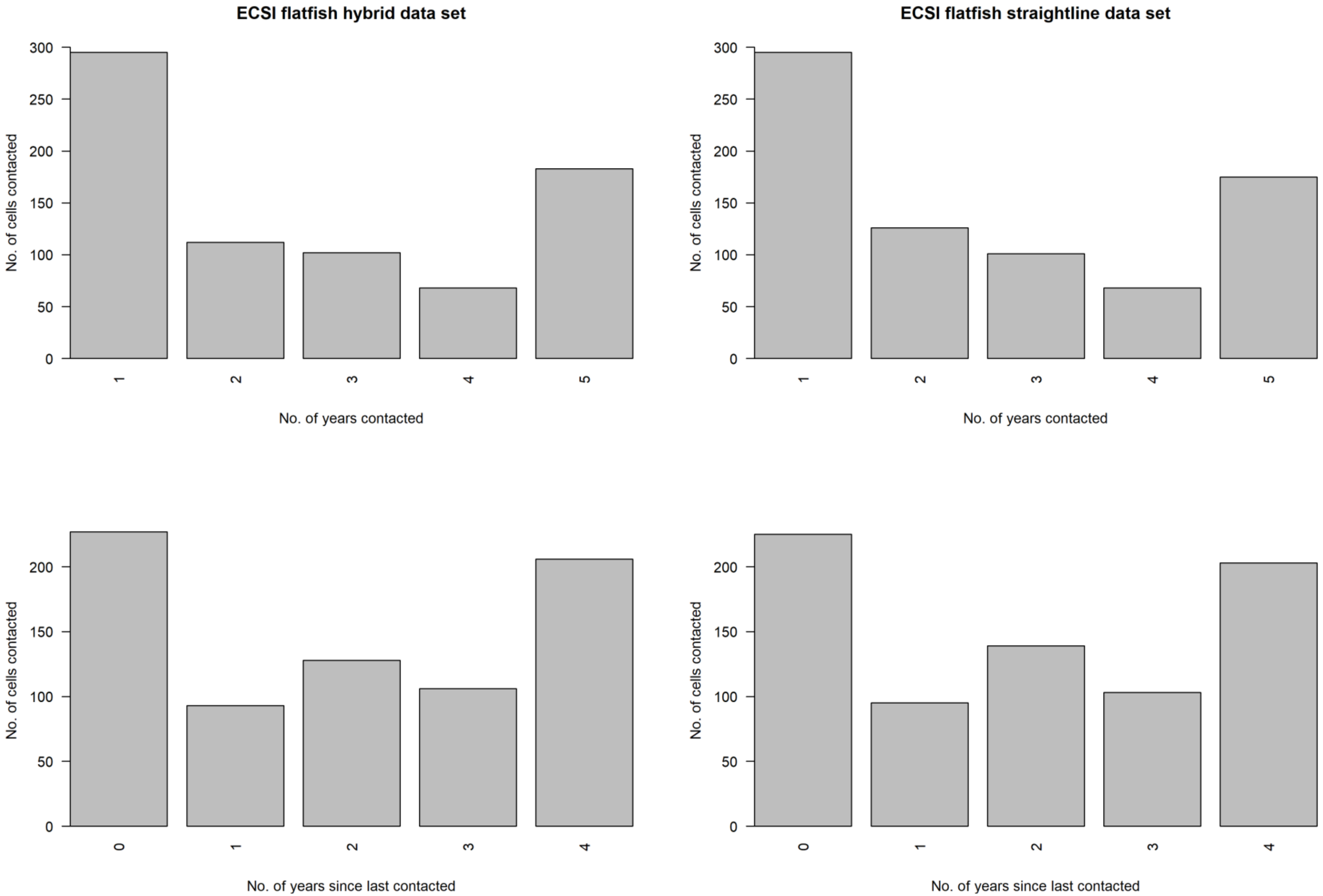

Figure F55: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F56: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

ECSI MIXED – Spatial extent

The summaries in this section consist of all tows in Fisheries Management Area 3 targeting any of the inshore targets in Table 2 excluding flatfish, tarakihi, and barracouta (see individual summaries for these species in this area).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F57. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 98.4% and 100.3%, or a difference of between -20 and 4 cells. This indicates that the hybrid data set sometimes contacted more cells than the straight-line data set, and sometimes fewer. The difference is however low, especially in the context of the total number of cells contacted.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 104.7–119.5%, or a difference of between 265 and 947 km^2.

The footprint was also larger for the hybrid data set in all years with ratios ranging from 102.9–109.6% or a difference of between 122 and 309 km^2, which is close in the context of the total area.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F57. At this resolution, there is little difference between the two data sets.

ECSI MIXED – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F58 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 60–100%. The only year in which there was a difference in the number of cells was 2023, but this numbered just -2 cells.

Ratios for both the aggregate area and footprint ranged from 33.3–100%. The ratios were identical because the aggregate areas and footprints were identical between the two measures of contact for each data sets. 2023, the only year in which there were differences between the data sets, still only had a difference of 0.8 km^2, even though there was an apparent large disparity by ratio.

When considering the footprint as a percentage of the aggregate area, the ratios were 100% in all years. This indicates that each data set has a footprint and aggregate area that match, and the percentages were the same between data sets. This closeness demonstrates that the ‘new’ areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing.

ECSI MIXED – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F59). The ratio between the two data sets for the median number of tows that contacted a cell was 107% but this was for a difference of just two tows. The ratio for the mean number was 108% and this represented a difference of 5.4 tows. The maximum number of tows had a ratio of 101%, a difference of 16 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 116%, representing a difference of just 0.1 km^2. The ratio for the mean is 114%, but again, the actual difference is relatively small at just 2.2 km^2. The ratio for the maximum is 111%, a difference of 34.6 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F58 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is little difference with respect to the spatial distribution of intensity. The straight-line data set however, needs a slightly higher upper limit for all years combined to cover the full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, making the ratio essentially meaningless. The ratio was 100% for both the median and the mean, with values of 5 and 7 km^2 respectively. Both data sets have a maximum footprint of 25 km^2 (the maximum possible, complete coverage in a cell), hence the ratio is 100%, a perfect match.

The same summary information by year is given in Table F60. For the number of tows that contacted a cell the median annual ratio ranged from 100–114%, representing a difference of no more than one tow in a given year. For the mean number of tows, the annual ratio ranged from 103–109%, which represented a maximum difference of 1.7 tows. The annual ratio for the maximum number of tows that contacted a cell ranged from 100–120%, representing a maximum difference of 97 tows.

The annual median ratios for the aggregate areas in a cell ranged from 106–121%, which represented an actual difference of no more than 0.5 km^2 in any one year. The ratios for the means ranged from 105–119%, which represented an actual difference of no more than 0.8 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 104–152% or 4–52.4 km^2.

The annual median ratios for the footprint in a cell ranged from 100–112%, but this represented a difference of no more than 0.2 km^2 in any one year. The ratio for the mean footprint was very close in each year, ranging from 103–112%, and represented a difference between data types of no more than 0.3 km^2. The ratios for the maximum footprint ranged from 99–108%, representing a maximum difference of 1.5 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

ECSI MIXED – Number of years contacted

There is almost no difference between the two data sets when comparing the number of years cells were contacted (Figure F59, upper two plots) nor for number of years since a cell was last contacted (Figure F59, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F60 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table F57: Number of cells contacted, aggregate area, footprint, footprint as a percentage of the EEZ, and footprint as a percentage of the fishable area for ECSI mixed for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1470	1466	100.3	5 870.3	5 605.6	104.7	4 359.4	4 235.1	102.9
2020	1219	1225	99.5	5 243.2	4 387.9	119.5	3 530.2	3 221.2	109.6
2021	1296	1311	98.9	5 778.6	4 974.1	116.2	3 700.9	3 560.7	103.9
2022	1176	1186	99.2	6 164.1	5 389.7	114.4	3 698.3	3 576.8	103.4
2023	1245	1265	98.4	7 107.1	6 160.4	115.4	4 366.7	4 214.6	103.6

Table F58: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for ECSI mixed. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	21	21	100.0	3.8	3.8	100.0	0.0	3.8	0.0	0.0	100.0	0.0
2020	0	1	0.0	0.0	0.0	–	0.0	0.0	–	–	–	–
2021	1	1	100.0	0.1	0.1	100.0	0.0	0.1	0.0	0.0	100.0	0.0
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	3	5	60.0	0.4	1.2	33.3	<0.1	1.2	0.0	0.0	100.0	0.0

Table F59: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for ECSI mixed, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	6.0	5.0	120.0	32.0	30.0	107.0
Aggregate area	<0.1	<0.1	–	1.1	0.9	122.0	7.1	6.1	116.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	5.0	5.0	100.0
	Mean			**3rd quartile**			**Maximum**		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	74.9	69.5	108.0	91.0	83.5	109.0	1845.0	1829.0	101.0
Aggregate area	17.7	15.5	114.0	21.1	18.1	117.0	349.4	314.8	111.0
Footprint	7.0	7.0	100.0	12.0	12.0	100.0	25.0	25.0	100.0

Table F60: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for ECSI mixed, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	3.0	3.0	100.0	8.0	8.0	100.0	17.4	16.9	103.0	20.0	20.0	100.0	544.0	539.0	101.0
2020	3.0	3.0	100.0	8.0	7.0	114.0	18.3	16.6	110.0	22.0	19.0	116.0	396.0	388.0	102.0
2021	3.0	3.0	100.0	9.0	9.0	100.0	18.9	17.2	110.0	21.0	19.0	111.0	469.0	463.0	101.0
2022	4.0	3.0	133.0	10.0	9.0	111.0	22.1	20.4	108.0	25.0	23.0	109.0	645.0	644.0	100.0
2023	4.0	3.0	133.0	11.0	10.0	110.0	23.6	21.6	109.0	28.0	26.0	108.0	590.0	493.0	120.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	1.7	1.6	106.0	4.0	3.8	105.0	5.0	4.7	106.0	94.0	89.2	105.0
2020	0.6	0.5	120.0	1.8	1.6	112.0	4.3	3.6	119.0	5.0	4.1	122.0	79.1	65.1	122.0
2021	0.6	0.5	120.0	2.1	1.8	117.0	4.5	3.8	118.0	5.2	4.4	118.0	112.5	101.5	111.0
2022	0.7	0.6	117.0	2.3	1.9	121.0	5.2	4.5	116.0	5.9	5.2	113.0	115.5	111.5	104.0
2023	0.7	0.6	117.0	2.5	2.2	114.0	5.7	4.9	116.0	6.8	5.9	115.0	152.8	100.4	152.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	1.6	1.5	107.0	3.0	2.9	103.0	4.3	4.2	102.0	21.5	21.2	101.0
2020	0.5	0.5	100.0	1.6	1.5	107.0	2.9	2.6	112.0	3.8	3.5	109.0	21.5	20.0	108.0
2021	0.6	0.5	120.0	1.7	1.7	100.0	2.9	2.7	107.0	4.0	3.8	105.0	23.7	22.5	105.0
2022	0.6	0.6	100.0	1.9	1.7	112.0	3.1	3.0	103.0	4.4	4.1	107.0	20.5	20.3	101.0
2023	0.6	0.6	100.0	2.2	2.0	110.0	3.5	3.3	106.0	5.0	4.7	106.0	22.6	22.8	99.0

Plots removed for data confidentiality reasons.

Figure F57: Distribution of the ECSI mixed footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F58: Distribution of the ECSI mixed aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

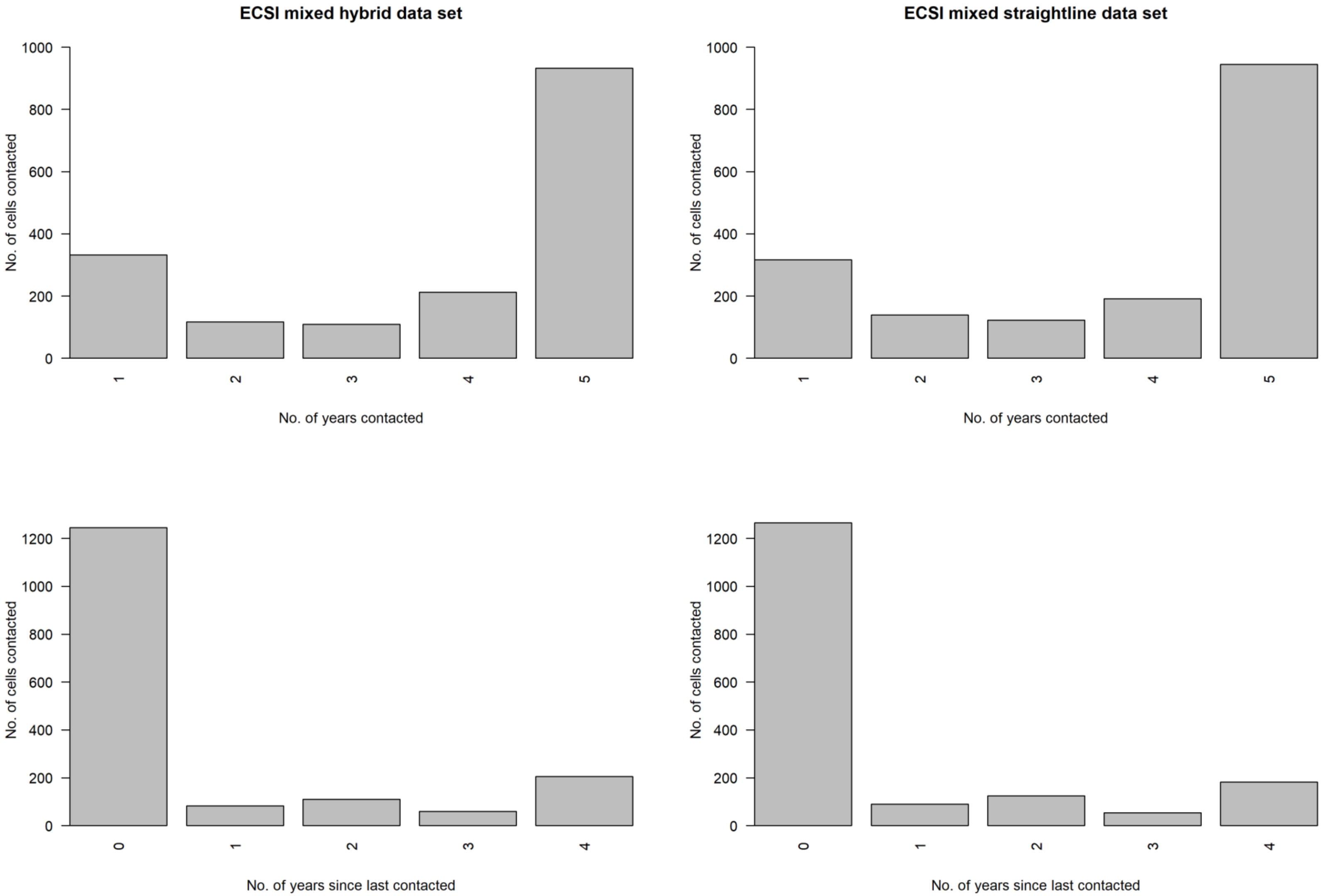

Figure F59: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right).

Plots removed for data confidentiality reasons.

Figure F60: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right).

SCSI STA – Spatial extent

The summaries in this section are for all tows targeting giant stargazer off the south coast of the South Island in FMA 5 (see Figure F61).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F61. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 100% and 102.7%, or a difference of between 0 and 6 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 104.1–123.1%, or a difference of between 33.6 and 223.8 km^2.

The footprint was slightly larger for the hybrid data set in all years with ratios ranging from 102–109.3% or a difference of between 13 and 75 km^2, which is close in the context of the total area of the footprint.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F61. At this resolution, there is little difference between the two data sets.

SCSI STA – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F62 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 0 (when there were no new cells contacted by the hybrid data set and 1 cell in the straight-line) to 110% (when 11 cells were contacted by the hybrid and 10 by the straight-line data set). Neither data set contacted new cells in 2022.

For years where there were new cells contacted by both data sets, the ratio for the aggregate area ranged from 100–111.1%, representing a difference of no more than 0.1 km^2. The corresponding footprints were the same as the aggregate areas so the ratios were again 100%, hence the ratios resulting from the footprint as a percentage of the aggregate area were also 100%. This closeness demonstrates that irrespective of which data set is used, the 'new' areas contacted were most likely just fishing activity on the margins of established areas, rather than any new or exploratory fishing.

SCSI STA – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F63). The ratio between the two data sets for the median number of tows that contacted a cell was 114%, but this represented a difference of just one tow. The ratio for the mean number was 110% and this represented a difference of 4.6 tows. The maximum number of tows had a ratio of 110%, or a difference of 54 tows (585 vs 531 tows).

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 113%, representing a difference of just 1.2 km^2. The ratio for the mean is 116%, representing a difference of 1.9 km^2. The ratio for the maximum is more substantial at 125%, 33.7 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F62 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution varies little. However, the hybrid data sets require higher categories than the straight-line data set in order to span the full range of data because overall, the aggregate area is higher for the former than it is for the latter.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 200% but this represents a difference of just 1 km^2. The ratio for the mean is a perfect match at 100% (5 km^2). The ratio for the maximum is 104%. The maximum footprint for the hybrid data is 25 km^2, the maximum possible footprint, whereas the maximum footprint for the straight-line data is slightly less than this at 24 km^2.

The same summary information by year is given in Table F64. For the number of tows, the annual median ranged from 100–142%, which represented a difference of no more than 2.5 tows in any one year. The annual ratio for the mean ranged from 103–112%, which represented a difference of no more than 1.9 tows. For the maximum, the annual ratio ranged from 103–119%, a maximum difference of 23 tows.

The annual median ratios for the aggregate areas in a cell ranged from 111–136%, which represented an actual difference of no more than 0.4 km^2 in any one year. The ratios for the means ranged from 103–121%, which represented an actual difference of no more than 0.9 km^2 in any one year. Ratios for the maximum aggregate area ranged from 111–150% or 2.7–12.7 km^2.

The annual median ratios for the footprint in a cell ranged from 100–118%, representing a difference of no more than 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 100–110%, and represented a difference between data types of no more than 0.3 km^2. The ratios for the maximum footprint ranged from 99–118%, representing a maximum difference of 2.8 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

SCSI STA – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted (Figure F63, upper two plots) nor for number of years since a cell was last contacted (Figure F63, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F64 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F61: Number of cells contacted, aggregate area, and footprint for SCSI STA for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	283	283	100.0	858.5	824.9	104.1	683.1	669.7	102.0
2020	238	238	100.0	990.6	856.9	115.6	687.4	644.7	106.6
2021	236	233	101.3	1 192.7	968.9	123.1	776.3	700.9	110.8
2022	217	214	101.4	976.8	817.0	119.6	678.9	621.4	109.3
2023	227	221	102.7	1 115.1	944.0	118.1	710.8	657.4	108.1

Table F62: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for SCSI STA. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	11	10	110.0	2.4	2.3	104.3	2.4	2.3	104.3	100.0	100.0	100.0
2020	6	6	100.0	2.6	2.6	100.0	2.6	2.6	100.0	100.0	100.0	100.0
2021	4	4	100.0	1.0	0.9	111.1	1.0	0.9	111.1	100.0	100.0	100.0
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	0	2	0.0	0.0	0.4	0.0	0.0	0.4	0.0	–	100.0	–

Table F63: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for SCSI STA, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	8.0	7.0	114.0
Aggregate area	<0.1	<0.1	–	0.4	0.4	100.0	1.7	1.5	113.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	2.0	1.0	200.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	51.4	46.8	110.0	61.5	53.0	116.0	585.0	531.0	110.0
Aggregate area	13.5	11.6	116.0	14.4	10.9	132.0	166.2	132.5	125.0
Footprint	5.0	5.0	100.0	8.0	7.0	114.0	25.0	24.0	104.0

Table F64: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for SCSI STA, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	4.0	4.0	100.0	11.7	11.4	103.0	16.0	15.0	107.0	89.0	86.0	103.0
2020	2.0	2.0	100.0	6.0	5.0	120.0	14.8	13.6	109.0	22.0	20.0	110.0	111.0	101.0	110.0
2021	2.0	2.0	100.0	8.5	6.0	142.0	17.8	15.9	112.0	25.0	23.0	109.0	142.0	119.0	119.0
2022	2.0	2.0	100.0	9.0	8.0	112.0	18.6	17.0	109.0	25.0	23.0	109.0	129.0	125.0	103.0
2023	2.0	2.0	100.0	8.0	8.0	100.0	19.5	18.4	106.0	21.5	21.0	102.0	139.0	129.0	108.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.3	133.0	1.0	0.9	111.0	3.0	2.9	103.0	4.2	4.1	102.0	21.6	18.9	114.0
2020	0.3	0.3	100.0	1.2	0.9	133.0	4.2	3.6	117.0	6.9	5.9	117.0	27.9	25.2	111.0
2021	0.4	0.4	100.0	1.6	1.4	114.0	5.1	4.2	121.0	6.6	5.8	114.0	42.8	33.9	126.0
2022	0.4	0.4	100.0	1.5	1.1	136.0	4.5	3.8	118.0	6.3	5.0	126.0	38.2	25.5	150.0
2023	0.4	0.4	100.0	1.6	1.4	114.0	4.9	4.3	114.0	5.3	4.4	120.0	44.4	38.8	114.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.9	0.9	100.0	2.4	2.4	100.0	3.7	3.5	106.0	12.4	12.5	99.0
2020	0.3	0.3	100.0	1.0	0.9	111.0	2.9	2.7	107.0	4.3	4.6	93.0	15.9	14.1	113.0
2021	0.4	0.4	100.0	1.5	1.3	115.0	3.3	3.0	110.0	5.0	4.5	111.0	18.6	15.8	118.0
2022	0.3	0.3	100.0	1.3	1.1	118.0	3.1	2.9	107.0	4.9	4.1	120.0	15.1	14.6	103.0
2023	0.4	0.4	100.0	1.2	1.2	100.0	3.1	3.0	103.0	4.0	3.7	108.0	17.1	16.8	102.0

Plots removed for data confidentiality reasons.

Figure F61: Distribution of the SCSI STA footprint for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F62: Distribution of the SCSI STA aggregate area for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

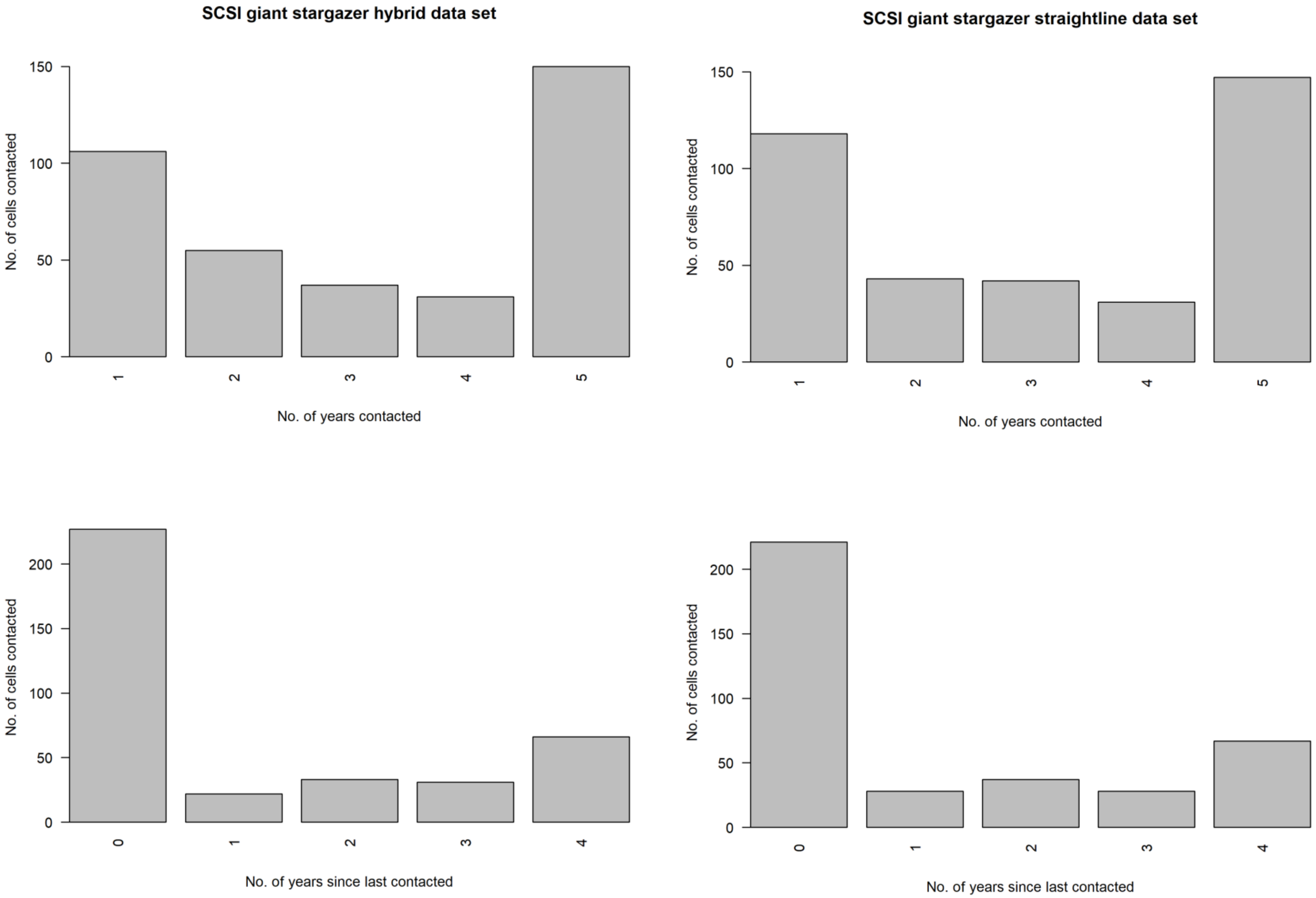

Figure F63: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for SCSI STA.

Plots removed for data confidentiality reasons.

Figure F64: Distribution of cells, by the number of years contacted (top two plots), and by the most recent year fished (bottom two plots) between 2019 and 2023 for the hybrid data and the straight-line data.

TBGB FLA – Spatial extent

The summaries in this section consist of all tows targeting flatfish in Tasman Bay and Golden Bay within FMA 7 (see Figure F65).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F65. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 96.8% and 110.7%, or a difference of between -5 and 11 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 114.8–146.8%, or a difference of between 155 and 453 km^2.

The footprint was higher for the hybrid data set in all years with ratios ranging from 107.4–130.3% or a difference of between 35 and 169 km^2.

The spatial distribution of the footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F65. At this resolution, there is little difference between the two data sets.

TBGB FLA – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F66 where the base footprint was created for 2008–2018 using the straight-line data set.

Neither data set had any new cells contacted during the five year time period since GPR data became available. The Tasman Bay and Golden Bay region is a very small area and it is quite plausible that all areas worth fishing have been contacted at some point in the 11-year period on which the base number of cells was contacted, especially as there are only 232 unique cells in the area that were contacted.

TBGB FLA – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F67). The ratio between the two data sets for the median number of tows that contacted a cell was 105%, a difference of just three tows. The ratio for the mean number was 115% and this, a difference of 15.1 tows. For the maximum number of tows, the ratio was 114%, a difference of 78 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 128%, representing a difference of 2.8 km^2. The ratio for the mean is 133%, representing a difference of 6.7 km^2. The ratio for the maximum is 146%, representing a more substantial difference of 60.4 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F66 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution differs little, but the hybrid data set requires higher upper limits to the categories in the legend to span full the range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 112%, a difference of just 1 km^2. The ratio for the mean is a perfect match at 100% (9 km^2 each). For the maximum, the ratio is 104%, with the hybrid data set having the maximum possible value of 25 km^2 , but the straight-line data set was slightly less than this at 24 km^2.

The same summary information by year is given in Table F68. For the number of tows that contacted a cell, the annual median ratio ranged from 104–164%, a maximum difference of 10.5 tows in any one year. For the mean, the annual ratio ranged from 106–124%, a maximum difference of seven tows in any one year. The annual ratio for maximum number of tows ranged from 105–129%, which represented a maximum difference of 42 tows in any one year.

The annual median ratios for the aggregate areas in a cell ranged from 111–187%, which represented an actual difference of no more than 2.6 km^2 in any one year. The ratios for the means ranged from 114–147%, which represented an actual difference of no more than 2.7 km^2 in any one year. Ratios for the maximum aggregate area ranged from 105–175% or 2.7–26.4 km^2.

The annual median ratios for the footprint in a cell ranged from 106–152%, representing a difference of no more than 1.4 km^2. The ratio for the mean footprint ranged from 104–126% in each year, representing a difference of no more than 1.1 km^2. The ratios for the maximum footprint ranged from 103–118%, representing a maximum difference of 2.9 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

TBGB FLA – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although there are slightly more cells in the hybrid data set that have one and five year of contact (Figure F67, upper two plots). There is also little difference in the number of years since a cell was last contacted between the two data sets although the hybrid data set has slightly more cells contacted in the most recent fishing year (zero years since contact) and slightly less for 1–4 years of contact when compared to the straight-line data set (Figure F67, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F68 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution.

Table F65: Number of cells contacted, aggregate area, and footprint for TBGB FLA for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	197	197	100.0	1 761.1	1 534.4	114.8	1 105.8	1 029.3	107.4
2020	167	166	100.6	1 457.0	1 003.6	145.2	905.1	736.0	123.0
2021	149	154	96.8	1 252.7	877.6	142.7	788.0	644.8	122.2
2022	114	103	110.7	573.9	391.0	146.8	359.7	276.0	130.3
2023	110	102	107.8	572.8	417.4	137.2	315.2	280.7	112.3

Table F66: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TBGB FLA. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value. NB: there have been no new cells contacted in TBGB during the time period whether considering at the hybrid or straight-line data sets.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0	0	–	0	0	–	0	0	–
2020	0	0	–	0	0	–	0	0	–	0	0	–
2021	0	0	–	0	0	–	0	0	–	0	0	–
2022	0	0	–	0	0	–	0	0	–	0	0	–
2023	0	0	–	0	0	–	0	0	–	0	0	–

Table F67: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TBGB FLA, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	8.0	8.0	100.0	64.0	61.0	105.0
Aggregate area	<0.1	<0.1	–	1.0	0.9	111.0	12.7	9.9	128.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	9.0	8.0	112.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	118.8	103.7	115.0	163.8	140.0	117.0	642.0	564.0	114.0
Aggregate area	27.3	20.6	133.0	37.4	28.2	133.0	190.5	130.1	146.0
Footprint	9.0	9.0	100.0	16.0	15.0	107.0	25.0	24.0	104.0

Table F68: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TBGB FLA, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	6.0	5.0	120.0	24.0	23.0	104.0	41.0	38.5	106.0	59.0	60.0	98.0	226.0	216.0	105.0
2020	8.5	9.0	94.0	26.0	23.5	111.0	36.7	30.8	119.0	56.0	47.8	117.0	186.0	144.0	129.0
2021	8.0	6.0	133.0	27.0	16.5	164.0	35.7	28.7	124.0	51.0	40.0	127.0	146.0	135.0	108.0
2022	2.0	2.0	100.0	9.0	8.0	112.0	21.3	19.6	109.0	28.8	25.0	115.0	110.0	94.0	117.0
2023	3.0	3.0	100.0	8.5	7.0	121.0	22.8	20.9	109.0	32.2	29.8	108.0	122.0	107.0	114.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.8	0.8	100.0	4.2	3.8	111.0	8.9	7.8	114.0	12.9	11.7	110.0	54.9	52.2	105.0
2020	1.6	1.2	133.0	5.4	4.0	135.0	8.7	6.0	145.0	13.5	9.1	148.0	61.5	35.1	175.0
2021	1.6	1.0	160.0	5.6	3.0	187.0	8.4	5.7	147.0	11.0	7.8	141.0	39.1	33.8	116.0
2022	0.4	0.4	100.0	1.8	1.3	138.0	5.0	3.8	132.0	7.0	4.5	156.0	33.0	26.2	126.0
2023	0.5	0.4	125.0	1.7	1.2	142.0	5.2	4.1	127.0	5.8	5.1	114.0	38.4	28.6	134.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.7	100.0	3.6	3.4	106.0	5.6	5.2	108.0	9.5	9.0	106.0	20.9	20.2	103.0
2020	1.4	1.1	127.0	4.3	3.4	126.0	5.4	4.4	123.0	8.0	7.3	110.0	19.2	16.6	116.0
2021	1.5	1.0	150.0	4.1	2.7	152.0	5.3	4.2	126.0	8.3	6.6	126.0	19.2	16.3	118.0
2022	0.4	0.4	100.0	1.6	1.2	133.0	3.2	2.7	119.0	5.6	3.4	165.0	15.8	14.2	111.0
2023	0.5	0.4	125.0	1.5	1.1	136.0	2.9	2.8	104.0	4.0	4.4	91.0	16.0	14.3	112.0

Plots removed for data confidentiality reasons.

Figure F65: Distribution of the TBGB FLA footprint for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F66: Distribution of the TBGB FLA aggregate area for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

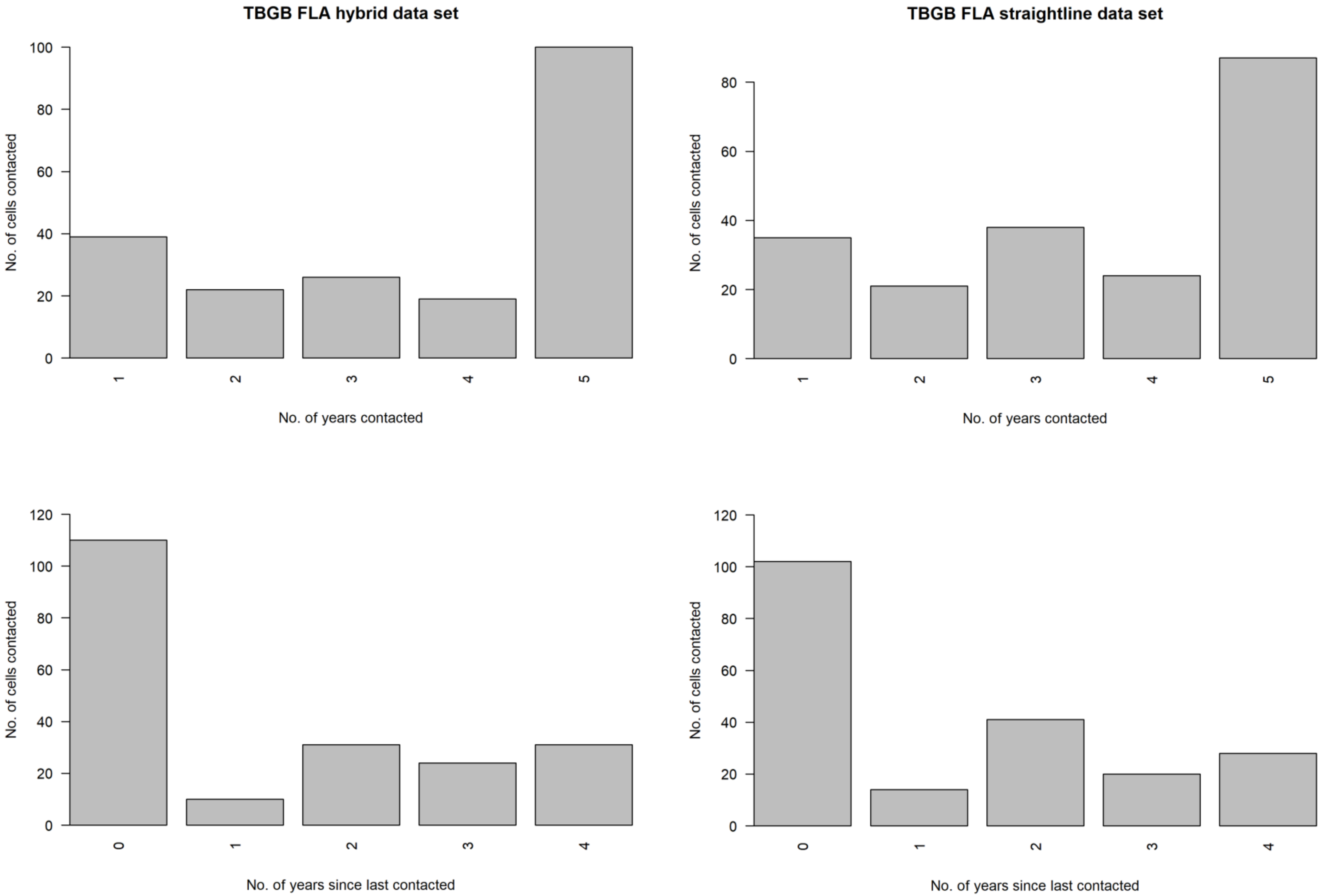

Figure F67: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for TBGB FLA.

Plots removed for data confidentiality reasons.

Figure F68: Distribution of cells, by the number of years contacted (top two plots), and by the most recent year fished (bottom two plots) between 2019 and 2023 for the hybrid data and the straight-line data.

TBGB MIXED – Spatial extent

The summaries in this section consist of all tows within Tasman Bay and Golden Bay within Fisheries Management Area 7 targeting any of the inshore targets in Table 2 excluding tarakihi (see individual summary of tarakihi in TAR 7 for tarakihi that includes this area).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F69. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 97.5% and 100%, or a difference of between -2 and 5 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 109.1–135.9%, or a difference of between 268 and 862 km^2.

The footprint was higher for the hybrid data set in all years with ratios ranging from 103.8–114.4% or a difference of between 69.1 and 212.9 km^2.

The spatial distribution of the footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F69. At this resolution, there is little difference between the two data sets.

TBGB MIXED – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F70 where the base footprint was created for 2008–2018 using the straight-line data set.

Neither data set had any new cells contacted during the five year time period since GPR data became available. The Tasman Bay and Golden Bay region is a very small area and it is quite plausible that all areas worth fishing had been contacted at some point in the 11-year period on which the base number of cells was contacted, especially as there are only 232 unique cells in the area that were contacted.

TBGB MIXED – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F71). The ratio between the two data sets for the median number of tows that contacted a cell was 112%, a difference of 27 tows. The ratio for the mean number of tows was 112%, which represented a difference of 32.7 tows. For the maximum number of tows, the ratio was 108%, a difference of 99 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 130%, representing a difference of 13.4 km^2. The ratio for the mean is 126%, representing a difference of 14.3 km^2. The ratio for the maximum is 111%, a difference of 28.4 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F70 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution differs little, but the hybrid data set requires higher upper limits to the categories in the legend to span full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is a perfect match at 100% (17 km^2) as is the mean (15 km^2) and the maximum (25 km^2 the largest possible footprint in a cell).

The same summary information by year is given in Table F72. For the number of tows that contacted a cell, the annual median ratio ranged from 103–134%, a maximum difference of 15 tows in any one year. For the mean, the annual ratio ranged from 104–118%, a maximum difference of 10.7 tows. The annual ratio for maximum number of tows ranged from 104–120%, which represented a maximum difference of 40 tows in any one year.

The annual median ratios for the aggregate areas in a cell ranged from 106–137%, which represented an actual difference of no more than 3.9 km^2 in any one year. The ratios for the means ranged from 109–138%, which represented an actual difference of no more than 4.4 km^2 in any one year. Ratios for the maximum aggregate area ranged from 105–212% or 3–64.3 km^2.

The annual median ratios for the footprint in a cell ranged from 101–121%, representing a difference of no more than 1.4 km^2. The ratio for the mean footprint ranged from 104–115% in each year, representing a difference of no more than 1.1 km^2. The ratios for the maximum footprint ranged from 97–116%, representing a maximum difference of 3.2 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

TBGB MIXED – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although there are slightly more cells in the hybrid data set that have one year of contact (Figure F71, upper two plots). There is little difference in the number of years since a cell was last contacted between the two data sets although the straight-line data set has slightly more cells contacted in the most recent fishing year (zero years since contact) and the hybrid data set has slightly more cells with four years since last contacted (Figure F71, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F72 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution and both data sets show that almost all sets have been contacted in all five years in the time series and hence most cells were contacted in the most recent fishing year.

Table F69: Number of cells contacted, aggregate area, and footprint for TBGB mixed for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	228	228	100.0	3 205.5	2 937.5	109.1	1 911.4	1 842.3	103.8
2020	203	205	99.0	3 262.0	2 400.1	135.9	1 734.8	1 521.9	114.0
2021	197	196	100.5	3 504.2	2 744.5	127.7	1 845.4	1 652.0	111.7
2022	196	196	100.0	2 740.3	2 100.0	130.5	1 522.9	1 331.0	114.4
2023	195	200	97.5	3 137.8	2 382.6	131.7	1 559.9	1 433.9	108.8

Table F70: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TBGB mixed. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value. NB: there have been no new cells contacted in TBGB during the time period whether considering at the hybrid or straight-line data sets.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0	0	–	0	0	–	0	0	–
2020	0	0	–	0	0	–	0	0	–	0	0	–
2021	0	0	–	0	0	–	0	0	–	0	0	–
2022	0	0	–	0	0	–	0	0	–	0	0	–
2023	0	0	–	0	0	–	0	0	–	0	0	–

Table F71: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TBGB mixed, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	61.0	57.5	106.0	257.0	230.0	112.0
Aggregate area	<0.1	<0.1	–	10.8	8.0	135.0	58.0	44.6	130.0
Footprint	<0.1	<0.1	–	5.0	5.0	100.0	17.0	17.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	297.3	264.6	112.0	445.0	398.0	112.0	1414.0	1315.0	108.0
Aggregate area	68.9	54.6	126.0	107.6	83.4	129.0	282.0	253.6	111.0
Footprint	15.0	15.0	100.0	23.0	23.0	100.0	25.0	25.0	100.0

Table F72: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TBGB mixed, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	17.8	17.0	105.0	49.5	48.0	103.0	63.9	61.2	104.0	100.0	97.0	103.0	239.0	228.0	105.0
2020	18.0	15.0	120.0	59.0	44.0	134.0	68.9	58.2	118.0	115.0	95.0	121.0	218.0	202.0	108.0
2021	23.0	20.0	115.0	71.0	56.5	126.0	75.6	66.8	113.0	107.0	89.2	120.0	313.0	296.0	106.0
2022	18.8	16.0	118.0	40.0	34.5	116.0	57.5	50.2	115.0	83.0	69.2	120.0	236.0	196.0	120.0
2023	18.0	16.8	107.0	46.0	39.5	116.0	70.0	60.2	116.0	87.0	83.0	105.0	586.0	563.0	104.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	3.1	3.1	100.0	10.8	10.2	106.0	14.1	12.9	109.0	22.6	20.3	111.0	59.6	56.6	105.0
2020	3.3	2.6	127.0	12.1	8.9	136.0	16.1	11.7	138.0	25.6	17.7	145.0	70.3	51.9	135.0
2021	5.0	3.3	152.0	14.4	10.5	137.0	17.8	14.0	127.0	26.7	20.1	133.0	90.2	78.5	115.0
2022	3.8	2.7	141.0	9.1	7.0	130.0	14.0	10.7	131.0	20.5	15.7	131.0	65.0	55.5	117.0
2023	4.2	2.8	150.0	10.2	8.1	126.0	16.1	11.9	135.0	21.1	15.8	134.0	121.8	57.5	212.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.8	2.7	104.0	8.0	7.9	101.0	8.4	8.1	104.0	13.9	13.5	103.0	21.2	20.5	103.0
2020	2.7	2.5	108.0	8.2	6.8	121.0	8.5	7.4	115.0	13.9	12.0	116.0	21.9	21.1	104.0
2021	3.1	2.9	107.0	9.0	8.1	111.0	9.4	8.4	112.0	14.9	13.2	113.0	23.3	23.2	100.0
2022	3.3	2.4	138.0	7.0	5.8	121.0	7.8	6.8	115.0	12.2	10.6	115.0	21.2	21.8	97.0
2023	3.3	2.6	127.0	7.1	6.5	109.0	8.0	7.2	111.0	11.1	10.4	107.0	23.8	20.6	116.0

Plots removed for data confidentiality reasons.

Figure F69: Distribution of the TBGB mixed footprint for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F70: Distribution of the TBGB mixed aggregate area for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

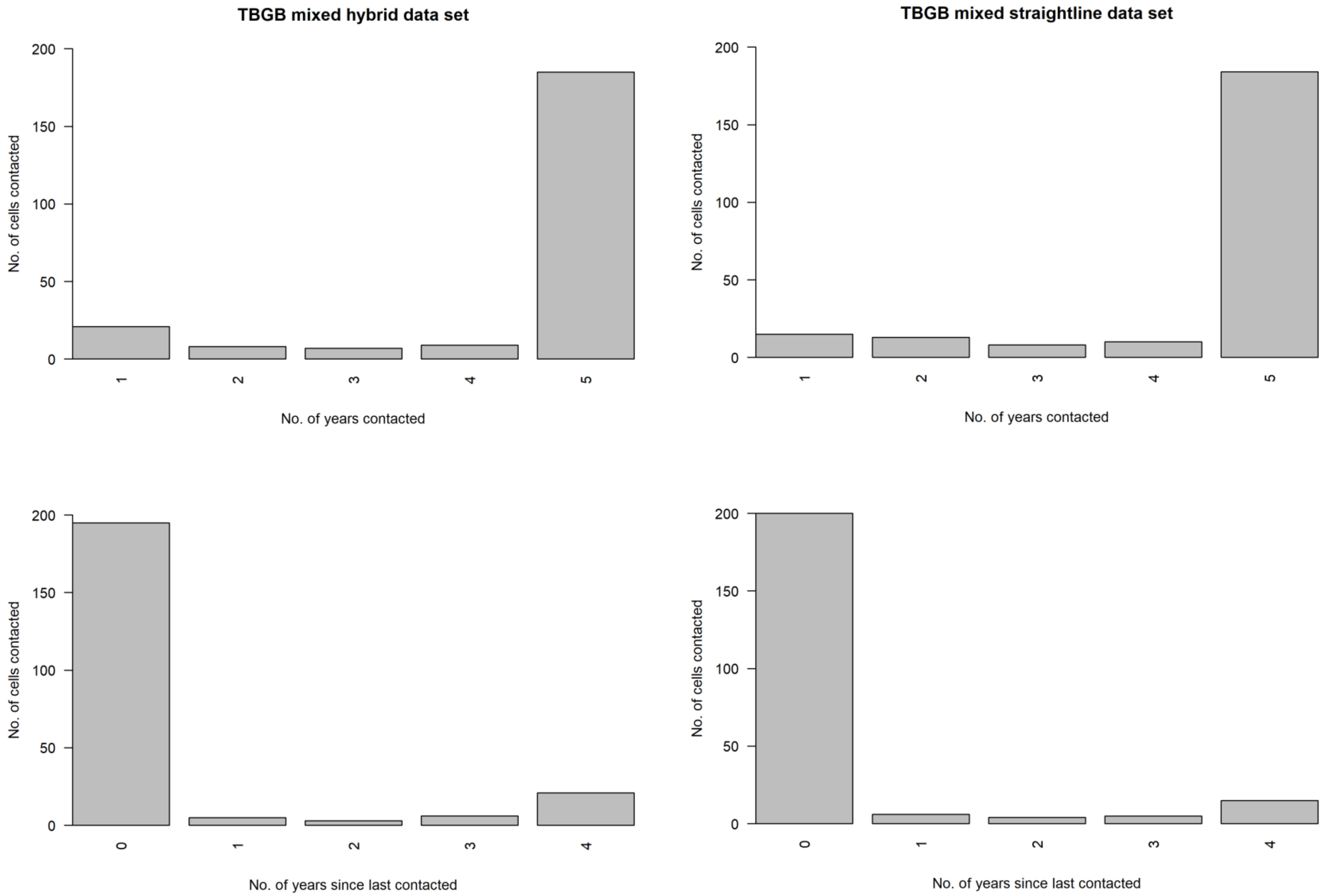

Figure F71: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for TBGB mixed.

Plots removed for data confidentiality reasons.

Figure F72: Distribution of cells, by the number of years contacted (top two plots), and by the most recent year fished (bottom two plots) between 2019 and 2023 for the hybrid data and the straight-line data.

TBGB MIXED 2 – Spatial extent

The summaries in this section consist of all tows within Tasman Bay and Golden Bay within Fisheries Management Area 7 targeting any of the inshore targets in Table 2 excluding flatfish, tarakihi, and barracouta (see individual summaries of flatfish in Tasman Bay and Golden Bay, tarakihi in TAR 7, and barracouta in BAR 7 for these species that include this area).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F73. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 97.5% and 101%, or a difference of between -5 and 2 cells.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 103–130.5%, representing a difference of between 41.4 and 599.7 km^2.

The footprint was higher for the hybrid data set in all years with ratios ranging from 101.4–116% or a difference of between 14.9 and 165.6 km^2.

The spatial distribution of the footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F73. At this resolution, there is little difference between the two data sets.

TBGB MIXED 2 – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F74 where the base footprint was created for 2008–2018 using the straight-line data set.

Neither data set had any new cells contacted during the five year time period since GPR data became available. The Tasman Bay and Golden Bay region is a very small area and it is quite plausible that all areas worth fishing have been contacted at some point in the 11-year period on which the base number of cells was contacted, especially as there are only 232 unique cells in the area that were contacted.

TBGB MIXED 2 – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F75). The ratio between the two data sets for the median number of tows that contacted a cell was 105%, a difference of 7.5 tows. The ratio for the mean number was 110% and represented a difference of 18 tows. For the maximum number of tows, the ratio was 105%, a difference of 49 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 114%, representing a difference of 4.2 km^2. The ratio for the mean is 122%, representing a difference of 8.1 km^2. The ratio for the maximum is 109%, a difference of 18.6 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F74 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The overall spatial distribution differs little, but the hybrid data set requires higher upper limits to the categories in the legend to span full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is a perfect match at 100% (17 km^2) as is the mean (15 km^2) and the maximum (25 km^2, the largest possible footprint in a cell).

The same summary information by year is given in Table F76. For the number of tows that contacted a cell, the annual median ratio ranged from 100–125%, a maximum difference of 6.5 tows in any one year. For the mean, the annual ratio ranged from 101–116%, a maximum difference of 7.7 tows. The annual ratio for maximum number of tows ranged from 96–107%, which represented a maximum difference of 18 tows in any one year.

The annual median ratios for the aggregate areas in a cell ranged from 96–137%, which represented an actual difference of no more than 1.8 km^2 in any one year. The ratios for the mean ranged from 103–135%, which represented an actual difference of no more than 3.4 km^2 in any one year. Ratios for the maximum aggregate area were slightly more substantial. ranging from 105–227% or 1.5–67.1 km^2.

The annual median ratios for the footprint in a cell ranged from 100–127%, representing a difference of no more than 1.1 km^2. The ratio for the mean footprint ranged from 100–113% in each year, representing a difference of no more than 0.8 km^2. The ratios for the maximum footprint ranged from 98–129%, representing a maximum difference of 5.3 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

TBGB MIXED 2 – Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted although there are slightly more cells in the hybrid data set that have one year of contact and slightly fewer that have two years of contact (Figure F75, upper two plots). There is little difference in the number of years since a cell was last contacted between the two data sets although the straight-line data set has slightly more cells contacted in the most recent fishing year (zero years since contact) and the hybrid data set has slightly more cells with four years since last contacted (Figure F75, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F76 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is very little difference that can be seen at this resolution and both data sets show that almost all sets have been contacted in all five years in the time series and hence most cells were contacted in the most recent fishing year.

Table F73: Number of cells contacted, aggregate area, and footprint for TBGB mixed 2 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	225	225	100.0	1 444.5	1 403.1	103.0	1 108.5	1 093.6	101.4
2020	202	200	101.0	1 805.0	1 396.5	129.3	1 198.1	1 032.5	116.0
2021	195	194	100.5	2 251.5	1 866.9	120.6	1 395.6	1 250.9	111.6
2022	195	195	100.0	2 166.4	1 709.0	126.8	1 317.5	1 160.7	113.5
2023	195	200	97.5	2 565.0	1 965.3	130.5	1 428.4	1 302.0	109.7

Table F74: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for TBGB Mixed 2. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value. NB: there have been no new cells contacted in TBGB during the time period whether considering at the hybrid or straight-line data sets.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0	0	–	0	0	–	0	0	–
2020	0	0	–	0	0	–	0	0	–	0	0	–
2021	0	0	–	0	0	–	0	0	–	0	0	–
2022	0	0	–	0	0	–	0	0	–	0	0	–
2023	0	0	–	0	0	–	0	0	–	0	0	–

Table F75: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for TBGB Mixed 2, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	54.0	49.8	108.0	158.0	150.5	105.0
Aggregate area	<0.1	<0.1	–	8.4	5.9	142.0	33.9	29.7	114.0
Footprint	<0.1	<0.1	–	4.0	4.0	100.0	15.0	15.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	191.7	173.7	110.0	284.0	253.2	112.0	1090.0	1041.0	105.0
Aggregate area	44.7	36.6	122.0	70.7	55.2	128.0	227.8	209.2	109.0
Footprint	13.0	13.0	100.0	21.0	21.0	100.0	25.0	25.0	100.0

Table F76: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for TBGB Mixed 2, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	10.0	10.0	100.0	23.0	23.0	100.0	28.8	28.4	101.0	40.0	40.0	100.0	111.0	104.0	107.0
2020	13.0	12.0	108.0	32.0	25.5	125.0	38.9	34.1	114.0	55.8	45.2	123.0	156.0	152.0	103.0
2021	15.5	14.2	109.0	36.0	33.0	109.0	49.2	44.7	110.0	70.5	61.0	116.0	272.0	254.0	107.0
2022	17.0	13.0	131.0	33.0	28.0	118.0	45.3	40.1	113.0	66.0	60.0	110.0	187.0	194.0	96.0
2023	18.0	14.0	129.0	38.0	35.5	107.0	57.2	49.5	116.0	76.5	66.0	116.0	552.0	539.0	102.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.4	1.4	100.0	4.8	5.0	96.0	6.4	6.2	103.0	9.4	9.0	104.0	29.0	27.5	105.0
2020	2.6	2.0	130.0	6.7	4.9	137.0	8.9	7.0	127.0	13.2	9.5	139.0	41.7	37.3	112.0
2021	2.9	2.3	126.0	7.9	6.6	120.0	11.5	9.6	120.0	16.5	13.5	122.0	77.1	66.1	117.0
2022	3.5	2.4	146.0	7.5	5.8	129.0	11.1	8.8	126.0	17.4	12.1	144.0	52.6	49.6	106.0
2023	3.7	2.7	137.0	8.9	7.2	124.0	13.2	9.8	135.0	17.5	13.5	130.0	120.1	53.0	227.0
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.3	1.3	100.0	4.2	4.2	100.0	4.9	4.9	100.0	7.4	7.2	103.0	16.4	15.6	105.0
2020	2.3	2.0	115.0	5.2	4.1	127.0	5.9	5.2	113.0	8.8	7.7	114.0	19.0	18.5	103.0
2021	2.2	2.0	110.0	6.3	5.7	111.0	7.2	6.4	112.0	10.8	9.9	109.0	22.7	22.3	102.0
2022	2.7	2.1	129.0	5.3	5.0	106.0	6.8	6.0	113.0	10.0	8.9	112.0	21.2	21.7	98.0
2023	3.0	2.4	125.0	6.3	5.8	109.0	7.3	6.5	112.0	10.6	9.6	110.0	23.7	18.4	129.0

Plots removed for data confidentiality reasons.

Figure F73: Distribution of the TBGB Mixed 2 footprint for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F74: Distribution of the TBGB Mixed 2 aggregate area for the 2019–2023 fishing years combined (top two plots) and 2023 (bottom two plots) for the hybrid and straight-line data sets.

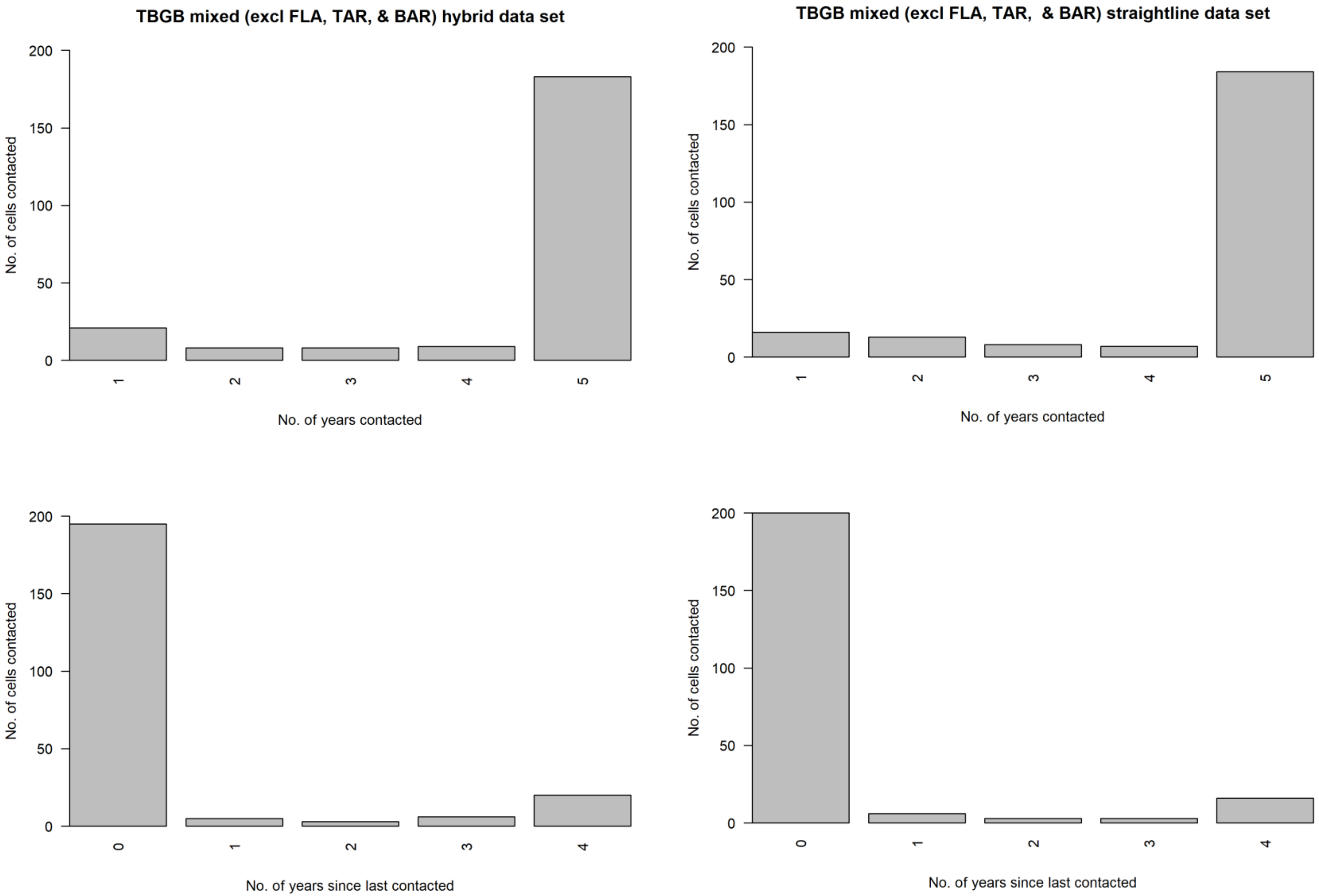

Figure F75: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for TBGB Mixed 2.

Plots removed for data confidentiality reasons.

Figure F76: Distribution of cells, by the number of years contacted (top two plots), and by the most recent year fished (bottom two plots) between 2019 and 2023 for the hybrid data and the straight-line data.

WCNI MIXED – Spatial extent

The summaries in this section consist of all tows along the west coast of the North Island within Fisheries Management Areas 7 and 8 targeting any of the inshore targets in Table 2 excluding tarakihi and barracouta (see individual summaries of tarakihi in TAR 7 and TAR 8, and barracouta in BAR 7 for these species in this area).

The annual total numbers of cells, aggregate swept area, and footprint are given in Table F77. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 95.7% and 99.8%, or a difference of between -57 and -3 cells. This indicates that the hybrid data set contacted fewer cells than the straight-line data set in all years.

The aggregate area was larger for the hybrid data set in all years with ratios ranging from 102.3–107.2%, or a difference of between 117 and 397 km^2.

The ratios for the footprint ranged from 99–101% or a difference of between -44.4 and 39 km^2, which is close in the context of the total area.

The footprint for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figure F77. At this resolution, there is little difference between the two data sets.

WCNI MIXED – Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table F78 where the base footprint was created for 2008–2018 using the straight-line data set.

The ratios for the number of new cells contacted in each year ranged from 66.7–100%. In terms of the difference in the numbers of new cells contacted however, the maximum value was just four cells, and in 2022, neither data set contacted any new cells.

Ratios for the aggregate area of new cells contacted ranged from 74.5–117.1%, but the difference in terms of area never exceeded -2.6 km^2.

As for the number of cells and aggregate area, the footprint was also higher for the hybrid data set in years where there was a difference, with ratios ranging from 76.3–115.6%, with the maximum difference this represents being just -2.3 km^2.

When considering the footprint as a percentage of the aggregate area, the ratios ranged from 98–102.4%. This indicates that overall, each data set has aggregate areas and footprints that are generally close to one another, even though there may be some small differences between data sets.

WCNI MIXED – Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table F79). The ratio between the two data sets for the median number of tows that contacted a cell was 108% but this was for a difference of just one tow. The ratio for the mean number was also 108% and this represented a difference of 3.6 tows. The maximum number of tows had a ratio of 103%, a difference of 19 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical, but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 113%, representing a difference of just 0.4 km^2. The ratio for the mean is 109%, but again, the actual difference is relatively small at just 1.3 km^2. The ratio for the maximum is 101%, a difference of 2.6 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure F78 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is little difference with respect to the spatial distribution of intensity. The hybrid data set however, needs a slightly higher upper limit for all years combined to cover the full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, making the ratio essentially meaningless. The ratio for the median and mean was 100% in all cases, or 3 and 6 km^2 respectively. Both data sets have a maximum footprint of 25 km^2 (the maximum possible, complete coverage in a cell), hence the ratio is 100%, a perfect match.

The same summary information by year is given in Table F80. For the number of tows that contacted a cell the median annual ratio ranged from 100–133%, representing a difference of no more than two tows in a given year. For the mean number of tows, the annual ratio ranged from 102–109%, which represented a maximum difference of 1.3 tows. The annual ratio for the maximum number of tows that contacted a cell ranged from 87–108%, representing a difference of no more than -17 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–119%, which represented an actual difference of no more than 0.3 km^2 in any one year. The ratios for the means ranged from 103–111%, which represented an actual difference of no more than 0.5 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 95–107%, which represents a maximum difference of 2.8 km^2.

The annual median ratios for the footprint in a cell ranged from 100–112%, but this represented a difference of no more than 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 100–106%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 94–105%, representing a maximum difference of 0.6 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types.

WCNI MIXED – Number of years contacted

There is almost no difference between the two data sets when comparing the number of years cells were contacted (Figure F79, upper two plots) nor for number of years since a cell was last contacted (Figure F79, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure F80 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table F77: Number of cells contacted, aggregate area, and footprint for WCNI mixed for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1351	1354	99.8	5 087.9	4 971.2	102.3	3 732.8	3 723.4	100.3
2020	1117	1153	96.9	5 276.5	4 924.0	107.2	3 382.7	3 375.4	100.2
2021	1282	1339	95.7	6 222.9	5 848.0	106.4	4 295.9	4 340.3	99.0
2022	1179	1194	98.7	6 283.5	5 886.2	106.7	4 105.7	4 066.8	101.0
2023	1111	1135	97.9	4 993.4	4 701.2	106.2	3 464.7	3 482.3	99.5

Table F78: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for WCNI mixed. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	30	30	100.0	14.4	12.3	117.1	14.1	12.2	115.6	97.9	99.2	98.7
2020	8	12	66.7	7.5	7.7	97.4	6.3	6.6	95.5	84.0	85.7	98.0
2021	16	17	94.1	7.6	10.2	74.5	7.4	9.7	76.3	97.4	95.1	102.4
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	5	5	100.0	0.8	1.0	80.0	0.8	1.0	80.0	100.0	100.0	100.0

Table F79: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for WCNI mixed, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	3.0	100.0	13.0	12.0	108.0
Aggregate area	<0.1	<0.1	–	0.7	0.6	117.0	3.5	3.1	113.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	3.0	3.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	50.0	46.4	108.0	62.0	57.0	109.0	571.0	552.0	103.0
Aggregate area	15.7	14.4	109.0	17.3	15.6	111.0	208.5	205.9	101.0
Footprint	6.0	6.0	100.0	10.0	10.0	100.0	25.0	25.0	100.0

Table F80: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for WCNI mixed, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	1.0	200.0	4.0	4.0	100.0	11.7	11.5	102.0	14.0	14.0	100.0	151.0	150.0	101.0
2020	2.0	2.0	100.0	6.0	5.0	120.0	14.8	13.7	108.0	19.0	17.0	112.0	182.0	169.0	108.0
2021	2.0	2.0	100.0	8.0	6.0	133.0	15.6	14.3	109.0	21.0	19.0	111.0	123.0	117.0	105.0
2022	2.0	2.0	100.0	7.0	6.0	117.0	16.9	15.9	106.0	23.0	21.0	110.0	178.0	183.0	97.0
2023	3.0	2.0	150.0	7.0	6.0	117.0	14.5	13.6	107.0	18.0	17.0	106.0	117.0	134.0	87.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.1	1.1	100.0	3.8	3.7	103.0	4.1	4.1	100.0	59.0	56.2	105.0
2020	0.4	0.4	100.0	1.4	1.3	108.0	4.7	4.3	109.0	5.2	4.3	121.0	64.5	64.6	100.0
2021	0.5	0.4	125.0	1.8	1.6	112.0	4.9	4.4	111.0	6.1	5.4	113.0	51.2	48.0	107.0
2022	0.5	0.5	100.0	1.9	1.6	119.0	5.3	4.9	108.0	6.4	5.8	110.0	52.0	54.6	95.0
2023	0.6	0.5	120.0	2.0	1.7	118.0	4.5	4.1	110.0	5.4	4.9	110.0	36.3	37.1	98.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.4	0.4	100.0	1.1	1.1	100.0	2.8	2.7	104.0	3.5	3.6	97.0	22.8	22.2	103.0
2020	0.4	0.4	100.0	1.3	1.2	108.0	3.0	2.9	103.0	3.8	3.7	103.0	22.6	22.9	99.0
2021	0.5	0.4	125.0	1.6	1.5	107.0	3.4	3.2	106.0	4.9	4.5	109.0	20.5	20.6	100.0
2022	0.5	0.5	100.0	1.6	1.6	100.0	3.5	3.4	103.0	4.9	4.7	104.0	21.1	21.5	98.0
2023	0.6	0.5	120.0	1.8	1.6	112.0	3.1	3.1	100.0	4.3	4.1	105.0	17.1	18.2	94.0

Plots removed for data confidentiality reasons.

Figure F77: Distribution of the WCNI mixed footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure F78: Distribution of the WCNI mixed aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

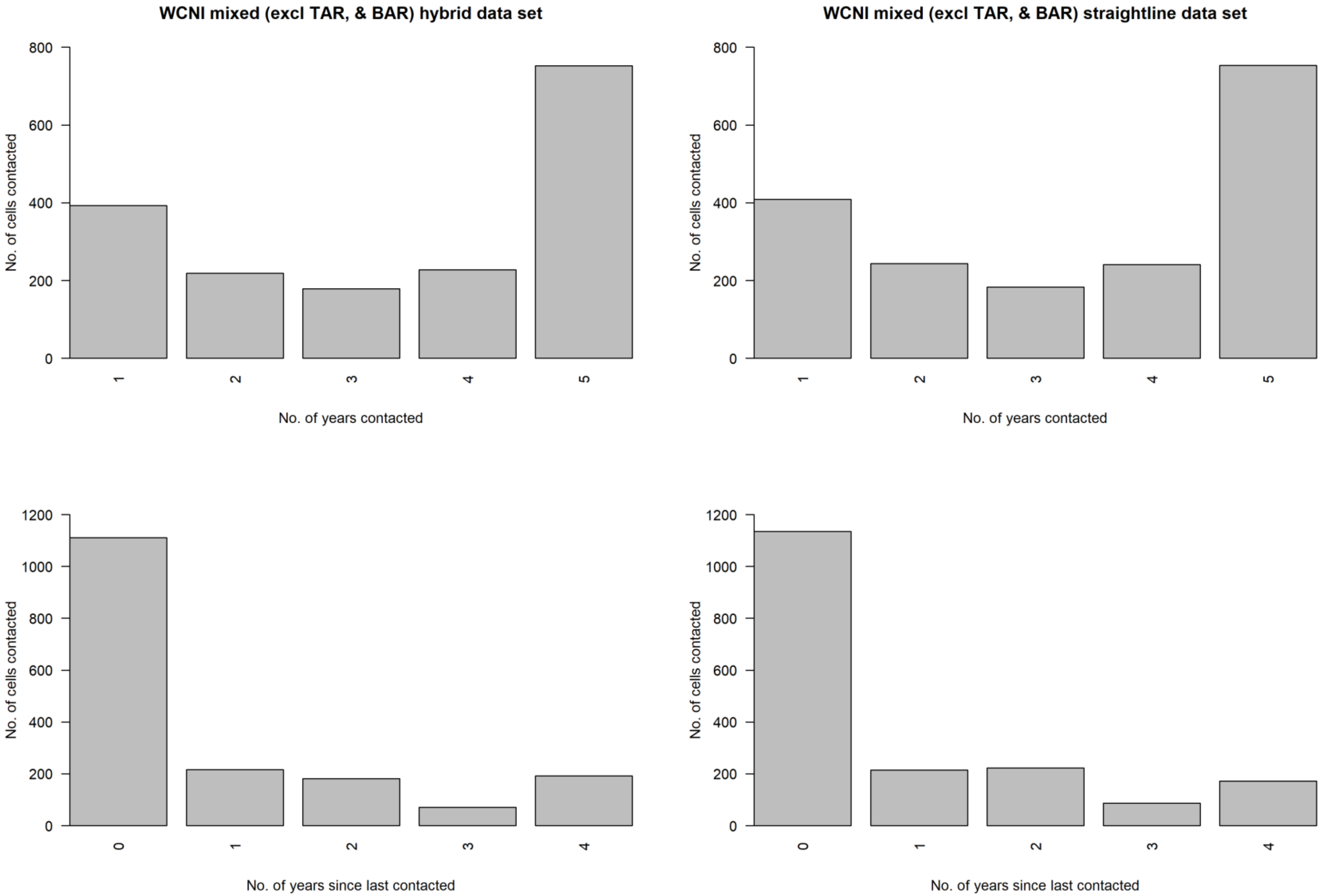

Figure F79: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for WCNI mixed.

Plots removed for data confidentiality reasons.

Figure F80: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right) for WCNI mixed.

APPENDIX G

OEO/ORH Marine Stewardship Council (MSC) Assessment Areas

The summaries in this section consist of all tows targeting hoki, hake, or ling in the bycatch assessment areas as shown in Figure G1.

OEO/ORH MSC Assessment Areas – ESCR Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table G1. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 99.8% and 101.7%, or a difference of between -1 and 8 cells, indicating that in some years the hybrid data set contacted more cells and in other years the straight-line data set contacted more.

For the aggregate area, values were higher in every year for the hybrid data, with ratios ranging from 100.7–111.4%, representing differences of between 7.6 and 218.4 km^2.

The footprint was also larger in every year for the hybrid data set, albeit to a lesser degree than the aggregate area, with ratios of between 100.1–106.2%, or a maximum difference of representing a maximum difference of 90.6 km^2.

The footprint and aggregate area for the hybrid and straight-line data sets for all years combined and for the most recent fishing years are shown in Figures G1–2. At this resolution, there is little appreciable difference.

OEO/ORH MSC Assessment Areas – ESCR Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table G2 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 50% to 100%. While a 50% ratio may seem high for the 2020 fishing year, this represents a difference of just 1 vs 2 cells. Neither data set contacted any new cells in 2019.

The ratios for the aggregate area of the new cells contacted ranged from 100–175%. The maximum difference however, was just 0.3 km^2.

Values for the footprints were exactly the same as the aggregate areas (meaning the areas contacted in the new cells were contacted only once). As a result, the corresponding ratios for the footprint as a percentage of the aggregate area all match at 100%. These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

OEO/ORH MSC Assessment Areas – ESCR Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table G3). The ratio between the two data sets for the median number of tows that contacted a cell was 100% or 14 tows for each data set. The ratio for the mean number was 103%, a difference of just one tow. The ratio for the maximum number of tows was 104.9% and represented a difference of 33 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 104%, representing a difference of just 0.2 km^2. The ratio for the mean is 110%, but again, the actual difference is small at just 0.9 km^2. The ratio for the maximum was also 110%, or 21.8 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure G2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity. Of all the MSC assessment areas for OEO/ORH combined, the aggregate area is highest for ESCR, and ranged between 0 and 400 km^2 by cell for all years combined.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median, mean, and maximum footprint are all 100%, with values of 3, 6, and 25 km^2 respectively.

The same summary information by year is given in Table G4. The annual median for the number of tows that contacted a cell was 100% each year, with the annual values ranging between three and seven tows. The ratio for the mean number of tows ranged from 100–106.5%, representing a difference of no more than 0.6 tows in any one year. For the maximum, the ratio ranged from 97.3 to 107.5%, and represented a maximum difference of 13 tows.

The annual median ratios for the aggregate areas in a cell ranged from 90–100%, which represented an actual difference of no more than -0.2 km^2 in any one year. The ratios for the means ranged from 100–110%, which represented an actual difference of no more than 0.5 km^2 in any one year. The ratio for the maximum aggregate area ranged from 100–120%, representing a maximum difference of -13.3 km^2.

The annual median ratios for the footprint in a cell ranged from 100% in all years except in 2020 when it was 106.2%, or a difference of 0.1 km^2. The ratio for the mean footprint ranged from 100–105.9%, representing a maximum difference of 0.2 km^2. The ratios for the maximum footprint ranged from 95.1–104.5%, representing a maximum difference of -0.9 km^2.

OEO/ORH MSC Assessment Areas – ESCR Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted (Figure G3, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure G3, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure G4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

OEO/ORH MSC Assessment Areas – NWCR Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table G5. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 92.9% and 104.6%, or a difference of between -15 and 11 cells, indicating that in some years the hybrid data set contacted more cells and in other years the straight-line data set contacted more.

For the aggregate area, values were higher for the hybrid data set in all years, with ratios ranging from 104.9–121.1%, representing a difference of between 23 and 101 km^2 each year.

Ratios for the footprint ranged between 97.2 and 106.8%, indicating that it was smaller in some years and larger in others for the hybrid data set. The differences ranged between -11.5 and 23.7 km^2.

The footprint and aggregate area for the hybrid and straight-line data sets for all years combined and for the most recent fishing years are shown in Figures G1–2. At this resolution, there is little appreciable difference.

OEO/ORH MSC Assessment Areas – NWCR Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table G6 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 60% (hybrid data set contacting fewer new cells) to 200% (hybrid data set contacting more cells). However, new cells were only contacted in 2019 and 2020, and the differences only represented one cell in 2019 and -2 cells in 2020.

Ratios for the aggregate area of the new cells contacted were 216.7% in 2019 and 9.1% in 2020 but the actual differences in area were just 0.7 and -1 km^2 respectively.

Values for the footprints were exactly the same as the aggregate areas (meaning the areas contacted in the new cells were contacted only once). As a result, the corresponding ratios for the footprint as a percentage of the aggregate area all match at 100%. These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

OEO/ORH MSC Assessment Areas – NWCR Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table G7). The ratio between the two data sets for the median number of tows that contacted a cell was 100% (four tows each). The ratio for the mean number was 105.9% and represented a difference of 0.7 tows. The ratio for the maximum number of tows was 119.3% and represented a difference of 23 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 95.5% (-0.1 km^2). The ratio for the mean is 108.3%, but again, the actual difference is small at just 0.5 km^2. The ratio for the maximum was 125.7%, or 10.8 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure G2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity. For NWCR, the aggregate area ranged between 0 and 50 km^2 by cell for all years combined.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median and mean are both an exact match at 100% (2 and 4 km^2 respectively). The ratio for the maximum footprint was 95.2%, a difference of -1 km^2.

The same summary information by year is given in Table G8. The annual median for the number of tows that contacted a cell ranged from 100–150%, representing a difference of no more than 1 tows. The ratio for the mean number of tows ranged from 100–116.7%, representing a difference of no more than 0.7 tows. For the maximum, the ratio ranged from 100–142.5% representing a maximum difference of 17 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–112.5%, which represented an actual difference of no more than 0.1 km^2 in any one year. The ratios for the means ranged from 100–125%, which represented an actual difference of no more than 0.5 km^2 in any one year. The ratio for the maximum aggregate area ranged from 89.3–224.3%, a maximum difference of 14.3 km^2.

The annual median ratios for the footprint in a cell ranged from 100–108.3% but in no year did the actual difference in square kilometres exceed 0.1 km^2. The ratio for the mean footprint was very close in each year, ranging from 95.8–111.8%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 77.2–127.5%, representing a maximum difference of 2.2 km^2.

OEO/ORH MSC Assessment Areas – NWCR Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted but the hybrid data set did contact slightly more cells overall (Figure G5, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure G5, lower two plots). Again, the hybrid data set contacted slightly more cells overall than the straightline, but the distributions are much the same.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure G6 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

OEO/ORH MSC Assessment Areas – ORH 7A Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table G9. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged from 98.7–103%, or a difference of between -11 and 22 cells, indicating that in some years the hybrid data set contacted more cells and in other years the straight-line data set contacted more.

The aggregate area was higher in every year for the hybrid data set, with ratios ranging from 103–112.7%, representing differences of between 46 and 267 km^2.

The footprint was also larger in every year for the hybrid data set with ratios of between 101.5% and 108.7%, representing differences of between 20 and 134 km^2.

The footprint and aggregate area for the hybrid and straight-line data sets for all years combined and for the most recent fishing years are shown in Figures G1–2. At this resolution, there is little appreciable difference.

OEO/ORH MSC Assessment Areas – ORH 7A Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table G10 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 100–142.4%, representing differences of between 0 and 14 cells.

The ratios for the aggregate area of the new cells contacted ranged from 100.1–104.9 for the first four years of the time period, representing differences of between 0.4 and 4.6 km^2. This increased to 178.5% in 2023, a difference of 17.9 km^2.

Ratios for the footprints ranged from 99.7–104.6% for the first four years of the time period representing differences of between -0.5 and 4.1 km^2. This increased to 170.5% in 2023 when there was a difference of 16 km^2 between the two data sets. It should be noted that while 2023 has the biggest difference between the two data sets in terms of both the ratios and the area, both data sets recorded substantially lower values than in the previous four years.

When considering the footprint as a percentage of the aggregate area, the ratios are close to 100% in all years, ranging from 95.5–101.1%. These ratios indicate that whether using the hybrid data set or the straight line data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

OEO/ORH MSC Assessment Areas – ORH 7A Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table G11). The ratio between the two data sets for the median number of tows that contacted a cell was 100% with 15 tows each. The ratio for the mean number was 102.8% and represented a difference of 0.6 tows. The ratio for the maximum number of tows was 132.4% and represented a more substantial difference of 68 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 100% (7.3 km^2). The ratio for the mean is 104.8%, but again, the actual difference is small at just 0.5 km^2. The ratio for the maximum was 149.1%, a more substantial difference of 49.6 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure G2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity. For ORH 7A, the aggregate area ranged between 0 and 10 km^2 by cell for all years combined.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median was 116.7% with a difference of just one between the two data sets. The mean footprint is was an exact match with a ratio of 100% (7 km^2). The ratio for the maximum footprint was 104%, a difference of 1 km^2.

The same summary information by year is given in Table G12. The annual median for the number of tows that contacted a cell ranged from 100–125%, representing a difference of no more than one tow. The ratio for the mean number of tows ranged from 98.6–105.7%, representing a difference of no more than 0.3 tows. For the maximum, the ratio ranged from 88.4–125.6%, which represented a maximum difference of 13 tows in any one year.

The annual median ratios for the aggregate areas in a cell ranged from 92.9–110.5%, which represented an actual difference of no more than 0.2 km^2 in any one year. The ratios for the means ranged from 100–109.7%, which represented an actual difference of no more than 0.3 km^2 in any one year. The ratio for the maximum aggregate area ranged from 100.9–197.9%, a maximum difference of 19.1 km^2.

The annual median ratios for the footprint in a cell ranged from 93.1–110.5% but in no year did the actual difference in square kilometres exceed 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 100–109.1%, and represented a difference between data types of no more than 0.2 km^2. The ratios for the maximum footprint ranged from 97.6–140.7%, representing a maximum difference of 5.5 km^2.

OEO/ORH MSC Assessment Areas – ORH 7A Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted (Figure G6, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure G6, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure G4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table G1: Number of cells contacted, aggregate area, and footprint for MSC assessment area ESCR for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	412	413	99.8	1 094.3	1 086.7	100.7	759.5	759.0	100.1
2020	492	493	99.8	2 076.5	1 978.1	105.0	1 415.9	1 371.6	103.2
2021	497	491	101.2	2 952.4	2 758.8	107.0	1 983.3	1 908.4	103.9
2022	487	479	101.7	2 343.9	2 212.6	105.9	1 592.7	1 566.3	101.7
2023	435	434	100.2	2 127.7	1 909.3	111.4	1 546.3	1 455.7	106.2

Table G2: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for MSC assessment area ESCR. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2020	1	2	50.0	<0.1	0.7	–	<0.1	0.7	0.0	–	100.0	–
2021	1	1	100.0	0.6	0.6	100.0	0.6	0.6	100.0	100.0	100.0	100.0
2022	1	1	100.0	0.7	0.4	175.0	0.7	0.4	175.0	100.0	100.0	100.0
2023	1	1	100.0	0.6	0.6	100.0	0.6	0.6	100.0	100.0	100.0	100.0

Table G3: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for MSC assessment area ESCR, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	3.0	100.0	14.0	14.0	100.0
Aggregate area	<0.1	<0.1	–	0.8	0.8	100.0	4.7	4.5	104.4
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	3.0	3.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	34.3	33.3	103.0	42.0	41.2	101.9	702.0	669.0	104.9
Aggregate area	15.4	14.5	106.2	19.6	19.2	102.1	400.2	378.4	105.8
Footprint	6.0	6.0	100.0	12.0	12.0	100.0	25.0	25.0	100.0

Table G4: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for MSC assessment area ESCR, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	2.0	50.0	3.0	3.0	100.0	7.8	7.8	100.0	7.0	7.0	100.0	107.0	110.0	97.3
2020	2.0	2.0	100.0	5.0	5.0	100.0	10.2	9.9	103.0	11.0	10.0	110.0	186.0	173.0	107.5
2021	2.0	2.0	100.0	7.0	7.0	100.0	12.4	12.1	102.5	16.0	16.0	100.0	158.0	151.0	104.6
2022	2.0	2.0	100.0	4.0	4.0	100.0	10.0	9.9	101.0	12.5	13.0	96.2	137.0	129.0	106.2
2023	2.0	2.0	100.0	6.0	6.0	100.0	9.8	9.2	106.5	13.0	12.0	108.3	116.0	114.0	101.8
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.4	75.0	1.1	1.1	100.0	2.7	2.6	103.8	2.7	2.8	96.4	50.4	52.6	95.8
2020	0.6	0.7	85.7	2.0	2.1	95.2	4.2	4.0	105.0	4.5	4.4	102.3	105.3	97.3	108.2
2021	0.7	0.6	116.7	2.6	2.5	104.0	5.9	5.6	105.4	7.5	7.4	101.4	96.0	90.3	106.3
2022	0.6	0.5	120.0	1.5	1.5	100.0	4.8	4.6	104.3	6.0	6.0	100.0	81.4	68.1	119.5
2023	0.7	0.6	116.7	2.3	2.5	92.0	4.9	4.4	111.4	6.4	5.9	108.5	73.1	70.1	104.3
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	1.0	1.0	100.0	1.8	1.8	100.0	2.3	2.4	95.8	17.3	18.2	95.1
2020	0.6	0.6	100.0	1.7	1.6	106.2	2.9	2.8	103.6	3.9	3.8	102.6	24.2	23.8	101.7
2021	0.6	0.6	100.0	2.0	2.0	100.0	4.0	3.9	102.6	6.3	5.9	106.8	23.8	23.3	102.1
2022	0.5	0.5	100.0	1.5	1.5	100.0	3.3	3.3	100.0	4.9	4.7	104.3	23.1	22.1	104.5
2023	0.7	0.6	116.7	2.2	2.2	100.0	3.6	3.4	105.9	5.4	5.2	103.8	21.5	21.6	99.5

Table G5: Number of cells contacted, aggregate area, and footprint for MSC assessment area NWCR for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	230	242	95.0	580.4	479.4	121.1	429.0	411.9	104.2
2020	196	211	92.9	490.4	467.4	104.9	397.3	408.8	97.2
2021	211	204	103.4	633.3	599.6	105.6	484.2	485.1	99.8
2022	190	196	96.9	330.1	300.9	109.7	263.9	257.9	102.3
2023	249	238	104.6	403.3	373.8	107.9	371.8	348.1	106.8

Table G6: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for MSC assessment area NWCR. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	2	1	200.0	1.3	0.6	216.7	1.3	0.6	216.7	100.0	100.0	100.0
2020	3	5	60.0	0.1	1.1	9.1	0.1	1.1	9.1	100.0	100.0	100.0
2021	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table G7: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for MSC assessment area NWCR, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	4.0	4.0	100.0
Aggregate area	<0.1	<0.1	–	0.8	0.8	100.0	2.1	2.2	95.5
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	2.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	12.6	11.9	105.9	14.5	14.0	103.6	142.0	119.0	119.3
Aggregate area	6.5	6.0	108.3	7.3	7.4	98.6	52.9	42.1	125.7
Footprint	4.0	4.0	100.0	6.0	6.0	100.0	20.0	21.0	95.2

Table G8: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for MSC assessment area NWCR, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	2.0	2.0	100.0	4.9	4.2	116.7	5.8	5.8	100.0	57.0	40.0	142.5
2020	1.0	1.0	100.0	3.0	2.0	150.0	4.8	4.3	111.6	7.0	6.0	116.7	30.0	28.0	107.1
2021	1.0	1.0	100.0	3.0	3.0	100.0	5.7	5.6	101.8	6.0	6.0	100.0	38.0	35.0	108.6
2022	1.0	1.0	100.0	2.0	2.0	100.0	3.6	3.2	112.5	3.0	3.0	100.0	32.0	32.0	100.0
2023	1.0	1.0	100.0	2.0	2.0	100.0	3.0	3.0	100.0	4.0	4.0	100.0	16.0	15.0	106.7

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	0.9	0.8	112.5	2.5	2.0	125.0	2.8	2.5	112.0	25.8	11.5	224.3
2020	0.6	0.6	100.0	1.3	1.2	108.3	2.5	2.2	113.6	3.7	3.1	119.4	13.1	14.1	92.9
2021	0.7	0.8	87.5	1.7	1.6	106.2	3.0	2.9	103.4	3.2	3.2	100.0	23.5	23.7	99.2
2022	0.7	0.7	100.0	0.9	0.9	100.0	1.7	1.5	113.3	1.8	1.5	120.0	13.9	12.8	108.6
2023	0.5	0.5	100.0	0.8	0.8	100.0	1.6	1.6	100.0	2.1	1.9	110.5	7.5	8.4	89.3

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.5	100.0	0.8	0.8	100.0	1.9	1.7	111.8	2.4	2.2	109.1	10.2	8.0	127.5
2020	0.6	0.6	100.0	1.3	1.2	108.3	2.0	1.9	105.3	2.8	2.7	103.7	8.4	9.2	91.3
2021	0.7	0.7	100.0	1.6	1.6	100.0	2.3	2.4	95.8	2.9	2.9	100.0	14.6	15.8	92.4
2022	0.7	0.7	100.0	0.9	0.9	100.0	1.4	1.3	107.7	1.6	1.5	106.7	7.1	9.2	77.2
2023	0.5	0.5	100.0	0.8	0.8	100.0	1.5	1.5	100.0	2.0	1.9	105.3	7.2	7.3	98.6

Table G9: Number of cells contacted, aggregate area, and footprint for OEO/ORH - ORH 7A for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	475	475	100.0	1 528.5	1 482.6	103.1	1 336.2	1 316.2	101.5
2020	674	665	101.4	1 855.4	1 659.2	111.8	1 602.2	1 473.7	108.7
2021	751	729	103.0	2 804.6	2 721.7	103.0	2 492.4	2 426.8	102.7
2022	841	852	98.7	3 530.3	3 382.0	104.4	3 141.2	3 060.0	102.7
2023	686	671	102.2	2 363.8	2 097.3	112.7	1 880.7	1 746.4	107.7

Table G10: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023, for the hybrid and straight-line data sets for MSC assessment area ORH 7A. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	32	31	103.2	98.7	94.1	104.9	93.3	89.2	104.6	94.5	94.8	99.7
2020	70	70	100.0	85.5	82.9	103.1	85.0	81.5	104.3	99.4	98.3	101.1
2021	85	80	106.2	175.1	174.7	100.2	166.3	166.8	99.7	95.0	95.5	99.5
2022	120	119	100.8	317.4	317.0	100.1	297.7	296.1	100.5	93.8	93.4	100.4
2023	47	33	142.4	40.7	22.8	178.5	38.7	22.7	170.5	95.1	99.6	95.5

Table G11: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for MSC assessment area ORH 7A, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	4.0	75.0	15.0	15.0	100.0
Aggregate area	<0.1	<0.1	–	1.5	1.6	90.0	7.3	7.3	100.0
Footprint	<0.1	<0.1	–	2.0	2.0	100.0	7.0	6.0	116.7

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	21.8	21.2	102.8	30.0	30.0	100.0	278.0	210.0	132.4
Aggregate area	10.9	10.4	104.8	15.2	15.0	101.3	150.6	101.0	149.1
Footprint	7.0	7.0	100.0	12.0	11.0	109.1	25.0	24.0	104.2

Table G12: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for MSC assessment area ORH 7A, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	5.0	4.0	125.0	6.8	6.6	103.0	9.0	9.0	100.0	90.0	77.0	116.9
2020	1.0	2.0	50.0	3.0	3.0	100.0	5.6	5.3	105.7	6.0	6.0	100.0	63.0	64.0	98.4
2021	2.0	2.0	100.0	6.0	6.0	100.0	7.1	7.2	98.6	10.0	10.0	100.0	49.0	41.0	119.5
2022	3.0	3.0	100.0	7.0	7.0	100.0	8.4	8.1	103.7	11.0	11.0	100.0	54.0	43.0	125.6
2023	1.0	1.0	100.0	3.0	3.0	100.0	6.8	6.5	104.6	6.0	7.0	85.7	76.0	86.0	88.4

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.7	100.0	2.1	1.9	110.5	3.2	3.1	103.2	4.3	4.3	100.0	47.1	37.4	125.9
2020	0.8	0.7	114.3	1.5	1.5	100.0	2.8	2.5	112.0	3.3	3.1	106.5	33.2	28.2	117.7
2021	0.8	0.8	100.0	2.9	3.0	96.7	3.7	3.7	100.0	5.7	5.6	101.8	30.5	20.4	149.5
2022	1.5	1.2	125.0	3.3	3.2	103.1	4.2	4.0	105.0	5.8	5.6	103.6	38.6	19.5	197.9
2023	0.7	0.6	116.7	1.3	1.4	92.9	3.4	3.1	109.7	3.5	3.4	102.9	45.0	44.6	100.9

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.7	100.0	2.1	1.9	110.5	2.8	2.8	100.0	4.1	4.1	100.0	20.2	18.6	108.6
2020	0.8	0.7	114.3	1.5	1.4	107.1	2.4	2.2	109.1	3.2	3.1	103.2	18.3	16.3	112.3
2021	0.8	0.8	100.0	2.7	2.9	93.1	3.3	3.3	100.0	5.3	5.2	101.9	17.5	13.2	132.6
2022	1.5	1.2	125.0	3.2	3.1	103.2	3.7	3.6	102.8	5.3	5.2	101.9	19.0	13.5	140.7
2023	0.7	0.6	116.7	1.3	1.3	100.0	2.7	2.6	103.8	3.3	3.3	100.0	20.7	21.2	97.6

Plots removed for data confidentiality reasons.

Figure G1: Distribution of the OEO/ORH MSC assessment area footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure G2: Distribution of the OEO/ORH aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

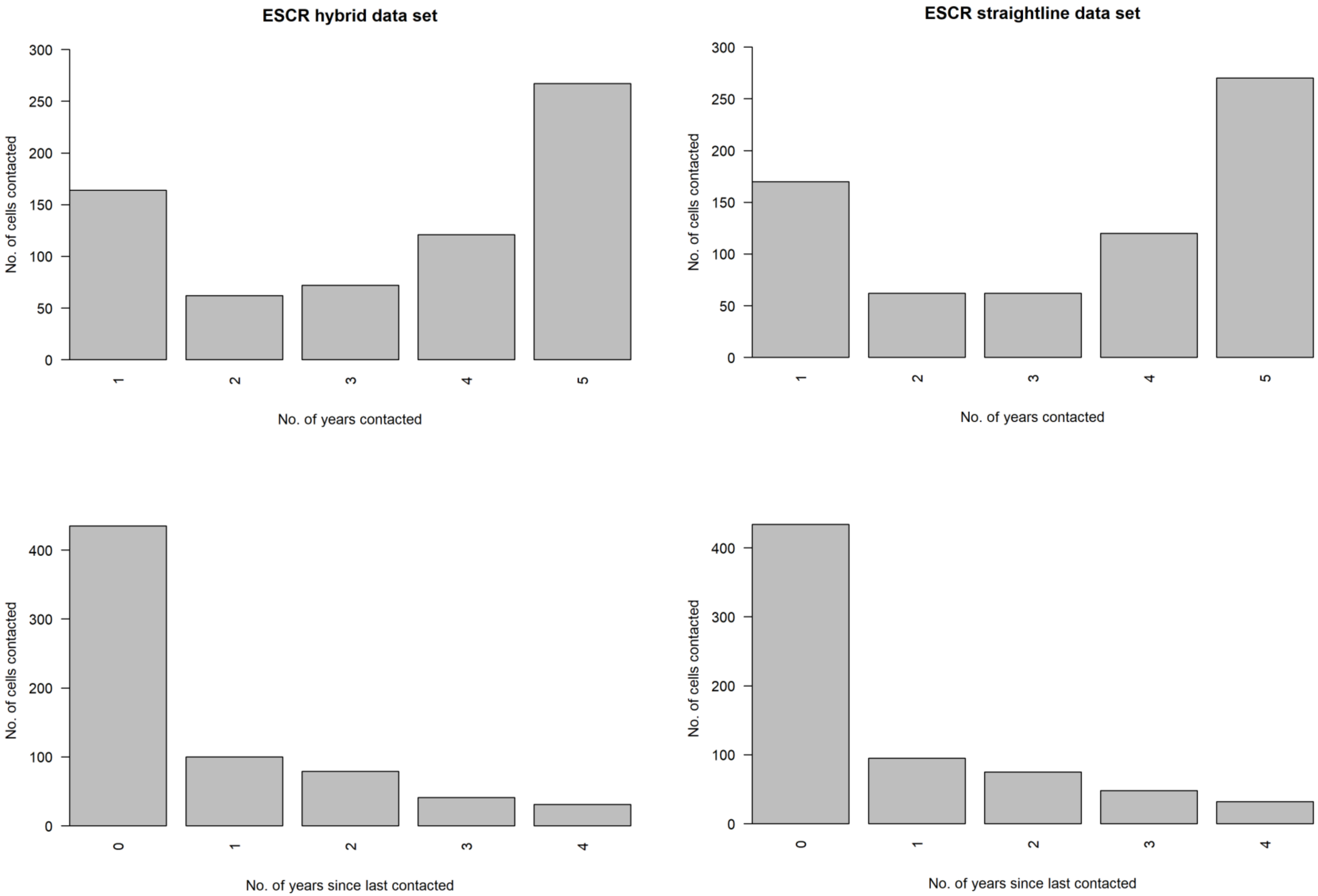

Figure G3: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the ESCR subarea.

Plots removed for data confidentiality reasons.

Figure G4: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left and the straight-line data (right).

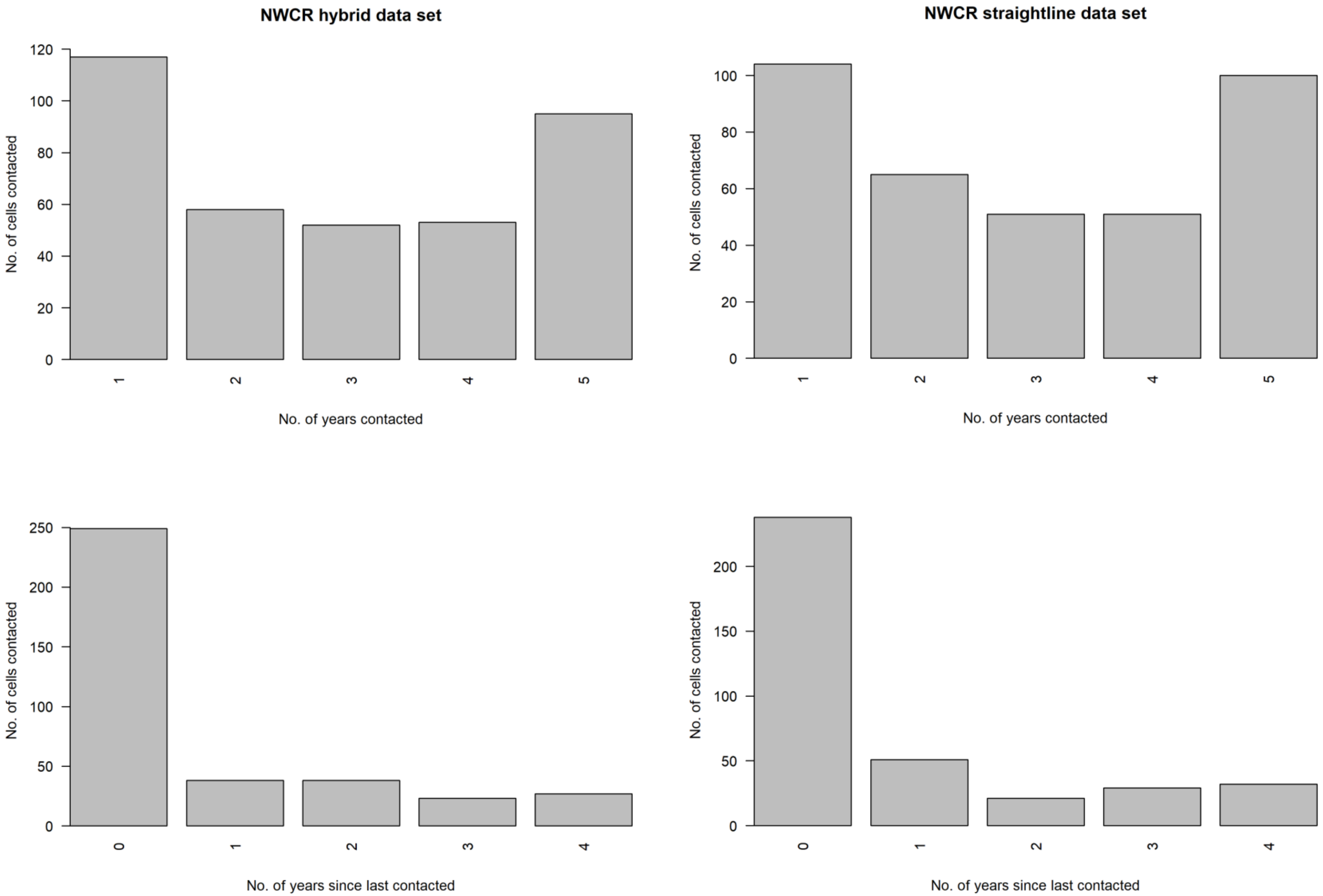

Figure G5: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the NWCR subarea.

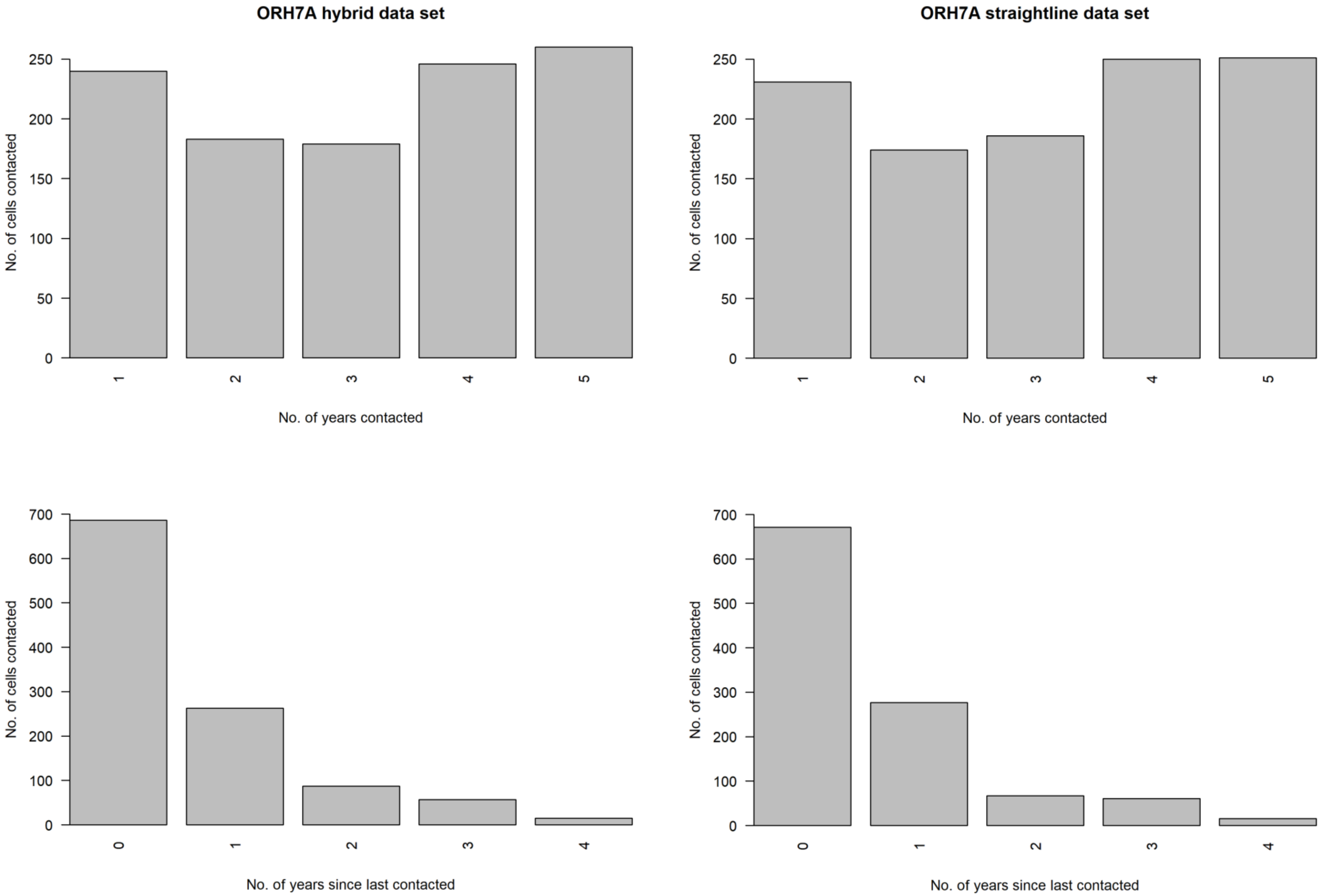

Figure G6: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the ORH 7A subarea.

APPENDIX H

HOK/HAK/LIN Bycatch Assessment Areas

The summaries in this section consist of all tows targeting hoki, hake, or ling in the bycatch assessment areas as shown in Figure H1.

HOK/HAK/LIN Bycatch Assessment Areas – WCNI9 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H1. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 90.6% and 112.5%, or a difference of between -5 and 4 cells, indicating that in some years the hybrid data set contacted more cells and in other years the straight-line data set contacted more.

For the aggregate area, the ratios ranged from 97.9–103.2%, but this represented a difference of no more than 2.9 km^2.

The footprint was also smaller in every year for the hybrid data set with ratios of between 91.8–99.8%, or a maximum difference of -4.4 km^2.

The footprint and aggregate area for the hybrid and straight-line data sets for all years combined and for the most recent fishing years are shown in Figures H1–2. At this resolution, there is little appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – WCNI9 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H2 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 20% (hybrid data set contacting fewer new cells) to 130.8% (hybrid data set contacting more cells). While a 20% ratio may seem high for the 2019 fishing year, this represent a difference of just 1 vs 5 cells. Neither data set contacted any new cells in 2021 or 2022.

Correspondingly, the ratios for the aggregate area of the new cells contacted was similar, ranging from 29.4–117.1%. Again, the 2019 value may seem high but represents just 1.2 km^2.

Values for the footprints were exactly the same as the aggregate areas (meaning the areas contacted in the new cells were contacted only once. As a result, the corresponding ratios for the footprint as a percentage of the aggregate area all match at 100%. These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

HOK/HAK/LIN Bycatch Assessment Areas – WCNI9 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H3). The ratio between the two data sets for the median number of tows that contacted a cell was 200% but this represented a difference of just one tow. The ratio for the mean number was 110% and represented a difference of 0.5 tows. The ratio for the maximum number of tows was 93.1% and represented a difference of -2 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 100% (0.5 km^2). The ratio for the mean is 110%, but again, the actual difference is small at just 0.2 km^2. The ratio for the maximum was 101.7%, or 0.3 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity. For WCNI9, the aggregate area ranged between 0 and 50 km^2 by cell.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (1 km^2). The mean footprint is also an exact match with a ratio of 100% (2 km^2). The ratio for the maximum footprint was 92.3%, a difference of -1 km^2.

The same summary information by year is given in Table H4. The annual median for the number of tows that contacted a cell ranged from 66.7–100%, representing a difference of no more than -1 tows. The ratio for the mean number of tows ranged from 87.5–108.7%, representing a difference of no more than -0.4 tows. For the maximum, the ratio ranged was 100% in all years, as the maximum number of tows matched between the data sets each year.

The annual median ratios for the aggregate areas in a cell ranged from 87.5–150%, which represented an actual difference of no more than 0.2 km^2 in any one year. The ratios for the means ranged from 90.9–116.7%, which represented an actual difference of no more than 0.1 km^2 in any one year. The ratio for the maximum aggregate area ranged from 92.9–106.9%, a maximum difference of -0.6 km^2.

The annual median ratios for the footprint in a cell ranged from 85.7–150% but in no year did the actual difference in square kilometres exceed 0.2 km^2. The ratio for the mean footprint was very close in each year, ranging from 90–116.7%, and represented a difference between data types of no more than 0.1 km^2. The ratios for the maximum footprint ranged from 78–101.9%, representing a maximum difference of -0.9 km^2.

HOK/HAK/LIN Bycatch Assessment Areas – WCNI9 Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted but the straight-line data set did contact slightly more cells overall (Figure H3, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure H3, lower two plots). Again, the straight-line data set contacted slightly more cells overall than the hybrid data set, but the distributions are much the same.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

HOK/HAK/LIN Bycatch Assessment Areas – WCSI7 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H5. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 102.6% and 109.7%, or a difference of between 17 and 55 cells.

The aggregate area was larger for the hybrid data set than the straight-line data set in every year, with ratios ranging from 161.8–235.4%, and represent substantial areas of between 4245 and 8123 km^2.

The footprint was also larger for the hybrid data set with ratios of between 123.2% and 147.5% or a difference of between 99 and 1528 km^2, smaller ratios and areas than the aggregate area, demonstrating relatively high levels of intensity, most likely as a result of the spawning fisheries for hoki, hake and ling here.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – WCSI7 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H6 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 100–111.1. The maximum difference this represents is just one cell.

Ratios for the aggregate area of the new cells contacted ranged from 95.9%–192.9%. This seemingly large maximum ratio actually represents just 1.3 km^2, indicating that the aggregate areas overall are low.

For the footprint, the ratios were slightly more wide ranging, being between 76.5 and 103.6%, but the actual differences were no more than 0.5 km^2 in any one year.

When comparing the footprint as a percentage of the aggregate area, the ratios were close in all years, ranging from 97.1–100%. These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

HOK/HAK/LIN Bycatch Assessment Areas – WCSI7 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H7). The ratio between the two data sets for the median number of tows that contacted a cell was 162.5% but this represented a difference of just five tows. The ratio for the mean number was 147.7% and represented a difference of 30.9 tows. The ratio for the maximum number of tows was 124.9% and represented a more substantial difference of 634 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 183.9%, representing a difference of just 2.6 km^2. The ratio for the mean is 185.6%, representing a relatively substantial difference 33 km^2. The most substantial difference is for the maximum (268%) or 2215 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). While the overall spatial extent is not much different between the two data types, the hybrid data set has a wider extent of the most intensely contacted areas, and requires different categories with higher upper ranges than the straight-line data set to cover the full range of data.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 166.7%, but this difference is just 2 km^2. The mean footprint is similar with a ratio of 112.5% (a difference of just 1 km^2). The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table H8. The annual median for the number of tows that contacted a cell ranged from 100–180%, representing a difference of no more than 4 tows. The ratio for the mean number of tows ranged from 123.2–160.5%, representing a difference of 11.5 tows. For the maximum, the ratio ranged from 109.3–157.9%, representing a relatively substantial maximum difference of 234 tows.

The annual median ratios for the aggregate areas in a cell ranged from 108–212.5%, which represented an actual difference of no more than 2.1 km^2 in any one year. The ratios for the means ranged from 148.5–222.1%, which represented a maximum difference of 11.6 km^2. The maximum aggregate area showed the most substantial differences, with ratios ranging from 139–623.3% or a maximum of 962 km^2.

The annual median ratios for the footprint in a cell ranged from 107.1–200% but in no year did the actual difference in square kilometres exceed 2.1. The ratio for the mean footprint ranged from 113.3–139.2%,and represented a difference between data types of no more than 1.6 km^2. The ratios for the maximum footprint were ranged from 100–103.7% in each year, with both data types having footprints at or close to the maximum possible (24 km^2) in each year.

HOK/HAK/LIN Bycatch Assessment Areas – WCSI7 Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted, although there are more cells with just one year of contact for the straight-line data set (Figure H5, upper two plots). The overall distributions are similar however and five years of contact is the largest category for both data sets.

Similarly, there is little difference between the two data sets for the number of years since a cell was last contacted (Figure H5, lower two plots). For both, the most recent fishing year had the largest number of cells at just over 600.

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution, and most of the area has been contacted in the most recent year.

HOK/HAK/LIN Bycatch Assessment Areas – PUYS5 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H9. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged from 97.1–103.8%, or a difference of between -2 and 4 cells.

While fewer cells were contacted by the hybrid data set in some years, the aggregate area was larger than the straight-line data set every year, with ratios ranging from 135.7–199.4%, or a difference of between 218 and 768 km^2.

The footprint was also larger for the hybrid data set in each year with ratios of between 112.4% and 139.6% or a difference of between 50 and 177 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – PUYS5 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H10 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets was 100% in 2019, an exact match with three cells for each data set. One new cell was contacted by the straight-line data set in 2020 but not by the hybrid data set, and no new cells were contacted by either from 2021–2023.

For 2019, the aggregate area and footprint were identical to one another for both data sets, hence the ratio for all other measures was 100%. Given that the Puysegur Trench area is a small and well established fishing area and the base footprint was comprises of 29 of 34 years in the data set, the lack of new cells contacted is not surprising.

HOK/HAK/LIN Bycatch Assessment Areas – PUYS5 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H11). The ratio between the two data sets for the median number of tows that contacted a cell was 82.7% but this represented a difference of just 0.5 tows. The ratio for the mean number was 122.5% and represented a difference of 15.3 tows. The ratio for the maximum number of tows was 119.3% and represented a more substantial difference of 98 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 85.3%, representing a difference of just -1.4 km^2. The ratio for the mean is 171.3%, representing a difference of 18 km^2. The most substantial difference is for the maximum (162.9%) or 128 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (5 km^2) as it is for the mean (8 km^2). The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore also an exact match of 100%.

The same summary information by year is given in Table H12. The annual median for the number of tows that contacted a cell ranged from 100–114.3%, representing a difference of no more than 3 tows.

The ratio for the mean number of tows ranged from 115.5–128.3%, representing a difference of no more than 7.2 tows. For the maximum, the ratio ranged from 87.6–115.5%, representing a maximum difference of 23 tows.

The annual median ratios for the aggregate areas in a cell ranged from 84.2–160%, which represented an actual difference of no more than 1.7 km^2 in any one year. The ratios for the means ranged from 139.7–191%, which represented an actual difference of no more than 7.6 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 109.4–273.4% or a maximum difference of 43.3 km^2.

The annual median ratios for the footprint in a cell ranged from 100–122.2% but in no year did the actual difference in square kilometres exceed 0.6. The ratio for the mean footprint was very close in each year, ranging from 115.4–135.7%, and represented a difference between data types of no more than 1.5 km^2. The ratios for the maximum footprint ranged from 111.6–135.4%, representing a maximum difference of 6.4 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types, but always slightly larger for the hybrid data.

HOK/HAK/LIN Bycatch Assessment Areas – PUYS5 Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure H6, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure H6, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution and most cells were contacted in the most recent fishing year.

HOK/HAK/LIN Bycatch Assessment Areas – STEW5 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H13. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 98.2% and 101.5%, or a difference of between -14 and 8 cells.

While fewer cells were contacted by the hybrid data set in some years, the aggregate area was larger than the straight-line data set in all years with ratios ranging from 178.1–210.1%, and represented relatively substantial areas of between 3820 and 5460 km^2.

The footprint was also larger for the hybrid data set in all years with ratios of between 109.6 and 115.3% or a difference of between 307 and 490 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – STEW5 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H14 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 66.7% (hybrid data set contacting fewer new cells) to 100% (an exact match). The maximum difference in the number of new cells contacted in any one year is just -2 cells.

The aggregate area of the new cells contacted shows generally similar ratios, ranging from 57.1% to 117.5%, with the differences in area ranging from just -0.3–0.7 km^2.

For the footprint of the new cells contacted, the ratio ranged from 66.7–117.9%, but the actual differences were no more than 0.7 km^2 in any one year.

When comparing the footprint as a percentage of the aggregate area, the ratios were relatively close in most years (87.5–116.7%). This is because for each data set, the aggregate area and footprint are relatively similar, most likely because the new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas. Hence the ratios for these values between the two data sets will be relatively close to 100%.

HOK/HAK/LIN Bycatch Assessment Areas – STEW5 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H15). The ratio between the two data sets for the median number of tows that contacted a cell was 111.1% but this represented a difference of just one tow. The ratio for the mean number was 144.1% and represented a difference of 16.4 tows. The ratio for the maximum number of tows was 148.3% and represented a more substantial difference of 505 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 121.7%, representing a difference of just 1 km^2. The ratio for the mean is 189.5%, a difference of 22.2 km^2. The most substantial difference is for the maximum (488.9%) or 3601.6 vs 736.6 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). The hybrid data set shows a higher degree of intensity in the western portion of the area, and there is a need to have different categories with higher upper ranges for the hybrid data set. The overall spatial distribution is much the same however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (4 km^2) as is the mean footprint (8 km^2). The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table H16. The annual median for the number of tows that contacted a cell ranged from 100–125%, representing a difference of no more than one tow. The ratio for the mean number of tows ranged from 132.4–150.5%, representing a difference of no more than 5.3 tows. For the maximum, the ratio ranged from 131.5–164.5%, representing a more substantial maximum difference of 149 tows.

The annual median ratios for the aggregate areas in a cell ranged from 107.7–141.7%, which represented an actual difference of no more than 1 km^2 in any one year. The ratios for the means ranged from 178.9–207.5%, which represented an actual difference of no more than 7.2 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 443.6–578.4% or 543–658 km^2.

The annual median ratios for the footprint in a cell ranged from 100–136.4% but in no year did the actual difference in square kilometres exceed 0.8. The ratio for the mean footprint ranged from 108.3–112.8% and represented a difference between data types of no more than 0.7 km^2. The ratios for the maximum footprint ranged from 101.6–103.8% in each year. While neither data set had the maximum possible 25 km^2 in any year, both were close in all years, hence the ratios are very similar, and the maximum difference between the two was only 0.9 km^2.

HOK/HAK/LIN Bycatch Assessment Areas – STEW5 Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure H7, upper two plots) although the hybrid data set has slightly fewer cells that were contacted in only one year. Overall though, the distribution is much the same.

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure H7, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

HOK/HAK/LIN Bycatch Assessment Areas – SQUAK6 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H17. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 86.5% and 112.6%, or a difference of between -23 and 12 cells.

While fewer cells were contacted by the hybrid data set in most years, the aggregate area was larger for the hybrid than the straight-line data set with ratios ranging from 108.7–142.7%, or a difference of between 40 and 253 km^2.

The footprint was also larger for the hybrid data set in all years except 2019, with ratios of between 87.3 and 114.8% or a difference of between -47 and 75 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – SQUAK6 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H18 where the base footprint was created for 1990–2018 using the straight-line data set. Neither data set recorded any new cells being contacted, other than six cells each in 2020. The aggregate area was almost the same between the two data sets (4 vs 3.9 km^2), and the corresponding aggregate areas for each data set matched the footprints, hence the ratios for both were 102.6%. As each data set's aggregate area and footprint matched, the ratio for the footprint as a percentage of the aggregate area was a match at 100%.

These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is the same and suggests that any new cells contacted are likely to be minor exploratory fishing or fishing on the margins of established areas.

HOK/HAK/LIN Bycatch Assessment Areas – SQUAK6 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H19). The ratio between the two data sets for the median number of tows that contacted a cell was 80% but this represented a difference of just one tow. The ratio for the mean number was 125.8% and represented a difference of 3.1 tows. The ratio for the maximum number of tows was 132.3% and represented a more substantial difference of 30 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 96%, representing a difference of just 0.1 km^2. The ratio for the mean is 134.5%, but again, the actual difference is small at just 3 km^2. The most substantial difference is for the maximum (155.3%) or 52 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (2 km^2) as is the mean footprint (5 km^2). The ratio for the maximum footprint is 92%, or a difference of 2 km^2. The footprint for the straight-line data set is 25 km^2, the maximum possible, but is slightly smaller for the hybrid data set at 23 km^2.

The same summary information by year is given in Table H20. The annual median for the number of tows that contacted a cell ranged from 50–200%, representing a difference of no more than two tows. The ratio for the mean number of tows ranged from 103.4–147.4%, representing a difference of no more than 2.7 tows. For the maximum, the ratio ranged from 114.8–145.8%, representing a maximum difference of 11 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–183.3%, which represented an actual difference of no more than 1 km^2 in any one year. The ratios for the mean ranged from 109.1–165.7%, which represented an actual difference of no more than 2.3 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 87.8–197% or -1.8–14.8 km^2.

The annual median ratios for the footprint in a cell ranged from 100–158.3% but in no year did the actual difference in square kilometres exceed 0.7. The ratio for the mean footprint ranged from 89.5–133.3%, and represented a difference between data types of no more than 1 km^2. The ratios for the maximum footprint ranged from 79.8–132.3%, representing a maximum difference of 4.2 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

HOK/HAK/LIN Bycatch Assessment Areas – SQUAK6 Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted, although the hybrid data set has slightly more cells with one year of contact and slightly fewer with two years of contact (Figure H8, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted, except that the hybrid data set has few cells contacted in the most recent fishing year (Figure H8, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

HOK/HAK/LIN Bycatch Assessment Areas – SUBA6 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H21. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 112% and 124%, or a difference of between 24 and 49 cells.

Ratios for the aggregate area were larger for the hybrid data set than the straight-line data set in all years, with substantial ratios ranging from 161.8–284.8%, or a difference of between 688 and 2146 km^2.

The footprint was also larger for the hybrid data set in all years with ratios of between 136.8% and 172.3% or a difference of between 259 and 655 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is little difference.

HOK/HAK/LIN Bycatch Assessment Areas – SUBA6 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H22 where the base footprint was created for 1990–2018 using the straight-line data set. New cells were contacted in just 2020 and 2021, with ratios of 106.7 and 200% respectively, representing just two cells and one cell respectively.

For the 2020 fishing year, the ratio for the aggregate area was 106%, or a difference of 1.2 km^2. The corresponding footprint had a ratio of 105.6% - the footprint and aggregate area matched for the straight-line but there was a difference of 0.1 km^2 for the hybrid data set. Hence, the ratio for the footprint as a percentage of the aggregate area was very close at 99.5%.

For the 2021 fishing year, the differences were more substantial. The ratio for the aggregate area was 2550%, although this was a difference of 9.8 km^2. The corresponding footprint had a ratio of 900%, or a difference of 3.5 vs 0.4 km^2 and a resulting ratio for the footprint as a percentage of the aggregate area of 35.3%. While these are large numbers percentage-wise they are not large considering the overall footprint and the difference is just one new cell contacted. Quite likely, this is one tow that went back over the top of itself, hence the apparent large discrepancy between the hybrid data and the straight-line data.

Either way, it is likely that these few new cells contacted are very limited minor exploratory fishing or fishing on the margins of established areas.

HOK/HAK/LIN Bycatch Assessment Areas – SUBA6 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H23). The ratio between the two data sets for the median number of tows that contacted a cell was a match at 100% (two tows). The ratio for the mean number was 160.4% and represented a difference of 9.9 tows. The ratio for the maximum number of tows was 159.7% and represented a more substantial difference of 191 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area was 133.3%, representing a difference of just 0.4 km^2. The ratio for the mean was 177.6%, but again, the actual difference is relatively small at just 8.3 km^2. The most substantial difference is for the maximum (180%) or 422.9 vs 234.9 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity. There is however, a need to have different categories with higher upper ranges for the hybrid data set. The overall spatial location of intensity is much the same, however.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (1 km^2). The ratio for the mean footprint 125% representing a difference of 1 km^2. The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table H24. The annual median for the number of tows that contacted a cell ranged from 50–100%, representing a difference of no more than -1 tow. The ratio for the mean number of tows ranged from 125.6–207.5%, representing a difference of no more than 7.2 tows. For the maximum, the ratio ranged from 127.7–164%, representing a maximum difference of 57 tows.

The annual median ratios for the aggregate areas in a cell ranged from 100–127.3%, which represented an actual difference of no more than 0.4 km^2 in any one year. The ratios for the means ranged from 141.4–250%, which represented an actual difference of no more than 5.7 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 138–237.3% or 27–62 km^2.

The annual median ratios for the footprint in a cell ranged from 100–118.7% but in no year did the actual difference in square kilometres exceed 0.3. The ratio for the mean footprint ranged from 112.1–153.3%, and represented a difference between data types of no more than 1.6 km^2. The ratios for the maximum footprint ranged from 102.5–134.7%, representing a maximum difference of 5.9 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell, and were generally fairly close for both data types, but always slightly larger for the hybrid data.

HOK/HAK/LIN Bycatch Assessment Areas – SUBA6 Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure H9, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted, but there are slightly more cells with 0–1 year since last contacted for the hybrid data set (Figure H9, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

HOK/HAK/LIN Bycatch Assessment Areas – CHAT4 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H25. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 95% and 100.1%, or a difference of between -83 and 1 cells.

While fewer cells were contacted by the hybrid data set in all but one year, the aggregate area was larger than the straight-line data set in every year with ratios ranging from 123.4–130.5%, or substantial differences of between 6323 and 9615 km^2.

Ratios for the footprint were noticeably smaller than for the aggregate area, ranging from 96.9–101.7%, and the differences in area were substantially smaller too at between -407 and 209.2 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference in the extent.

HOK/HAK/LIN Bycatch Assessment Areas – CHAT4 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H26 where the base footprint was created for 1990–2018 using the straight-line data set. New cells were only recorded for both data sets in 2019 and 2020. The hybrid data set contacted one new cell in 2022 but the straight-line data set contacted none.

Just eight new cells were contacted by the hybrid data set vs six by the straight-line data set in 2019, and two cells vs one cell in 2020. The aggregate areas and corresponding footprints matched each other for each data type and were small (0.2–1.5 km^2). As such, the ratios for the footprint as a percentage of the aggregate area were also 100% in both years where both data sets recorded new cells being contacted.

This indicates that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

HOK/HAK/LIN Bycatch Assessment Areas – CHAT4 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H27). The ratio between the two data sets for the median number of tows that contacted a cell was 122.7% but this represented a difference of just five tows. The ratio for the mean number was 122.8% and represented a difference of 16 tows. The ratio for the maximum number of tows was 136.3% and represented a more substantial difference of 345 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both '<0.1' they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 122.2%, representing a difference of just 3.6 km^2. The ratio for the mean is 131.2%, representing a difference of 19.3 km^2. The most substantial difference is for the maximum (161.8%) or 1469.3 vs 907.9 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the spatial distribution of intensity. There is, however, a need to have different categories with higher upper ranges for the hybrid data set.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 90% (-1 km^2). The mean footprint is an exact match with a ratio of 100% (11 km^2). The maximum footprint for both data types is equal to the area of a cell, which cannot exceed 25 km^2, and so the ratio is therefore an exact match of 100%.

The same summary information by year is given in Table H28. The annual median for the number of tows that contacted a cell ranged from 111.1–120%, representing a difference of no more than 2 tows. The ratio for the mean number of tows ranged from 117.2–127.8%, representing a difference of no more than 6.2 tows. For the maximum, the ratio ranged from 125.3–160%, representing a substantial maximum difference of 141 tows.

The annual median ratios for the aggregate areas in a cell ranged from 108.6–132.1%, which represented an actual difference of no more than 2 km^2 in any one year. The ratios for the means ranged from 123.6–137.3%, which represented an actual difference of no more than 7 km^2 in any one year. The maximum aggregate area showed more substantial differences, with ratios ranging from 141.9–196.3% or 80–213 km^2.

The annual median ratios for the footprint in a cell ranged from 98.2–112.2% but in no year did the actual difference in square kilometres exceed 0.6. The ratio for the mean footprint was very close in each year, ranging from 101.2–106.8%, and represented a difference between data types of no more than 0.5 km^2. The ratios for the maximum footprint were 100% in ever year, as the maximum footprint was 25 km^2 for both data sets in every year, the maximum footprint possible.

HOK/HAK/LIN Bycatch Assessment Areas – CHAT4 Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure H10, upper two plots) or for the number of years since a cell was last contacted (Figure H10, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

HOK/HAK/LIN Bycatch Assessment Areas – COOK8 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H29. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 91.9% and 101.8%, or a difference of between -5 and 1 cells.

While fewer cells were contacted by the hybrid data set in most years, the aggregate area was larger than the straight-line data set every year with ratios ranging from 109.3–133.6%, or a difference of between 45 and 148 km^2.

The footprint however was smaller for the hybrid data set in every year with ratios of between 86.7% and 95.1% or a difference of between -23.7 and -6.7 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – COOK8 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H30 where the base footprint was created for 1990–2018 using the straight-line data set. Neither data set recorded contacting any new cells between 2019 and 2023. Given that this is a very small area that has been frequently fished for a long period of time, this is not surprising.

HOK/HAK/LIN Bycatch Assessment Areas – COOK8 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H31). The ratio between the two data sets for the median number of tows that contacted a cell was 78.6% but this represented a difference of just -1.5 tows. The ratio for the mean number was 104.7% and represented a difference of 2.8 tows. The ratio for the maximum number of tows was 105.6% and represented a difference of 31 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because while the numbers are both ‘<0.1’ they are not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 55%, representing a difference of just -0.9 km^2. The ratio for the mean is 118.7%, but again, the actual difference is small at just 4 km^2. The most substantial difference is for the maximum (124.3%) or 327.9 vs 263.7 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity. There is, however, a need to have different categories with higher upper ranges for the hybrid data set.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is 50% (-1 km^2). The ratio for the mean footprint is 75%, representing a difference of -1km^2. The ratio for the maximum footprint is 91.3% or a difference of 2 km^2.

The same summary information by year is given in Table H32. The annual median for the number of tows that contacted a cell ranged from 76.9–156.2%, representing a difference of no more than 4.5 tows. The ratio for the mean number of tows ranged from 101.8–121%, representing a difference of no more than 3.9 tows. For the maximum, the ratio ranged from 101.2–117.4%, representing a maximum difference of 12 tows.

The annual median ratios for the aggregate areas in a cell ranged from 69.2–200%, which represented an actual difference of no more than 0.3 km^2 in any one year. The ratios for the means ranged from 108.6–143.8%, which represented an actual difference of no more than 3.2 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 109.1–143.1% or 4–19 km^2.

The annual median ratios for the footprint in a cell ranged from 66.7–133.3% but in no year did the actual difference in square kilometres exceed -0.4. The ratio for the mean footprint was close in each year, ranging from 89.3–104.5%, and represented a difference between data types of no more than -0.3 km^2. The ratios for the maximum footprint ranged from 84.2–94.6%, representing a maximum difference of -2.3 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

HOK/HAK/LIN Bycatch Assessment Areas – COOK8 Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted, although the hybrid data set has more cells with only one year of contact compared to the straight-line data set (Figure H11, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted, although the hybrid data set has fewer cells with one year since last contact and more cells with two years since last contact compared with the straight-line data set (Figure H11, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

HOK/HAK/LIN Bycatch Assessment Areas – EAST2 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H33. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 88.7% and 98.1%, or a difference of between -15 and -3 cells.

While fewer cells were contacted by the hybrid data set in each year, the aggregate area was larger for the hybrid data set than the straight-line data set each year with ratios ranging from 101.1–120.4%, or a difference of between 2 and 30 km^2.

The footprint was smaller in all years except 2023 for the hybrid data set with ratios of between 93.4% and 101.6% or a difference of between -33.3 and 1.1 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – EAST2 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H34 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 16.7% (hybrid data set contacting fewer new cells) to 133.3% (hybrid data set contacting more cells). The difference by number was between one and five cells. Neither data set recorded contacting any new cells in 2022 or 2023.

The ratio for the aggregate area of the new cells contacted ranged from 9.1–116.7% While this seems a lot as a percentage, the biggest difference is just -3 km^2.

For the footprint, the ratios were slightly more wide ranging, being between 9.7% and 116.7%. Again, while this seems like a major disparity in terms of percentage, the largest difference is actually small at just -2.8 km^2.

When comparing the footprint as a percentage of the aggregate area, the ratios were close in all years between the two data sets (100–106.5%). This is because within each data set, the aggregate areas and footprints were close. These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

HOK/HAK/LIN Bycatch Assessment Areas – EAST2 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H35). The ratio between the two data sets for the median number of tows that contacted a cell was a match at 100% (three tows). The ratio for the mean number was 105.3% and represented a difference of 0.6 tows. The ratio for the maximum number of tows was 103.1% and represented four tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because the numbers are both ‘<0.1’ and not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 90%, representing a difference of just -0.1 km^2. The ratio for the mean is 111.1%, but again, the actual difference is small at just 0.4 km^2. The ratio for the maximum was 112.1% or 61.2 vs 54.6 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (1 km^2). The mean footprint is also an exact match with a ratio of 100% (2 km^2). The ratio for the maximum footprint is 94.1%, or a difference of -1 km^2.

The same summary information by year is given in Table H36. The annual median for the number of tows that contacted a cell ranged was 100% in all years, a perfect match each year. The ratio for the mean number of tows ranged from 100–111.4%, representing a difference of no more than 0.5 tows. For the maximum, the ratio ranged from 100–116%, representing a maximum difference of four tows.

The annual median ratios for the aggregate areas in a cell ranged from 83.3–125%, which represented an actual difference of no more than 0.1 km^2 in any one year. The ratios for the means ranged from 100–127.8%, which represented an actual difference of no more than 0.5 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 105–143% or 0.2–4.9 km^2.

The annual median ratios for the footprint in a cell ranged from 83.3–125% but in no year did the actual difference in square kilometres exceed 0.1. The ratio for the mean footprint was very close in each year, ranging from 94.4–110%, and represented a difference between data types of no more than 0.1 km^2. The ratios for the maximum footprint ranged from 77.7–99.1%, representing a maximum difference of -0.8 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

HOK/HAK/LIN Bycatch Assessment Areas – EAST2 Number of years contacted

There is almost no discernible difference between the two data sets when comparing the number of years cells were contacted (Figure H12, upper two plots). Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted (Figure H12, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

HOK/HAK/LIN Bycatch Assessment Areas – NORTH1 Spatial extent

The annual total numbers of cells, aggregate swept area, and footprint are given in Table H37. For the five-year period the hybrid:straight-line ratio for the number of cells contacted ranged between 88% and 102%, or a difference of between -20 and 3 cells.

The aggregate area for the hybrid data set was larger than the straight-line data set in all years, with ratios ranging from 101–104%, or a difference of between 13.7 and 34.2 km^2.

The footprint was smaller for the hybrid data in all years except 2019, with ratios ranging from 78.9–100.9, or a difference of between -120.2 and 6 km^2.

The footprint and aggregate areas for the hybrid and straight-line data sets for all years combined and for the most recent fishing years is shown in Figures H1–2. At this resolution, there is no appreciable difference.

HOK/HAK/LIN Bycatch Assessment Areas – NORTH1 Extent of new cells contacted across the time series

The number of cells that were fished in one year, but not in previous years, is shown in Table H38 where the base footprint was created for 1990–2018 using the straight-line data set. The ratio for the number of new cells contacted each year between the two data sets ranged from 100–114.3%. The biggest difference in the number of new cells contacted was in 2020 when no new cells were contacted by the hybrid data set but six new cells were contacted by the straight-line data set.

The aggregate area of the new cells contacted shows generally similar ratios, ranging from 90.9% to 114.3%, with the differences in area ranging from just -0.2–0.3 km^2.

For the footprint, the ratio ranged were also ranged between 90.9 and 114.3%, with the differences in area ranging from -0.5 km–0.3 km^2 in any one year.

When comparing the footprint as a percentage of the aggregate area, the ratios ranged from 97–100%. These ratios indicate that whether using the hybrid data set or the aggregate data set, the footprint and aggregate area for new cells is almost the same (within data sets) and suggests that any new cells contacted in a year are likely to be minor exploratory fishing or fishing on the margins of established areas.

HOK/HAK/LIN Bycatch Assessment Areas – NORTH1 Intensity

For the combined 2019–2023 data, the minimum number of tows for contacted cells was one for both data types (Table H39). The ratio between the two data sets for the median number of tows that contacted a cell was 150% but this represented a difference of just one tow. The ratio for the mean number was 111.2% and represented a difference of 3.8 tows. The ratio for the maximum number of tows was 139.1% and represented a more substantial difference of 185 tows.

For the aggregate area the minimum area was essentially the same for both data types at less than 0.1 km^2. Ratios have not been calculated because the numbers are both '<0.1' and not identical but the values are so small as to not warrant further consideration. The ratio for the median aggregate area is 114.3%, representing a difference of just 0.1 km^2. The ratio for the mean is also 109.7%, but again, the actual difference is small at just 1.1 km^2. The most substantial difference is for the maximum (153.4%) or 278.2 vs 181.3 km^2.

The spatial distribution of the aggregate area for both data types is shown in Figure H2 for all years combined (upper two plots) and for the most recent fishing year (lower two plots). As with the footprint, at this resolution, there is no appreciable difference with respect to the distribution of intensity.

As for the aggregate area, the minimum footprint is very small, <0.1 km^2 for both data sets, meaning that the ratio is essentially meaningless. The ratio for the median is an exact match at 100% (1 km^2) and was for the mean footprint as well (3 km^2). The ratio for the maximum footprint was 95.7%, or a difference of -1 km^2.

The same summary information by year is given in Table H40. The annual median for the number of tows that contacted a cell ranged from 66.7–133.3%, representing a difference of no more than -2 tows. The ratio for the mean number of tows ranged from 100.6–121.6%, representing a difference of no more than 3.6 tows. For the maximum, the ratio ranged from 86.7–159.5%, representing a maximum difference of 69 tows.

The annual median ratios for the aggregate areas in a cell ranged from 87.5–150%, which represented an actual difference of no more than 0.3 km^2 in any one year. The ratios for the means ranged from 100–116.7%, which represented an actual difference of no more than 1 km^2 in any one year. The maximum aggregate area shows more substantial differences, with ratios ranging from 88.7–183.6% or -7.7–35.7 km^2.

The annual median ratios for the footprint in a cell ranged from 85.7–125% but in no year did the actual difference in square kilometres exceed 0.2. The ratio for the mean footprint was very close in each year, ranging from 83.3–100%, and represented a difference between data types of no more than -0.5 km^2. The ratios for the maximum footprint ranged from 88.1–99.5%, representing a maximum difference of -1.9 km^2. In no year did the maximum footprint for either data type equal 25 km^2, the maximum possible in a cell.

HOK/HAK/LIN Bycatch Assessment Areas – NORTH1 Number of years contacted

There is little difference between the two data sets when comparing the number of years cells were contacted, apart from the hybrid data set having noticeably fewer cells with just one year of contact compared with the straight-line data set (Figure H13, upper two plots).

Similarly, there was little difference between the two data sets for the number of years since a cell was last contacted, although the hybrid data set had fewer cells with zero years since contact, when compared to the straight-line data set (Figure H13, lower two plots).

The spatial distribution for the number of years a cell was contacted for both data sets is shown in Figure H4 (upper two plots) and for the most recent year contacted (lower two plots). For both, there is almost no difference that can be seen at this resolution.

Table H1: Number of cells contacted, aggregate area, and footprint for area WCNI9 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	48	53	90.6	32.4	33.1	97.9	31.3	31.6	99.1
2020	85	87	97.7	81.9	80.1	102.2	74.8	75.7	98.8
2021	36	32	112.5	35.6	36.0	98.9	31.9	32.9	97.0
2022	77	75	102.7	94.0	91.1	103.2	84.8	85.0	99.8
2023	54	59	91.5	57.3	57.6	99.5	49.1	53.5	91.8

Table H2: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area WCNI9, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1	5	20.0	0.5	1.7	29.4	0.5	1.7	29.4	100.0	100.0	100.0
2020	17	13	130.8	4.8	4.1	117.1	4.8	4.1	117.1	100.0	100.0	100.0
2021	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	1	2	50.0	0.0	0.4	0.0	0.0	0.4	0.0	–	100.0	–

Table H3: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area WCNI9, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	2.0	1.0	200.0
Aggregate area	<0.1	<0.1	–	0.2	0.2	100.0	0.5	0.5	100.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	5.5	5.0	110.0	4.0	4.0	100.0	27.0	29.0	93.1
Aggregate area	2.2	2.0	110.0	1.5	1.3	115.4	18.1	17.8	101.7
Footprint	2.0	2.0	100.0	1.0	1.0	100.0	12.0	13.0	92.3

Table H4: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for area WCNI9, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	1.0	1.0	100.0	1.6	1.5	106.7	2.0	2.0	100.0	4.0	4.0	100.0
2020	1.0	1.0	100.0	1.0	1.0	100.0	2.5	2.4	104.2	3.0	3.5	85.7	11.0	11.0	100.0
2021	1.0	2.0	50.0	2.0	3.0	66.7	2.8	3.2	87.5	3.0	3.2	93.8	13.0	13.0	100.0
2022	1.0	1.0	100.0	2.0	2.0	100.0	3.0	3.0	100.0	4.0	4.0	100.0	9.0	9.0	100.0
2023	1.0	1.0	100.0	2.0	2.0	100.0	2.5	2.3	108.7	3.0	3.0	100.0	7.0	7.0	100.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.2	0.2	100.0	0.6	0.4	150.0	0.7	0.6	116.7	1.1	1.1	100.0	2.1	2.1	100.0
2020	0.2	0.2	100.0	0.4	0.4	100.0	1.0	0.9	111.1	1.1	1.0	110.0	7.8	8.4	92.9
2021	0.2	0.3	66.7	0.7	0.8	87.5	1.0	1.1	90.9	1.5	1.6	93.8	6.1	6.4	95.3
2022	0.2	0.2	100.0	0.5	0.5	100.0	1.2	1.2	100.0	1.5	1.7	88.2	6.2	5.8	106.9
2023	0.3	0.2	150.0	0.7	0.7	100.0	1.1	1.0	110.0	1.4	1.2	116.7	4.8	4.7	102.1
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.2	0.2	100.0	0.6	0.4	150.0	0.7	0.6	116.7	1.0	1.0	100.0	1.8	1.9	94.7
2020	0.2	0.2	100.0	0.4	0.4	100.0	0.9	0.9	100.0	1.0	1.0	100.0	6.6	7.0	94.3
2021	0.2	0.3	66.7	0.6	0.7	85.7	0.9	1.0	90.0	1.5	1.6	93.8	3.2	4.1	78.0
2022	0.2	0.2	100.0	0.5	0.5	100.0	1.1	1.1	100.0	1.5	1.7	88.2	5.3	5.2	101.9
2023	0.3	0.2	150.0	0.7	0.7	100.0	0.9	0.9	100.0	1.3	1.2	108.3	3.5	4.1	85.4

Table H5: Number of cells contacted, aggregate area, and footprint for area WCSI7 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	624	569	109.7	15 542.1	8 847.2	175.7	5 279.9	4 285.4	123.2
2020	636	585	108.7	12 480.8	7 711.8	161.8	4 402.2	3 411.2	129.1
2021	668	651	102.6	10 549.9	6 304.9	167.3	4 616.6	3 515.4	131.3
2022	536	512	104.7	13 291.3	6 887.5	193.0	4 233.7	3 204.7	132.1
2023	668	632	105.7	14 122.5	5 999.8	235.4	4 748.2	3 220.0	147.5

Table H6: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area WCSI7, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	1	1	100.0	0.1	0.1	100.0	0.1	0.1	100.0	100.0	100.0	100.0
2020	17	17	100.0	7.1	7.4	95.9	7.1	7.4	95.9	100.0	100.0	100.0
2021	10	9	111.1	2.7	1.4	192.9	2.7	1.4	192.9	100.0	100.0	100.0
2022	0	2	–	0.0	0.2	–	0.0	0.2	–	0.0	100.0	–
2023	9	9	100.0	3.5	3.4	102.9	3.4	3.4	100.0	97.1	100.0	97.1

Table H7: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area WCSI7, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	13.0	8.0	162.5
Aggregate area	<0.1	<0.1	–	0.9	0.7	128.6	5.7	3.1	183.9
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	5.0	3.0	166.7
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	95.7	64.8	147.7	97.0	65.0	149.2	3185.0	2551.0	124.9
Aggregate area	70.7	38.1	185.6	64.2	30.7	209.1	3532.7	1318.1	268.0
Footprint	9.0	8.0	112.5	20.0	16.0	125.0	25.0	25.0	100.0

Table H8: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for area WCSI7, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	9.0	8.0	112.5	29.8	23.3	127.9	38.5	30.0	128.3	692.0	564.0	122.7
2020	2.0	2.0	100.0	7.0	7.0	100.0	30.3	24.6	123.2	35.0	26.0	134.6	789.0	722.0	109.3
2021	2.0	2.0	100.0	8.0	6.0	133.3	23.0	17.1	134.5	32.0	23.0	139.1	552.0	481.0	114.8
2022	2.0	1.0	200.0	11.0	7.0	157.1	33.9	22.4	151.3	45.5	30.0	151.7	514.0	439.0	117.1
2023	2.0	2.0	100.0	9.0	5.0	180.0	26.8	16.7	160.5	29.0	18.0	161.1	638.0	404.0	157.9
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	5.4	5.0	108.0	24.9	15.5	160.6	29.7	21.4	138.8	732.6	270.9	270.4
2020	0.8	0.6	133.3	3.3	2.4	137.5	19.6	13.2	148.5	22.3	12.4	179.8	620.0	446.0	139.0
2021	0.7	0.5	140.0	3.5	2.5	140.0	15.8	9.7	162.9	22.0	13.5	163.0	506.7	224.0	226.2
2022	0.9	0.6	150.0	4.8	3.2	150.0	24.8	13.5	183.7	31.4	15.9	197.5	527.8	210.6	250.6
2023	0.9	0.6	150.0	5.1	2.4	212.5	21.1	9.5	222.1	18.7	9.6	194.8	1145.6	183.8	623.3
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	0.9	111.1	4.5	4.2	107.1	8.5	7.5	113.3	16.2	13.6	119.1	24.9	24.8	100.4
2020	0.8	0.6	133.3	2.9	2.3	126.1	6.9	5.8	119.0	12.0	9.0	133.3	25.0	25.0	100.0
2021	0.7	0.5	140.0	3.1	2.3	134.8	6.9	5.4	127.8	13.0	9.5	136.8	24.8	24.2	102.5
2022	0.8	0.6	133.3	3.9	2.8	139.3	7.9	6.3	125.4	14.5	10.3	140.8	25.0	24.1	103.7
2023	0.9	0.6	150.0	4.2	2.1	200.0	7.1	5.1	139.2	11.7	7.4	158.1	24.8	24.7	100.4

Table H9: Number of cells contacted, aggregate area, and footprint for area PUYS5 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	132	130	101.5	1 236.4	767.7	161.1	644.0	511.8	125.8
2020	102	105	97.1	829.5	611.1	135.7	455.6	405.4	112.4
2021	110	106	103.8	1 323.8	663.8	199.4	624.5	447.2	139.6
2022	104	106	98.1	1 732.7	964.9	179.6	689.7	561.0	122.9
2023	101	103	98.1	1 501.4	806.2	186.2	584.7	457.0	127.9

Table H10: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area PUYS5, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	3	3	100.0	0.5	0.5	100.0	0.5	0.5	100.0	100.0	100.0	100.0
2020	0	1	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2021	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table H11: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area PUYS5, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	4.0	3.0	133.3	21.5	26.0	82.7
Aggregate area	<0.1	<0.1	–	1.2	1.1	109.1	8.1	9.5	85.3
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	5.0	5.0	100.0
	Mean			**3rd quartile**			**Maximum**		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	83.4	68.1	122.5	121.8	74.5	163.5	605.0	507.0	119.3
Aggregate area	44.2	25.8	171.3	50.3	32.4	155.2	332.3	204.0	162.9
Footprint	8.0	8.0	100.0	14.0	14.0	100.0	25.0	25.0	100.0

Table H12: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for area PUYS5, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	8.0	7.0	114.3	15.9	12.9	123.3	22.2	15.0	148.0	99.0	113.0	87.6
2020	2.0	2.0	100.0	6.0	6.0	100.0	17.9	15.5	115.5	17.8	15.0	118.7	121.0	108.0	112.0
2021	2.0	2.0	100.0	9.0	8.5	105.9	21.6	17.4	124.1	29.8	20.8	143.3	127.0	110.0	115.5
2022	4.8	7.0	68.6	15.5	12.5	124.0	32.6	25.4	128.3	48.5	24.8	195.6	175.0	174.0	100.6
2023	2.0	3.0	66.7	9.0	9.0	100.0	27.8	21.7	128.1	36.0	25.0	144.0	172.0	149.0	115.4
	Aggregate area 1st Quartile			**Aggregate area median**			**Aggregate area mean**			**Aggregate area 3rd Quartile**			**Aggregate area maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.6	0.7	85.7	3.0	2.4	125.0	9.4	5.9	159.3	13.5	6.8	198.5	75.6	49.3	153.3
2020	0.6	0.7	85.7	3.2	2.0	160.0	8.1	5.8	139.7	9.8	7.1	138.0	59.0	38.1	154.9
2021	0.6	0.5	120.0	4.1	3.5	117.1	12.0	6.3	190.5	14.8	8.5	174.1	94.6	34.6	273.4
2022	1.4	1.7	82.4	7.4	5.7	129.8	16.7	9.1	183.5	22.3	11.2	199.1	81.7	74.7	109.4
2023	1.0	1.1	90.9	3.2	3.8	84.2	14.9	7.8	191.0	22.5	9.6	234.4	100.2	56.9	176.1
	Footprint 1st Quartile			**Footprint median**			**Footprint mean**			**Footprint 3rd Quartile**			**Footprint maximum**		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.5	0.7	71.4	2.3	2.3	100.0	4.9	3.9	125.6	7.9	5.6	141.1	23.1	20.7	111.6
2020	0.6	0.7	85.7	2.2	2.0	110.0	4.5	3.9	115.4	7.5	5.8	129.3	21.6	18.7	115.5
2021	0.5	0.5	100.0	3.3	2.7	122.2	5.7	4.2	135.7	8.6	6.9	124.6	24.5	18.1	135.4
2022	1.1	1.5	73.3	4.1	4.1	100.0	6.6	5.3	124.5	10.8	8.4	128.6	23.3	20.3	114.8
2023	0.9	0.9	100.0	2.6	2.6	100.0	5.8	4.4	131.8	8.9	6.6	134.8	24.5	19.4	126.3

Table H13: Number of cells contacted, aggregate area, and footprint for area STEW5 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	779	793	98.2	11 131.4	6 220.5	178.9	4 118.0	3 750.7	109.8
2020	716	708	101.1	8 556.7	4 736.9	180.6	3 159.0	2 852.3	110.8
2021	753	746	100.9	10 936.9	5 898.4	185.4	3 926.8	3 582.6	109.6
2022	683	673	101.5	9 471.2	4 507.4	210.1	3 306.7	2 868.7	115.3
2023	774	777	99.6	12 449.9	6 989.9	178.1	4 691.1	4 201.5	111.7

Table H14: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area STEW5, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	7	7	100.0	0.9	1.0	90.0	0.9	1.0	90.0	100.0	100.0	100.0
2020	2	3	66.7	0.8	0.8	100.0	0.7	0.8	87.5	87.5	100.0	87.5
2021	10	11	90.9	5.0	4.9	102.0	4.9	4.9	100.0	98.0	100.0	98.0
2022	12	14	85.7	4.7	4.0	117.5	4.6	3.9	117.9	97.9	97.5	100.4
2023	2	2	100.0	0.4	0.7	57.1	0.4	0.6	66.7	100.0	85.7	116.7

Table H15: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area STEW5, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	2.0	2.0	100.0	10.0	9.0	111.1
Aggregate area	<0.1	<0.1	–	1.0	0.9	111.1	5.6	4.6	121.7
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	4.0	4.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	51.0	35.4	144.1	47.0	37.0	127.0	1550.0	1045.0	148.3
Aggregate area	47.0	24.8	189.5	34.3	24.2	141.7	3601.6	736.6	488.9
Footprint	8.0	8.0	100.0	14.0	14.0	100.0	25.0	25.0	100.0

Table H16: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for STEW5, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	4.0	4.0	100.0	14.2	10.0	142.0	14.0	11.0	127.3	355.0	270.0	131.5
2020	1.0	1.0	100.0	5.0	4.0	125.0	14.3	10.8	132.4	16.0	13.0	123.1	287.0	200.0	143.5
2021	1.0	1.0	100.0	5.0	4.0	125.0	15.4	10.9	141.3	16.0	14.0	114.3	336.0	242.0	138.8
2022	2.0	2.0	100.0	6.0	5.0	120.0	15.8	10.5	150.5	13.0	11.0	118.2	380.0	231.0	164.5
2023	2.0	2.0	100.0	7.0	6.0	116.7	17.2	12.3	139.8	18.0	14.0	128.6	248.0	175.0	141.7
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.9	0.8	112.5	3.2	2.7	118.5	14.3	7.8	183.3	12.3	8.9	138.2	828.8	171.3	483.8
2020	0.9	0.8	112.5	2.8	2.6	107.7	12.0	6.7	179.1	9.6	8.1	118.5	700.4	157.9	443.6
2021	0.8	0.8	100.0	3.4	2.4	141.7	14.5	7.9	183.5	12.7	9.9	128.3	754.2	130.4	578.4
2022	0.8	0.7	114.3	3.3	2.7	122.2	13.9	6.7	207.5	9.2	7.3	126.0	778.0	167.7	463.9
2023	1.1	1.2	91.7	4.4	3.6	122.2	16.1	9.0	178.9	14.9	10.4	143.3	547.4	118.1	463.5
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.9	0.8	112.5	2.6	2.6	100.0	5.3	4.7	112.8	8.1	6.9	117.4	24.3	23.6	103.0
2020	0.8	0.8	100.0	2.4	2.3	104.3	4.4	4.0	110.0	6.8	6.3	107.9	24.4	23.5	103.8
2021	0.8	0.8	100.0	3.0	2.2	136.4	5.2	4.8	108.3	8.2	7.3	112.3	24.3	23.5	103.4
2022	0.8	0.6	133.3	2.7	2.4	112.5	4.8	4.3	111.6	6.7	6.1	109.8	24.2	23.5	103.0
2023	1.0	1.1	90.9	3.7	3.2	115.6	6.1	5.4	113.0	9.4	8.0	117.5	24.7	24.3	101.6

Table H17: Number of cells contacted, aggregate area, and footprint for area SQUAK6 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	101	116	87.1	536.9	494.1	108.7	321.5	368.1	87.3
2020	107	95	112.6	259.7	204.5	127.0	187.1	179.0	104.5
2021	101	103	98.1	600.5	467.4	128.5	325.2	302.9	107.4
2022	97	91	106.6	247.4	207.5	119.2	191.1	182.2	104.9
2023	147	170	86.5	846.3	593.0	142.7	582.9	507.8	114.8

Table H18: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area SQUAK6, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2020	6	6	100.0	4.0	3.9	102.6	4.0	3.9	102.6	100.0	100.0	100.0
2021	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table H19: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km[2] cell for area SQUAK6, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	4.0	5.0	80.0
Aggregate area	<0.1	<0.1	–	0.7	0.9	77.8	2.4	2.5	96.0
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	2.0	2.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	15.1	12.0	125.8	21.0	15.0	140.0	123.0	93.0	132.3
Aggregate area	11.7	8.7	134.5	14.3	8.8	162.5	145.5	93.7	155.3
Footprint	5.0	5.0	100.0	7.0	7.0	100.0	23.0	25.0	92.0

Table H20: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for SQUAK6, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	4.0	2.0	200.0	6.1	5.0	122.0	9.0	7.0	128.6	31.0	27.0	114.8
2020	1.0	1.0	100.0	1.0	2.0	50.0	3.0	2.9	103.4	3.0	3.0	100.0	21.0	14.0	150.0
2021	1.0	1.0	100.0	3.0	3.0	100.0	6.6	5.6	117.9	10.0	8.0	125.0	36.0	25.0	144.0
2022	1.0	1.0	100.0	2.0	2.0	100.0	3.9	3.7	105.4	5.0	4.5	111.1	19.0	15.0	126.7
2023	2.0	2.0	100.0	5.0	4.0	125.0	8.4	5.7	147.4	12.5	8.0	156.2	35.0	24.0	145.8
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.7	100.0	2.2	1.2	183.3	5.3	4.3	123.3	7.3	4.8	152.1	40.7	31.6	128.8
2020	0.4	0.4	100.0	1.0	1.0	100.0	2.4	2.2	109.1	1.8	1.8	100.0	26.2	13.3	197.0
2021	0.5	0.6	83.3	1.6	1.3	123.1	5.9	4.5	131.1	8.1	5.4	150.0	55.6	43.9	126.7
2022	0.5	0.6	83.3	1.2	1.1	109.1	2.6	2.3	113.0	3.1	2.8	110.7	12.9	14.7	87.8
2023	0.7	0.9	77.8	3.0	2.0	150.0	5.8	3.5	165.7	7.5	4.8	156.2	34.4	19.6	175.5
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.7	100.0	1.9	1.2	158.3	3.2	3.2	100.0	4.8	4.2	114.3	17.3	17.6	98.3
2020	0.4	0.4	100.0	1.0	1.0	100.0	1.7	1.9	89.5	1.8	1.7	105.9	14.2	11.0	129.1
2021	0.5	0.6	83.3	1.3	1.2	108.3	3.2	2.9	110.3	4.9	4.2	116.7	16.2	20.3	79.8
2022	0.5	0.6	83.3	1.2	1.1	109.1	2.0	2.0	100.0	2.6	2.7	96.3	10.0	10.0	100.0
2023	0.7	0.9	77.8	2.4	1.8	133.3	4.0	3.0	133.3	5.6	4.6	121.7	17.2	13.0	132.3

Table H21: Number of cells contacted, aggregate area, and footprint for area SUBA6 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	313	276	113.4	2 571.4	1 589.0	161.8	1 430.6	1 028.0	139.2
2020	224	200	112.0	2 220.8	1 328.8	167.1	1 112.8	813.6	136.8
2021	253	204	124.0	1 794.5	993.3	180.7	928.6	669.3	138.7
2022	207	182	113.7	1 308.5	621.0	210.7	793.1	487.2	162.8
2023	347	308	112.7	3 307.2	1 161.2	284.8	1 585.4	920.3	172.3

Table H22: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area SUBA6, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2020	32	30	106.7	21.0	19.8	106.1	20.9	19.8	105.6	99.5	100.0	99.5
2021	2	1	200.0	10.2	0.4	2550.0	3.6	0.4	900.0	35.3	100.0	35.3
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table H23: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area SUBA6, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	2.0	2.0	100.0
Aggregate area	<0.1	<0.1	–	0.7	0.6	116.7	1.6	1.2	133.3
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	1.0	1.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	26.3	16.4	160.4	10.0	9.0	111.1	511.0	320.0	159.7
Aggregate area	19.0	10.7	177.6	7.5	5.8	129.3	422.9	234.9	180.0
Footprint	5.0	4.0	125.0	6.0	5.0	120.0	25.0	25.0	100.0

Table H24: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for SUBA6, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	2.0	2.0	100.0	9.5	6.9	137.7	7.0	5.0	140.0	87.0	59.0	147.5
2020	1.0	1.0	100.0	2.0	2.0	100.0	13.8	10.0	138.0	10.0	7.0	142.9	120.0	94.0	127.7
2021	1.0	1.0	100.0	1.0	2.0	50.0	9.8	7.8	125.6	6.0	5.0	120.0	109.0	74.0	147.3
2022	1.0	1.0	100.0	2.0	2.0	100.0	10.1	6.4	157.8	7.5	6.0	125.0	76.0	52.0	146.2
2023	1.0	1.0	100.0	3.0	3.0	100.0	13.9	6.7	207.5	9.0	6.0	150.0	146.0	89.0	164.0
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.8	87.5	1.9	1.6	118.7	8.2	5.8	141.4	6.8	4.7	144.7	88.8	61.9	143.5
2020	0.8	0.7	114.3	2.1	1.8	116.7	9.9	6.6	150.0	7.7	5.5	140.0	97.6	70.7	138.0
2021	0.5	0.5	100.0	1.1	1.1	100.0	7.1	4.9	144.9	4.3	3.7	116.2	102.8	61.3	167.7
2022	0.6	0.6	100.0	1.4	1.1	127.3	6.3	3.4	185.3	4.5	2.9	155.2	59.3	29.3	202.4
2023	1.0	0.7	142.9	2.0	1.6	125.0	9.5	3.8	250.0	6.1	3.9	156.4	107.0	45.1	237.3
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.7	0.8	87.5	1.7	1.5	113.3	4.6	3.7	124.3	5.5	4.1	134.1	24.0	22.4	107.1
2020	0.8	0.7	114.3	2.1	1.8	116.7	5.0	4.1	122.0	6.4	5.0	128.0	24.2	23.6	102.5
2021	0.5	0.5	100.0	1.1	1.1	100.0	3.7	3.3	112.1	3.6	3.4	105.9	23.9	22.7	105.3
2022	0.6	0.6	100.0	1.3	1.1	118.2	3.8	2.7	140.7	3.9	2.6	150.0	22.9	17.0	134.7
2023	1.0	0.7	142.9	1.9	1.6	118.7	4.6	3.0	153.3	5.1	3.6	141.7	24.7	19.7	125.4

Table H25: Number of cells contacted, aggregate area, and footprint for area CHAT4 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
1842	1841	100.1	37 792.7	29 301.0	129.0	14 499.3	14 377.1	100.8
1575	1658	95.0	32 390.0	24 855.3	130.3	12 240.4	12 031.2	101.7
1675	1682	99.6	33 372.2	27 048.9	123.4	13 155.4	13 058.5	100.7
1633	1660	98.4	38 046.5	30 331.3	125.4	13 650.7	13 766.9	99.2
1571	1640	95.8	41 151.9	31 536.6	130.5	12 672.5	13 079.5	96.9

Table H26: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area CHAT4, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	8	6	133.3	1.5	1.3	115.4	1.5	1.3	115.4	100.0	100.0	100.0
2020	2	1	200.0	0.2	0.5	40.0	0.2	0.5	40.0	100.0	100.0	100.0
2021	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2022	1	0	–	0.2	0.0	–	0.2	0.0	–	100.0	–	–
2023	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–

Table H27: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area CHAT4, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	3.0	3.0	100.0	27.0	22.0	122.7
Aggregate area	<0.1	<0.1	–	1.7	1.6	106.2	19.8	16.2	122.2
Footprint	<0.1	<0.1	–	1.0	1.0	100.0	9.0	10.0	90.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	86.1	70.1	122.8	104.0	84.8	122.6	1295.0	950.0	136.3
Aggregate area	81.1	61.8	131.2	90.7	70.7	128.3	1469.3	907.9	161.8
Footprint	11.0	11.0	100.0	21.0	22.0	95.5	25.0	25.0	100.0

Table H28 Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for CHAT4, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	2.0	2.0	100.0	10.0	9.0	111.1	22.1	18.4	120.1	27.0	22.0	122.7	251.0	194.0	129.4
2020	3.0	2.0	150.0	9.0	8.0	112.5	21.5	17.0	126.5	26.0	20.0	130.0	248.0	198.0	125.3
2021	3.0	3.0	100.0	10.0	9.0	111.1	21.1	18.0	117.2	29.0	24.0	120.8	236.0	167.0	141.3
2022	3.0	3.0	100.0	12.0	10.0	120.0	24.1	20.0	120.5	31.0	26.2	118.3	288.0	180.0	160.0
2023	3.0	3.0	100.0	12.0	10.0	120.0	28.5	22.3	127.8	36.0	30.0	120.0	406.0	265.0	153.2
	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.5	1.5	100.0	7.6	7.0	108.6	20.5	15.9	128.9	24.9	20.8	119.7	291.1	177.4	164.1
2020	2.0	1.6	125.0	7.4	5.6	132.1	20.6	15.0	137.3	23.4	17.3	135.3	271.0	191.0	141.9
2021	1.6	1.8	88.9	7.5	6.7	111.9	19.9	16.1	123.6	25.5	21.2	120.3	247.0	163.3	151.3
2022	2.2	2.1	104.8	9.8	7.9	124.1	23.3	18.3	127.3	30.4	23.3	130.5	350.6	178.6	196.3
2023	2.1	1.8	116.7	9.0	7.0	128.6	26.2	19.2	136.5	30.5	22.4	136.2	501.6	289.1	173.5
	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.2	1.4	85.7	5.6	5.7	98.2	7.9	7.8	101.3	13.2	13.1	100.8	25.0	25.0	100.0
2020	1.8	1.5	120.0	5.5	4.9	112.2	7.8	7.3	106.8	12.3	11.5	107.0	25.0	25.0	100.0
2021	1.5	1.7	88.2	5.6	5.5	101.8	7.9	7.8	101.3	12.8	12.5	102.4	25.0	25.0	100.0
2022	1.9	2.0	95.0	6.2	6.3	98.4	8.4	8.3	101.2	13.9	13.3	104.5	25.0	25.0	100.0
2023	1.8	1.6	112.5	5.8	5.7	101.8	8.1	8.0	101.2	13.1	12.9	101.6	25.0	25.0	100.0

Table H29: Number of cells contacted, aggregate area, and footprint for area COOK8 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	81	80	101.2	614.0	561.9	109.3	201.4	220.8	91.2
2020	57	62	91.9	394.6	349.3	113.0	131.4	138.1	95.1
2021	58	57	101.8	468.6	366.4	127.9	124.7	134.1	93.0
2022	56	60	93.3	586.0	438.5	133.6	154.0	177.7	86.7
2023	53	54	98.1	581.8	443.7	131.1	125.4	140.3	89.4

Table H30: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area COOK8, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	0	0	–	0	0	–	0	0	–	0	0	–
2020	0	0	–	0	0	–	0	0	–	0	0	–
2021	0	0	–	0	0	–	0	0	–	0	0	–
2022	0	0	–	0	0	–	0	0	–	0	0	–
2023	0	0	–	0	0	–	0	0	–	0	0	–

Table H31: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area COOK8, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	2.0	50.0	5.5	7.0	78.6
Aggregate area	<0.1	<0.1	–	0.4	0.4	100.0	1.1	2.0	55.0
Footprint	<0.1	<0.1	–	0.0	0.0	–	1.0	2.0	50.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	61.8	59.0	104.7	56.2	51.0	110.2	588.0	557.0	105.6
Aggregate area	25.4	21.4	118.7	14.1	13.1	107.6	327.9	263.7	124.3
Footprint	3.0	4.0	75.0	5.0	6.0	83.3	21.0	23.0	91.3

Table H32: Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for COOK8, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	2.0	50.0	5.0	6.5	76.9	22.6	22.2	101.8	21.0	19.5	107.7	258.0	255.0	101.2
2020	1.0	1.0	100.0	7.0	4.5	155.6	16.5	14.4	114.6	31.0	19.0	163.2	72.0	70.0	102.9
2021	2.0	1.0	200.0	7.0	7.0	100.0	18.2	16.7	109.0	26.5	24.0	110.4	81.0	69.0	117.4
2022	2.8	2.8	100.0	12.5	8.0	156.2	22.5	18.6	121.0	32.2	26.2	122.9	85.0	79.0	107.6
2023	1.0	1.0	100.0	7.0	5.5	127.3	25.2	22.6	111.5	49.0	42.0	116.7	148.0	143.0	103.5

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.4	75.0	0.9	1.3	69.2	7.6	7.0	108.6	5.7	4.9	116.3	93.3	78.9	118.3
2020	0.4	0.3	133.3	1.8	0.9	200.0	6.9	5.6	123.2	6.8	5.0	136.0	42.1	38.6	109.1
2021	0.6	0.7	85.7	2.0	1.6	125.0	8.1	6.4	126.6	8.4	6.6	127.3	48.5	38.9	124.7
2022	0.6	0.7	85.7	2.9	2.0	145.0	10.5	7.3	143.8	12.9	8.5	151.8	59.4	41.5	143.1
2023	0.4	0.4	100.0	1.9	1.5	126.7	11.0	8.2	134.1	11.2	9.1	123.1	89.6	70.7	126.7

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.4	75.0	0.8	1.2	66.7	2.5	2.8	89.3	3.2	3.3	97.0	19.4	20.5	94.6
2020	0.3	0.3	100.0	1.2	0.9	133.3	2.3	2.2	104.5	2.8	3.6	77.8	13.7	15.0	91.3
2021	0.5	0.6	83.3	1.1	1.1	100.0	2.2	2.4	91.7	3.2	3.9	82.1	10.3	11.7	88.0
2022	0.5	0.7	71.4	1.7	1.7	100.0	2.8	3.0	93.3	4.4	4.0	110.0	11.6	13.5	85.9
2023	0.4	0.4	100.0	1.0	1.1	90.9	2.4	2.6	92.3	2.6	3.9	66.7	12.3	14.6	84.2

Table H33: Number of cells contacted, aggregate area, and footprint for area EAST2 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	273	283	96.5	641.1	611.3	104.9	473.5	506.8	93.4
2020	151	154	98.1	186.8	184.8	101.1	162.0	164.2	98.7
2021	118	133	88.7	174.9	165.4	105.7	137.8	146.5	94.1
2022	80	84	95.2	133.5	116.4	114.7	87.6	87.9	99.7
2023	55	58	94.8	128.2	106.5	120.4	67.8	66.7	101.6

Table H34: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area EAST2, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	4	7	57.1	0.3	3.3	9.1	0.3	3.1	9.7	100.0	93.9	106.5
2020	4	3	133.3	1.4	1.2	116.7	1.4	1.2	116.7	100.0	100.0	100.0
2021	1	6	16.7	0.2	2.0	10.0	0.2	2.0	10.0	100.0	100.0	100.0
2022	0	0	–	0	0	–	0	0	–	0	0	–
2023	0	0	–	0	0	–	0	0	–	0	0	–

Table H35: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area EAST2, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	3.0	3.0	100.0
Aggregate area	<0.1	<0.1	–	0.4	0.4	100.0	0.9	1.0	90.0
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0

	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	12.0	11.4	105.3	14.0	13.0	107.7	132.0	128.0	103.1
Aggregate area	4.0	3.6	111.1	3.2	3.1	103.2	61.2	54.6	112.1
Footprint	2.0	2.0	100.0	3.0	3.0	100.0	16.0	17.0	94.1

Table H36 Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for EAST2, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

	No. of tows 1st Quartile			No. of tows median			No. of tows mean			No. of tows 3rd Quartile			No. of tows maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	1.0	1.0	100.0	2.0	2.0	100.0	7.1	6.6	107.6	8.0	8.0	100.0	45.0	42.0	107.1
2020	1.0	1.0	100.0	2.0	2.0	100.0	3.9	3.9	100.0	4.5	5.0	90.0	25.0	23.0	108.7
2021	1.0	1.0	100.0	3.0	3.0	100.0	4.9	4.4	111.4	7.8	6.0	130.0	24.0	23.0	104.3
2022	1.0	1.0	100.0	2.0	2.0	100.0	5.0	4.6	108.7	6.2	6.0	103.3	29.0	25.0	116.0
2023	1.0	1.0	100.0	1.0	1.0	100.0	6.2	5.7	108.8	5.0	3.0	166.7	44.0	44.0	100.0

	Aggregate area 1st Quartile			Aggregate area median			Aggregate area mean			Aggregate area 3rd Quartile			Aggregate area maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.7	0.7	100.0	2.3	2.2	104.5	2.4	2.1	114.3	23.2	20.4	113.7
2020	0.3	0.3	100.0	0.5	0.6	83.3	1.2	1.2	100.0	1.3	1.3	100.0	11.1	10.9	101.8
2021	0.3	0.3	100.0	0.8	0.7	114.3	1.5	1.2	125.0	2.0	1.6	125.0	11.0	9.4	117.0
2022	0.2	0.2	100.0	0.4	0.4	100.0	1.7	1.4	121.4	1.3	1.1	118.2	16.3	11.4	143.0
2023	0.2	0.1	200.0	0.5	0.4	125.0	2.3	1.8	127.8	1.0	0.9	111.1	20.9	19.9	105.0

	Footprint 1st Quartile			Footprint median			Footprint mean			Footprint 3rd Quartile			Footprint maximum		
Year	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio	Hybrid	Straight line	Ratio
2019	0.3	0.3	100.0	0.6	0.7	85.7	1.7	1.8	94.4	2.1	2.0	105.0	11.3	11.4	99.1
2020	0.2	0.2	100.0	0.5	0.6	83.3	1.1	1.1	100.0	1.2	1.2	100.0	7.6	8.2	92.7
2021	0.3	0.3	100.0	0.6	0.6	100.0	1.2	1.1	109.1	1.7	1.6	106.2	5.3	6.1	86.9
2022	0.2	0.2	100.0	0.4	0.4	100.0	1.1	1.0	110.0	1.0	1.1	90.9	7.5	8.1	92.6
2023	0.2	0.1	200.0	0.5	0.4	125.0	1.2	1.1	109.1	0.8	0.8	100.0	7.3	9.4	77.7

Table H37: Number of cells contacted, aggregate area, and footprint for area NORTH1 for fishing years 2019 to 2023 for the hybrid and straight-line data sets. Ratios are expressed for each measure as a percentage of the hybrid value to the straight-line value.

	No. of cells			Aggregate area (km^2)			Footprint (km^2)		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	329	329	100.0	1 353.7	1 340.0	101.0	701.1	695.1	100.9
2020	147	167	88.0	1 026.9	1 001.0	102.6	449.0	569.2	78.9
2021	178	185	96.2	939.8	912.0	103.0	461.7	557.9	82.8
2022	153	150	102.0	795.4	775.5	102.6	381.3	451.5	84.5
2023	200	211	94.8	883.2	849.0	104.0	448.3	519.1	86.4

Table H38: Number of new cells contacted by year, the corresponding aggregate area and footprint of those cells, and the footprint as a percentage of the aggregate area for fishing years 2019 to 2023 for area NORTH1, for the hybrid and straight-line data sets. The ratio of each measure is expressed as a percentage of the hybrid value to the straight-line value.

	No. of new cells			Aggregate area (km^2)			Footprint (km^2)			Footprint as % of aggregate area		
Year	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
2019	32	32	100.0	15.0	15.2	98.7	13.3	13.8	96.4	88.7	90.8	97.0
2020	0	6	–	–	2.0	–	–	2.0	–	–	–	–
2021	8	7	114.3	2.0	2.2	90.9	2.0	2.2	90.9	100.0	100.0	100.0
2022	0	0	–	0.0	0.0	–	0.0	0.0	–	–	–	–
2023	6	6	100.0	2.4	2.1	114.3	2.4	2.1	114.3	100.0	100.0	100.0

Table H39: Summary data for the number of tows that contact a cell, the aggregate area, and the footprint by 25-km^2 cell for area NORTH1, for the combined fishing years 2019–2023, for the hybrid and straight-line data. The ratio is expressed as a percentage of the hybrid values to the straight-line values.

	Minimum			1st quartile			Median		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	1.0	1.0	100.0	1.0	1.0	100.0	3.0	2.0	150.0
Aggregate area	<0.1	<0.1	–	0.3	0.3	100.0	0.8	0.7	114.3
Footprint	<0.1	<0.1	–	<0.1	<0.1	–	1.0	1.0	100.0
	Mean			3rd quartile			Maximum		
	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio	Hybrid	Straight-line	Ratio
No. of tows	37.6	33.8	111.2	14.0	13.0	107.7	658.0	473.0	139.1
Aggregate area	12.4	11.3	109.7	0.9	4.4	111.4	278.2	181.3	153.4
Footprint	3.0	3.0	100.0	3.0	4.0	80.0	22.0	23.0	95.7

Table H40 Annual summary data for the number of tows that contact each cell, the footprint, and the aggregate area for NORTH1, 2019–2023, giving the 25th percentile (1st Quartile), median, mean, 75th percentile (3rd Quartile), and the maximum. The minimum number of tows that contacted each cell was 1 and the minimum values for the footprint and aggregate areas was < 0.0001.

Plots removed for data confidentiality reasons.

Figure H1: Distribution of the HOK/HAK/LIN bycatch assessment area footprint for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

Plots removed for data confidentiality reasons.

Figure H2: Distribution of the HOK/HAK/LIN bycatch assessment area aggregate area for the 2019–2023 fishing years combined (upper plots) and 2023 (lower plots) for the hybrid and straight-line data sets.

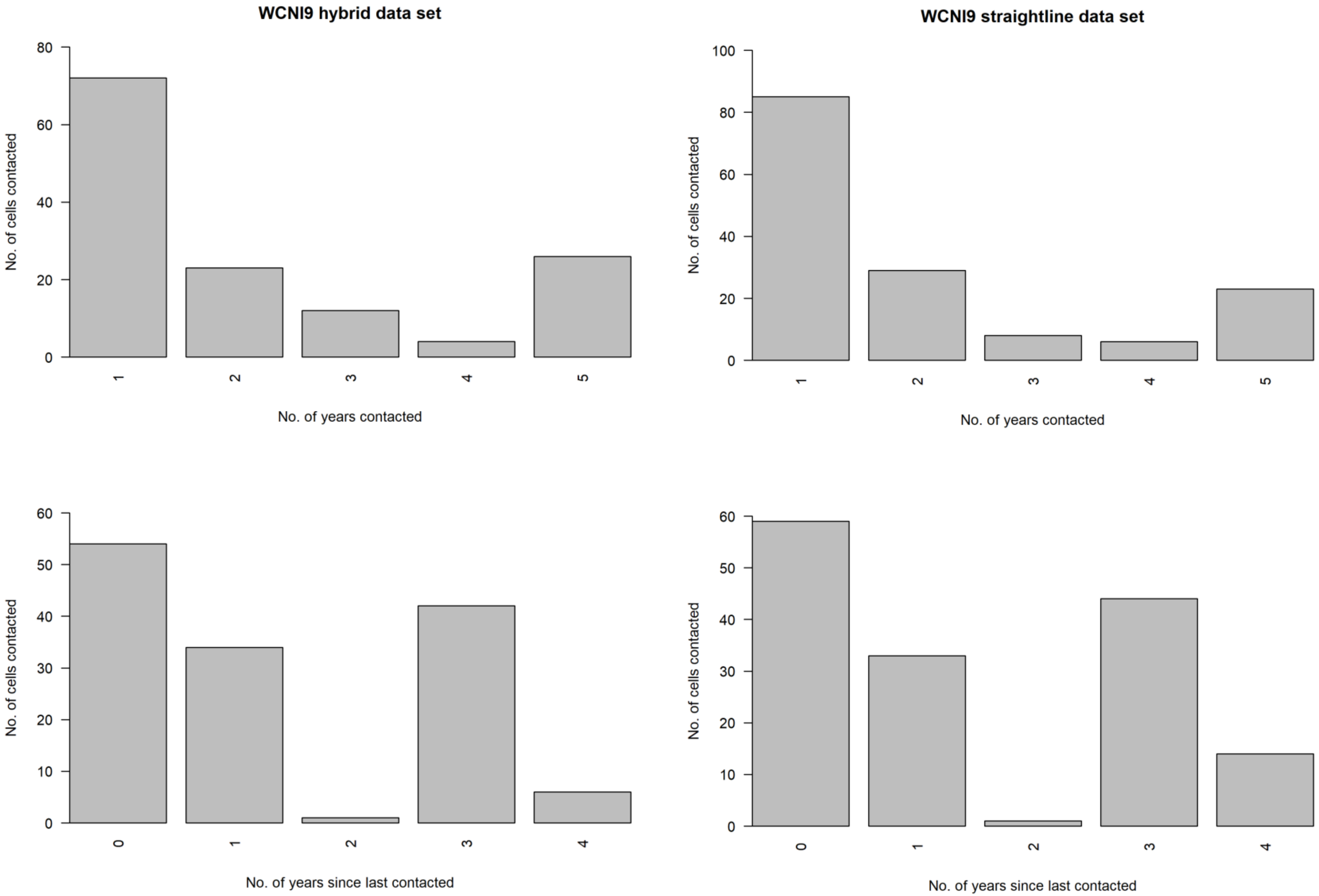

Figure H3: **The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the WCNI9 subarea.**

Plots removed for data confidentiality reasons.

Figure H4: Distribution of cells, by the number of years contacted (top), and by the most recent year fished (bottom) between 2019 and 2023 for the hybrid data (left) and the straight-line data (right) for the HOK/HAK/LIN bycatch assessment areas.

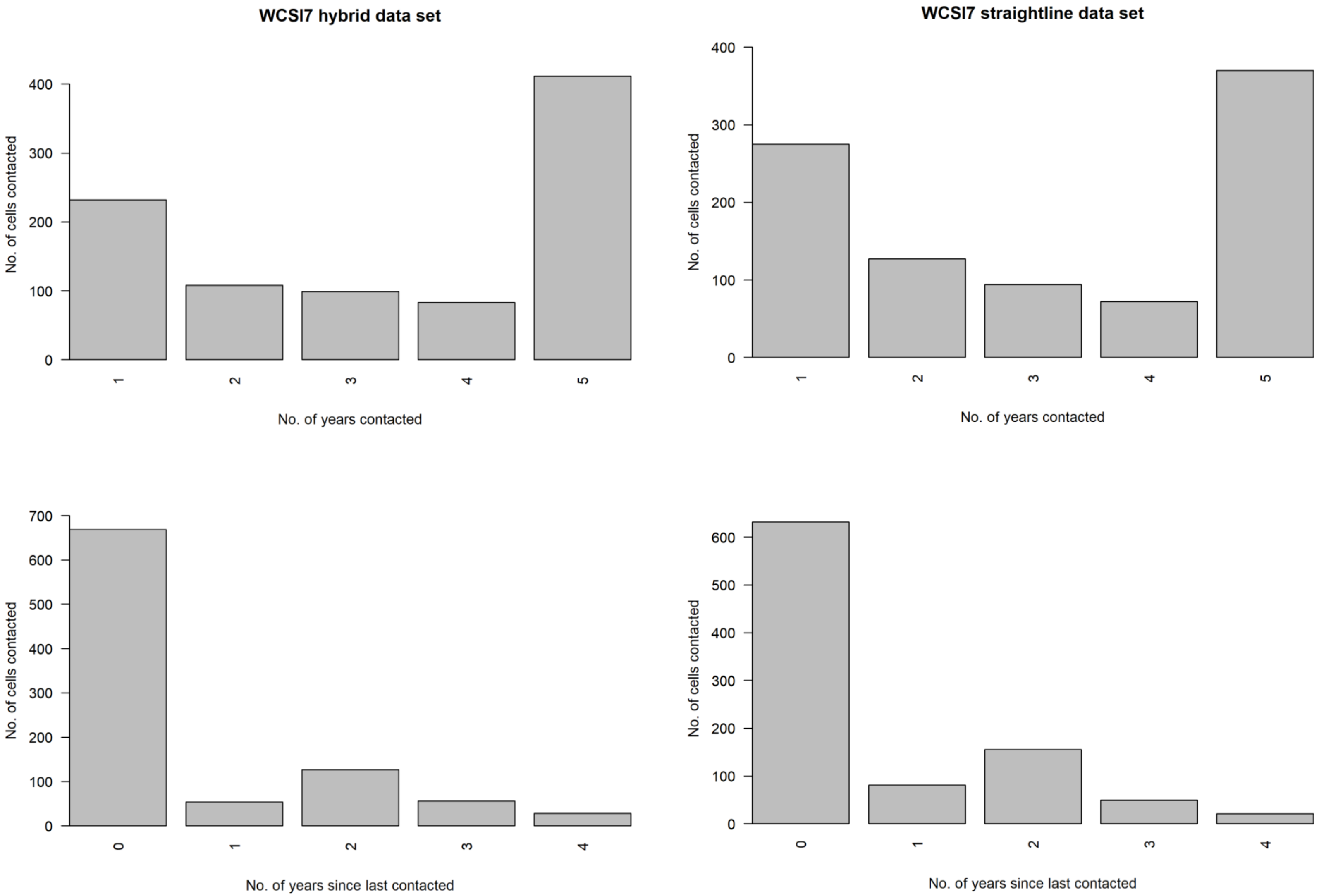

Figure H5: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the WCSI7 subarea.

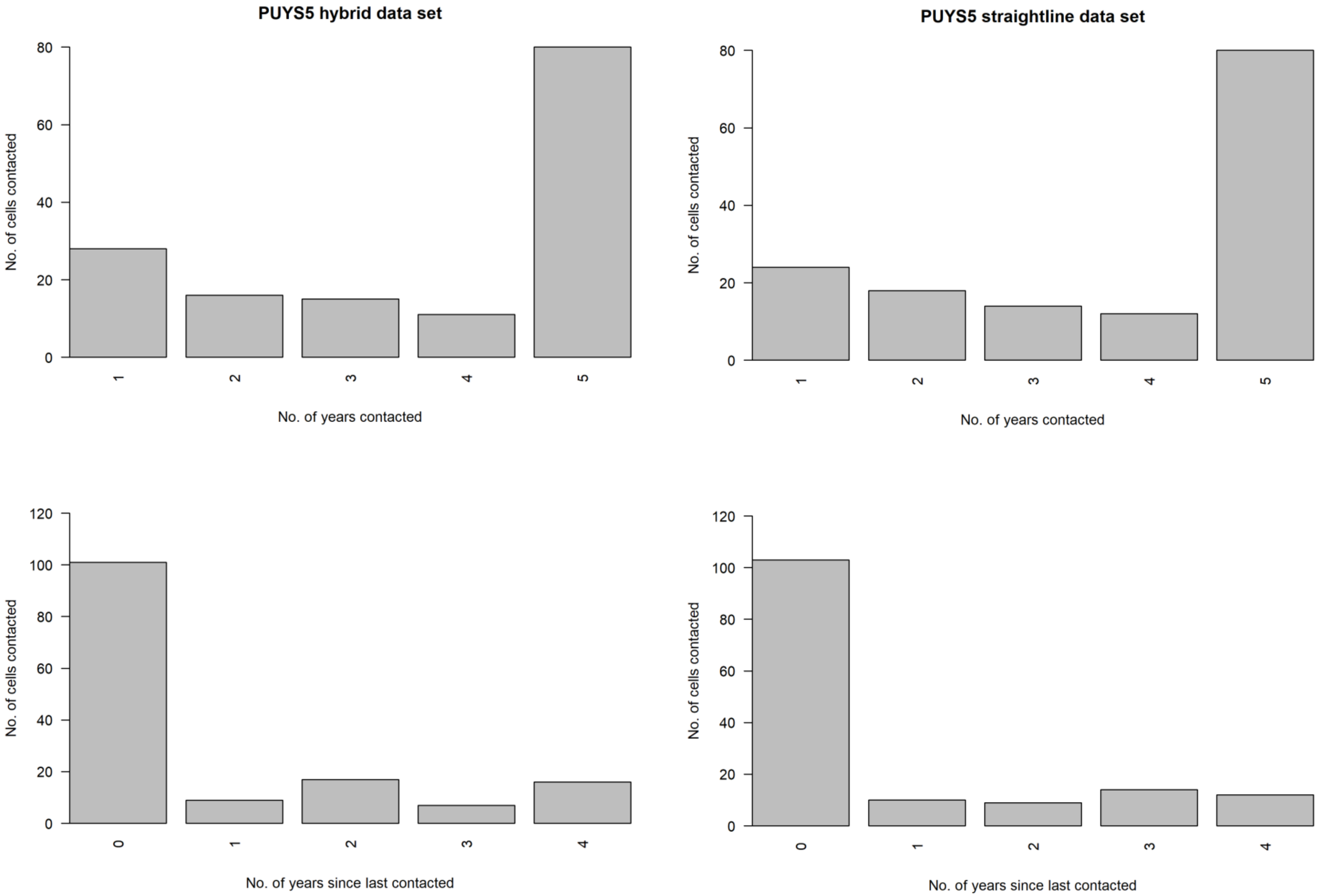

Figure H6: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the PUYS5 subarea.

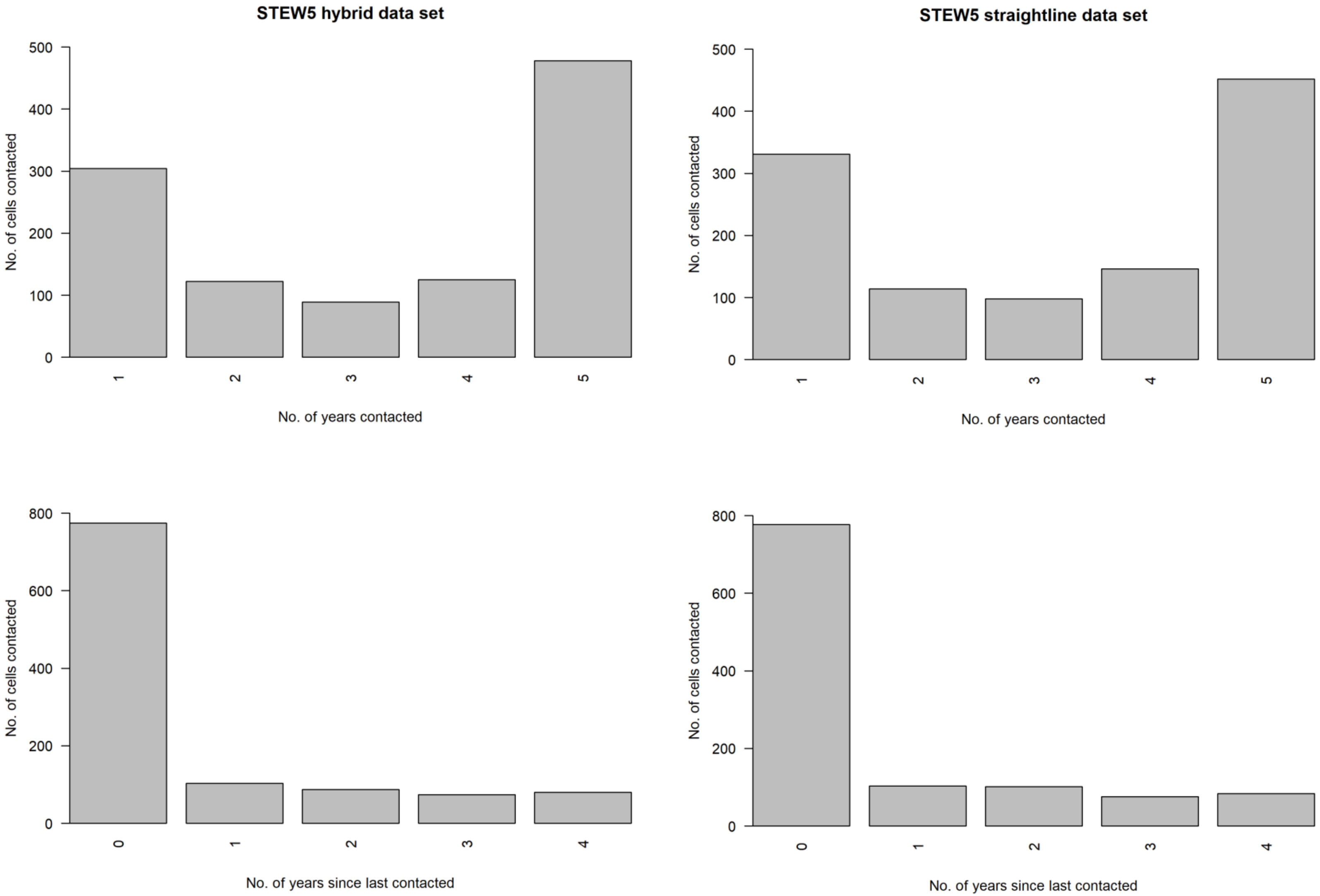

Figure H7: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the STEW5 subarea.

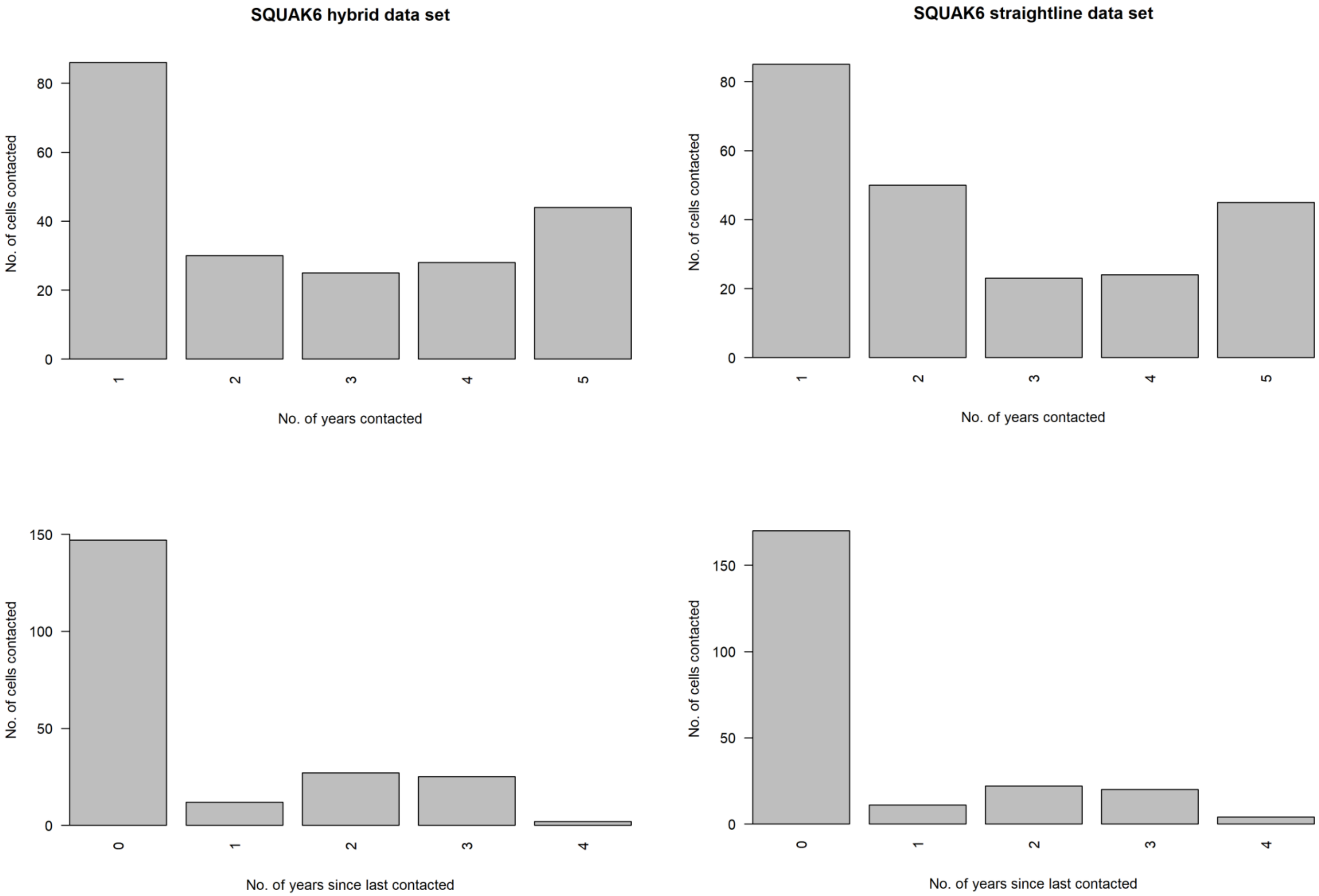

Figure H8: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the SQUAK6 subarea.

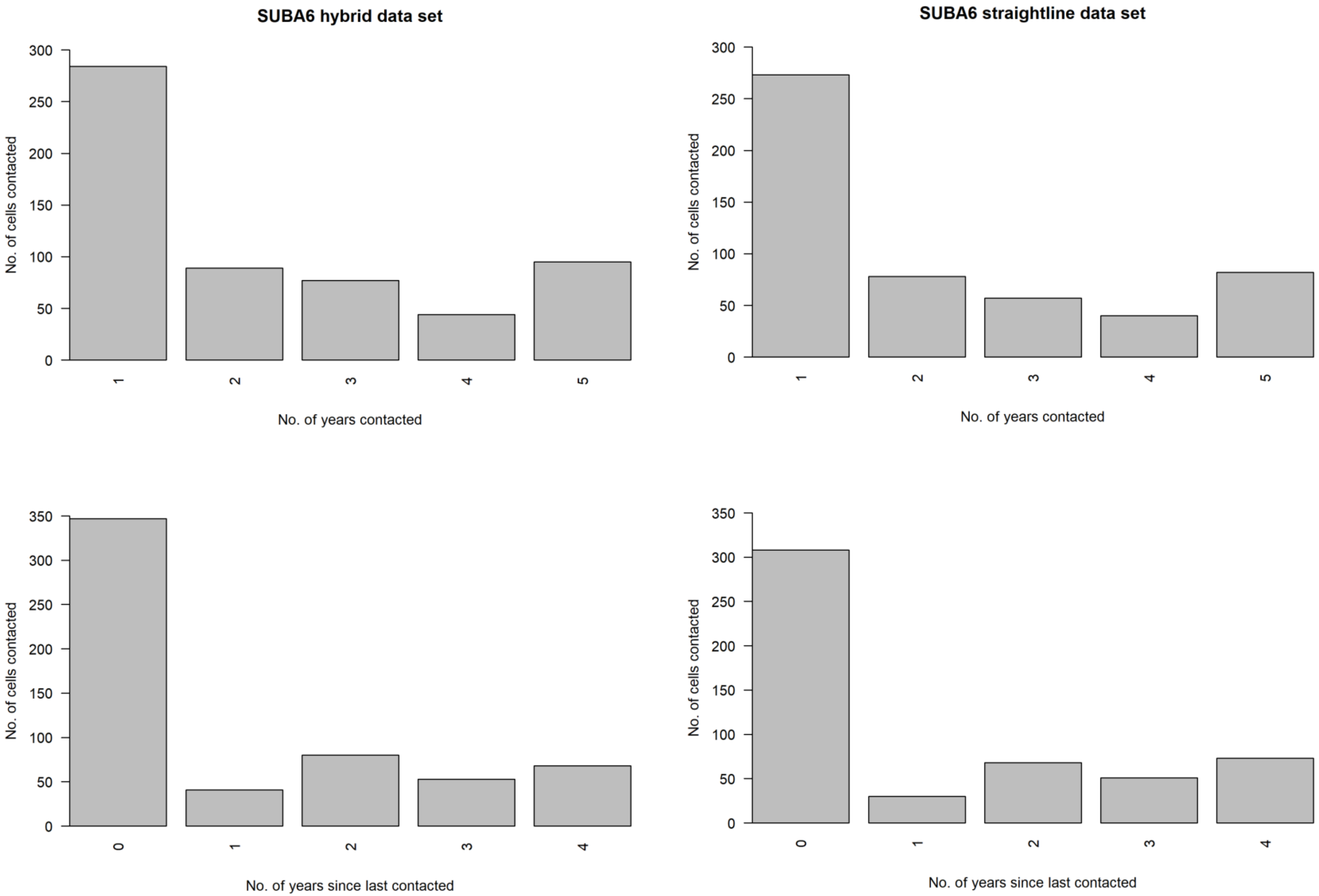

Figure H9: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the SUBA6 subarea.

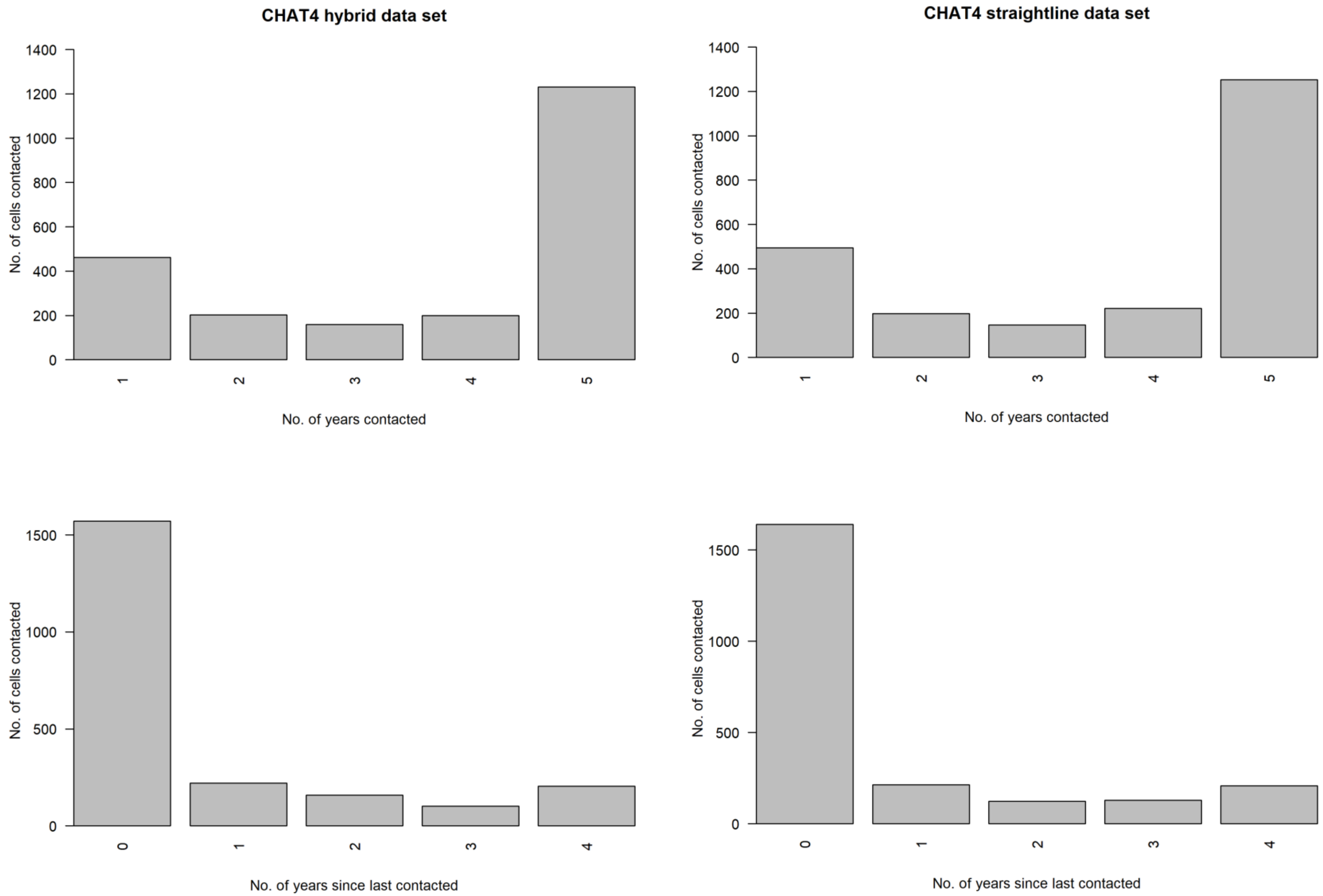

Figure H10: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the CHAT4 subarea.

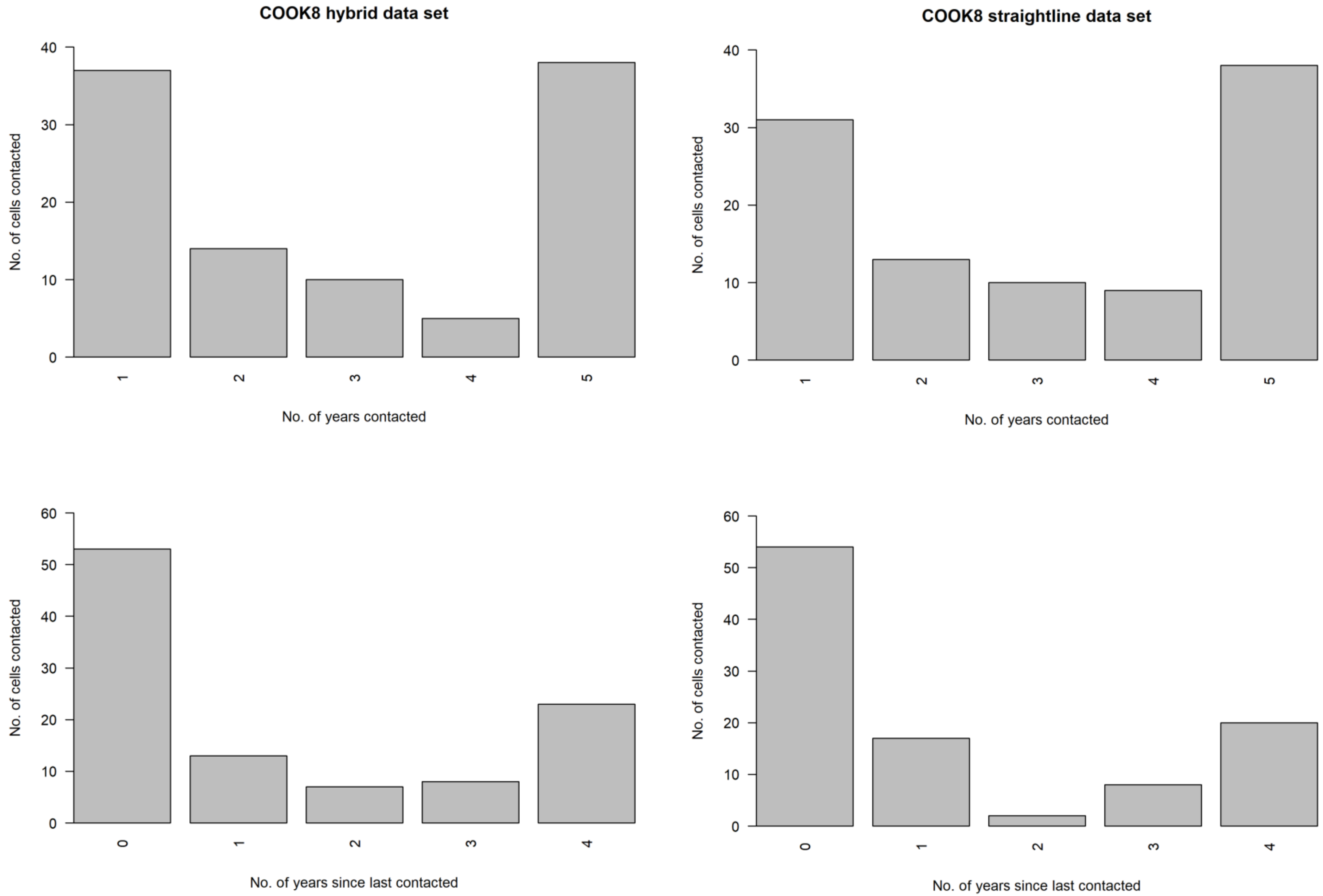

Figure H11: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the COOK8 subarea.

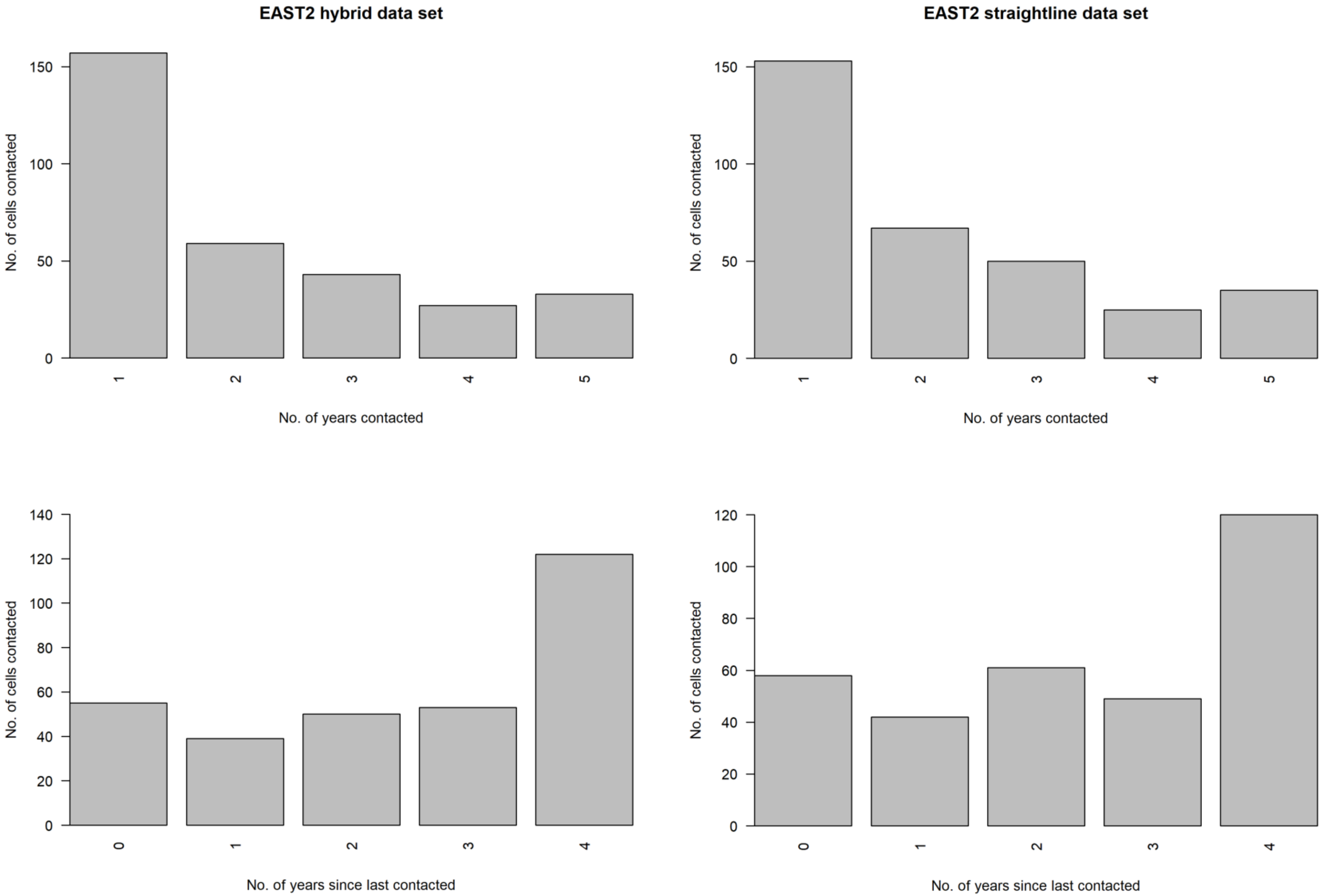

Figure H12: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the EAST2 subarea.

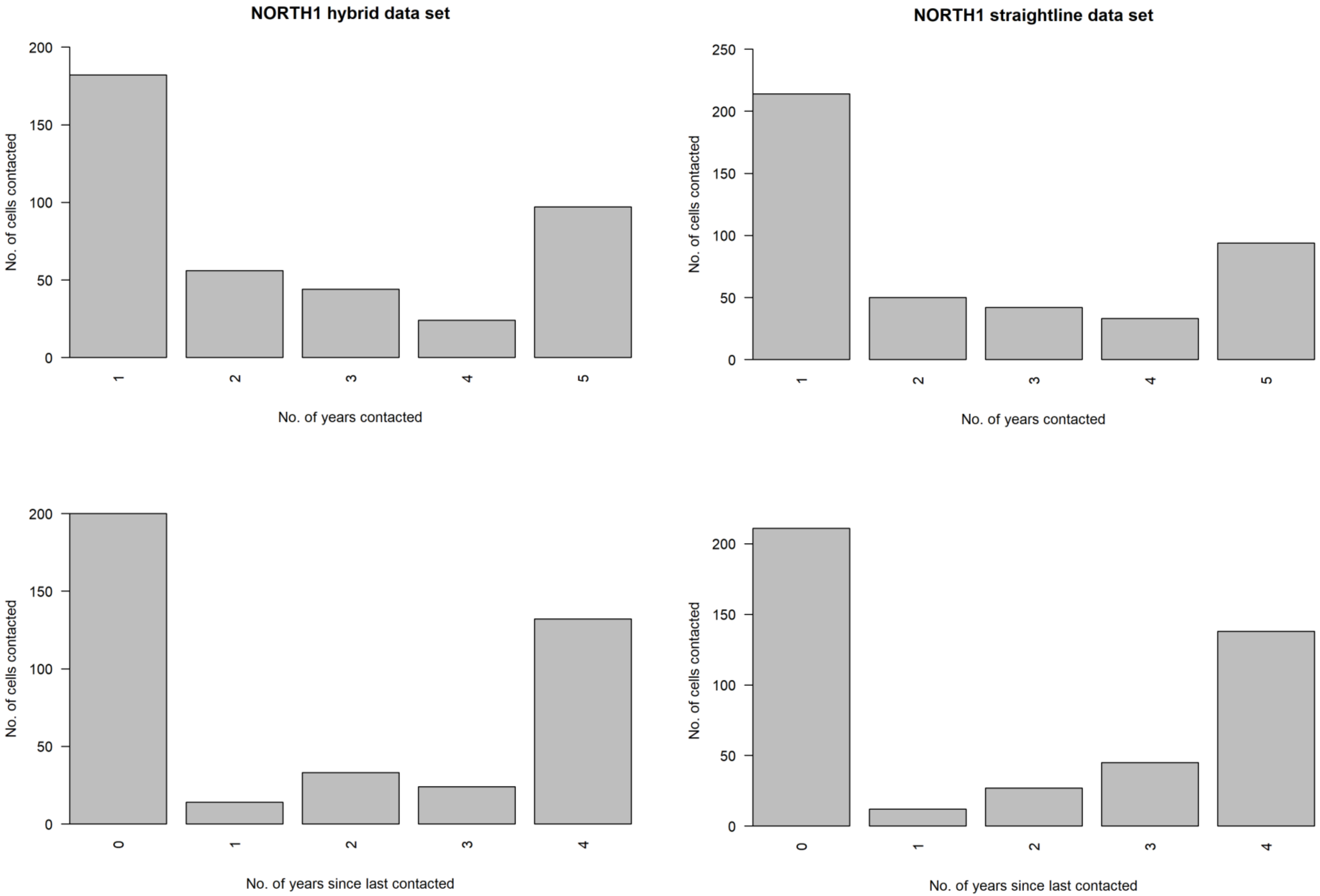

Figure H13: The number of cells contacted in annual year bins (upper) and the number of cells in each bin representing the number of years since a cell was last contacted (lower) for 2019–2023 for the hybrid data (left) and straight-line data (right) for the NORTH1 subarea.