Fisheries New Zealand
Tini a Tangaroa

Extent of bottom contact by commercial fishing activity in New Zealand waters, for 1989–90 to 2017–18

New Zealand Aquatic Environment and Biodiversity Report No. 259

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ISSN 1179-6480 (online)
ISBN 978-1-99-100376-8 (online)

April 2021

New Zealand Government

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The extent of the bottom-contacting trawl footprint in New Zealand waters open to trawling is updated by this report to include the 2018 (1 October 2017 to 30 September 2018) fishing year, where data are available for the commercial inshore (fishing years 2008–2018) and deepwater trawl fisheries (1990–2018). Effort data for other bottom-contacting fishing methods, Danish seine and shellfish dredge, are also summarised by fishery, for 1990 to 2018 (1989–90 to 2017–18).

Comparable tow-by-tow data from different collection methods has enabled generation of an all bottom-contacting trawl footprint representing inshore and offshore fishstocks, for 2008 to 2018 (the fishing years with data available for spatial representation of trawling effort, at the tow level). The trawl footprint for the combined inshore and deepwater fishstocks for these years contacted 294 913 km^2 of seafloor, which represented 21% of the waters open to trawling (fishable area) and 7% of the combined Territorial Sea and Exclusive Economic Zone (TS+EEZ). The footprint area declined from about 95 800 km^2 in 2008 to 89 000 km^2 in 2018. The annual inshore footprints were slightly larger (range of 42 180–48 200 km^2) than the Tier 1 annual footprints (40 418–45 589 km^2), but, for 2007–2018, the extent of the overall inshore footprint (147 896 km^2) was smaller than the deepwater Tier 1 footprint (152 413 km^2) and this reflects the more concentrated trawling in the narrow band of depths fished in the continental shelf waters. The combined Tier 1 and Tier 2 deepwater annual footprints extended over 45 528–52 570 km^2, with a 2008–2018 total of 177 267 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. Overlap of the footprints with depth zones, the Benthic-optimised Marine Environment Classification, surficial sediment layers, and probability of occurrence of some target species is presented by the broad fishery groups. Data inclusion and the effect of the methodology used are also discussed, and any changes to the methods are highlighted.

Caution is advised when interpreting these data and other footprint summaries presented in this report. The footprint is a relative, not an absolute, estimate of the coverage of bottom-contacting trawl gear. The difficulties created by the data resolution, the methods used to generate the spatial placement of an inshore tow including a duration-speed based distance measure (represented by a straight line) because of the lack of a reported finish position, and shortening of tows for targets such as orange roughy and hake are discussed in this report to aid in interpretation of the footprint results.

The data are stored in a Ministry for Primary Industries Geographic Information System geodatabase at the level of each tow, with the potential to analyse data at regional or smaller scales by target or groups of targets, as well as at a 25-km^2 cell grid level for the broad analysis of the given here.

1. INTRODUCTION

Bottom-contacting trawl gears, that is bottom trawls and midwater trawls used within one metre of the seafloor, target inshore and deepwater fishstocks within the Territorial Sea (TS) and the 200 n. mile New Zealand Exclusive Economic Zone (EEZ). Data collection methods for this fishing effort have varied by fleet and changed in recent years. Skippers of trawl vessels over 28 m in length and operating these gears when targeting deepwater species have reported catch and effort data on Trawl Catch Effort Processing Return (TCEPR) forms since 1 October 1989. In a move to digital data collection, the Electronic Reporting System (ERS) was introduced for use by deepwater vessels in October 2017. Skippers trawling for inshore fishstocks reported this commercial fishing activity primarily on Catch Effort Landing Return (CELR) forms between 1 October 1989 and 30 September 2007, and on Trawl Catch Effort Return (TCER) forms from 1 October 2007 to 2019; these forms collect data from vessels under 28 m in length. There are two exceptions to this: the use by some inshore skippers of TCEPR forms, generally in northern waters from the mid-1990s (see Baird et al. 2011), and the use of ERS data reporting by some smaller inshore vessels from January 2018, as part of the gradual move to use of the ERS by all vessels.

The TCER, TCEPR, and ERS data provide tow-by-tow information that can be used to generate annual trawl footprints to represent the area of the seafloor contacted by trawl gear. Estimates of the inshore trawl footprint are restricted to effort from 1 October 2007 onwards and methods to develop inshore footprints were developed by Baird et al. (2015) based mainly on TCER and some TCEPR data for a 5-y period (1 October 2007 to 30 September 2012) extracted from the Ministry for Primary Industries (MPI) database *warehou*. The analysis presented in this report for inshore fishstocks is limited to the fishing years 2008–2018 and uses the MPI CatchMapper software tool (Osborne 2018) and data extracted from the Enterprise Data Warehouse (EDW)—a database that includes the *warehou* form-based data and the ERS data (Baird & Mules 2019).

The overall research objective for the BEN201801 project reported in this document is to monitor the 'footprint' of trawl fishing for deepwater and inshore target species on or near the seabed for the 1990 to 2018 fishing years where, for example, the 1990 fishing year is between 1 October 1989 and 30 September 1990. This provides an opportunity to better understand the extent of the trawl footprint of vessels that operate in the shallower Territorial Sea waters and throughout the EEZ.

This report addresses part of the specific Objective 1: "*to help MPI groom data, develop and compile maps and summary statistics, and produce a report summarising at a national scale: all deepwater and inshore trawl fishing by year, depth zone, fishable area, and by any other agreed habitat classifications or proxies and to identify any trends of changes to meet management needs. A summary of Danish seine and dredge fishing data, by Statistical Area, is also required for this time period to complete this objective"*.

The project output addressed by this report describes the nature and extent of annual and total footprints for all deepwater and inshore fishstocks (All stocks) for 2008–2018, by the deepwater Tier 1 and Tier 2 fishstock groups for 1990–2018, and inshore fishstocks for 2008–2018. Trawl footprint summaries are presented relative to the 'fishable area'—waters open to trawling down to 1600 m. The overlap of the deepwater and inshore trawl footprints is also discussed, where relevant, relative to 200-m depth zones; the 15-class Benthic-optimised Marine Environment Classification (BOMEC) generated by Leathwick et al. (2012); interpolated distribution of surficial sediments for the continental shelf, slope, and deep ocean (Bostock et al. 2019a, 2019b); predicted distribution of likely occurrence for the deepwater Tier 1 target species (Leathwick et al. 2006); and voluntary closures in some inshore target fisheries.

This report provides the methods and results for Objective 1, with associated appendices to present the underlying data and the final output. Section 2 describes the trawl data sources and the general methodology used to groom the data and generate the spatial analyses. Section 3 summarises the

relevant tow-by-tow TCER, TCEPR, and ERS data for all bottom-contacting inshore and deepwater commercial trawling (all stocks) and presents the results of spatial analyses, including the aggregate trawl swept area (the sum of the estimated tow swept areas) and the footprint area, for fishing years 2008 to 2018 for which there are comparable data. Sections 4 and 5 provide this information for the inshore fishstocks (2008–2018) and the deepwater fishstocks (1990–2018), respectively. Both these sections also include summaries for trawl fishery groups requested by Fisheries New Zealand: inshore mixed trawl fisheries for specific Fishery Management Areas (FMAs) based on species Quota Management Area (QMA) fishstocks, snapper in SNA 1, and tarakihi in TAR 1 and TAR 2; and mixed target deepwater fisheries HAK/HOK/LIN/SWA/WWA (hake, hoki, ling, silver warehou, and white warehou) in bycatch assessment areas (see Anderson & Edwards 2018); and OEO/ORH (oreo species and orange roughy) in the main orange roughy areas. Section 6 provides summaries of the overlap of the footprint relative to depth and the predicted distributions listed in the paragraph above. In addition, to provide a broader picture of seafloor contact, Section 7 provides a coarser representation of effort for Danish seine and shellfish dredge fishing activity in specific fishery areas. Appendices provide supporting information for each section. Lastly, Section 8 discusses data quality and its effect on the results and provides recommendations for future work.

2. METHODS

2.1 Commercial trawl footprint

The methods below describe the data exploration and grooming and the preparation for 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; and Baird & Mules (2019) using the MPI spatial software CatchMapper. For the purposes of this study, the Territorial Sea and the EEZ (TS+EEZ) form the full extent of the maritime area around New Zealand as the analysis area; and the two EEZ enclaves are also included as waters available for fishing (total area of analysis is 4 111 569 km^2). Much of this is at depths that have not been exploited by fishing activity. Bottom-contacting trawling has been conducted mainly in continental shelf waters in depths defined by the distribution of target species, generally in waters shallower than 1600 m (Baird & Wood 2018).

2.1.1 Fishery data sources

The MPI Spatial Intelligence team accessed all TCEPR, TCER, and ERS trawl effort data, and the associated vessel information, from the EDW for 1990–2018 fishing years. Data collected on TCEPRs 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 have position information for the start of the tow only which necessitates the generation of an endpoint (see Baird et al. 2015). The ERS data collect similar data to the logbook forms described above; however, the position data are collected to four decimal points of a degree and thus are at a finer resolution than the TCER and TCEPR data which are generally reported at one decimal point.

2.1.2 Fishery data grooming and treatment

A summary of the grooming of main variables and the final dataset is presented in Appendix A. Broad queries on all bottom-contacting trawl data were run by the MPI Spatial Intelligence team using R statistical package (R Core Team 2018) to isolate duplicates or missing data, following the data treatment and grooming process used by Baird et al. (2015) and Baird & Mules (2019).

Data were treated separately by form type, and the primary grooming checks, numbers of changes, and final data are described in Appendix A. Particular attention in the error checking and 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, effort width (wingspread), and depth.

The inshore component included all inshore fishstocks (Table 1) and the deepwater component included the Tier 1 and Tier 2 fishstocks (Ministry for Primary Industries 2017) (Table 2). A full summary of the inshore data used is provided in Section 3 and Section 4. For the final all inshore fishstocks dataset for 2008–18, 85% of the 561 416 bottom-contacting tows were from TCERs, 14.5% from TCEPRs, and 0.4% from ERS (see Appendix A). For the deepwater Tier 1 and Tier 2 fishstocks for 1990–2018, 95.8% of the 1 178 476 tows were reported on TCEPR, 2.5% on TCER, and 1.7% on ERS; and for the deepwater 2008–18 dataset of 310 829 tows, 84% were reported on TCEPR, 9.5% on TCER, and 6.5% on ERS.

Fisheries New Zealand requested that mixed inshore trawl fisheries, delineated by Fishery Management Areas (FMAs) 1, 2, 3, 5, 7, and 8/9 (combined), be reported on (see Section 4).

Table 1: Common and scientific names for the target species codes for inshore bottom-contacting effort during 2008–18 fishing years. Data for all target codes given below were included for the total inshore analysis and the all stocks analysis.

Code: fishstock	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
BCO	Blue cod	*Parapercis colias*
BNS	Bluenose	*Hyperoglyphe antarctica*
ELE	Elephant fish	*Callorhinus millii*
FLA	Flatfish	*Rhombosolea retiaria, R. plebeia, R. tapirina, Pelotretis flavilatus*
FRO	Frostfish	*Lepidopus caudatus*
GSH	Dark ghost shark	*Hydrolagus novaezealandiae*
GUR	Red gurnard	*Chelidonichthys kumu*
HPB	Groper	*Polyprion oxygeneios*, *Polyprion americanus*
JDO	John dory	*Zeus faber*
JMA	Jack mackerels	*Trachurus declivis*, *T. murphyi*, *T. novaezealandiae*
KAH	Kahawai	*Arripis trutta*
LEA	Leatherjacket	*Parika scaber*
LIN	Ling	*Genypterus blacodes*
MOK	Moki	*Latridopsis ciliaris*
PAD	Paddle crab	*Ovalipes catharus*
POR	Porae	*Nemadactylus douglasii*
QSC	Queen scallop	*Zygochlamys delicatula*
RCO	Red cod	*Pseudophycis bachus*
RSK	Rough skate	*Zearaja nasuta*
RSN	Red snapper	*Centroberyx affinis*
SCH	School shark	*Galeorhinus galeus*
SKI	Gemfish	*Rexea solandri*
SNA	Snapper	*Chrysophrys auratus*
SPD	Spiny dogfish	*Squalus acanthias*
SPO	Rig	*Mustelus lenticulatus*
SSK	Smooth skate	*Dipturus innominatus*
STA	Giant stargazer	*Kathetostoma giganteum*
TAR	Tarakihi	*Nemadactylus macropterus*
TRE	Trevally	*Pseudocaranx dentex*
TRU	Trumpeter	*Latris lineata*
WAR	Blue warehou	*Seriolella brama*

Table 2: Tier 1 and Tier 2 deepwater fishstocks for which there was trawl effort during fishing years 1990–2018 (see Fisheries New Zealand 2019a for delineation of fishstock areas). There was no reported effort for pale ghost shark in these data.

Code: fishstock	Common name	Scientific name
Tier 1		
HAK: all	Hake	*Merluccius australis*
HOK: all	Hoki	*Macruronus novaezelandiae*
JMA: JMA 3, JMA 7	Jack mackerels	*Trachurus declivis*, *T. murphyi*, *T. novaezealandiae*
LIN: LIN 3–LIN 7	Ling	*Genypterus blacodes*
	Oreo species	*Allocyttus niger*, *Neocyttus rhomboidalis, Pseudocyttus maculatus*
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, BAR 5, BAR7	Barracouta	*Thyrsites atun*
BYX: all	Alfonsino	*Beryx splendens*, *B. decadactylus*
CDL: all	Black cardinalfish	*Epigonus telescopus*
EMA: EMA 3, EMA 7	English mackerel	*Scomber australasicus*
FRO: FRO 3–FRO 9	Frostfish	*Lepidopus caudatus*
GSH: GSH 4–GSH 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–RIB8	Ribaldo	*Mora moro*
SKI: SKI 3, SKI 7	Gemfish	*Rexea solandri*
SPD: SPD 4, SPD 5	Spiny dogfish	*Squalus acanthias*
SPE: SPE 3–SPE 7	Sea perch	*Helicolenus percoides*
SWA: all	Silver warehou	*Seriolella punctata*
WWA: all	White warehou	*Seriolella caerulea*

2.1.3 Generation of spatial output

The trawl data have position and operational data that allow spatial analysis and presentation. However, each data type required different treatment to generate swept area estimates. TCEPR data include both start and end positions (generally to the nearest 1 minute of arc, or about 1.852 km), as do ERS data (to a finer resolution), whereas TCER have tow start positions only, at the same resolution as TCEPR data. Thus, the groomed data were treated separately 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) and Baird & Mules (2019) for TCER data.

Where latitude and longitude data were truncated to the nearest minute of arc, the start and finish positions were randomly jittered using an offset of ± 0.5 minute to better represent the start and finish positions. The jittered values were stored as new fields in the dataset. 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. However, the use of random jittering does limit the artificial patchiness of effort created by the resolution of the data.

2.1.4 Preparation for estimating swept area from TCER forms

The TCER data lack information that describes the finish location. 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 spatially describe a tow track within

a trip, a tow direction was generated from the bearing between the start position of a tow and the start of the following tow (after Baird et al. 2015). A distance measure (in kilometres) was estimated from tow speed and tow duration data and used with the estimated bearing to generate finish co-ordinates.

The median number of tows per trip in the TCER data was 4 tows (range 1–151 tows, 75th percentile at 10 tows). This means a substantial number of tows had no following tow (in a given trip). Thus, the last tows and only tows of trips were identified, and, for each of these tows, 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 2 tows. This was used to generate finish co-ordinates (as above). Where this failed, tow end co-ordinates were generated by using the median estimated bearing values from tows for the same target species within 1/30th of a degree north/south or east/west, using a minimum number of 2 tows.

2.1.5 Spatial allocation of tows

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

1. **Doorspread**. The distance between the two trawl doors is considered the best measure of the width of the trawl path 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 generic doorspread values (with agreement from the Fisheries New Zealand Aquatic Environment Working Group) to each tow, 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 are given in Table A.2 in Appendix A, based on suggested values from industry representatives and net makers in the early 2000s, using the 'number of nets' data which were first collected on the TCER and TCEPR forms in the 2008 fishing year based, where available. Data from the 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.

   Appendix A presents data on the doorspread values as recorded by observers for a variety of vessels and targets (Figure A.1). These data suggest that the generic doorspread values used in this work may be reasonable for most targets, though there is a lack of observed data on flatfish trawls – and these fishstocks comprise a large amount of the inshore data in some areas.

2. **Tow distance.** For the TCEPR and ERS data, a distance (in kilometres) for each trawl track was calculated from the groomed start and fishing positions, assuming a straight-line tow.

3. **Speed-time distance.** For TCER data (which require the estimation of a tow finish position), a second distance value was calculated for each tow; this was based on the reported tow speed and the tow duration (the difference between the reported tow start and finish times) for use with the TCER data, as described above. This method was also used for some deepwater target TCEPR tows where short tows on hills resulted in the coordinates of the start and finish data being the same.

Each tow was converted into a trackline (distance between the start and finish locations). The trawl data were imported into a Geographic Information System (GIS) using MPI's CatchMapper tool and each trackline was buffered by the assigned doorspread to produce polygons to represent the trawl path (as a straight line). Deepwater tows for scampi, arrow squid, and hake had a cut-off point at 70 km in length and tow distances for other species were truncated at 55.56 km (after Black & Tilney 2017, Baird & Mules 2019). Tows for orange roughy on underwater features were truncated following the identification of long tows on features in northern waters and the methods used by Baird & Mules (2019) in appendix A of that report; this was extended to tows in other areas.

In some regions, the trawl polygons resulted in tow tracks going across land (for example, Farewell Spit at the northwestern edge of the South Island). Each trawl polygon was clipped by the fishable area layer (see Section 2.2.2), so that no effort remained on land or in any areas closed to fishing. Thus, these removed polygon sections were not included in the swept area analysis, but the remaining sections of the tow polygons contributed to the overall swept area and seafloor contact measures (see Section 2.1.6).

2.1.6 Measures used to summarise swept area

This study used the estimated swept area for each tow (in square kilometres), hereafter referred to as the *swept area*, as measures of the fishing intensity.

1. *Swept area* is the area (square kilometres) derived from the tow distance as measured between start and finish positions and the assigned doorspread. This measure was used to summarise the effort and the total for each fishing year, referred to as the *aggregate area*.
2. *Trawl footprint* is the area (square kilometres) that represents the seafloor area estimated to have been contacted by trawl gear.

2.1.7 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 5x5 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 TS+EEZ. This grid was generated in the Albers Conic Equal Area Projection for the New Zealand EEZ and re-projected to latitude and longitude degrees to overlay with effort data as a basis for spatial analysis.

The cell grid table was joined to the effort data to create a new database table to enable the spatial overlay of the grid with the estimated doorspread-based polygons of swept area. Thus, the effort could be analysed by grid cell to identify and quantify the amount of effort per cell over time and to generate an indicative 'footprint' of trawl effort on the seafloor. For area-based calculations, the data were re-projected to the Albers Conic Equal Area projection to minimise distortions caused by converging lines of longitude with increasing latitude using degrees as the co-ordinate units. For each cell, the sum of the area of all the portions of the estimated doorspread polygons that lie within that cell was calculated. Thus, a cell in any given fishing year may have a total swept area of 0 km^2 (unfished) or 25 km^2 (swept area is similar to the cell size), or perhaps 100 km^2, suggesting that for that year, the swept area was 4 times the cell area.

2.1.8 Underlying assumptions in 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 that used bottom trawl gear or midwater gear within 1 m of the seafloor, and second, the data are restricted to three data sources: TCER (2008–18), TCEPR (1990–2018), and ERS (2018).

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 or 2008, 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 stated time series.
2. It is assumed that the tow positions represent the position of the net when it starts or ends fishing; however, the tow positions represent the locations of the vessel at the start and end of fishing. The resolution of the majority of the position data is to the nearest minute (about 1.852 km – assuming no allowance for latitudinal changes).
3. It is assumed that the paths (trackline) of all tows follow a straight line between the reported start and end positions. In reality, tows may follow contours and may include turns, but the trackline data 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 was assumed to be closer to the 'real' length of a tow.
4. It is assumed that the gear is in contact with the seafloor throughout the tow.

5. The irregular nature of the seafloor is ignored, and it is assumed that within each cell the seafloor is homogeneous.
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 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'.

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

To determine the extent of coverage of the trawl footprint on 200-m depth zones, the potential 'fishable' area, and modelled environmental classification layers, as required in the project specifications, a series of GIS layers were acquired from MPI or generated from NIWA data. These are described below. 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). Appendix B provides maps of the spatial distribution of each of the layers used in this section.

2.2.1 Depth zone

This layer was created from the 2016 NIWA bathymetry data (Mitchell et al. 2012) to yield 200-m depth zones to a maximum depth of 1600 m, the depth that is close to the depth limit of current trawling effort (see Section 2.2.2). The area (in square kilometres) of each zone was calculated using tools in ArcGIS and is provided in the footprint overlap analysis in Section 6.1. The distribution of these zones is shown in Figure B.1 in Appendix B. The depth zones are restricted to waters open to trawling.

2.2.2 'Fishable' area

The 'fishable' area represents waters in 0–1600 m depths that are open to trawling: for example, waters exclusive of Benthic Protection Areas (BPAs) that were introduced in 2007, closed areas to protect underwater features including seamounts (the first of which were closed in 2001) and undersea cables and pipelines, marine farms, and marine reserves (for example, around the Auckland Islands group) (see Figure B.1). The area covered by the fishable area was calculated as 1 391 680 km^2, based on the equal area projection described above.

2.2.3 Benthic-optimised marine environment classification (BOMEC)

This layer comprises 15 classes that represent different environments generated from modelling the relationships between the distributions of relevant environmental variables to discriminate the distributions for eight taxonomic groups of benthic fish and invertebrates (Leathwick et al. 2012). The classification broadly describes three inshore classes (A, B, D), three shelf classes (C, E, F), and nine classes in deeper waters down to 3000 m (G–O) (see Figure B.1). Thus, it extends beyond the depths where trawling normally occurs. The area (in square kilometres) of each class was calculated, as above, and these areas are given in the footprint overlap analysis in Section 6.2.

2.2.4 Surficial sediment distribution

Sediment analyses and observations from a comprehensive range of sources were collated into a database nzSEABED to characterise and map the surficial sediments of the New Zealand continental shelf, slope, and deep ocean by Bostock et al. (2019a, 2019b). The data were interpolated using kriging in GIS to yield percent mud, sand, and gravel (to total 100% for each category) and carbonate content (% carbonate versus non-carbonate) to provide information about biological content. The distributions of these substrates are shown in Figure B.2 in Appendix B.

2.2.5 Inshore voluntary closures

Spatial layers for four voluntary closure areas around the South Island (shown in Figure B.3 in Appendix B) were provided by Fisheries New Zealand for investigation of any overlap of the 2008–

2018 inshore trawl footprint. Two voluntary closures are in the inshore waters of Tasman Bay-Golden Bay at the north of the South Island. The Farewell Spit voluntary closure to all fishing methods, effective from 1 January 2008, is in place to protect rig and the Tasman Bay voluntary closure to all trawling during 30 November-30 April is in place for snapper. The elephant fish voluntary closure to all trawling in a 1 n. mile wide strip of shallow water in the Canterbury Bight has been in place since 1 January 1995. The Otago voluntary closure to trawling, shellfish dredging, and Danish seining off the Otago coast was put in place to protect a sensitive seafloor area of Bryozoan beds, effective from 1 January 2002.

2.2.6 Probability of capture/annual distribution for the Tier 1 target species

For the seven fish target species in the deepwater Tier 1 group of fishstocks, Leathwick et al. (2006) predicted the distribution of the probability of capture during a standardised trawl in waters to a maximum depth of 1950 m within the outer EEZ boundary, based on presence/absence data and relevant modelled environmental variables (Figures B.4a and B.4b in Appendix B, see Section 6.5). For scampi and arrow squid, the annual distributions of the populations as mapped by MPI (www.nabis.govt.nz) are used as a proxy for the species distribution (see Figure B.4c). The arrow squid and scampi areas match the extent of the TS+EEZ; the areas of unknown presence, hotspot, and 90% and 100% annual distribution for arrow squid and scampi were calculated, as above.

2.3 Danish seine and shellfish dredge data

Data extracts were requested from MPI for fishing effort with the method codes of 'DS' for Danish seine sets for a variety of fish species and 'D' for dredge tows for scallop (*Pecten novaezelandiae*) and for oyster (*Ostrea chilensis*), for fishing years 1990–2018. This effort was recorded on CELRs and represents the daily effort of a vessel by target and area fished. The main grooming of these data was aimed at the fishery-specific statistical area data and the number of tows reported for each day of fishing and this is reported more fully in Section 7.0. The data summaries for these fishing methods use the numbers of Danish seine sets and shellfish dredge tows for each relevant fishery area, as reported in Section 7.0 and associated appendices.

3. COMMERCIAL TRAWLING ON OR NEAR THE SEAFLOOR, FOR ALL STOCKS DURING 2008–2018

This section gives an overall summary of bottom contact from inshore and deepwater trawl effort for the years for which data were available for both inshore and deepwater fishstocks: that is, 2008–2018. Overall summaries of the number of tows, estimated aggregate swept area and trawl footprint, and the distribution of the swept area measures by 25-km^2 cell are provided below; these are based on all stocks with bottom contact (i.e., the combined inshore and deepwater fishstocks) for 2008–2018. The underlying data summaries for all stocks are given in Appendix C, by inshore and deepwater groups.

3.1 Number of bottom-contacting tows

Overall, 872 245 tows were included in the dataset for the 2008–2018 all stocks spatial analyses, with 64% from inshore fishstocks (annual range 60–67%), 31% from deepwater Tier 1 fishstocks (29–34%), and 5% from deepwater Tier 2 fishstocks (4–6%) (Table 3). The number of tows in each fishing year decreased over the time series, from a peak in 2010 (89 673 tows) to a low in 2018 (70 513 tows); the greatest influence in annual change was from the inshore effort. Effort dropped from 51 662 tows in 2008 to 42 902 tows in 2018 for the inshore fishstocks; from 28 810 tows in 2008 to 24 955 tows in 2018 for the deepwater Tier 1 fishstocks; and from 5180 tows in 2008 to 2656 tows in 2018 for the deepwater Tier 2 fishstocks.

Table 3: The total number of bottom-contacting tows for the all stocks dataset for the spatial analysis, by fishing year for 2008–2018.

Fishing year	Inshore	Deepwater		Total
		Tier 1	Tier 2	
2008	51 662	28 810	5 180	85 652
2009	53 210	25 511	4 292	83 013
2010	59 070	26 495	4 108	89 673
2011	54 006	24 494	3 820	82 320
2012	53 243	23 731	3 547	80 521
2013	53 767	22 883	3 055	79 705
2014	53 300	23 521	3 441	80 262
2015	46 992	23 469	3 264	73 725
2016	46 166	24 196	2 952	73 314
2017	47 098	23 597	2 852	73 547
2018	42 902	24 955	2 656	70 513
All	561 416	271 662	39 167	872 245

3.2 Trawl footprint area, 2008–2018

From 2008 onwards, the data represent the effort of both the inshore small vessels and the offshore larger vessels. Thus, the coverage of the footprint extends from shallow coastal waters to trawlable depths of about 1600 m (Figure 1).

The total trawl footprint area for the 11 years analysed for all bottom-contacting fishstocks in the TS+EEZ was about 295 000 km^2; this footprint contacted 7.2% of the TS+EEZ seafloor area (2.1–2.4% annually) and 21.2% of the fishable area (6.4–7.0% annually) (Table 4). The total annual trawl footprint shows a slight decrease from about 96 000 km^2 in 2008 to 89 000 km^2 in 2018. The extents of the annual footprints for deepwater Tier 1 fishstocks and inshore fishstocks are similar in most years and show no real trends, generally at about 41 000–46 000 km^2. The deepwater Tier 2 fishstock footprint declined from about 9000 km^2 in 2008 to about 5000 km^2 in 2018.

3.3 Aggregate swept area, 2008–2018

The total aggregate swept area was estimated for all fishstocks in the TS+EEZ at about 1 747 000 km^2, and the annual aggregate swept area for 2018 was about 162 500 km^2 (Table 4). The 2018 aggregate area shows a decrease from the annual peak of about 170 000 km^2 in 2010 but is the largest estimate since 2011 and is similar to that for 2008. In the 2010 fishing year, the aggregate area was estimated at about 78 500 km^2 for the inshore effort and 91 500 km^2 for the combined deepwater fishstocks (Table 4). In 2018, the aggregate area for the inshore effort was the lowest estimate in the 11 fishing years, at about 63 800 km^2, and that for the combined deepwater fishstocks was the highest estimate, at 98 300 km^2. The distribution of the 2008–2018 and 2018 aggregate area for all stocks is shown in Figure 2.

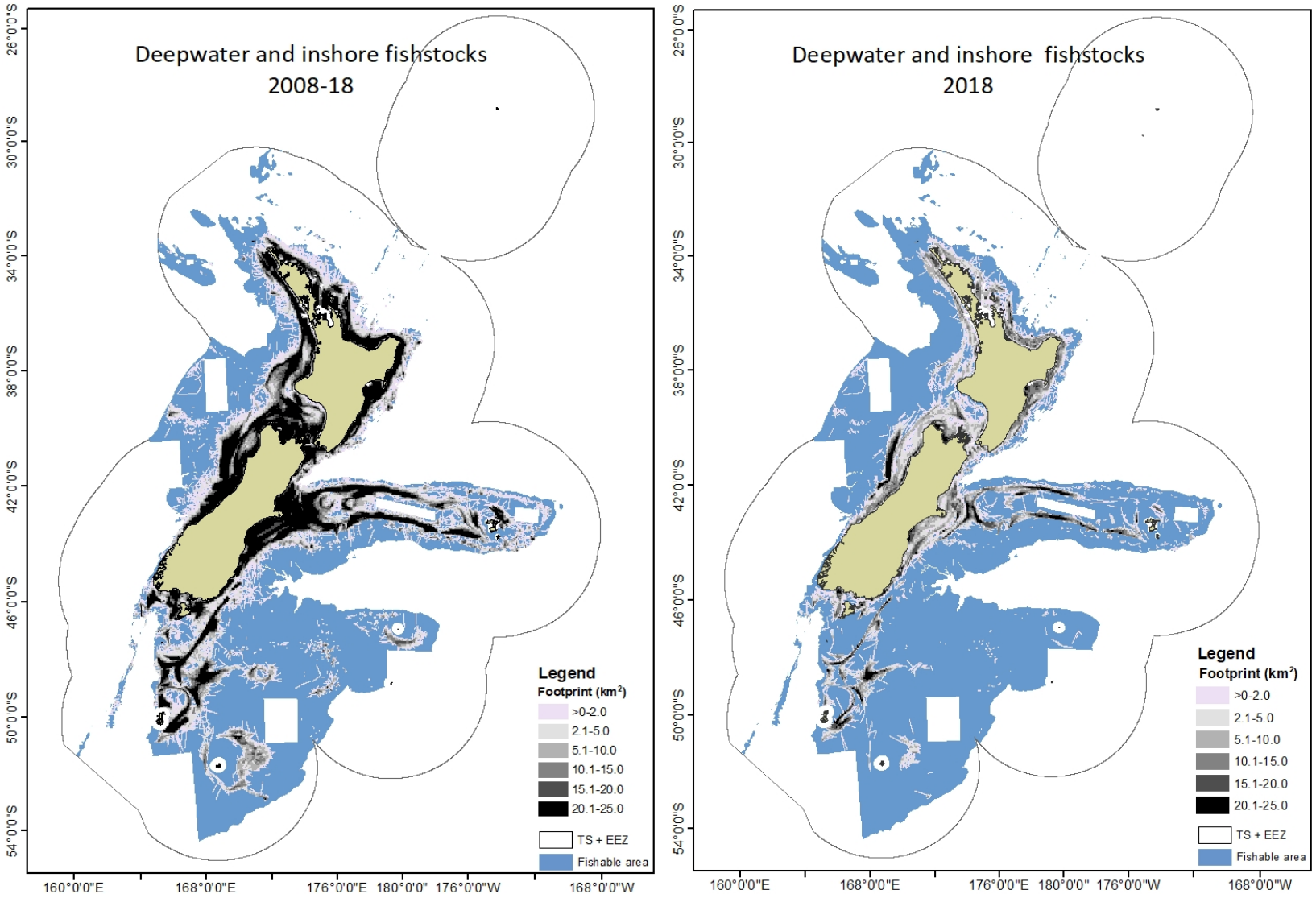

Figure 1: Distribution of the total all stocks bottom-contacting trawl footprint (km^2) per 25-km^2 cell, estimated from all inshore, deepwater Tier 1, and deepwater Tier 2 fishstocks, for fishing years 2008–2018 (left) and 2018 (right).

Table 4: Number of 25-km^2 cells that were contacted, aggregate area, and trawl footprint estimated for the deepwater Tier 1 and Tier 2 fishstocks, all inshore fishstocks, and all fishstocks combined, and the proportion of the combined TS+EEZ (4 111 569 km^2) ('EEZ') and the fishable area ('Fish') (1 391 680 km^2) contacted by the total annual footprint, for fishing years 2008–2018. Note: the footprints of each of the three groups will have some overlap; the total footprint was estimated for all fishstocks combined.

Fish	Number 25-km^2 cells contacted				Aggregate area (km^2)				Footprint (km^2)				EEZ	Fish
year	Tier 1	Tier 2	Inshore	Total	Tier 1	Tier 2	Inshore	Total	Tier 1	Tier 2	Inshore	Total	(%)	(%)
2008	11 407	5 100	9 600	19 072	78 800.6	11 511.8	72 154.6	162 561.9	44 903.9	9 213.4	45 299.9	95 771.8	2.3	6.9
2009	10 611	4 067	9 997	18 745	72 535.4	9 296.2	76 083.0	158 020.1	40 417.8	7 376.0	47 813.7	92 611.9	2.3	6.7
2010	11 026	4 264	9 818	18 621	83 957.9	7 481.5	78 474.6	170 043.5	45 588.7	6 488.2	48 198.2	97 209.8	2.4	7.0
2011	10 418	4 369	9 757	18 241	85 252.4	7 747.7	71 333.2	164 424.6	45 247.1	6 651.4	46 020.4	94 878.5	2.3	6.8
2012	9 718	3 836	9 456	17 512	83 253.2	6 637.2	68 856.6	158 831.2	43 405.8	5 747.0	44 066.0	90 523.6	2.2	6.5
2013	9 163	3 577	9 377	16 715	76 857.3	7 356.7	68 556.9	152 849.6	41 222.5	6 111.2	43 951.8	88 399.6	2.2	6.4
2014	9 611	4 134	9 609	17 527	78 626.7	7 435.7	71 965.1	158 140.4	43 752.8	6 214.1	46 122.3	92 977.2	2.3	6.7
2015	9 619	3 641	9 635	17 513	80 683.4	7 388.2	65 634.8	153 853.4	43 879.6	5 741.7	43 223.5	90 451.5	2.2	6.5
2016	9 546	3 687	9 537	17 504	78 856.6	5 853.2	64 219.3	149 062.9	41 694.2	5 015.7	42 179.6	86 879.0	2.1	6.2
2017	9 518	3 593	9 749	17 561	82 748.4	6 406.6	67 478.0	156 732.2	41 353.2	5 114.1	43 863.1	88 035.3	2.1	6.3
2018	9 363	3 161	9 356	17 067	92 622.3	5 885.3	63 852.3	162 474.3	43 215.4	4 748.0	43 145.4	89 027.7	2.2	6.4
Total	22 606	11 122	15 266	30 279	894 193.9	83 000.1	768 608.4	1 746 994.0	152 412.6	43 264.8	147 896.1	294 912.9	7.2	21.2

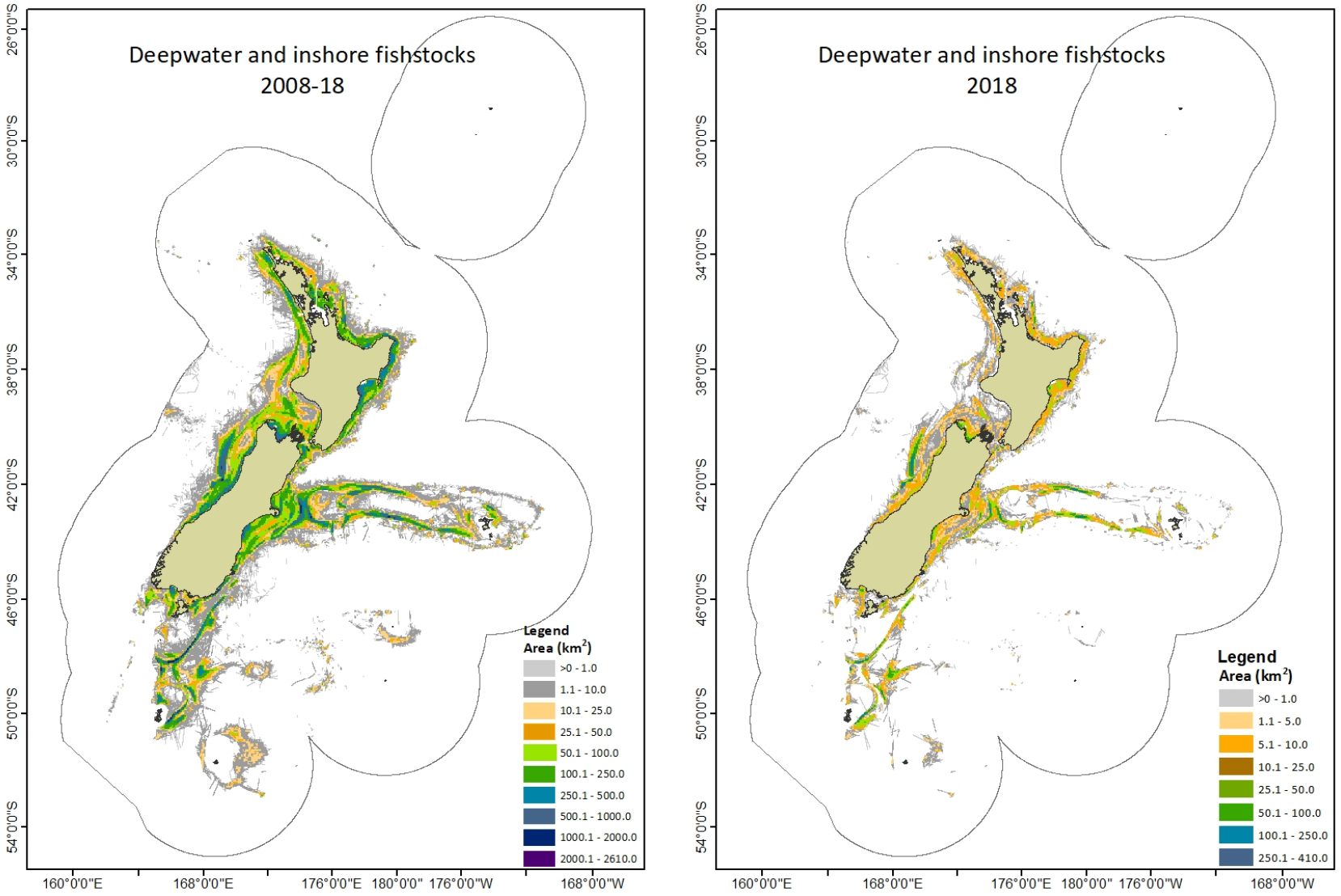

Figure 2: Distribution of the total all stocks bottom-contacting aggregate area (km^2) per 25-km^2 cell, estimated from all inshore, deepwater Tier 1, and deepwater Tier 2 fishstocks, for fishing years 2008–2018 (left) and 2018 (right).

3.4 Number of cells contacted

Overall, 30 279 25-km^2 cells were contacted by commercial trawls for all stocks during 2008–2018 in the TS+EEZ waters (see Table 4). There was a decrease in the annual number of contacted cells, from a peak in 2008 of 19 018 cells (with a low in 2013 when 16 653 cells were contacted) to 16 918 cells in 2018.

Figure 3 shows the annual numbers of cells and indicates the relative numbers of cells, within each fishing year, binned by the intensity of fishing within each cell, as measured by the aggregate area of each cell in that fishing year. An aggregate area of 25 km^2 is equivalent to the area of each cell. There were similar proportions of cells in each year for the bins with aggregate areas up to 25 km^2 (5000–6000 cells in each group). About 1500–1780 cells a year (9–10%) had aggregate areas of 25–100 km^2 and 45–132 cells (< 1%) had over 100 km^2 of aggregate area per cell (the largest number was in 2018).

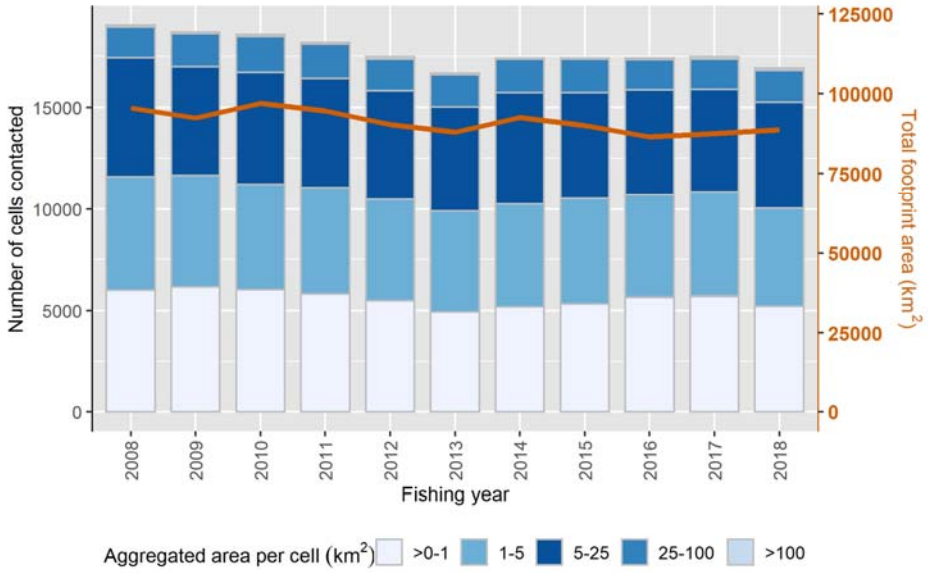

Figure 3: Number of cells with trawl contact (binned by the annual aggregate area (km^2) per cell) for combined inshore and deepwater Tier 1 and Tier 2 trawl fishstocks (bars), and the total trawl footprint (km^2) (line), by fishing year for 2008–2018.

3.5 Number of years a 25-km^2 cell was contacted, 2008–2018

About 34% of all cells contacted during 2008–2018 had bottom-contacting trawling each year (Table 5), and 17% had contact in only one year. The spatial distribution of the number of years fished per cell is shown in Figure 4. Cells with contact in one or two years tend to be on the outskirts of the main inshore and deepwater trawling areas in which trawling occurred in most years.

For any one year, the percentage of cells contacted in that year, but not the previous two years (that is, left fallow for two years), decreased from over 10% in 2010 to about 5% in the following years (Figure 5). Under 10% of annual cells in 2013–18 were not contacted by trawl gear in the previous five years.

Table 5: The number of cells contacted by all inshore and deepwater trawl fishstocks during 2008–2018, and the percentage of the total number of cells, by the number of years with contact.

	Number of years a cell had contact											
	1	2	3	4	5	6	7	8	9	10	11	All
No. cells	5 178	2 926	2 230	1 848	1 558	1 390	1 170	1 059	1 195	1 556	10 169	30 279
%	17.1	9.7	7.4	6.1	5.1	4.6	3.9	3.5	3.9	5.1	33.6	100.0

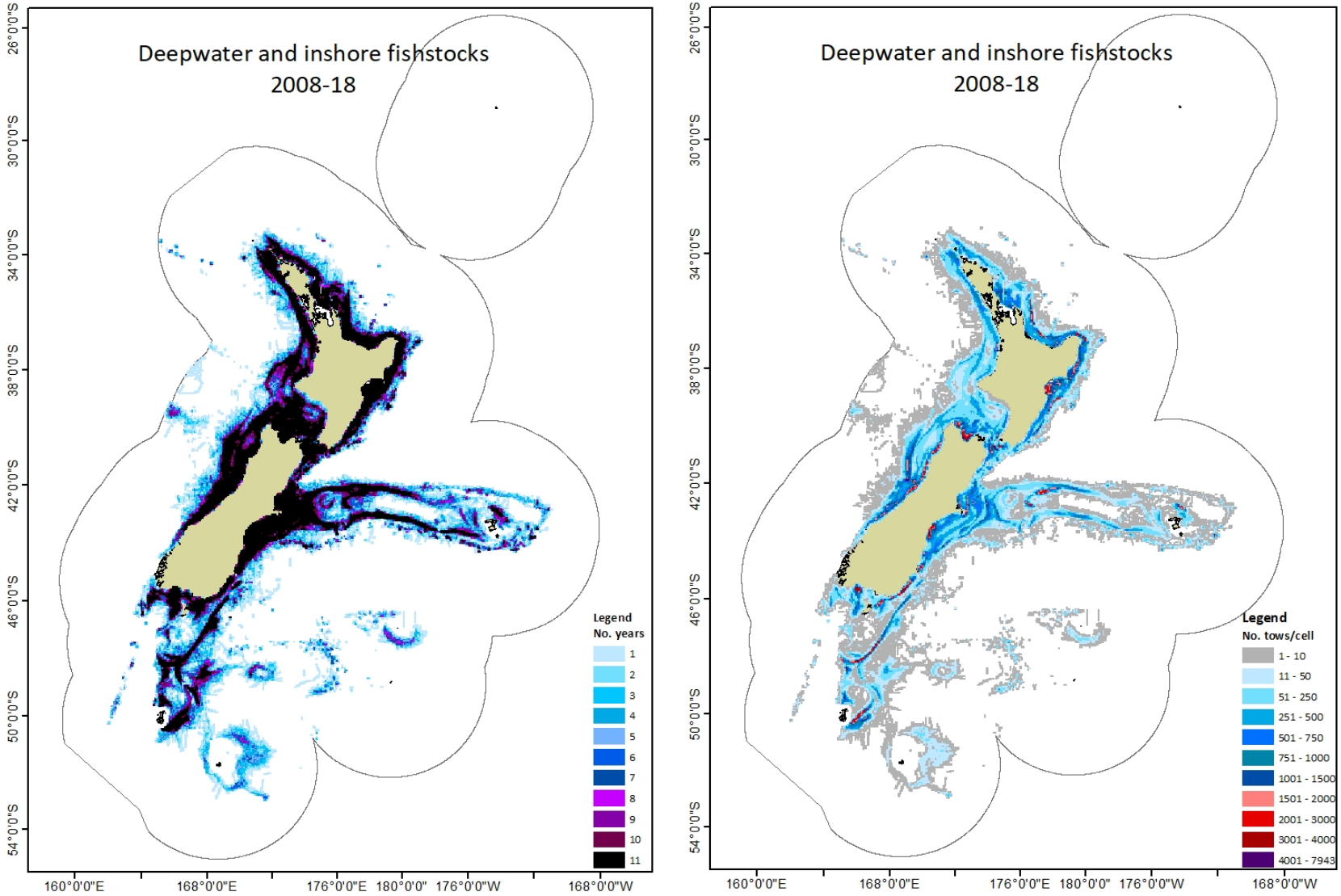

Figure 4: Distribution of the number of years each cell was contacted by trawling (left) and of the number of tows per 25-km^2 cell (right) for the combined inshore and deepwater fishstocks, 2008–2018.

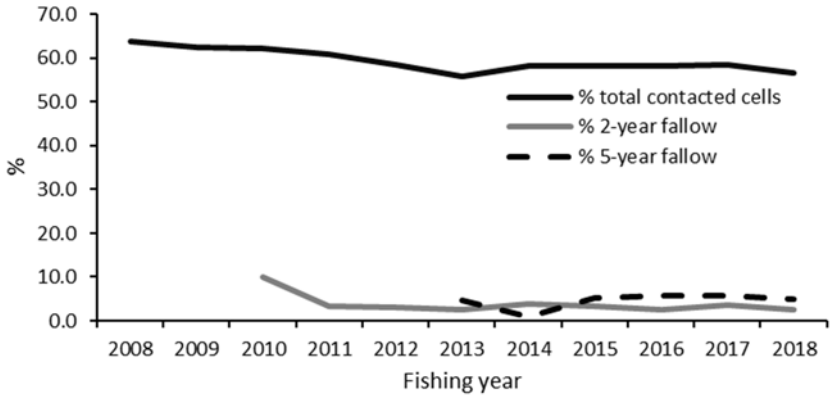

Figure 5: Percentage of the total number of contacted cells (30 279 cells during 2008–2018) with at least 1 trawl in each year (black line), and the percentage of the contacted cells in each year that was fallow (not contacted) for the previous 2 years (grey line) and previous 5 years (dashed line).

3.6 Intensity of tows in contacted cells, 2008–2018

About 11% of all cells had one tow per cell (effectively this means one part of a tow, given that tows cross at least one cell), 38% had up to 9 tows per cell, and 90% of cells had up to 500 tows per cell (Figure 6). The spatial distribution of these data is shown in Figure 4. About 300 cells during 2008–2018 were contacted by over 2000 tows and this effort represented concentrated patches of effort for shallow inshore fishstocks around the coastline and for deepwater fishstocks in the Bay of Plenty, Stewart-Snares shelf, Auckland Islands Shelf, and the Hokitika Canyon off the South Island west coast.

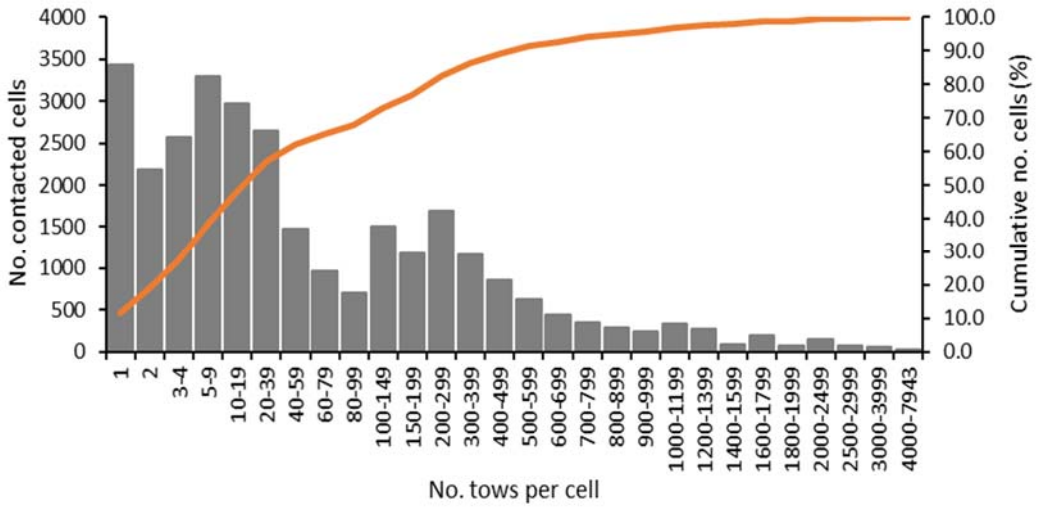

Figure 6: Number of tows per contacted cell, all stocks and all fishing years 2008–2018 combined.

4. COMMERCIAL TRAWLING ON OR NEAR THE SEAFLOOR, FOR INSHORE FISHSTOCKS DURING 2008–2018

The annual numbers of bottom-contacting inshore tows, for 2008–2018, and the annual aggregate areas and footprint areas are given in Tables 3 and 4. The extents of the total aggregate and footprint areas are shown in Figures 7 and 8. The underlying tow data are provided in Tables C.1–C.3 in Appendix C.

The number of inshore vessels with bottom-contacting tows decreased over the 11 years, from over 200 in 2008 to 152 vessels in 2018 (Table C.2). Most annual tows were reported on the TCER forms (85% overall, with annual range of 83–87%). The number reported on TCEPR forms has decreased and in 2018 there was a small representation of the ERS data collection from target tows mainly for barracouta, red gurnard, snapper, tarakihi, and trevally.

Over the 11 years of TCER data, the annual numbers of tows have decreased, from the peak in 2010 of over 59 000 tows to about 42 900 tows in 2018. These totals are higher than for the deepwater bottom-contacting effort, with the inshore annual totals about twice that for deepwater fishstocks in five of the 11 years (see Table 3). However, the spread of the effort, as measured by footprint, is similar to that seen for the deepwater Tier 1 targets, ranging between about 42 200 km^2 and 48 200 km^2 (see Table 4). The smaller size of the inshore gear resulted in smaller annual estimated totals for aggregate area compared with the deepwater Tier 1 fishstocks: in the 2018 fishing year, the numbers of contacted cells and footprint areas for inshore targets was almost identical to those for Tier 1 fishstocks, but the aggregate area for the Tier 1 fishstocks was 45% larger than the inshore aggregate area.

The spatial distributions of the 2008–2018 and 2018 total inshore aggregate area and footprint area by 25-km^2 cell are shown in Figures 7 and 8, respectively. Generally, the densest spread of swept area is close inshore where vessels fish the shallower depths of the continental shelf. Higher intensity is shown in FMA 1 in the Hauraki Gulf and Bay of Plenty; around East Cape and down the coast, including Hawke Bay, in FMA 2; Canterbury Bight and off Otago in FMA 3; southern coast in FMA 5; off the South Island west coast and Tasman and Golden bays in FMA 7; and waters north of Taranaki Bight in FMAs 8/9. The aggregate area and footprint area in FMA 4 indicate relatively low effort in comparison with bottom-contacting trawling around the main New Zealand islands.

The summary below is for the FMA-based mixed trawl fisheries as defined by the inshore fishstocks in each of the relevant FMAs (see Table 6). These FMA-based tows represent 98% of all inshore bottom-contacting tows in inshore waters and, ultimately, 97.5% of the total inshore aggregate swept area and 97% of the total inshore trawl footprint. The mixed trawl fishery groups were for all FMAs except for FMA 4, FMA 6, and FMA 10; the latter two are well offshore and most of the effort from these excluded FMAs was from FMA 4, close to the Chatham Islands (for example, in SPO 4 and TAR 4—see Table C.3). Fishstock areas are shown by target in the annual Fisheries New Zealand plenary reports (for example, see Fisheries New Zealand 2019a). A total of 3715 tows in FMA 4 were not included in the summaries below (see Table C.3); these tows were mainly in waters around the Chatham Islands. Another 8158 tows were not included because their targets were not listed for inclusion in the FMA-based mixed trawl fisheries: blue cod, bluenose, frostfish, dark ghost shark, hāpuku/bass, jack mackerels, ling, paddle crab, porae, queen scallops, red snapper, and trumpeter (see Table C.3).

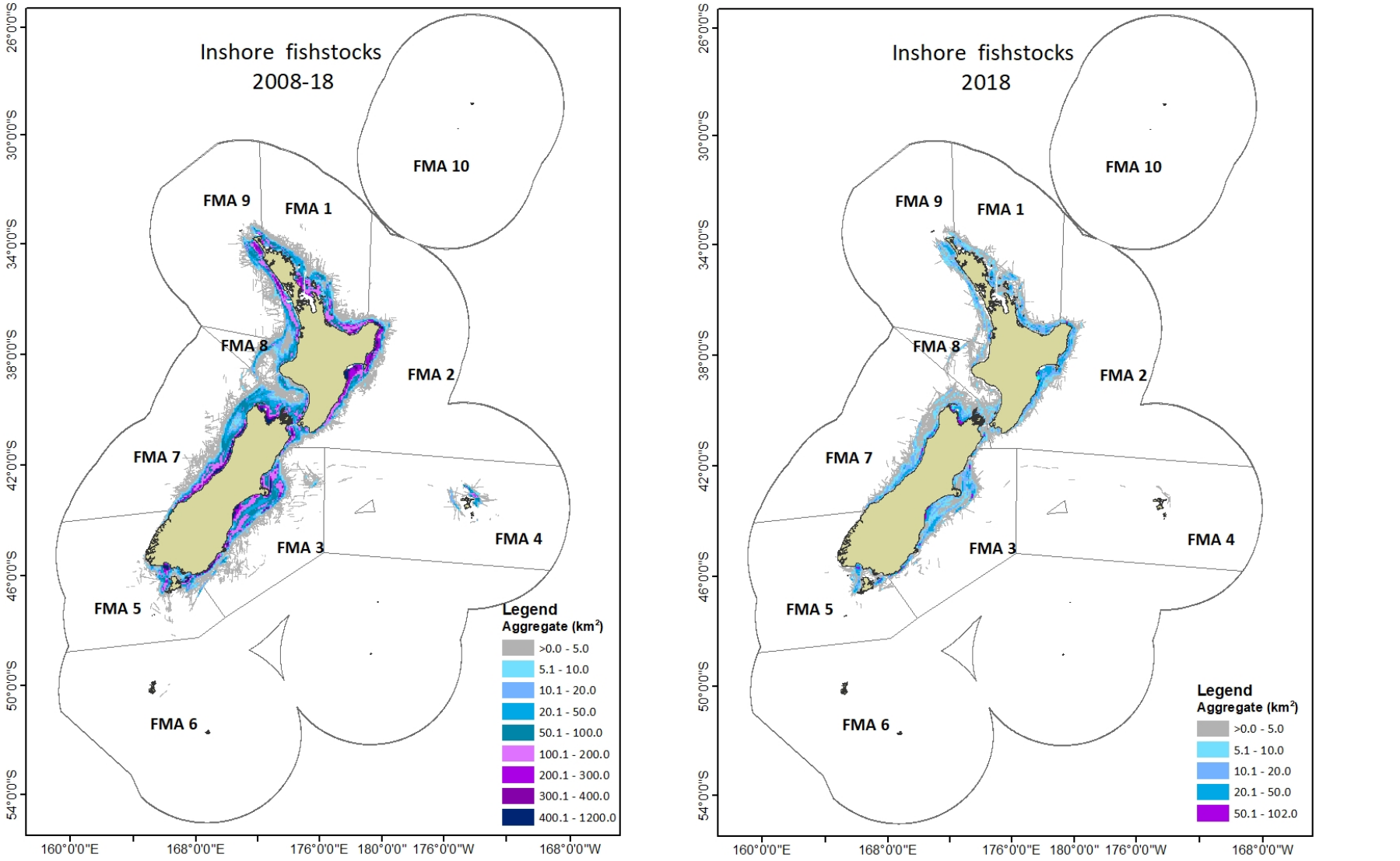

Figure 7: Distribution of the total 2008–2018 aggregate swept area (left) and the 2018 aggregate area (right), of each contacted cell, for all inshore fisheries. The FMAs 1–10 are indicated by grey lines within the TS+EEZ.

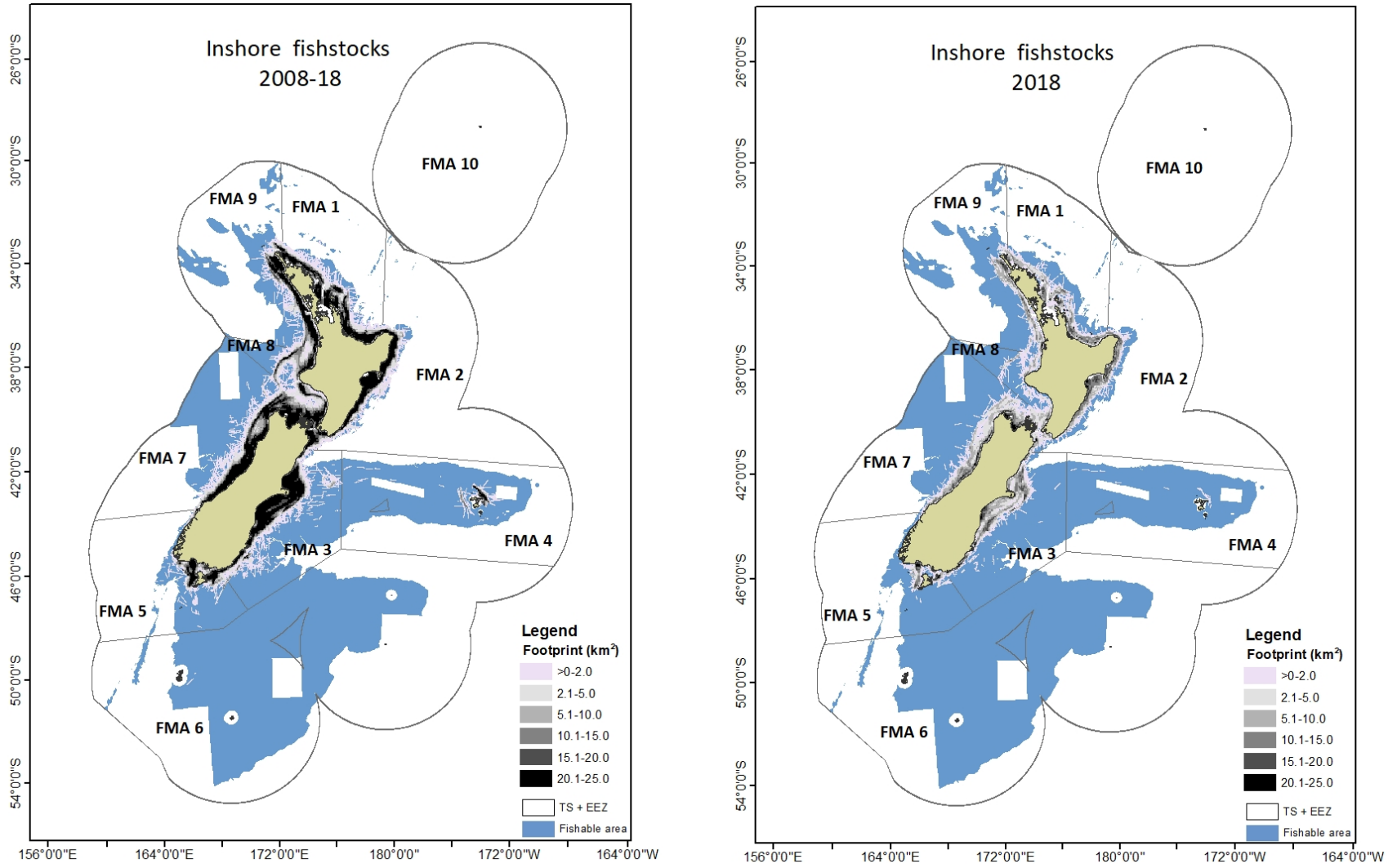

Figure 8: **Distribution of the 2008–2018 footprint (left) and the 2018 footprint (right), of each contacted cell, for all inshore fisheries. Note that 25 km^2 footprint per cell is equivalent to 100% contact in a cell, and 5 km^2 footprint per cell is equivalent to 20% contact, et cetera. The FMAs 1–10 are indicated by grey lines within the TS+EEZ.**

4.1 Inshore FMA-based mixed trawl fishery groups, 2008–2018

The QMA fishstocks included in this analysis are given in Table 6, by FMA group based on at least one tow reported in a relevant FMA. The results of analyses based on the inshore fishstocks included in FMAs 1, 2, 3, 5, 7, and 8/9 (see Figure 7 for FMA boundaries and Table 6 for the fishstocks included in the FMA-based groups) are presented in Appendix C (the number of tows with bottom contact), in Appendix D (the spatial coverage), and in Appendix E (the cell analyses). Overall, these data represent 69 fishstocks within the 6 FMA groups. The summary data for the FMA-based inshore fishstocks in the analysis years of 2008–2018 are given in Tables C.3 and C.4. Separate summaries required for SNA 1, TAR 1, and TAR 2 fishstocks are given in Section 4.4.

Table 6: Fishstock codes for inshore target species included in FMA-based mixed trawl fishery groups.

Code: fishstock	FMA 1	FMA 2	FMA 3	FMA 5	FMA 7	FMA 8/9
BAR 1	X	X	X			
ELE 3, 5, 7			X	X	X	
FLA 1, 2, 3, 7	X	X	X	X	X	X
GUR 1, 2, 3, 7, 8	X	X	X	X	X	X
JDO 1, 2, 3, 7	X	X		X	X	X
KAH 1, 2, 3, 8	X	X		X	X	X
LEA 1, 2, 3	X	X	X	X	X	X
MOK 1, 3	X	X		X	X	X
RCO 2, 3, 7		X	X	X	X	
RSK 3, 7			X			
SCH 1, 2, 3, 5, 7, 8	X	X	X	X	X	X
SKI 1, 2	X	X				
SNA 1, 2, 3, 7, 8	X	X	X	X	X	X
SPD 1, 3, 7		X	X		X	
SPO 2, 8		X				X
SSK 3			X			
STA 2, 3, 5, 7		X	X	X	X	
TAR 1, 2, 3, 5, 7, 8	X	X	X	X	X	X
TRE 1, 2, 3, 7	X	X	X		X	X
WAR 1, 2, 3, 7, 8	X	X	X	X	X	X

4.1.1 The annual number of tows

A total of 549 625 bottom-contacting tows were included in the 2008–2018 dataset used to estimate the extent and intensity of bottom contacting trawl effort by each of the mixed inshore trawl fisheries (defined by FMA). About 32% of the retained tows were for flatfish species, 23% for tarakihi, 12.5% for red gurnard, 7.5% for snapper, 6% for trevally, and 5% for red cod (Table C.4).

The number of mixed trawl fishery tows peaked in 2010 at about 57 500 tows and remained at 52 000–52 600 tows a year until numbers dropped in 2015 to under 47 000, with about 42 000 tows included in 2018 (Tables 7 and C.4). FMA 3 and FMA 7 had the largest numbers of tows (each accounting for about 25% of the total tows).

4.1.2 The aggregate area and the footprint area

The overall aggregate swept area for FMA-based inshore fisheries was about 750 000 km^2 for 2008–2018, and the total footprint area was about 143 000 km^2 (Table 7). The aggregate swept area peaked in 2010 at about 76 000 km^2, then followed a decreasing trend to its lowest estimate of about 62 700 km^2 in 2018.The trawl footprint area peaked in 2009 at about 46 400 km^2 with a low of about 41 500 km^2 in 2016. The estimated aggregate area for each FMA is provided by target and fishing year in Figure D.1 and Tables D.1–D.6. Figure D.1 also shows the FMA annual footprint. The trawl footprint for each FMA target and fishing year is provided in Figure D.2 and Tables D.7–D.12.

Table 7: Annual summary statistics for the FMA-based inshore trawl fishstocks: the number of bottom-contacting tows, the number of cells contacted, the aggregate swept area, and the trawl footprint, for fishing years 2008–2018.

Fishing year	No. tows	No. cells	Aggregated swept area (km^2)	Footprint area (km^2)
2008	50 493	9 201	69 812.7	43 783.9
2009	51 899	9 743	74 131.7	46 421.7
2010	57 488	9 394	75 898.7	46 389.3
2011	52 591	9 483	69 156.3	44 750.7
2012	52 367	9 302	67 730.1	43 446.5
2013	52 513	9 223	67 236.2	43 179.9
2014	52 084	9 349	69 572.8	44 623.1
2015	46 130	9 365	63 928.0	42 042.4
2016	45 594	9 396	63 249.7	41 506.5
2017	46 300	9 512	65 973.3	42 806.4
2018	42 166	9 160	62 679.9	42 325.1
2008–2018	549 625	14 764	749 369.2	143 189.6

4.2 Summary by FMA group

4.2.1 FMA1 mixed inshore trawl fishery

The aggregate area for FMA 1 accounted for 13% of the total inshore aggregate area. Over the 11 fishing years the aggregate swept area decreased from about 9000–10 300 km^2 before 2012 to 7200–8200 km^2 until 2017 and 2018 when estimated areas were about 9000 km^2. Tarakihi and snapper were the main contributors, then trevally and John dory (Table D1, Figure D.1).

The FMA 1 footprint followed the trend seen in the aggregate area for 2008–2018 (see Figure D.1); annual footprint areas ranged between 5200 and 7000 km^2 (Table D.7). Overall, the fishstocks in FMA 1 accounted for 15% of the total inshore footprint for 2008–2018. The footprint by target is shown in Figure D.2. Annual footprints for SNA 1 and TAR 1 were about 2000–2500 km^2 in most years. The SNA 1 footprint declined steadily until 2018 when it increased to a similar level estimated for the peak in 2009 (Table D.7). The TAR 1 footprint dropped to 1500 km^2 in 2013, then increased to over 2000 km^2 in subsequent years, peaking at 2900 km^2 in 2017.

For the remaining fishstocks in FMA 1, the TRE 1 footprint increased slightly whereas footprints for JDO 1 and GUR 1 declined over the 11 years, SKI 1 was reasonably steady until 2015, and BAR 1 and LEA 1 had minimal footprint areas (Figure D.2, Table D.7).

4.2.2 FMA 2 mixed inshore trawl fishery

About 18.5% of the 2008–2018 total inshore aggregate area was from FMA 2, and over half of the FMA 2 total swept area was from TAR 2 (Table D.2). The annual aggregate swept area decreased from a peak of 15 700 km^2 in 2011 to a low of 10 700 km^2. This decline is primarily a result of the decrease in the TAR 2 aggregate swept area from about 9000 km^2 in 2009 to 5600 km^2 in 2018 (Table D.2, Figure D.1). The aggregate swept area of the other main fishstock, GUR 2, remained relatively steady at about 3300–4000 km^2 after a peak of 6000 km^2 in 2010.

The FMA 2 footprint declined slightly over the time series, from a steady period of over 8000 km^2 for 2008–2011 to generally close to 7000 km^2 for 2012–18 (Figure D.1, Table D.8). This FMA accounted for 13% of the 2008–2018 total inshore footprint. The TAR 2 fishstock accounted for 80% of the FMA 2 footprint (Table D.8, Figure D.2). After a decline in footprint area between 2009 and 2011, the TAR 2 footprint was relatively steady at 4000–4600 km^2 during the remaining years. The GUR 2 footprint peaked at 3700 km^2 in 2010 then showed a gradual decline to 2400 km^2 in 2018. The remaining fishstocks with contact most years showed little annual variation, though BAR 1, MOK 1, and SKI 2 showed small increases in recent years.

4.2.3 FMA 3 mixed inshore trawl fishery

The eleven fishstocks in FMA 3 together contributed to 21% of the 2008–2018 total inshore aggregate area. The aggregate area was estimated at 14 000–17000 km^2 in most years (Table D.3, Figure D.1). The fishstocks FLA 3, BAR 1, TAR 3, and RCO 3 accounted for 84% of the 2008–2018 of the FMA 3 aggregate swept area. The annual swept area for FLA 3 increased to a peak at 6700 km^2 in 2013 then decreased to about 4100 km^2 in 2018. The BAR 1 swept area increased over the times series from under 2000 km^2 to a peak of 4300 km^2 in 2018. A slight increase in recent years was seen for TAR 3, whereas RCO 3 showed a decrease. Increases were also seen for GUR 3, RSK 3, and STA 3. Annual swept areas for ELE 3 and WAR 3 were reasonably steady. There were no data for SPD 3 after 2015 and minimal data for SSK 3.

There was no trend in the 2008–2018 FMA 3 footprint (range 8000–10 1000 km^2) (Figure D.1, Table D.9) which accounted for 20% of the total inshore footprint. Although the aggregate swept area for FLA 3 was over twice that estimated for BAR 1 and TAR 3, the 2008–2018 footprint for FLA 3 was equivalent to about 78% of that for those fishstocks and was similar to the footprint for RCO 3 (see Figure D.2). The FLA 3 annual footprint generally increased to 2013 (to 3350 km^2), then decreased over the following years to 2240 km^2 in 2018.

The TAR 3 footprint showed a slight increase in footprint (range 1600–2500 km^2), and the BAR 1 footprint increased slightly over the years to about 2000 km^2 before a larger increase in 2017 and 2018. A decreasing trend was seen for the RCO 3 footprint from about 1900 km^2 in 2008–09 until a spike in 2014 (2000 km^2) followed by a drop in subsequent years (range 800–1200 km^2).

Increases in annual footprints of other fishstocks over the times series were seen for GUR 3 and RSK 3; a decrease was seen for SPD 3; and the ELE 3, STA 3, and WAR 3 footprints were stable across the years.

4.2.4 FMA 5 mixed inshore trawl fishery

The FMA 5 fishstocks accounted for 6% of the total inshore aggregate area for 2008–2018, and the main fishstocks here were FLA 3 and STA 3 (Table D.4, Figure D.1), together being 83% of the 2008–2018 FMA 5 aggregate area total. Annual aggregate areas increased from 3300–3700 km^2 during 2008–2011 to over 4500 km^2 in 2012–2014, about 4000 km^2 in 2015–2017, to 3600 km^2 in 2018. Both FLA 3 and WAR 3 were the main contributors to the mid-period increase.

Annual aggregate areas were estimated at 1700–2500 km^2 for most years in FLA 3, with a peak in 2017 at 2500 km^2 before a drop in 2018 to 1700 km^2. For STA 5, the swept areas were generally between 1100 and 1600 km^2, except for in 2017 (840 km^2). The annual aggregate areas of the other main fishstock, WAR 3, steadily increased to peaks in 2012 (655 km^2) and 2014 (560 km^2), and then decreased in 2018 (to 135 km^2). Annual swept areas for GUR 3 and TAR 5 were inconsistent throughout the time series, with increases in recent years, and the relatively small swept areas for ELE 3 also increased in more recent years.

The FMA 5 trawl footprint for 2008–2018 was equivalent to 5.5% of the total inshore footprint and was consistent in its annual coverage, at 2000–2600 km^2, with over 2500 km^2 during 2012–16 (Table D.10, Figure D.1). The FLA 3 and STA 5 footprints showed no real trends, and the main contributors to the larger annual footprints were FLA 3, STA 5, and WAR 3 (Figure D.2). The drop in the STA 5 footprint in 2017 was largely offset by an increase in the FLA 3 footprint for that year.

4.2.5 FMA 7 mixed inshore trawl fishery

The FMA 7 group of fishstocks accounted for 26% of the FMA-based inshore aggregate swept area total for 2008–2018, and 43% of the FLA 7 swept area was from FLA 7 and 26% from TAR 7 (Table D.5). The annual aggregate swept area was between about 17 000–20 400 km^2 in most years, except 2015 and 2018 when it was about 16 000–16 500 km^2. Over the time series the FLA 7 aggregate swept area dropped from a peak in 2010 of 10 600 km^2 to about 6000–7500 km^2 during 2011–2016, increased to 7900 km^2 in 2017, and then decreased to 6500 km^2 in 2018 (Table D.5, Figure D.1). For

TAR 7, the swept area ranged between 4000 and 5300 km^2. The annual RCO 7 swept area was generally between 1000 and 2000 km^2 but dropped to 500 km^2 in 2018. Annual swept areas for GUR7 were under 1000 km^2 in 2008–2010 but increased to about 1600–2600 km^2 during 2012–2018.

There was no real trend in the FMA 7 footprint (Figure D.1, Table D.11) which contributed to 25% of the total inshore footprint for 2008–2018. The annual footprints ranged between 10 400 and 11 800 km^2. The annual footprints for TAR 7 and FLA 7 were similar in extent, but there was more spread geographically in the TAR 7 footprint because the TAR 7 2008–2018 footprint was about 10 000 km^2 larger than that for FLA 7. The FLA 7 footprint decreased over the time series (Figure D.2), whereas the TAR 7 footprint was reasonably steady. GUR 7 showed an overall increase in annual footprint, as did JDO 7 to a lesser extent. A decreasing trend was seen in RCO 7, whereas the remaining fishstocks showed no real trend over the 11 fishing years.

4.2.6 FMA 8/9 mixed inshore trawl fishery

Fishstocks in FMA 8 and FMA 9 accounted for 12.5% of the total 2008–2018 inshore aggregate area. Annual aggregate areas for FMA8/9 fishstocks were over 10 000 km^2 for 2008 and 2009 then decreased to about 8000–9000 km^2 for the remaining fishing years (Table D.6, Figure D.1). About 40% of the FMA 8/9 total swept area was from TRE 7, with another 28% from TAR 1 and TAR 8, 21% from GUR 1 and GUR 8, and 7.5% from SNA 8. The annual aggregate area for TRE 7 decreased over the time series from over 4000 km^2 to under 3000 km^2. The combined tarakihi stocks showed little variation over the time series, as did the combined red gurnard stocks. The SNA 8 fishstock declined steadily from 1300 km^2 in 2008 to 370 km^2 in 2018.

The total footprint from FMA8/9 accounted for 17.5% of the 2008–2018 inshore trawl footprint. Over the time series the annual footprints showed a decreasing trend from over 7000 km^2 in 2008 and 2009 to under 6000 km^2 in 2018 (Table D.12, Figure D.1). This decline is mainly from the TRE 7 and SNA 8 fishstocks (Figure D.2). Most other fishstocks showed no trend across the time series.

4.3 Coverage by 25-km^2 cell

The numbers of cells contacted each fishing year for the FMA-based inshore mixed trawl fisheries are given in Tables E.1–E.6 and Figure E.1 in Appendix E. Figure E.1 shows the annual numbers of cells and indicates the relative numbers of cells, within each fishing year, binned by the intensity of fishing within each cell, as measured by the aggregate area of each cell in that fishing year. It is likely that the number of cells with the smallest amount of aggregate swept area are exaggerated in the results presented below (see comment in Section 7.0). Section 4.3.7 gives the extent of increase in cell coverage during 2008–2018.

4.3.1 FMA 1 mixed inshore trawl fishery

A total of 2117 cells were contacted during 2008–2018 by FMA 1 fishstocks, with a peak of 1573 cells in 2017 and a median of 1450 cells contacted each year (Table E.1, Figure E.1). For all years combined, TAR 1 tows contacted 88%, SNA 1 tows contacted 76%, and TRE 1 tows contacted 64% of the cells with contact in FMA 1. Over 1000 cells were contacted in most years by TAR 1 tows, 830–995 by SNA 1 tows, and 575–822 by TRE 1 tows. The number of cells contacted each year by GUR 1 and JDO 1 tows generally decreased over time.

Similar numbers of cells each year had under 1 km^2 aggregate swept area per cell (446–550 cells) or 5–25 km^2 per cell (387–587 cells) (Figure E.1). Slightly fewer cells were in the 1–5 km^2 group (359–449 cells). Under 100 cells in any one year had 25–100 km^2 swept area (24–92 cells) and no cells in FMA 1 had over 100 km^2 swept area in a year. The drop in the annual number of cells in 2013 was largely from fewer cells in the 5–25 km^2 group; this group appeared to increase in size in 2017 and 2018.

4.3.2 FMA 2 mixed inshore trawl fishery

A total of 1774 cells were contacted during 2008–2018 by FMA 2 fishstocks, with a median of 1220 cells contacted each year (Table E.2, Figure E.1). The largest number of cells (1238 cells) was contacted

in 2018. TAR 2 tows contacted 95%, and GUR 2 contacted about 70%, of the cells in FMA 2 with trawling. Over 1000 cells were contacted by TAR 2 tows and about 700 by GUR 2 tows.

Across all fishstocks, the annual numbers of cells in the > 0–1 km^2 group and the 5–25 km^2 group (about 340–460 cells per year) were similar and showed no trend, though there may be a slight increase in recent years for the 5–25 km^2 group (Figure E.1). In contrast, the 1–5 km^2 group showed a small increase over the time series (from 221 in 2008 to 245 cells in 2018), and the 25–100 km^2 group showed an overall decrease from 195 in 2008 to 103 cells in 2018. In total, only 13 cells were estimated to have over 100 km^2 of aggregate swept area, with at least one cell in 8 of the 11 fishing years.

4.3.3 FMA 3 mixed inshore trawl fishery

For 2008–2018, 2936 cells were contacted by the FMA 3 fishstocks, and the number of cells contacted decreased over the time series from 1943 to 1768, with a peak of 1957 cells in 2010 (Table E.3, Figure E.1). The fishstocks TAR 3, BAR 1, FLA 3, and RCO 3 contacted at least 58% of the cells contacted in 2008–2018. These fishstocks were all reasonably consistent in the number of cells contacted each year; although there was an increase in the number of BAR 1 cells, and a decrease in the number of FLA 3 cells, over the last 5 years.

For all fishstocks, the number of cells with the smallest measures of aggregate swept area decreased over the time series: for cells with > 0–1 km^2, the numbers of cells decreased from about 665 in 2009 to 501 in 2018 and for cells with 1–5 km^2 the annual cell numbers decreased from 615 in 2008 to 426 in 2018 (see Figure E.1). The 5–25 km^2 group showed a small increase overall, from 592 in 2008 to 691 in 2018, via a sustained increase from 2009 to 2015. There was no trend in the 25–100 km^2 group across the years and few cells had over 100 km^2 swept area (total of 38 cells).

4.3.4 FMA 5 mixed inshore trawl fishery

For 2008–2018, 1155 cells were contacted by FMA 5 fishstocks, and between 575 (in 2009) and 710 cells (in 2015) were contacted each year (Table E.4, Figure E.1), with a median of 622 cells. The extent of the distribution of the contacted cells appears to be more defined by fishstocks in this area compared with others; that is, there are likely to be less cells with contact from different fishstocks. About 64% of the contacted cells had aggregate swept area from STA 5 tows, 47% from FLA 3 tows, and 40% from WAR 3 tows.

Across the seven fishstocks included in FMA 5, there were distinct differences in the numbers of cells in each of the aggregate swept area groups (Figure E.1). The largest number of cells contacted in any one fishing year was for the cell group with the smallest aggregate swept area; this 0–1 km^2 group showed a slight decrease over the time series from 314 cells in 2008 to 254 cells in 2018 (see Figure E.1). The 1–5 km^2 group and 5–25 km^2 group cell numbers showed no real trend other than a slight rise in the middle years, up to 202 cells in 2015 and 153 cells in 2013, respectively. This FMA had relatively few cells with 25–100 km^2 of contact compared with other FMAs and 18 cells with over 100 km^2 of swept area for 2008–2018.

4.3.5 FMA 7 mixed inshore trawl fishery

There was little variation in the number of cells contacted each year for the FMA 7 fishstocks (Table E.5, Figure E.1). A total of 3416 cells were contacted during 2008–2018, with between 2245 and 2364 cells contacted each year. About 86% of the total cells were contacted by the aggregate swept area of TAR 7 tows, 62% by FLA7 tows, 51% of GUR 7 tows, 42% by WAR 7 tows, 34% by JDO 7 tows, and 34% by STA 7 tows. Of these fishstocks, there was an increase in the middle period of years in the number of cells contacted by TAR 7 tows, an increase throughout the time series in the cells for GUR 7, JDO 7, and STA 7, whereas the annual number of cells contacted by WAR 7 tows was consistent throughout the time period.

The annual number of cells in each of the > 0–1 km^2, 1–5 km^2, and 5–25 km^2 swept area groups were similar throughout the 2008–2018 time period (Figure E.1), generally between about 600 and 800 cells

per year, with a slight decrease for the > 0–1 km^2 group, a slight increase for the 1–5 km^2 group, and no real trend evident for the 5–25 km^2 group. There was no trend evident in the 25–100 km^2 group (137 cells in 2018 and 207 cells in 2012), and a total of 49 cells with over 100 km^2 were contacted in 9 of the 11 fishing years.

4.3.6 FMA 8/9 mixed inshore trawl fishery

For 2008–2018, 3248 cells were contacted by FMA 8/9 fishstocks, and between 1687 (in 2008) and 2068 cells (in 2009) were contacted each year (Table E.6, Figure E.1), with a median of 1911 cells (in 2016). The annual distribution had little variation between 2009 and 2018. Trawling in the FMA 9 area of TAR 1 and TAR 8 contacted 43% and 48% of the 2008–2018 total of contacted cells, respectively; FMA 9 area of GUR 1 and GUR 8 tows contacted 30% and 25%, respectively; TRE 7 tows contacted 40% of cells; and SNA 8 tows contacted 38%.

For all the fishstocks, there was a slight increase in the annual number of cells with > 0–1 km^2 aggregate swept area from 648 cells in 2008 to a peak of 892 in 2017 (Figure E.1). Between 445 cells (2008) and 666 cells (2014) with 1–5 km^2 aggregate swept area were contacted annually indicating a slight increase over the fishing years, whereas a slight decrease was evident for the 5–25 km^2 cells (annual range of 422 in 2016 to 526 in 2012). The number of 25–100 km^2 cells decreased gradually over the time series, from 82 in 2008 to 38 in 2018. There were no cells in the >100 km^2 group in FMAs 8/9.

4.3.7 'New' area contacted ('new cells')

Table E.7 summarises the data by fishstock for FMAs 1, 2, 3, 5, 7, and 8/9 to indicate the number of cells contacted in a fishing year, but not in previous years. For example, for each FMA, cells with no contact in 2008–12 but contact in 2013 are named 'new cells for 2014'; cells with contact in 2014, but no contact in 2008–13, are classed as 'new cells in 2015', et cetera. The aggregate swept area and the footprint of these 'new cells' are given in the tables for each FMA fishstock with new cell data. The distribution of cells contacted during 2008–12, and those contacted in 2013–18 but not in 2008–12 (new cells) is shown in Figure 9. Generally, the footprint of these new cells is small and similar to the aggregate area; this suggests that these area measures represent the end of a tow or contact by a portion of a tow rather than a new area that is being explored. It is likely that most of the data in these tables represent artefacts of the methods used to estimate the location of the tow swept area. The new cells plot in Figure 9 indicates that there are cells at the edge of the inshore footprint that likely represent tows that have an incorrect bearing, are too long, and are in unrealistic depths for these fishstocks.

4.3.8 Number of years a 25-km^2 cell was contacted, 2008–2018

Of the 14 674 cells with mixed trawl fishery contact in 2008–2018, 17% were contacted in one year only and 42% were contacted each year (Table 8). The spatial distribution of the number of years contacted is shown in Figure 3, with the long-standing main fishery areas evident in the green and blue colours. Note that many of the cells with a few years of contact are on the fringes of the main fishery areas and appear to show trawl swept area that may be misleading in that it shows a larger extent than perhaps is real (see above).

Table 8: The number of cells contacted by the FMA-based inshore trawl fishstocks during 2008–2018 and the percentage of the total number of cells, by the number of years with contact.

	Number of years a cell had contact											
	1	2	3	4	5	6	7	8	9	10	11	All
No. cells	2 455	1 272	887	668	538	484	422	458	526	755	6 209	14 674
%	16.7	8.7	6.0	4.6	3.7	3.3	2.9	3.1	3.6	5.1	42.3	100.0

4.3.9 Intensity of contact in 25-km^2 cells, 2008–2018

The spatial distribution of the number of tows per 25-km^2 cell for 2008–2018 and 2018 is shown in Figure 10.

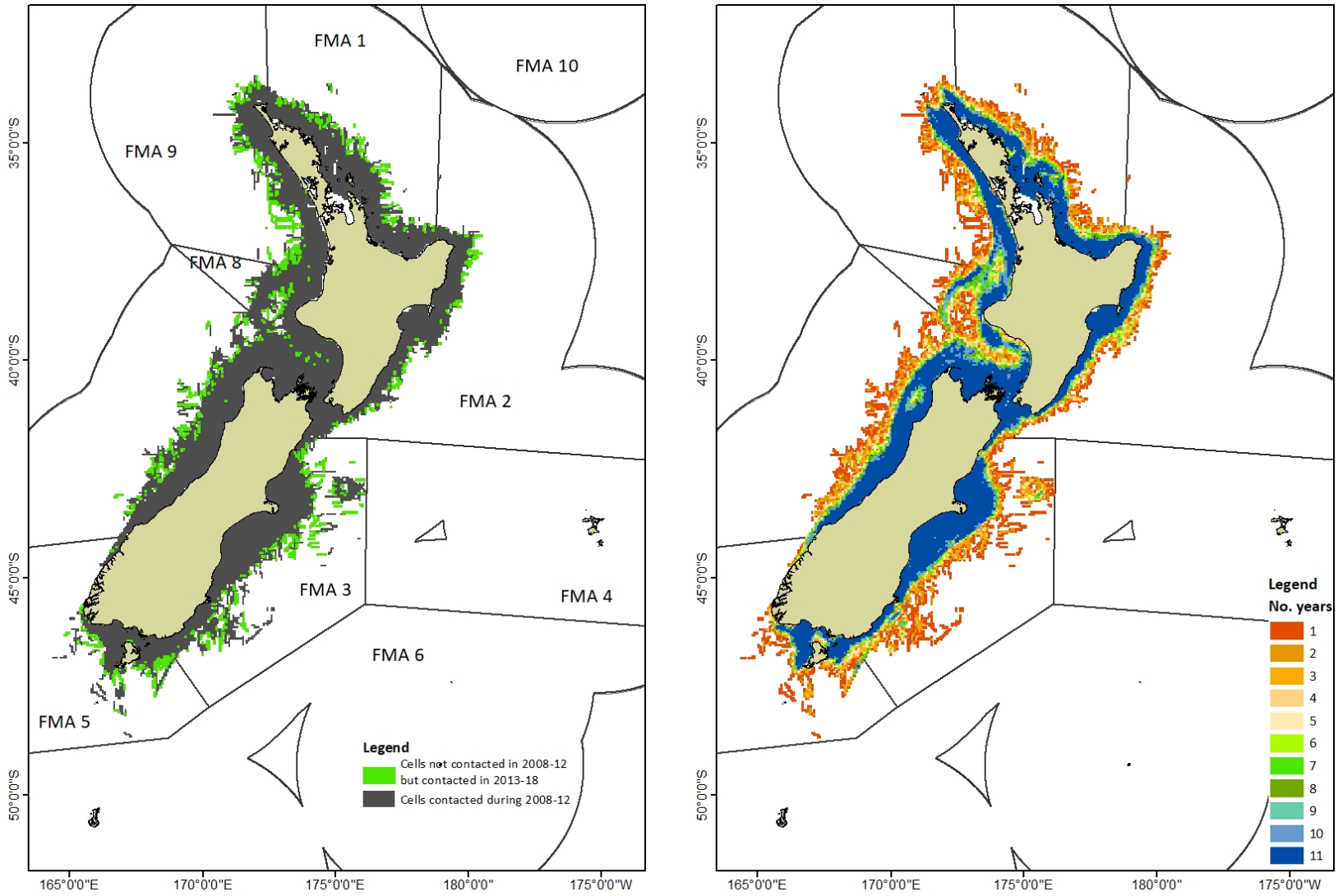

Figure 9: Distribution of cells contacted by trawling for inshore fishstocks during 2008–2012 and cells contacted by inshore fishstocks in 2013–2018 that were not contacted during 2008–2012 (left) and number of years each cell was contacted by trawling for FMA-based inshore fishstocks for 2008–2018 (right).

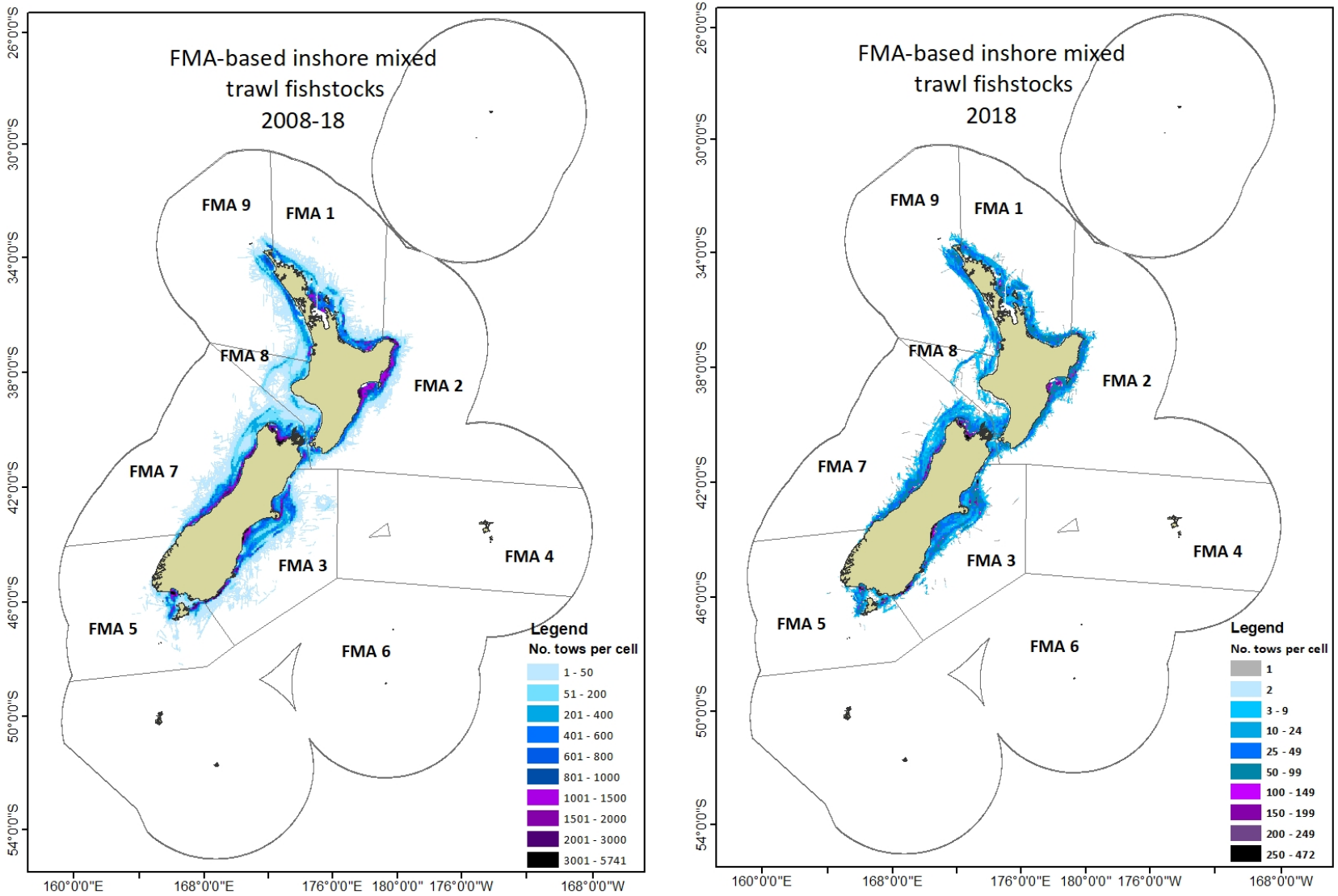

Figure 10: Number of tows in each contacted cell during 2008–2018 (left) and for 2018 (right) for FMA-based inshore fishstocks during 2008–2018.

About 11% of all contacted cells had one tow per cell (effectively this means one part of a tow, given that tows contact at least one cell) and over 50% had up to 9 tows per cell (Figure 11). Almost 90% of cells had up to 600 tows per cell. A total of 50 cells had 3000–5741 tows per cell: these cells are in shallow waters off East Cape, in Hawke Bay, in Tasman Bay and Golden Bay, in the south Canterbury Bight, off the southeast coast of the South Island, off the southern South Island coast in Te Waewae Bay. Cells in these areas also had the highest intensity in 2018.

The maximum number of tows per cell for the 11-y period was 5741 tows, with a median of 33 tows, and 75% of cells had fewer than 253 tows (Table E.8). There were few differences in the intensity of effort per cell between the years, with the annual median at 12 or 14 tows per cell (except in 2009), mean of 29–32 tows (except in 2010 when it was 35), and 75% of contacted cells each year had no more than 34–41 tows. The annual maximum tows per cell was lowest in 2018 (472 tows per cell) and the maximum was in 2010, at 750 tows per cell. FMA 2, FMA 3, and FMA 7 had the highest numbers of tows per cell, with the greatest intensity (as measured by the number of tows per cell) in FMA 2 cells. FMA 5 and FMA 8/9 had the lowest intensity, with annual medians of 4–7 tows per cell. The summary statistics for the aggregate swept area per cell are given in Table E.9. Median areas per cell were similar in the FMAs, at about 0.5 km^2, but maximum aggregate areas per cell were higher in FMA 2, FMA 5, and FMA 7, with the lowest maximum values in FMA 1 and FMA 8/9.

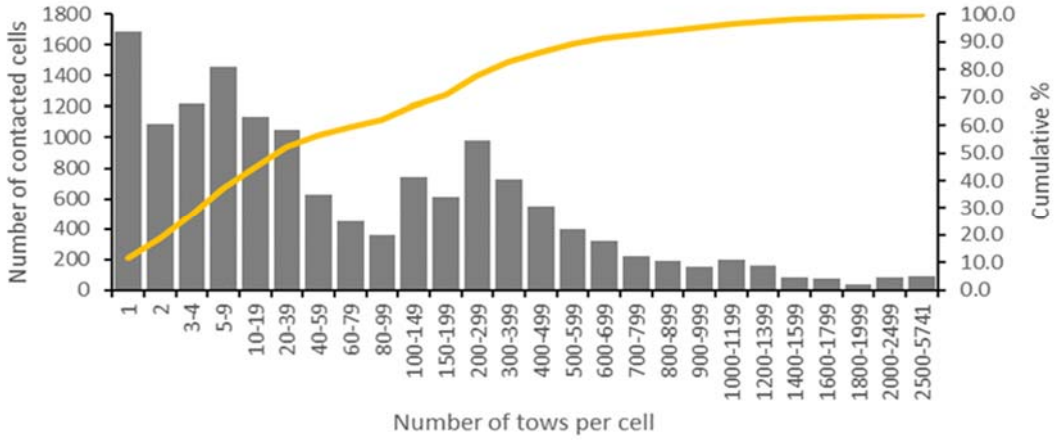

Figure 11: Number of tows per contacted cell, all fishing years combined, for the FMA-based mixed fishery groups, 2008–18. The spatial distribution of these cells is shown in Figure 10.

4.4 SNA 1, TAR 1, and TAR 2 fishstocks, 2008–2018

Summary data for SNA 1, TAR 1, and TAR 2 are given in Appendix F.

4.4.1 SNA 1 fishstock

The number of bottom-contacting tows that targeted snapper in SNA 1 peaked at about 3400 tows in 2012 and 2013 then decreased to about 2100 in 2017, followed by an increase to about 2500 tows in 2018 (Table 9). The annual estimated aggregate swept area and footprint showed a similar trend: the aggregate area varied between almost 2200 km^2 (for 2017) to a peak of 3318 km^2 (in 2009 and 2018); the footprint area ranged from about 1900 km^2 (for 2016 and 2017, with peaks at about 2600 km^2 (in 2009 and 2018).

The number of cells contacted each year was greatest in 2018, at 995 cells. The number of new cells in a year (relative to the previous fishing years, from a base period of 2008–2013), and the small amount of footprint generated from these cells, suggested that the 'new' footprint area represented snapper trawl swept area polygons located in depths outside the trawling depths for snapper. The 2008–2018 SNA 1 data indicate that 75% of reported tow start depths were shallower than 60 m, with a median of 48 m and mean of 54 m; however, Table F.1 and Figure F.1 in Appendix F show the broad depth distribution

of the footprint data based on the grid distribution, with contacted cells beyond 200 m. Figure F.1 also shows the distribution of cells contacted during 2014–2018 but not in 2008–2013: a distribution generally outside snapper trawling depths.

Table 9: Number of bottom-contacting tows, aggregate area (km^2), footprint (km^2), number of cells contacted, and number of new cells in recent years, where snapper was the reported target for bottom-contacting trawling in fishstock SNA 1, for fishing years 2008–2018. New cells in 2014 are cells where there was fishing in 2014, but not during 2008–2013 when 1389 cells were contacted; new cells in 2015 are cells with contact in 2015, but not in 2008–2014, etc.

					New cells from 2008–2013 (n=1389)		
Fishing year	No. tows	Aggregate area (km^2)	Footprint area (km^2)	No. cells	No. new cells	Aggregate area (km^2)	Footprint area (km^2)
2008	2 855	2 928.7	2 383.5	900			
2009	3 303	3 318.2	2 569.7	911			
2010	2 995	2 989.0	2 381.6	880			
2011	3 221	2 982.3	2 405.1	927			
2012	3 436	3 009.9	2 380.7	948			
2013	3 359	2 956.9	2 291.9	834			
2014	2 889	2 712.0	2 139.0	857	39	10.6	10.6
2015	2 655	2 550.1	2 103.4	890	35	8.9	8.8
2016	2 244	2 203.3	1 881.6	837	44	14.6	14.6
2017	2 131	2 182.0	1 904.3	881	19	3.2	3.2
2018	2 494	3 318.5	2 648.5	995	76	24.8	24.8
Total	31 582	31 150.9	10 950.4	1 602			

4.4.2 TAR 1 fishstock

Annual tarakihi tows numbered between 1250 and 2095; and although the number of tows dropped off in 2018, at 1483 tows, the estimated aggregate area for that year was similar to that estimated for 2008 when effort totalled 1841 tows (Table 10). However, the decreasing, then increasing, trend in the number of tows in the middle of the time period was matched with similar trends in the swept area measures to peaks of 5637 km^2 (aggregate area) and 4647 km^2 (footprint).

Table 10: Number of bottom-contacting tows, aggregate area (km^2), footprint (km^2), number of cells contacted, and number of new cells in recent years, where tarakihi was the reported target for bottom-contacting trawling in fishstock TAR 1, for fishing years 2008–2018. See Table 9 for explanation of new cells.

					New cells from 2008–2013 (n=2725)		
Fishing year	No. tows	Aggregate area (km^2)	Footprint area (km^2)	No. cells	No. new cells	Aggregate area (km^2)	Footprint area (km^2)
2008	1 841	4 966.1	4 086.9	1 726			
2009	2 016	5 533.9	4 310.5	1 745			
2010	2 095	4 439.9	3 589.6	1 688			
2011	1 854	4 319.1	3 471.9	1 606			
2012	1 759	4 123.7	3 364.8	1 514			
2013	1 250	3 267.8	2 648.9	1 427			
2014	1 612	4 136.8	3 439.5	1 705	157	58.1	57.6
2015	1 761	4 547.7	3 714.2	1 697	100	31.6	31.4
2016	1 742	4 673.9	3 824.0	1 750	112	35.6	35.4
2017	1 787	5 636.6	4 646.8	1 916	117	35.6	36.0
2018	1 483	4 997.6	4 030.8	1 668	49	14.5	14.3
Total	19 200	50 643.0	19 473.5	3 260			

This fishstock includes FMAs 1 and 9 and the spread of effort reported here (in terms of cells contacted) is thus greater than that measured for the SNA 1 fishstock, with twice the number of cells contacted by the TAR 1 fishstock compared with that for the SNA 1. Another effect on the extent of the TAR 1 fishstock is the range of depths covered by the tarakihi fishery. Reported depth data indicate that most effort is under 200 m, with a median of 153 m and mean of 160 m. The distribution data for TAR 1 are given in Table F.2 and shown in Figure F.1. Cells contacted in 2014–2018, but not in 2008–2013, were mainly in the outer extent of the cell distribution (generally in deeper depths).

4.4.3 TAR 2 fishstock

A decreasing trend was seen in the annual number of tows in the TAR 2 fishstock during 2008–2018, from 5550 tows in 2009 to 3299 tows in 2018 (Table 11). This was reflected in the gradual decrease in the estimated aggregate swept area, from about 9000 km^2 in 2009 to 5740 km^2 in 2018, and in the annual footprint from about 5500 km^2 in 2009 to 4100 km^2 in 2018.

The depth range and new cells contacted in 2014–2018 are given in Table F.3 and shown in Figure F.1. The undersea topography of most of FMA 2 constricts the available area for fishing along a large part of the coast. New cells contacted were primarily at the edges of the main fishery extent, as for SNA 1 and TAR 1.

Table 11: Number of bottom-contacting tows, aggregate area (km^2), footprint (km^2), number of cells contacted, and number of new cells in recent years, where tarakihi was the reported target for bottom-contacting trawling in fishstock TAR 2, for fishing years 2008–2018. See Table 9 for explanation of new cells.

					New cells from 2008–2013 (n=1561)		
Fishing year	No. tows	Aggregate area (km^2)	Footprint area (km^2)	No. cells	No. new cells	Aggregate area (km^2)	Footprint area (km^2)
2008	5 339	8 522.0	5 382.1	1 157			
2009	5 550	9 054.7	5 486.9	1 105			
2010	5 249	8 285.5	5 137.3	1 051			
2011	5 088	7 515.6	4 818.2	1 038			
2012	4 619	6 482.7	4 046.9	1 094			
2013	4 532	6 334.2	4 179.0	1 050			
2014	4 858	7 242.2	4 596.3	1 075	34	8.4	8.4
2015	4 262	6 734.4	4 525.3	1 109	39	12.8	12.8
2016	3 437	5 518.3	3 922.6	1 029	16	4.8	4.8
2017	3 488	5 740.7	4 029.1	1 034	13	2.1	2.1
2018	3 299	5 590.4	4 103.7	1 080	26	6.0	6.0
Total	49 721	77 020.7	14 842.2	1 689			

5. DEEPWATER FISHSTOCKS, 2008–2018

5.1 Deepwater data

This section discusses the deepwater fishstocks for a subset of the years (2008–2018) for comparability across years in the use of form types used for the footprint analysis (TCER and TCEPR) and to match that for the combined deepwater and inshore analysis in Section 3 and the inshore fishery analysis in Section 4. Data for the full deepwater dataset for 1990–2018 are presented in three Appendices for the main metrics and are compared with the 2008–2018 data in the following sections, including the overlap analyses. Note that for 1990–2007, the data are from TCEPRs only.

The underlying tow data and results of analyses based on the deepwater Tier 1 and Tier 2 fishstocks are presented in Appendix C (the number of tows with bottom contact), Appendix G (the spatial coverage), and Appendix H (the cell-based analyses).

5.2 The annual number of tows

Appendix C gives summary data for the 1990–2018 numbers of tows (Tables C.5–C.7.) A dataset of 310 829 tows targeting deepwater Tier 1 and Tier 2 fishstocks was used to generate the swept area analyses for 2008–2018 (Table 12). These numbers represent 26.4% of the total bottom-contacting tows for 1990–2018 (1 178 476 tows) (Tables C.5 and C.6).

The annual number of tows decreased during 2008–2018, from almost 34 000 tows in 2008 to about 27 500 tows in 2018, with the smallest number of tows recorded in 2013. This overall decrease continues the declining trend since the peak of tows in 1998 at about 60 600 tows during a decade of higher effort (at least 50 000 tows a year during 1994–2003) (Tables C.5 and C.6) and reflects the strong influence of the changes in the Total Allowable Commercial Catch (TACC) for hoki during the past 29 years (Fisheries New Zealand 2019a).

For 2008–2018, trawling for hoki accounts for 32% of the total tows, scampi for 16%, and orange roughy for 9% (Table C.5, Table 12). The numbers of tows per year during 2008–2018 increased for the main target, hoki, to a peak of 10 822 tows in 2018. Other Tier 1 targets show little change over most years (ling, scampi), decreases (arrow squid, hake, jack mackerels, oreo species), or fluctuations (orange roughy, southern blue whiting). Of the main Tier 2 targets, tow numbers for barracouta and silver warehou were steady in most years, whereas alfonsino and black cardinalfish numbers declined.

During 2008–2018, there was a small drop in the numbers of vessels in the dataset from over 110 a year to 96 vessels in 2018 (Table C.7). The vessel numbers for 1990–2007 peaked in 1997 (168 vessels). During these years, most of these vessels targeted both the Tier 1 and Tier 2 fishstocks. In 2008, a change in reporting requirements for the small vessels targeting these fishstocks, from the CELR to the TCER, resulted in increased numbers of vessels because TCER vessels are included in this analysis. Note that these vessel data rely on the individual vessel identifiers in the Fisheries New Zealand data and include more than one unique vessel record for some vessels that have re-registered, particularly in years after 2013 when there was a change in the ownership of some foreign-owned vessels; this is unlikely to affect the number of individual vessels in a fishing year but will impact on the total numbers of vessels.

Table 12: Number of bottom-contacting tows, footprint (km^2), aggregate area (km^2), number of cells contacted. The percent of the TS+EEZ area (4 111 569 km^2) and the 'fishable' area (1 391 580 km^2) contacted by the footprint is also provided.

Fishing year	No. tows	Footprint (km^2)	Aggregate (km^2)	No. cells	Footprint as % TS+EEZ	Footprint as % 'fishable' area
2008	33 990	52 570.7	90 312.4	13 638	1.3	3.8
2009	29 803	46 555.3	81 831.6	12 560	1.1	3.3
2010	30 603	50 680.6	91 439.5	12 864	1.2	3.6
2011	28 314	50 640.6	93 000.1	12 551	1.2	3.6
2012	27 278	48 074.8	89 890.3	11 639	1.2	3.5
2013	25 938	46 186.9	84 214.0	10 937	1.1	3.3
2014	26 962	48 631.7	86 062.4	11 754	1.2	3.5
2015	26 733	48 396.9	88 071.6	11 452	1.2	3.5
2016	27 148	45 950.2	84 709.8	11 331	1.1	3.3
2017	26 449	45 528.4	89 154.9	11 363	1.1	3.3
2018	27 611	47 092.9	98 507.5	10 788	1.1	3.4
Total	310 829	177 266.8	977 194.1	25 501	4.3	12.7

Tier 1 tows accounted for 87% of the total bottom-contacting tows during the 11 fishing years (see Table C.5, Table 12). Numbers of Tier 1 tows reported by smaller vessels (on TCERs) were highest in 2014–2016 at over 1650 tows a year then decreased slightly to under 1600 tows in 2018 (Table C.7). Numbers of TCEPR tows decreased from about 27 500 to under 22 500 tows in 2016 and 2017; in 2018, most Tier 1 tows were from ERS data collection. For Tier 2 tows, about 64% were from larger vessels using TCEPRs and ERS. There was a steady decrease in the numbers of Tier 2 tows each year, with fewer annual tows reported from most of the fishstocks (Table C.6). The number of Tier 2 tows reported in 2018 was about half that reported in 2008.

5.3 The aggregate swept area and the footprint area

During 2008–2018, the estimated aggregate area totalled about 977 200 km^2, equivalent to a footprint of almost 177 300 km^2 (see Table 12). The annual aggregate area ranged from almost 82 000 km^2 in 2009 to 98 500 km^2 in 2018, with under 90 000 km^2 estimated for the 2012–17 fishing years. These 2008–2018 years represent a period of lower annual aggregate area compared with that seen in 1990–2007 (Table G.1 in Appendix G); between 1992 and 2004 (except in 1994), the annual range of estimated aggregate swept areas was 138 000–174 080 km^2, with the peak in 1998.

The distribution of the aggregate area by 25-km^2 cell, for 2008–2018 and 2018, is shown in Figure 12. The maximum per cell was estimated at 2595 km^2 over the 11 years and 410 km^2 for 2018; this cell was located off the South Island west coast. The aggregate swept area for 1990–2018 is shown in Figure G.1 in Appendix G.

The deepwater footprint declined over the 11 years, from about 52 570 km^2 in 2008 to about 47 000 km^2 in 2018 after a low of 45 528 km^2 in 2017. The 2008–2018 fishing years represent a period of lower annual footprints compared with 1992–2004 (except in 1994), when footprint estimates were about 65 000–82 800 km^2 a year, with the peak years being 2002 and 2003 (Table G.1). The reduced distribution of the 2018 footprint relative to that for 2008–2018 is shown in Figure 13. The 2008–2018 footprint shows a more defined extent in some of the traditional fishery areas than seen for the 1990–2007 footprint (Figure G.2).The total footprint area for 2008–2018 is equivalent to 18% of the total aggregate swept area for the 11 years (see Table 12); for the 1990–2018 data, the equivalent metric is 10% (see Table G.1). Overall, about 1% of the TS+EEZ and 3% of the fishable area has been contacted annually, and 4% and 13%, respectively for the combined 2008–2018 fishing years (Table 12). For comparison, the overlap for the combined 1990–2018 deepwater data is 8.5% of the TS+EEZ and 25% of the fishable area for the 1990–2018 data.

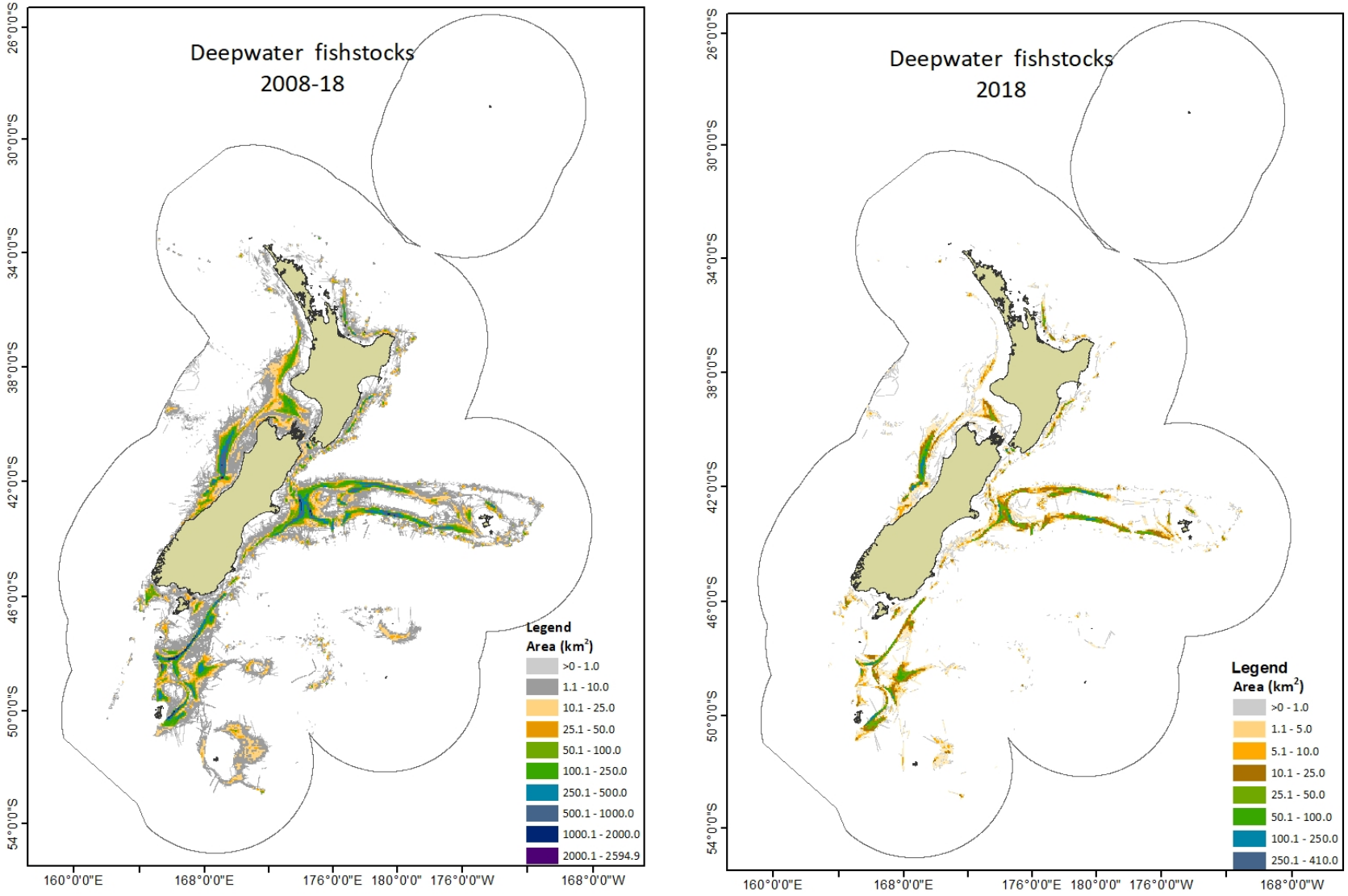

Figure 12: Distribution of the deepwater fishstock aggregate swept area, summed by 25-km^2 cell, for 2008–2018 (left) and 2018 (right).

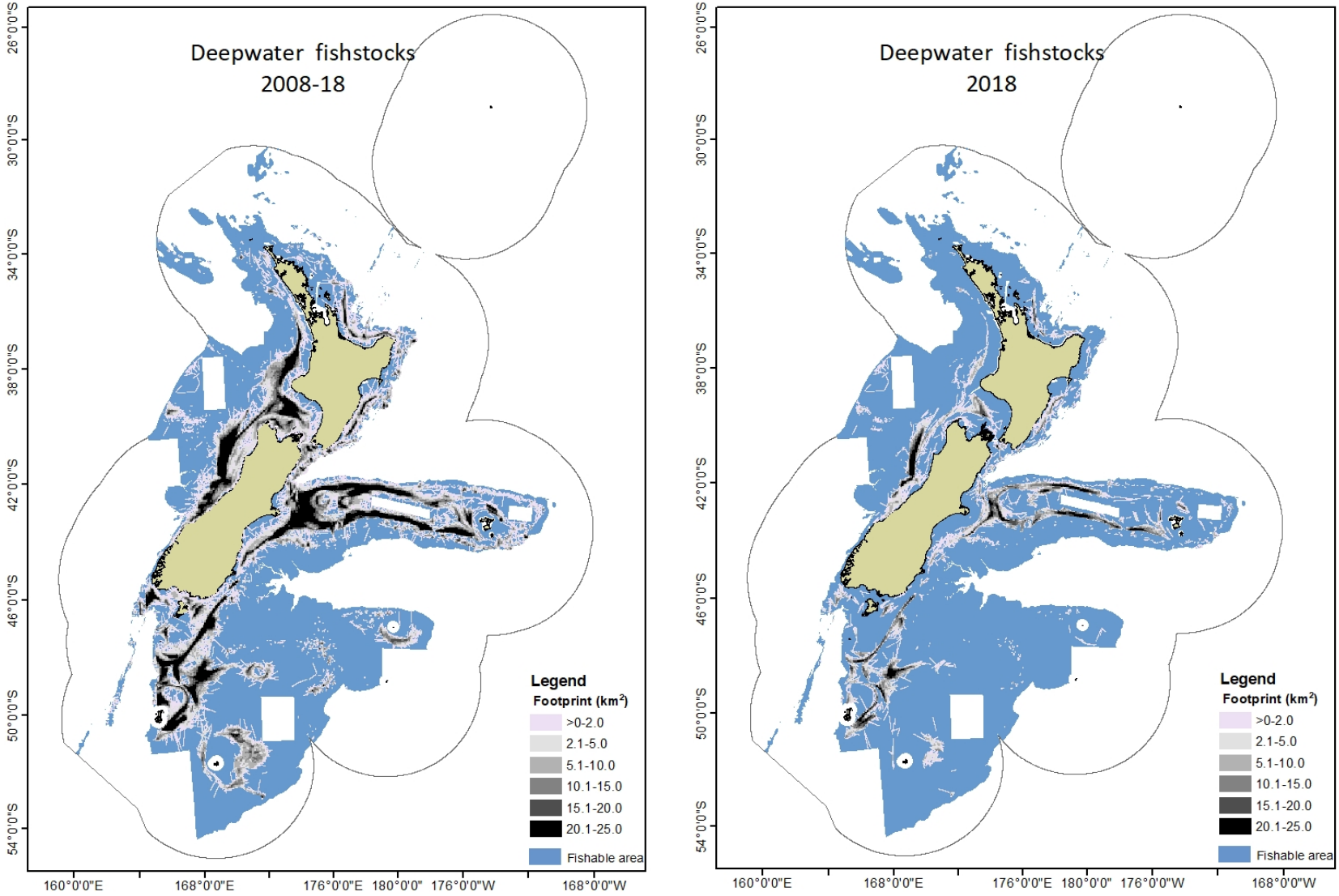

Figure 13: Distribution of the deepwater fishstock footprint, by 25-km^2 cell, for 2008–2018 (left) and 2018 (right).

5.3.1 Tier 1 fishstocks aggregate swept area, 2008–2018

Tier 1 fishstocks accounted for 91% of the estimated aggregate swept area for deepwater fishstocks for 2008–2018, with a total aggregate swept area of about 894 200 km^2 (Table G.2). There was no trend in the annual Tier 1 totals across the 11 years. Hoki trawls accounted for 59% of the Tier 1 fishstock total aggregate swept area. Arrow squid trawls accounted for 13% of the Tier 1 aggregate swept area, for 2008–2018, with another 9% from scampi trawls, 6.5% from jack mackerel trawls, 5% from hake trawls, and 3% from ling trawls. Orange roughy, oreo, and southern blue whiting trawls accounted for about 1% each of the 2008–2018 aggregate swept area total.

There was a steady increase in the hoki annual aggregate swept areas over the 11 years, with over 65 000 km^2 estimated for 2018, twice that for 2008, but substantially lower than the peak years of 1995–2004 when aggregate swept areas ranged from 71 600 km^2 to 113 410 km^2, as shown in Figure G.3 in Appendix G. The hoki aggregate swept area increased from 40% of the Tier 1 total in 2008 to 70% in 2018.

Decreases in annual aggregate swept areas during 2008–2018 were evident in all other Tier 1 fishstocks, except scampi. Arrow squid showed substantially smaller swept areas during the 11 years (under 15 100 km^2) than in 1990–2007 (17 800–43 100 km^2 (see Figure G.3)). The estimated aggregate swept area for scampi ranged between 6000 and 7800 km^2 during 2008–15 before increasing to over 8100 km^2 during 2016 to 2018, similar levels to those seen in peak years of 2002 and 2003. Hake showed a marked overall decrease from 8800 km^2 to 867 km^2 during 2008–2018, and ling dropped from 7100 km^2 in 2008 to about 2000–2500 km^2 during 2010–18. Jack mackerel aggregate swept areas were generally lower than those estimated for the period before 2008 and decreased to under 4000 km^2 in 2015–2018. Orange roughy estimates for 2008–2018 were low compared with earlier years and showed declines from 2008 to under 850 km^2 for 2011–2015, before increasing in 2016–2018 to about 1000 km^2. Oreo aggregate swept areas were steady at about 1000–1400 km^2 during 2008–2011, then declined to under 500 km^2 in 2016–2018, well below areas estimated for 1990–2007.

5.3.2 Tier 1 fishstocks footprint area, 2008–2018

The annual Tier 1 footprint has been relatively flat during 2008–2018, at between 40 417 km^2 in 2009 to 45 453 km^2 in 2010 (Table G.3); however, these 11 years represent a sustained period of the lowest annual Tier 1 footprints during the expanded time period of 1990–2018 when annual footprints ranged from 50 000 km^2 to over 75 000 km^2 during 1991–2006 (see Figure G.3).

Hoki was the main contributor of the larger footprint areas before 2008 (Figure G.4). The hoki footprint covered 51% of the 2008–2018 Tier 1 footprint (Table G.3), and the annual increase in the hoki footprint resulted in a 10 000 km^2 increase between 2008 and 2018. However, at almost 30 000 km^2, this was substantially lower than the peak of close to 55 000 km^2 in 2003. About 43% of the 2008 Tier 1 footprint was covered by the hoki footprint in 2008 and this increased to 69% of the 2018 Tier 1 footprint. Footprints estimated for jack mackerels, ling, arrow squid, and scampi covered 14%, 9%, 9%, and 8% of the total 2008–2018 Tier 1 footprint, respectively.

Annual footprints for arrow squid and jack mackerel were also lower in 2008–2018 than in 1990–2007 (Figure G.4, Table G.3): jack mackerel decreased by about 50% during 2008–2018, from about 6100 km^2 to under 3000 km^2 in 2017 and 2018; and arrow squid decreased from a peak of 5760 km^2 in 2010 to about 3100 km^2 in 2018. Other than hoki, scampi was the only Tier 1 target that showed an increase during 2008–2018, continuing the pattern of gradual increase during 1990–2007 fishing years; in recent years, the estimated scampi footprint was the second largest annual footprint area (over 4000 km^2) after hoki. All other Tier 1 targets showed decreasing trends throughout 2008–2018, except orange roughy which had a smaller footprint during 2011–2015, followed by an increase to about 800 km^2 in subsequent years.

The spatial distributions of the Tier 1 footprint area for 2008–2018 and 2018 are shown in Figure G.5.

5.3.3 Tier 2 fishstocks aggregate swept area, 2008–2018

The estimated aggregate swept area for Tier 2 fishstocks during 2008–2018 declined by more than 50% from 11 500 km^2 in 2008 to 5880 km^2 in 2018 (Table G.4), and this was primarily driven by the effort for barracouta and silver warehou. These two targets contributed 39% and 40%, respectively, to the total aggregate swept area estimated for 2008–2018 Tier 2 fishstocks. However, all the other main Tier 2 targets in 2008–2018 also decreased: alfonsino, sea perch, white warehou, and black cardinalfish. Aggregate swept areas for lookdown dory and rubyfish showed no trend.

Over the longer time series of 1990–2018, the 2008–2018 data for barracouta were similar to aggregate swept areas in the previous 10 years (at generally between about 2000 and 3500 km^2), but lower than the 1990–1996 period (Figure G.6). The silver warehou aggregate swept areas decreased from almost 5000 km^2 in 2008 to about 2000 km^2 in 2018 (similar to that for 1990–1996, but more than twice that for 1997–2005). For white warehou, the aggregate swept areas were reasonably constant in years where there was effort, from the early 2000s; estimated areas for 2008–2018 varied between 200 and 450 km^2. Aggregate swept areas for sea perch in 2008–2018 varied but were generally about 280–380 km^2 from 2013, less than those in 2003 and 2004, but higher than earlier years. Alfonsino aggregate swept areas were variable between 2008–2018 (210–530 km^2), as they were in earlier years. Black cardinalfish areas, at about 110–215 km^2, were smaller in 2008–2012 than earlier years (particularly mid-1990s to mid-2000s) and declined to under 50 km^2 in 2018. Thus, many of the Tier 2 fishstocks reflect the inconsistent nature of targeting/reporting by target compared with targets such as barracouta and silver warehou.

5.3.4 Tier 2 fishstocks footprint area, 2008–2018

The footprint area for Tier 2 fishstocks during 2008–2018 showed an overall steady decrease from 9200 km^2 in 2008 to 4750 km^2 in 2008 (Table G.5, Figure G.6). Barracouta and silver warehou targeting had the most influence over the trajectory of the footprint, for 2008–2018 as well as the earlier years (Figure G.7). The silver warehou footprint showed an overall decreasing trend for 2008–2018 (from almost 3900 km^2 in 2008 to about 1800 km^2 in 2018), following a marked increase after 2004; whereas the barracouta footprint was reasonably stable (at about 2000–2500 km^2) after a sharp decline from the peak of 4000 km^2 in 2008. Both these targets showed declines after 1995 during 1990–2006 before increasing in 2007 to peaks of about 4000 km^2 in 2008.

Annual footprint areas for some Tier 2 fishstocks were steady throughout 2008–2018, albeit at relatively low levels, whereas fishstocks such as alfonsino showed a slight increase and white warehou a small decrease. Fishstocks with small numbers of tows that yielded 2008–2018 total footprints of under 200 km^2 included English mackerel, frostfish, pale ghost shark, and ribaldo.

The spatial distribution of the Tier 2 footprint, all fishstocks combined, for 2008–2018 and 2018 are shown in Figure G.8.

5.3.5 Combined deepwater fishstocks HAK/HOK/LIN/SWA/WWA, 2008–2018

Number of bottom-contacting tows. These five targets (hake, hoki, ling, silver warehou, and white warehou) represent a mixed middle depths fishery. Together, their effort is represented in the bycatch assessment areas shown in Figure G.9 in Appendix G (after Anderson & Edwards 2018). Of the 136 230 bottom-contacting tows for this mixed fishery during 2008–2018, 40% were from CHAT4, 25% from WCSI7, 16% from STEW5, and 8% from COOK8 (Table G.6). Between about 11 400 and 13 500 tows were conducted each year. Effort was reasonably consistent in each year for each area; though over the 11 years, effort in CHAT4 decreased slightly and effort in WCSI7 increased slightly. Each of these areas have different seafloor topography, with some that are restricted in the available trawling area by a lack of flat seafloor and sharp depth changes (for example, COOK8, PUYS5, EAST2, and NORTH1).

Aggregate swept area. The estimated aggregate swept area for the mixed fishery increased from about 53 600 km^2 in 2008 to 71 360 km^2 in 2018, even though in each of those years, the numbers of tows made were very similar (Tables G.6 and G.7). The main areas contributing to the 2008–2018 aggregate area total were CHAT4 (54% of the total), WCSI7 (21%), and STEW5 (16.5%). CHAT4 showed an

overall decrease in number of tows made, but an increase in the annual aggregate swept areas. WCSI7 showed an increase in the aggregate swept area over the time series and some disparity between the range of swept area estimates relative to the number of tows. Although the effort in STEW5 was reasonably constant over the 11 years, the aggregate swept area in 2018 was almost double that in 2008 (given a similar number of tows). There was a large increase in hoki tows in 2018 compared with the number in 2008; the percentage of hoki trawls in the HAK/HOK/LIN/SWA/WWA fishery in STEW5 was 35% in 2008 and it was 64% in 2018. The aggregate swept area estimated for 2018 is also influenced by the use of twin trawls (and therefore larger doorspread values) in this area (since 2009, relative to 2008–2018), and the data indicate that trawls were longer, especially hoki trawls, in 2018 compared with 2008.

Footprint area. In contrast, the footprint area for this mixed fishery during 2008–2018 showed only relatively small changes from year to year (range 28 346–33 218 km^2) (Table G.8). From the 2008–2018 total footprint area of 100 544 km^2, 51% was from CHAT4, 18% from STEW5, 15% from WCSI7, and 6% from SUBA6. The annual footprint in most areas showed little variation; the exceptions being STEW5 which increased overall, COOK8 which decreased, and SUBA6 which fluctuated throughout the 11-y period, reflecting the inconsistent number of tows. The distribution of the footprint is shown in Figure G.9.

5.3.6 Combined deepwater fishstocks OEO/ORH, 2008–2018

Three areas were used to summarise the OEO/ORH effort and these are shown in Figure G.9: ORH7A (in 800–1600 m depths, minus the Benthic Protection Area), Northwest Chatham Rise (NWCR, in 800–1600 m depths, not including the part that is on the south Chatham Rise and closed seamounts), and East & South Chatham Rise (ESCR, in 800–1600 m depths, minus the Benthic Protection Area and the seamount closure).

Number of bottom-contacting tows. Most effort was in the ESCR area (Table G.9), and various management restrictions over these years resulted in very few tows in some years in NWCR and ORH7A (see appendix D, Baird & Mules 2019). Over the last 3 years about 1200 tows were reported annually in ESCR, an increase from 2011–2015, but less than the over 2200 tows reported during 2008 and 2009 fishing years. In NWCR, apart from the 2011–2013 years, more than 200 tows were reported in most years up to 2015, followed by an increase to about 400–463 tows for 2016–2018. Effort in ORH7A gradually built up from 2009 to a peak of 152 tows in 2013, then increased markedly in 2015 to 703 tows, and decreased in the following years to 353 tows in 2018.

Aggregate swept area. The estimated aggregate swept area generally decreased in ESCR (Table G.9). As the numbers of tows increased during 2016–2018, the annual aggregate swept areas remained similar to those estimated for 2012–2015 when the numbers of tows were less (about 900 tows compared with about 1200 tows in 2016–2018). This may be a result of grooming that shortened tows associated with underwater features or may reflect more long tows in the earlier years, but this is not corroborated by the relative numbers of cells contacted each year. It may be that the swept areas were more concentrated in the same cells. The annual aggregate swept areas for NWCR and ORH7A were highest in the last 4 years, with a steady increase estimated for the NWCR and an overall decrease in the ORH7A annual swept areas.

Footprint area. The ESCR footprint has decreased overall, from over 530 km^2 in 2008 and 2009 to 260–280 km^2 in 2016–2018 fishing years. The annual footprints for NWCR and ORH7A were smaller, at just over 100 km^2 during the most recent years for NWCR and between 189 km^2 (in 2015) and 116 km^2 (in 2018). The 2008–2018 footprint is shown in Figure G.9.

5.4 Deepwater fishstock coverage by 25-km^2 cell

Appendix H gives figures and tables for the cell-based summaries for deepwater Tier 1 and Tier 2 fishstocks.

5.4.1 Number of cells contacted, 2008–2018

Bottom-contacting deepwater fishstocks contacted 25 501 25-km^2 cells during 2008–2018 (see Table 12). The number of contacted cells contacted decreased by about 21% between 2008 and 2018. The number of cells in 2018 was the lowest count for the full time series from 1990–2018 (see Table G.1).

Tier 1 fishstocks 22 606 cells during 2008–2018 (Table H.1), and the annual number of cells decreased from 11 407 cells in 2008 to 9363 in 2018, with a minimum of 9163 cells in 2013. About 48% of the cells were contacted by hoki tows, 19% by ling, 15% by scampi, and 15% by arrow squid tows. Annual cell numbers for some fishstocks were reasonably consistent throughout 2008–2018 (hoki, jack mackerels, scampi, and southern blue whiting). For hake, ling, and oreo fishstocks, the annual numbers of cells decreased from 2008 to 2018. Orange roughy had some years of lower numbers during 2011–2015, and arrow squid showed an overall decrease in cell numbers.

The mixed fishery combination of HAK/HOK/LIN/SWA/WWA fishstocks contacted 61% of the total Tier 1 cells for 2008–2018, with 49% from CHAT4, 18% from STEW5, and 12% from WCSI7 (Table H.2). These main areas contacted decreasing numbers of cells over the years; for example, cell numbers contacted in CHAT4 decreased from over 5000 in 2008 to under 3000 in 2018.

Tier 2 fishstocks contacted 11 091 cells during 2008–2018 (Table H.3), with barracouta and silver warehou each contacting 42% of the total cells. Sea perch and alfonsino fishstocks contacted 11.5% and 9%, respectively. The annual numbers decreased from 5094 in 2008 to 3161 cells in 2018. Most of that decrease was from barracouta and silver warehou tows.

5.4.2 Distribution of aggregate swept area per cell, 2008–2018

Figure 14 illustrates the annual numbers of cells contacted by the deepwater footprint and indicates the relative numbers of cells within each fishing year, binned by the intensity of fishing within each cell, as measured by the aggregate swept area of each cell in that fishing year. An aggregate swept area of 25 km^2 in a cell is equivalent to the area of each cell; however, this swept area may represent tow swept area polygons that cross each other or are overlaid and therefore may not contact the 25 km^2 of seafloor in the cell. In each year, over 70% of cells were from the bins of the smallest aggregate swept area (>0–1 km^2, >1–5 km^2), and the numbers of cells in each bin group decreased over the time series except for the two groups with the highest aggregate swept areas: the numbers of cells in these latter two groups were greatest in the last two years, especially 2018. About 774–955 cells (equivalent to a seafloor area of 29 354–24 880 km^2) a year had aggregate swept areas of 25–100 km^2 and 66–130 (1650–3251 km^2 seafloor area) cells had over 100 km^2 of aggregate swept area per cell.

Figure H.1 presents summarised data in the format shown in Figure 14, for the two fishstock groups and the main Tier 1 and Tier 2 fishstocks, for 1990–2018, as requested by Fisheries New Zealand. The combined HAK/HOK/LIN/SWA/WWA fishstocks plot (Figure H.1) reflects the management of the hoki fishery, with regular decreases in the overall TACC from 2002 to 2008 and 2009, before small incremental increases in the following years: some of these changes resulted in hoki effort re-distribution through stock quota changes (Fisheries New Zealand 2019a), as well as effort re-distribution to other target fishstocks, such as the middle depths fishstock in this mixed fishery group. During 2008–2018, the numbers of cells in each intensity bin were reasonably constant across the years, other than the >0–1 km^2 bin which showed an overall decrease. There was a slight increase in the footprint for this mixed fishery during 2008–2018.

The summaries for the combined orange roughy and oreo fisheries and separately in Figure H.1. Access to these fisheries was affected by fisheries management including amendments to the TACCs. Changes to the TACCs in the main orange roughy fishery areas during 2008–2018 (ORH 7A, ORH 3B, and ORH 2B) followed substantial changes in earlier years (Fisheries New Zealand 2019a) and resulted in substantial decreases in available quota: decreases from 10 500 t in 2008 to 3600 t in 2012 and 2013, followed by increases to 5197 t in 2017 and 2018 in ORH 3B; 1 t (effectively a closure during 2001–10) then an increase to 500 t for 2011–2014, and a further increase to 1600 t during 2015–2018 for

ORH 7A; and decreases from 1700 t in 2008 to 725 t 2015–2018 in ORH 2A (Fisheries New Zealand 2019a).

For two oreo fisheries, the TACCs were constant throughout 2008–2018, at 2500 t for OEO 1 and 6000 t for OEO 6, after amendments in earlier years; OEO 4 had a drop in TACC from 7000 t implemented in 2004 to 3000 t for 2016–2018; and the TACC for OEO 3A remained at 6000 t for 2008–2018 (Fisheries New Zealand 2019a). The effect of the management of these fisheries is evident in the decrease in the footprint and cell numbers, as well as the spread of the aggregate swept area by cell. These fisheries are primarily conducted on underwater features requiring short tows down slopes often restricted in the available trawling area. Most cell contacted by these fishstocks are in the >0–1 km^2 bins, with the remainder in the 1–5 km^2 and 5–25 km^2 with no cells in the most intensively contacted bins. The larger number of >0–1 km^2 cells relative to other bins may also result from a mismatch of cell size with respect to the resolution of the data.

Cell summaries are also provided for arrow squid, scampi, southern blue whiting, black cardinalfish, alfonsino, redbait, rubyfish, and barracouta in Figure H.1. Although cell-based analyses allow for summaries of intensity within a cell, with a cell with an aggregate swept area of 25 km^2 appearing to indicate that the whole area of that cell was contacted, and that a cell with 100 km^2 had been contacted across its entire surface four times by trawls in that year, caution is required in the interpretation of these plots, primarily because of the assumptions listed in the methods, the patchiness of the fishing effort within a cell, the resolution of the position data, and the cell size used for a broadscale analysis.

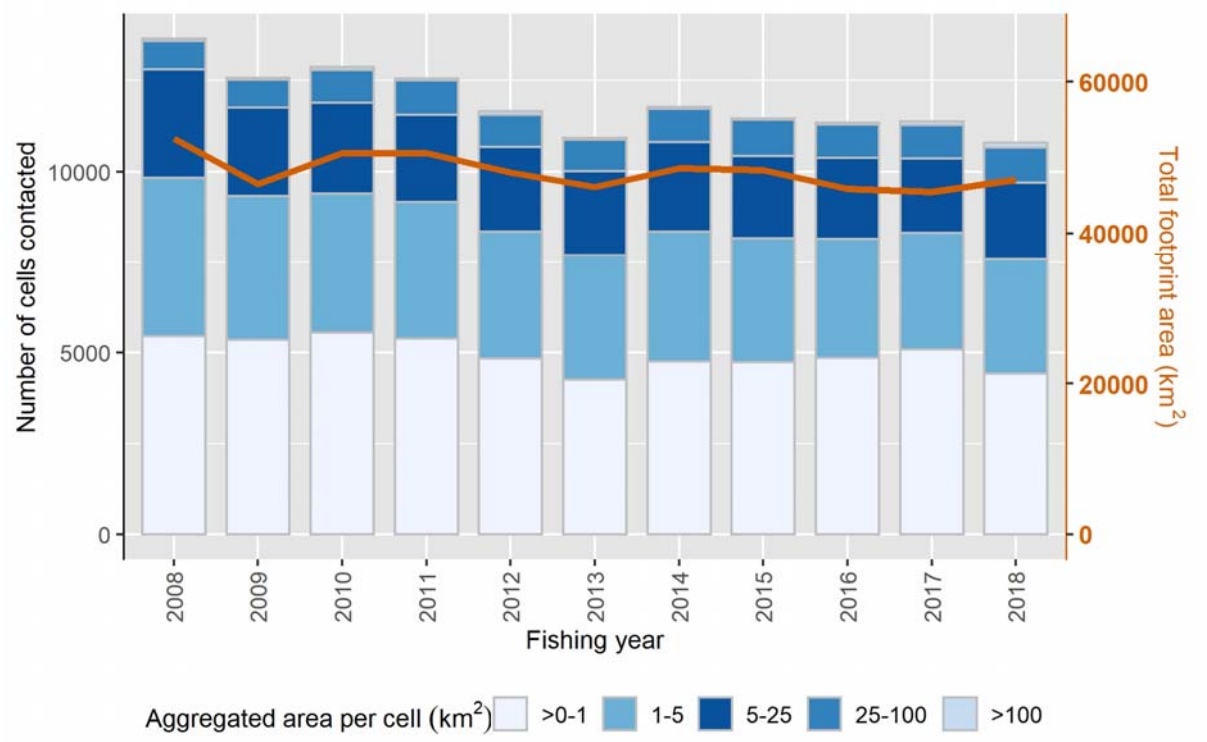

Figure 14: Number of cells with trawl contact (binned by the annual aggregate swept area (km^2) per cell) for combined deepwater Tier 1 and Tier 2 trawl fishstocks (bars), and the total trawl footprint (km^2) (line), by fishing year for 2008–2018.

5.4.3 Number of years a 25-km^2 cell was contacted, 2008–2018

About 17% of the 25 501 cells contacted by the deepwater footprint during 2008–2018 were contacted each year, 23.5% were contacted in only one year, and 36% were contacted in two years (Table 13). A similar distribution is seen for the Tier 1 fishstocks; but for the Tier 2 footprint, higher proportions of the total cells were contacted in one or two years only.

Less than half of the total cells contacted by the 2008–2018 deepwater footprint were contacted in a year, apart from 2008 (Figure 15). For 2014–2018, about 13% of cells were contacted each year, but not the previous two years (that is, left fallow for two years). About 4% annual cells in during 2016–2018 were not contacted by trawl gear in the previous five years.

The spatial distribution of the number of years fished per cell for the deepwater fishstocks by tier is shown in Figure 16. For each tier, the main fishstock trawling areas are well defined by the cells that were contacted in most years, with the Tier 2 fishstock cells with frequent contact in the shallower waters off the west coast South Island, on the Stewart-Snares shelf, and off the northwestern South Island. Cells with contact in one or two years tend to be on the outskirts of the main trawling areas or in waters distant from the main areas. The spatial distribution of the number of years contacted by the combined Tier 1 and Tier 2 deepwater fishstocks for 1990–2018 is provided in Figure H.2 in Appendix H for comparison.

Table 13: The number of cells contacted by the deepwater Tier 1 and Tier 2 fishstocks during 2008–2018, and the percentage of the total number of cells, by the number of years with contact, for each tier.

	Number of years a cell had contact by Tier 1 fishstocks											
	1	2	3	4	5	6	7	8	9	10	11	All
No. cells	5 933	3 041	2 171	1 637	1 385	1 149	954	856	875	951	3 654	22 606
%	26.2	13.5	9.6	7.2	6.1	5.1	4.2	3.8	3.9	4.2	16.2	100.0

	Number of years a cell had contact by Tier 2 fishstocks											
	1	2	3	4	5	6	7	8	9	10	11	All
No. cells	3 726	1 634	1 110	819	713	595	541	420	456	447	630	11 091
%	33.6	14.7	10.0	7.4	6.4	5.4	4.9	3.8	4.1	4.0	5.7	100.0

	Number of years a cell had contact by combined Tier 1 and Tier 2 deepwater fishstocks											
	1	2	3	4	5	6	7	8	9	10	11	All
No. cells	5 988	3 240	2 383	1 905	1 590	1 392	1 253	1 038	1 153	1 263	4 296	25 501
%	23.5	12.7	9.3	7.5	6.2	5.5	4.9	4.1	4.5	5.0	16.8	100.0

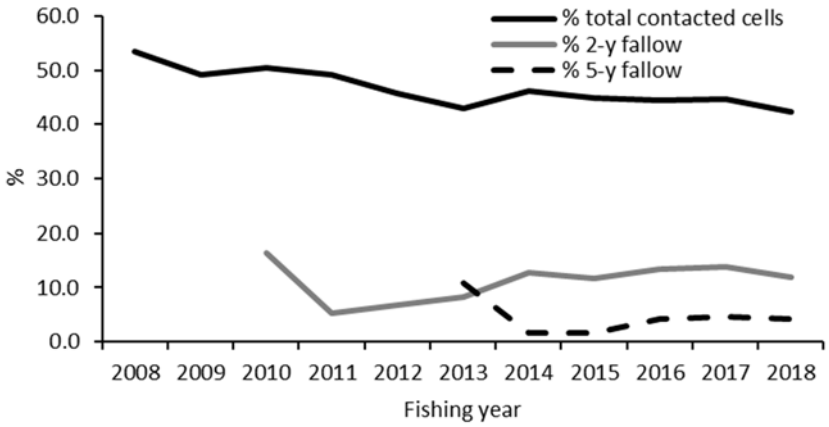

Figure 15: Percentage of the total number of contacted cells (25 501 cells during 2008–2018) with at least 1 trawl in each year (black line), and the percentage of the contacted cells in each year that was fallow (not contacted) for the previous 2 years (grey line) and previous 5 years (dotted dark grey line).

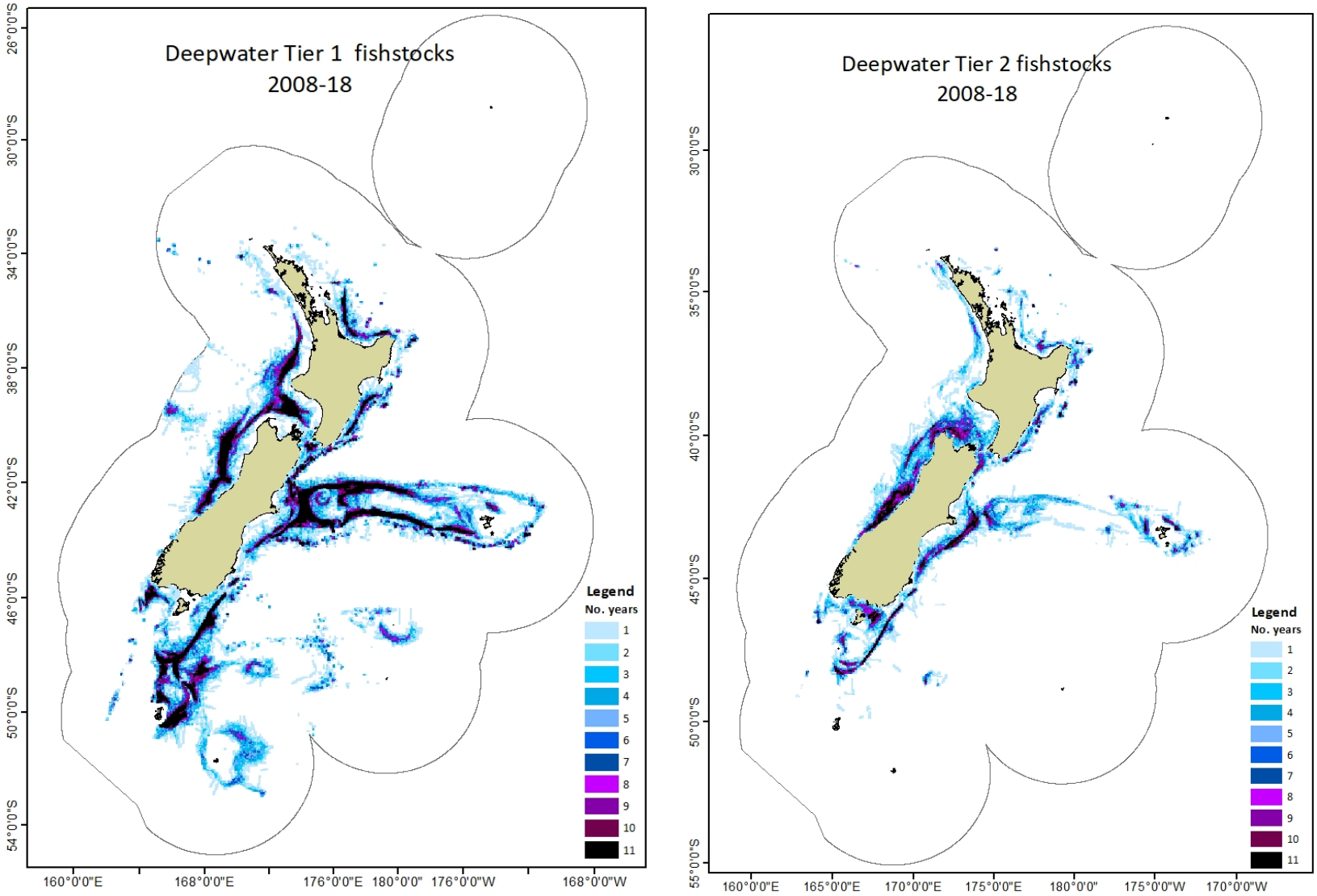

Figure 16: Distribution of the number of years a cell was contacted for Tier 1 fishstocks (left) and Tier 2 fishstocks (right), during 2008–2018.

5.4.4 Intensity of tows in contacted cells, 2008–2018

In total, 17% of all cells were contacted by only one tow, 51% of cells had up to 9 tows per cell, and 90% had up to 200 tows (Figure 17). The distribution of these data is shown, for Tier 1 and Tier 2 separately, in Figure 18. A total of 115 cells were contacted by 2000–3999 tows per cell, and another 9 cells with between 4000–7775 tows: these cells are in scampi fisheries in the Bay of Plenty, east of Hawke Bay, on the Chatham Rise, and east of the Auckland Islands; in hoki fisheries off the west coast South Island, Cook Strait, and off Stewart Snares shelf; in arrow squid fisheries east of Auckland Islands and Stewart-Snares shelf. Cells with the highest contact by Tier 2 tows were off East Cape and Hawke Bay, as well as on the Stewart-Snares shelf.

The maximum number of tows per cell for the 11-y period was 7788 tows, with a mean of 14 tows per cell each year for 2008–2017 (maximum number of tows per cell at 638–974 a year) and for 16 tows per cell in 2018 (maximum of 1156 tows per cell).

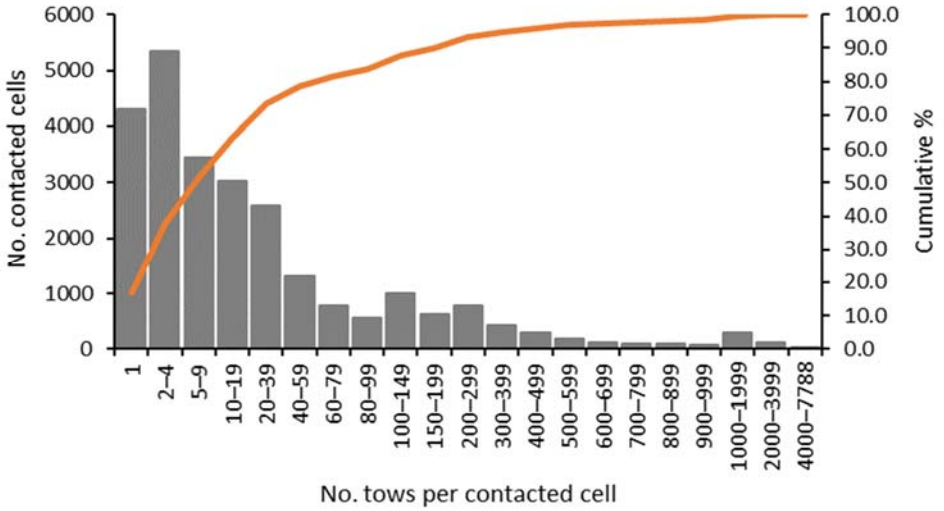

Figure 17: Number of deepwater tows per contacted cell, all fishing years combined, 2008–2018.

5.4.5 Number of 'new' cells contacted by the deepwater footprint, 1990–2018

In any given year, cells that have not been contacted by the estimated footprint in previous years are identified as 'new' cells. Table G.1 gives the number of new cells contacted each year by the deepwater trawl footprint between 1990 and 2018; this means that a cell contacted in the 1991 fishing year but not in the 1990 fishing year is considered a 'new' cell, as is a cell contacted in 1992 but not in 1990 and 1991, et cetera. However, this is an artificial start to trawling data; there was trawling before the 1990 fishing year. The discussion below relates to a subset of fishing years and the newly trawled ('new' cells) areas relative to that subset (see Baird & Wood 2018).

Table H.4 gives the numbers of 'new' cells and the footprint area and aggregate swept area estimated with those cells for Tier 1 and Tier 2 fishstocks, where, for example, 'new' cells in 2013 were cells not contacted by the tier group or Tier 1 target fishstocks in 1990–2012, and 'new' cells in 2014 were not contacted during 1990–2014, et cetera. For many of these fishstocks, the amounts of swept area or footprint in these 'new' cells is small and suggest that the cells may have contact from the end of tows or tows crossing the edges of cells. For example, the footprint area of the 'new' cells for hoki each year represent about 3–4% of the area of the 'new' cells, and the footprint area for the orange roughy and scampi 'new' cells is equivalent to about 1% of the 'new' cells area for each year. The estimated aggregate swept area and the footprint areas are also similar, which implies that this is generally not sustained targeted trawling. It is most likely an artefact from the data resolution and the methodology used to location the tows and generate a tow polygon. The distributions of these 'new' cells, by Tier 1 and Tier 2 fishstocks, are mapped in Figure H.3. Many are at the edge of the main effort.

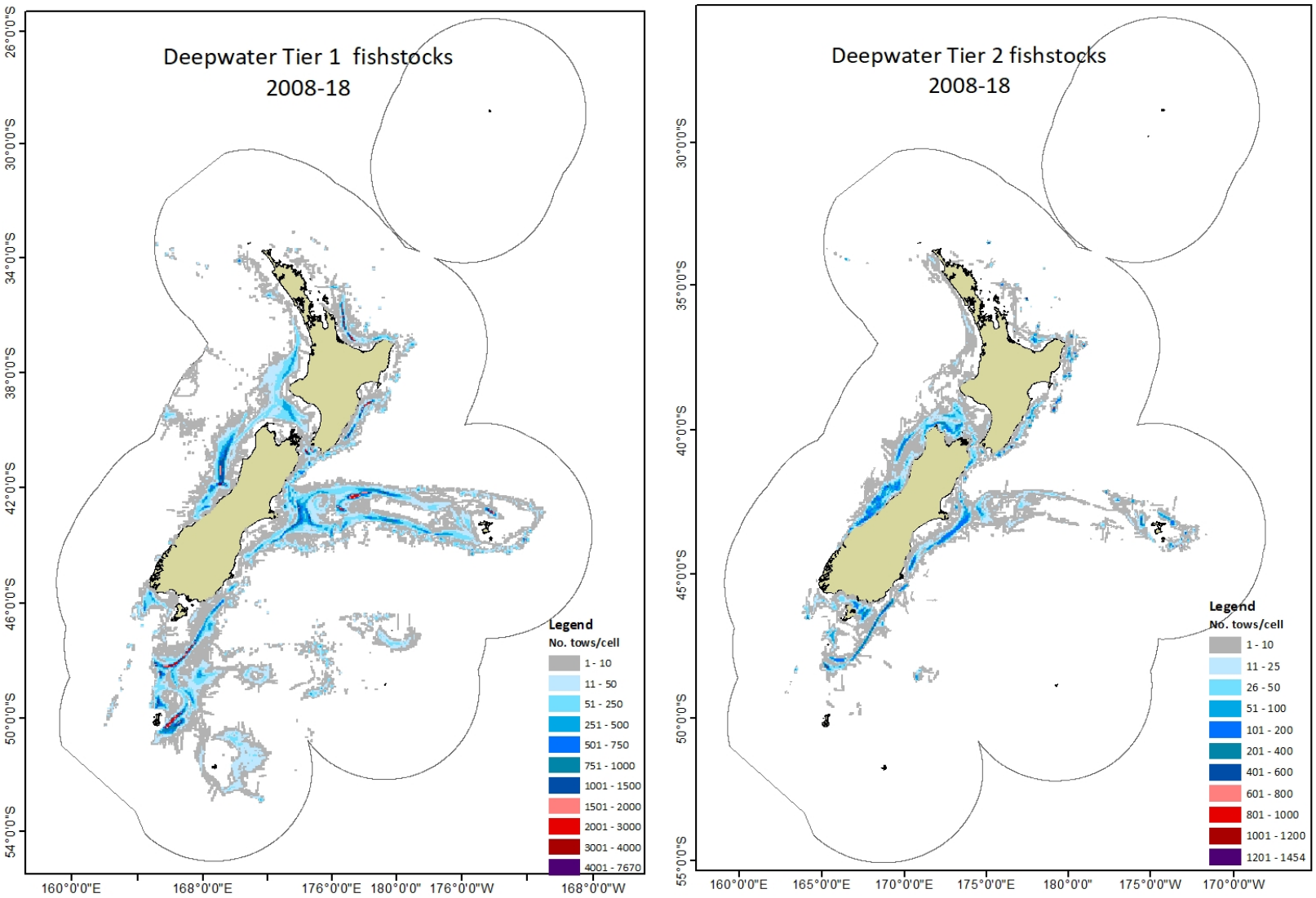

Figure 18: Distribution of the number of tows per 25-km^2 cell for Tier 1 fishstocks (left) and Tier 2 fishstocks (right), during 2008–2018.

6. OVERLAP OF TOTAL INSHORE AND DEEPWATER TRAWL FOOTPRINT WITH ENVIRONMENTAL LAYERS

GIS shapefiles of the footprint overlap data shown below are available from MPI Spatial Intelligence team. These files contain the underlying data and represent where the footprint overlaps the 'fishable' area (waters open to trawling down to 1600 m) and other areas of interest within the TS+EEZ: 200-m depth zones (within the 'fishable area), BOMEC, surficial sediment distribution, the inshore voluntary closure areas, and the Tier 1 species 'preferred habitat' (see Section 2.2).

6.1 Overlap of the 200-m depth zones within the 'fishable' area, 2008–2018

About 60% of the seafloor in waters shallower than 200 m are estimated to be contacted by the 2008–2018 footprint of the combined inshore and deepwater stocks (Table 14), 31% of the narrower band of 200–400 m depths off the shelf edge, 25% of the more expansive area of 400–600 m, and 15% of the 600–800 m depths. A similar distribution was seen in the 2018 data, though there was a higher percentage of overlap in 400–600 m than in 200–400 m relative to the 2008–2018 proportions.

Overall, the total inshore footprint contacted almost 9% of the waters open to trawling during 2008–2018 and 3% in 2018, with little difference between fishing years (about 16% overlap in under 200 m, 2.5% in 200–400 m, and 3% of the total fishable area each year). The inshore footprint was largely on the continental shelf within the 200 m depth contour where 45% of the area was contacted by inshore trawl fisheries. The reported fishing depth data indicated that 75% of all the inshore fishing was in 30–85 m depths (median of 50 m). The shallowest depths were trawled for flatfish, with most tows in 17–40 m. Snapper and red gurnard were mainly targeted in 30–65 m, John dory and trevally in 40–75 m, red cod in 40–95 m, barracouta in about 50–120 m, and tarakihi and stargazer in about 75–140 m.

For the deepwater fishstocks, 19% of the seafloor area in under 200 m was contacted during 2008–2018, 10% of 200–400 m, 24% of 400–600 m, and 15% of 600–800 m (Table 14). The Tier 1 footprint overlap of each depth zone, by target, is given for 2008–2018 and 2018 in Tables 15 and 16. The deepwater Tier 1 footprint contacted 11% of the fishable seafloor in 2008–2018 and about 3% in 2018.

The annual footprint for Tier 1 fishstocks during 2008–2018 decreased in the shallower depth zones, increased in 400–600 m and 600–800 m, and decreased in waters deeper than 800 m. Over the 11-y period, 5.6% of the fishable area was contacted by the hoki footprint. About 90% of the Tier 1 footprint was in depths shallower than 800 m, and the 200–400 m and 400–600 m zones have the highest proportion of footprint overlap (21% and 23%, respectively). Hoki is the main contributor in 400–800 m depths, with hoki, ling, scampi, and squid important in 200–400 m and jack mackerels and arrow squid important in waters shallower than 200 m. The 2008–2018 hoki footprint has the greatest coverage of 200–800 m waters, contacting about 6% of the 200–400 m zone, 16% of the 400–600 m zone, and 13% of the 600–800 m zone (see Table 15).

Orange roughy, oreo, and hoki footprints overlap about 1% of the area in 800–1000 m, as do oreo and orange roughy footprints in the 1000–1200 m zone. The deepest depth zones have under 1% overlap by these targets. The overlap for 2018 follows the same pattern as that seen for the full 2008–2018 dataset.

All fishstocks show footprint overlap in depths outside the likely trawling depths for a target, as a result of the mismatch in resolution of the data and poor definition of tow direction or tow length: this outlying footprint area is evident in, for example, Figure 7, where effort extends away from the edges of the main fishery areas. However, the bulk of the footprint for each target is in relevant depths.

Table 14: The total area of each 200-m depth zone and the percentage of each depth zone area covered by the 2008–2018 and 2018 bottom-contacting trawl footprint for the all stocks (inshore and deepwater combined), for inshore fishstocks, and for Tier 1, Tier 2, and combined deepwater fishstocks. Note that the Inshore data given here are for the FMA-based mixed trawl footprint and represent 98% of the inshore footprint.

Depth zone		2008–18 overlap (%)					2018 overlap (%)				
				Deepwater stocks					Deepwater stocks		
(m)	Area (km^2)	All stocks	Inshore	Tier 1	Tier 2	All	All stocks	Inshore	Tier 1	Tier 2	All
< 200	249 341.9	60.2	45.4	13.1	8.6	19.2	18.0	14.3	1.9	0.9	2.7
200–400	98 295.9	31.4	10.7	21.0	9.7	10.0	7.9	2.4	4.9	1.3	5.9
400–600	253 939.2	24.6	1.2	23.0	3.6	24.3	9.5	0.2	9.1	0.4	9.4
600–800	185 161.6	14.7	0.8	14.4	1.0	14.7	4.6	0.1	4.7	0.1	4.7
800–1000	166 645.0	8.0	0.7	4.7	0.4	5.0	1.4	0.1	0.6	0.0	0.6
1000–1200	144 930.5	5.8	0.5	2.9	0.3	3.1	0.8	0.0	0.3	0.0	0.3
1200–1400	168 376.8	1.7	0.3	0.8	0.1	0.9	0.3	0.0	0.1	0.0	0.1
1400–1600	124 988.8	0.8	0.2	0.4	0.1	0.5	0.1	0.0	<0.1	0.0	0.0
≤ 1600	1 391 679.7	21.2	8.8	11.0	3.1	12.7	6.4	2.6	3.1	0.3	3.4

Table 15: The total area of the seafloor in each depth zone within 'fishable' waters, all depth zones ≤ 1600 m combined, and the percentage of each depth zone covered by the 2008–2018 bottom-contacting trawl footprint for each Tier 1 deepwater target species and for the Tier 1 targets combined. – indicates no footprint data.

Depth	Area	Footprint area overlap (%)									
zone (m)	(km^2)	HAK	HOK	JMA	LIN	OEO	ORH	SBW	SCI	SQU	Tier 1
< 200	249 341.9	0.1	1.3	8.4	0.7	<0.1	<0.1	<0.1	0.2	3.3	13.1
200–400	98 295.9	0.3	6.5	1.2	4.3	<0.1	<0.1	1.5	6.9	4.0	21.0
400–600	253 939.2	2.2	16.4	<0.1	2.4	<0.1	<0.1	2.9	2.0	0.5	23.0
600–800	185 161.6	2.2	12.7	<0.1	0.8	0.1	0.1	<0.1	0.1	0.3	14.4
800–1000	166 645.0	0.2	1.5	<0.1	0.1	1.6	1.2	<0.1	<0.1	<0.1	4.7
1000–1200	144 930.5	<0.1	0.4	<0.1	<0.1	1.1	1.3	<0.1	<0.1	<0.1	2.9
1200–1400	168 376.8	<0.1	0.1	<0.1	<0.1	0.2	0.5	<0.1	<0.1	<0.1	0.8
1400–1600	124 988.8	<0.1	0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	0.4
≤ 1600	1 391 679.7	0.8	5.6	1.6	1.0	0.4	0.4	0.6	0.9	1.0	11.0

Table 16: The total area of each depth zone within 'fishable' waters, all depth zones ≤ 1600 m combined, and the percentage of each depth zone covered by the 2018 bottom-contacting trawl footprint for the Tier 1 deepwater target species and the combined Tier 1 targets. – indicates no footprint data.

Depth	Area	Footprint area overlap (%)									
zone (m)	(km^2)	HAK	HOK	JMA	LIN	OEO	ORH	SBW	SCI	SQU	Tier 1
< 200	249 341.9	<0.1	0.1	1.1	<0.1	<0.1	<0.1	–	<0.1	0.7	1.9
200–400	98 295.9	<0.1	1.3	0.1	0.3	<0.1	<0.1	<0.1	2.3	1.3	4.9
400–600	253 939.2	0.1	7.7	<0.1	0.4	<0.1	<0.11	0.3	0.9	<0.1	9.1
600–800	185 161.6	0.3	4.5	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.7
800–1000	166 645.0	<0.1	0.3	–	<0.1	0.1	0.2	–	<0.1	<0.1	0.6
1000–1200	144 930.5	<0.1	<0.1	–	<0.1	0.1	0.2	–	<0.1	<0.1	0.3
1200–1400	168 376.8	<0.1	<0.1	–	<0.1	<0.1	0.1	–	<0.1	–	0.1
1400–1600	124 988.8	–	<0.1	–	–	<0.1	<0.1	–	<0.1	–	<0.1
≤ 1600	1 391 679.7	0.1	2.2	0.2	0.1	0.0	0.1	0.1	0.3	0.2	3.1

6.2 Overlap of the 15-class BOMEC, 2008–2018

For 2008–2018, the overlap of the all stocks footprint was greatest in BOMEC classes A–D, where the inshore footprint contacted 60–90% of the classes (Table 17); in class G, where 65% of the (relatively small) area was contacted by the inshore footprint and 40% by the deepwater footprint; in class I, where the deepwater footprint contacted 52% of the area; in class E, where both inshore and deepwater footprint contact was similar (21–23%); and in class H, where 28% of the seafloor area was contacted by the deepwater footprint and 14% by the inshore footprint.

Classes in predominantly deeper water, but not out to 3000 m, such as classes J, L, and M, cover the largest areas of seafloor within fishing depths and the percentage overlap is appreciably smaller. In the deeper classes, the overlap is mainly from the deepwater Tier 1 footprint: 9.5% of class J, 12% of class L, 2% of class M, and under 1% of class N. Overlap of class K, a very small area north of the North Island (see Figure B.1), was from the inshore footprint only (3%). The 2018 overlap showed a similar overlap pattern to that of the 2008–2018 overlap.

Table 17: The total area of each BOMEC class and the percentage of each class area covered by the 2008–2018 and 2018 bottom-contacting trawl footprint for the all stocks (inshore and deepwater combined), for inshore fishstocks, and for Tier 1, Tier 2, and combined deepwater fishstocks. – indicates no overlap.

		2008–18 overlap (%)					2018 overlap (%)				
BOMEC				Deepwater stocks					Deepwater stocks		
Class	Area (km^2)	All stocks	Inshore	Tier 1	Tier 2	All	All stocks	Inshore	Tier 1	Tier 2	All
A	27 557.0	59.0	58.7	0.2	1.5	1.8	20.2	20.1	< 0.1	0.1	0.1
B	12 420.0	90.2	89.0	4.4	25.0	27.0	38.6	36.9	0.5	2.3	2.8
C	89 710.2	72.1	57.5	19.5	8.3	25.0	19.4	16.6	2.7	0.4	3.0
D	27 267.9	77.6	75.1	2.4	5.2	7.3	27.5	26.6	0.3	0.2	0.5
E	60 989.8	38.0	22.8	14.1	12.2	20.8	10.3	6.4	2.5	2.1	4.2
F	38 608.5	9.3	–	9.3	0.1	9.3	1.0	–	1.0	< 0.1	1.0
G	6 341.9	74.1	64.7	26.8	21.0	39.0	20.5	14.7	4.8	2.2	6.8
H	138 551.4	38.4	13.8	23.3	8.9	28.0	10.8	3.4	6.5	1.1	7.5
I	52 223.9	52.0	1.3	50.0	7.7	51.6	21.2	0.1	20.4	1.3	21.1
J	311 360.4	11.6	1.6	9.5	1.5	10.4	3.3	0.2	3.0	0.1	3.1
K	1 289.1	2.9	2.8	–	–	–	0.3	0.3	–	–	–
L	198 577.0	12.1	–	12.0	0.2	12.1	3.9	–	3.9	< 0.1	3.9
M	233 825.5	2.3	0.1	2.2	0	2.2	0.6	< 0.1	0.6	< 0.1	0.6
N	493 034.7	0.8	0.2	0.6	0.1	0.6	0.1	< 0.1	0.1	< 0.1	0.1
O	935 315.2	< 0.1	0.0	< 0.1	< 0.1	<	< 0.1	< 0.1	< 0.1	< 0.1	<
All	2 627 072.6	11.2	5.5	5.8	1.6	6.7	3.4	1.6	1.6	0.2	1.8

6.3 Overlap of sediment layers: percentage carbonate, gravel, mud, and sand

This section presents a preliminary look at the use of the surficial sediments data in relation to the all stocks trawl footprint. The overlap of the 2008–2018 and the 2018 combined inshore and deepwater footprint with the area of the substrate classes is summarised in Table 18. There are overlaps between substrate types: for example, 0–20% sand could overlap with 80–100% gravel (compare figures in Figure B.2).

The areas of the classes in each substrate type for this TS+EEZ-wide subset of the original output (figure 3, Bostock et al. 2019a) are large; the greatest overlap of the 11-y all stocks footprint is with the 60–80% and 80–100% Sand classes, at 23% and 20%, respectively; these are the smallest (in seafloor area) Sand class. For Carbonate, the greatest overlap is in the 20–40% class; for Gravel, classes 0–20% and 20–40% have the highest overlap (note the vastly different seafloor areas of these classes); and for Mud (where the class seafloor areas are similar in size) the largest overlap is in the 0–20% class.

Table 18: Percentage overlap of the seafloor area of the substrate classes by the 2008–2018 and 2018 all stocks (inshore and deepwater fishstocks combined). For gravel, mud, and sand, the percentage classes total 100%, and for carbonate the percentage represents the proportion that is carbonate vs. non-carbonate.

Substrate	Class (%)	Class area (km^2)	2008–2018 overlap	2018 overlap
Carbonate	0–20	926 764.1	7.3	2.6
Carbonate	20–40	818 608.4	12.0	3.7
Carbonate	40–60	782 044.8	7.1	2.0
Carbonate	60–80	600 899.8	4.9	1.6
Carbonate	80–100	519 662.3	5.9	1.8
Gravel	0–20	2 535 379.0	8.8	2.9
Gravel	20–40	504 713.7	8.5	2.6
Gravel	40–60	318 555.8	3.6	0.9
Gravel	60–80	170 432.6	1.4	0.2
Gravel	80–100	108 750.5	1.2	0.2
Mud	0–20	762 571.7	12.1	3.4
Mud	20–40	732 798.3	9.4	2.7
Mud	40–60	739 087.0	8.2	3.1
Mud	60–80	695 296.7	6.1	2.1
Mud	80–100	768 737.1	2.2	0.7
Sand	0–20	1 169 746.0	2.1	0.7
Sand	20–40	1 099 216.0	5.4	1.9
Sand	40–60	944 924.3	10.1	3.3
Sand	60–80	370 066.2	20.2	5.7
Sand	80–100	116 733.9	23.4	7.1

6.4 Inshore footprint overlap with voluntary closures

Figure B.3 shows the locations of these voluntary closures around the South Island. The overlap of the inshore footprint and the voluntary closure areas are shown in Figures 19 and 20. The seafloor area of each voluntary closure is between about 330 and 380 km^2 for all areas except the Otago voluntary closure (almost 100 km^2) (Table 19). The data suggest there was a reasonable overlap of the inshore trawl footprint in all areas but the Otago voluntary closure. However, the broad scale of the underlying methodology and analysis of the inshore fishstocks is not suitable for distinguishing trawl contact in small isolated areas such as these (see Section 8.0), and these overlap results should be treated with caution. Figure 21 shows the extent of the snapper Tasman Bay voluntary closure area and start points of tows made during 2014–2018, including those that appear to be inside the closure. However, the resolution of the location data, and the lack of knowledge about the actual vessel track used when trawling, contribute to uncertainty as to whether this voluntary closure area has had trawling inside it or not.

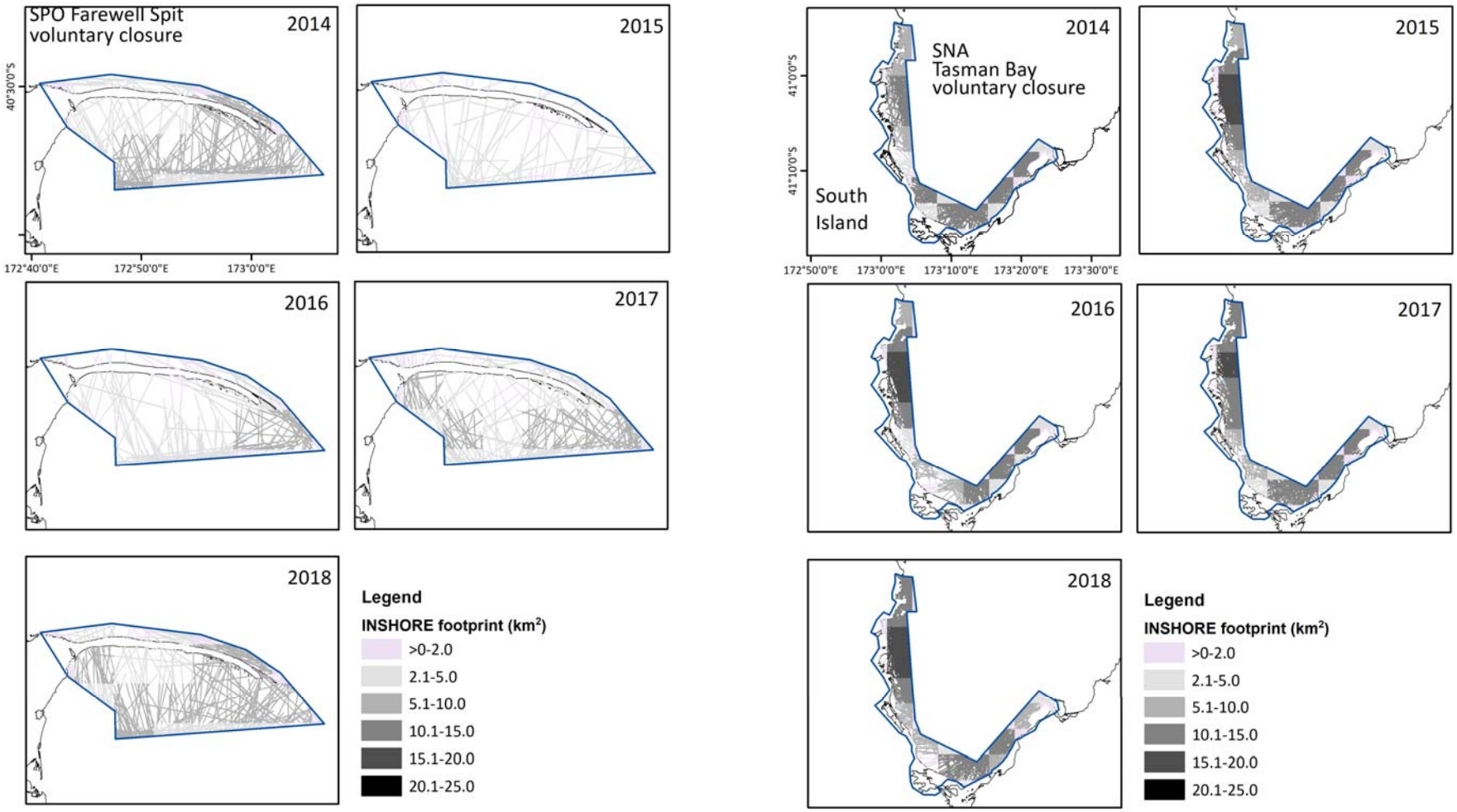

Figure 19: Overlap of 2014–2018 inshore trawl footprint with the Farewell Spit voluntary closure (left) and the SNA Tasman Bay voluntary closure (right).

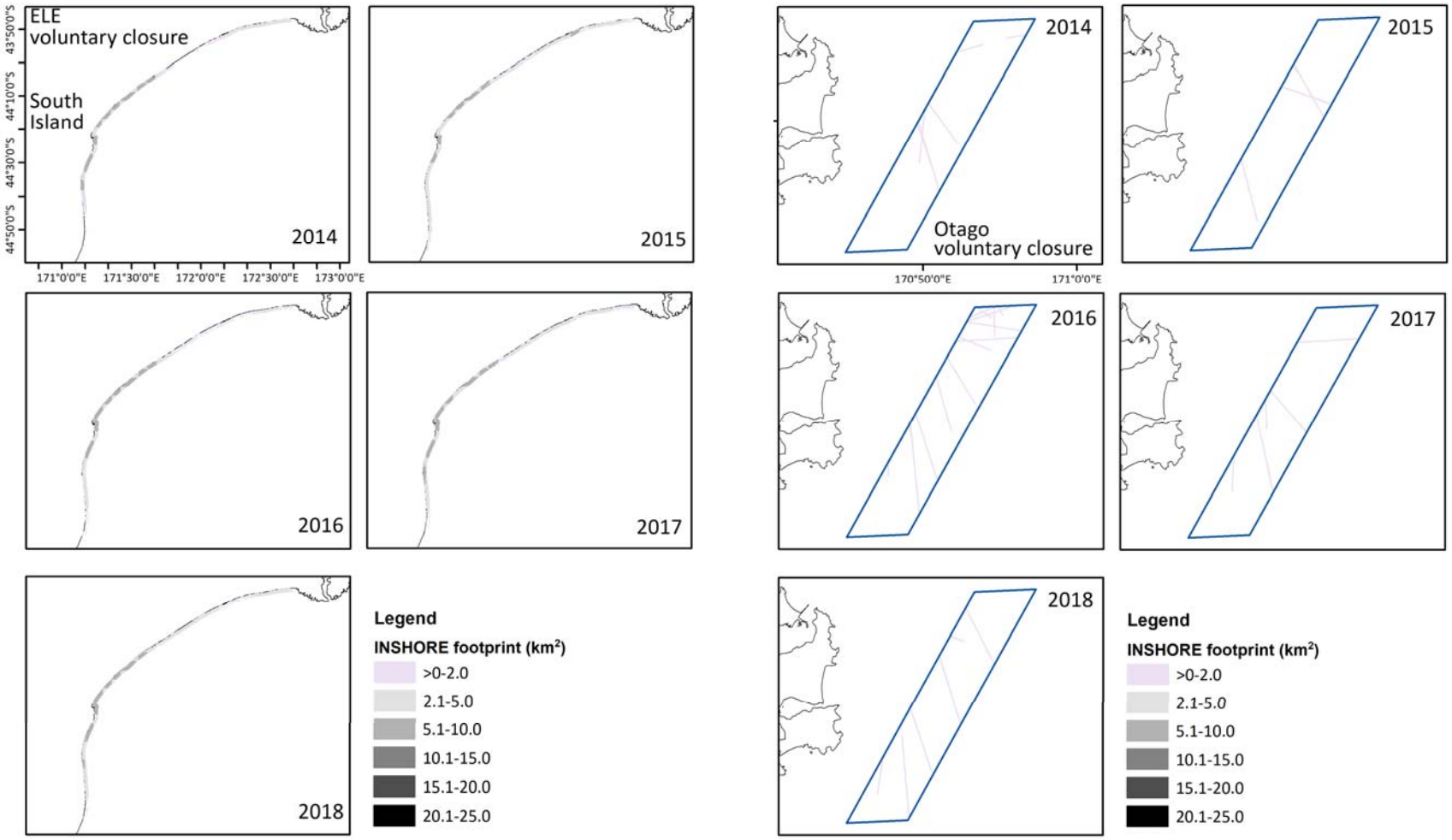

Figure 20: Overlap of 2014–2018 inshore trawl footprint with the ELE voluntary closure (left) and the Otago voluntary closure (right).

Table 19: Area of seafloor in each of the voluntary closure areas and the percentage of each area contacted by the inshore footprint for 2014–2018.

Voluntary closure	Area (km^2)	Footprint area overlap (%)					
		2014	2015	2016	2017	2018	Total
Otago	95.9	1.6	1.1	3.6	1.6	2.0	9.5
ELE Canterbury Bight	380.8	42.3	40.5	42.2	46.1	44.3	81.4
SNA Tasman Bay	356.2	42.8	48.2	43.4	45.9	44.5	66.9
SPO Farewell Spit	328.9	26.6	12.1	18.1	22.5	27.9	63.3
All	1 162.0	34.7	31.6	32.6	35.7	36.2	65.9

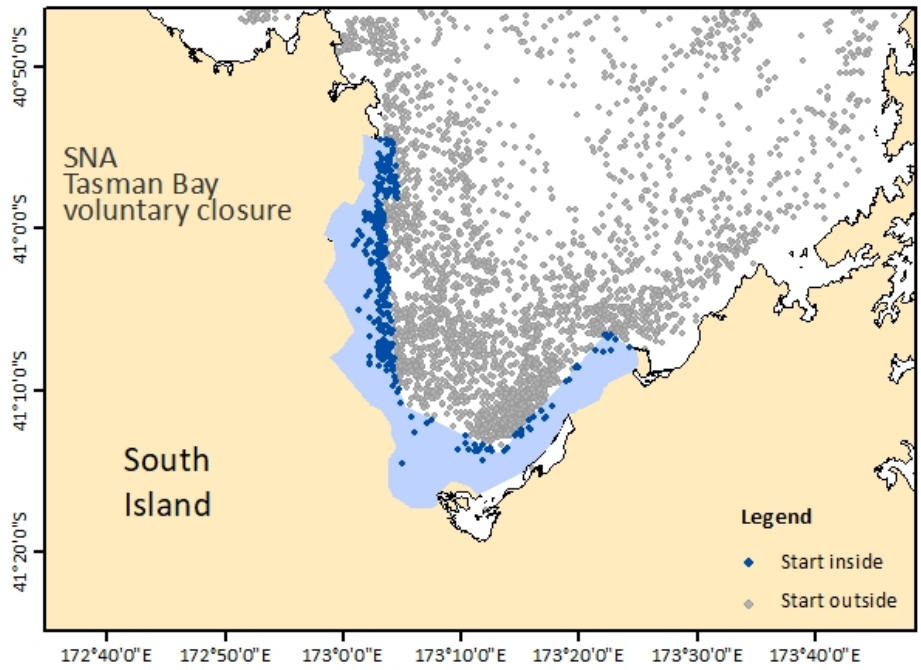

Figure 21: Location of start points for 2014–18 inshore tows in relation to the SNA Tasman Bay voluntary closure.

6.5 Overlap of preferred fish habitat/annual distribution for Tier 1 species, 1990–2018

The overlap of each Tier 1 target footprint on their 'preferred habitat' distribution for the seven fish species (or annual distribution for scampi and arrow squid) is provided as percentage overlap in Table 20, for 1990–2018. Figures B.4a–B.4c show the predicted distributions of these targets. This overlap is presented as the percent overlap for the probablity of capture of a fish from a standardised trawl, where over 90% is the body of water in which a trawl is most likely to capture the species. For most targets, the greatest overlap of the footprint was where the probability of capture was highest. However, for a few targets, such as hake and jack mackerels, the footprint overlap was higher in areas where the probablity of capture was 60–90% and 50–90%, respectively. The footprints of the annual distributions for scampi and arrow squid are also given in Table 20.

Table 20: The total area of each 'preferred habitat' (probability of capture) and the percentage of each species 'preferred habitat' (probability of capture) area (for HAK, HOK, JMA, LIN, OEO, ORH, and SBW) or area of the annual distribution (for SCI and SQU) covered by the 1990–2018 and 2018 bottom-contacting trawl footprint for the Tier 1 deepwater target species.

Preferred habitat (%)	HAK area (km^2)	HAK footprint overlap (%)		HOK area (km^2)	HOK footprint overlap (%)		JMA area (km^2)	JMA footprint overlap (%)	
		1990–2018	2018		1990–2018	2018		1990–2018	2018
0	202 097	0.2	0.0	204 964	0.2	< 0.01	1 418 074	0.1	< 0.01
0.1–1.0	244 964	0.1	0.0	330 294	0.7	< 0.01	33 410	0.7	< 0.01
1.1–5.0	577 217	0.1	< 0.01	291 969	1.7	< 0.1	67 480	1.9	< 0.01
5.1–10.0	204 473	0.2	< 0.01	111 676	3.8	0.1	49 148	2.2	0.02
10.1–0.0	170 408	0.3	< 0.01	134 901	3.8	0.1	54 084	4.4	0.14
20.1–30.0	103 565	0.6	< 0.01	59 165	5.9	0.2	49 732	12.2	0.34
30.1–40.0	79 792	1.1	< 0.01	42 155	7.3	0.3	42 506	15.6	0.61
40.1–50.0	72 627	2.3	< 0.10	34 019	9.1	0.4	37 320	13.1	0.66
50.1–60.0	67 559	3.6	0.13	32 943	9.7	0.5	33 291	16.3	1.25
60.1–70.0	63 800	5.3	0.20	35 693	8.5	0.7	36 193	27.2	2.43
70.1–80.0	56 649	11.3	0.48	39 001	10.8	0.8	28 729	24.5	1.72
80.1–90.0	26 713	17.3	0.63	64 032	11.0	1.4	14 934	18.3	2.23
90.1–95.0	2 827	11.3	0.26	138 827	15.7	2.8	5 123	1.4	0.0
95.1–99.0	240	2.4	0.0	353 292	32.8	6.7	2 907	0.3	0.0
0.0–99.0	1 872 931	1.2	0.04	1 872 931	9.7	1.6	1 872 931	2.6	0.2

Table 20: — *continued.*

Preferred habitat (%)	LIN area (km^2)	LIN footprint overlap (%)		OEO area (km^2)	OEO footprint overlap (%)		ORH area (km^2)	ORH footprint overlap (%)	
		1990–2018	2018		1990–2018	2018		1990–2018	2018
0	26 441	< 0.1	0	706 800	0.1	< 0.001	994 473	< 0.1	< 0.001
0.1–1.0	718 182	< 0.1	< 0.01	171 801	< 0.1	< 0.001	141 916	0.1	< 0.01
1.1–5.0	205 226	0.1	< 0.01	260 248	0.1	< 0.001	156 027	0.2	< 0.01
5.1–10.0	81 338	0.2	< 0.01	124 020	0.2	< 0.01	67 560	0.4	0.01
10.1–0.0	114 741	0.5	0.01	114 076	0.2	< 0.01	73 394	0.5	0.03
20.1–30.0	77 477	1.7	0.04	70741	0.3	0.01	49 725	0.7	0.05
30.1–40.0	47 409	2.7	0.09	48 614	0.4	0.01	36 247	0.8	0.03
40.1–50.0	36 658	3.6	0.16	44 832	0.5	0.01	30 953	1.0	0.04
50.1–60.0	40 624	2.9	0.12	45 664	0.6	0.01	31 241	1.0	0.03
60.1–70.0	35 529	3.4	0.22	48 856	1.0	0.02	39 780	1.0	0.04
70.1–80.0	48 160	3.0	0.16	62 442	2.1	0.03	49 936	1.3	0.07
80.1–90.0	106 259	3.4	0.14	81 103	3.9	0.05	57 127	2.1	0.10
90.1–95.0	141 069	5.9	0.26	45 309	6.7	0.16	34 929	4.1	0.21
95.1–99.0	193 818	5.2	0.34	48 425	15.7	0.43	109 623	10.9	0.43
0.0–99.0	1 872 931	1.6	0.08	1 872 931	0.9	0.02	1 872 931	1.0	0.04

Table 20: — *continued.*

Preferred habitat (%)	SBW Area (km^2)	SBW Footprint overlap (%) 1990–2018	SBW Footprint overlap (%) 2018
0	1 197 845	< 0.1	0.00
0.1–1.0	240 707	0.1	0.00
1.1–5.0	201 706	0.2	0.00
5.1–10.0	28 602	1.4	0.01
10.1–20.0	22 369	2.4	0.01
20.1–30.0	15 581	2.9	0.01
30.1–40.0	12 632	3.3	0.01
40.1–50.0	11 644	3.3	0.01
50.1–60.0	10 187	5.8	0.02
60.1–70.0	9 455	8.3	0.01
70.1–80.0	12 704	10.9	0.11
80.1–90.0	26 675	14.0	0.41
90.1–95.0	23 575	23.1	1.03
95.1–99.0	59 249	15.7	0.61
0.0–99.0	1 872 931	1.3	0.04

Annual distribution*	SCI Area (km^2)	SCI Footprint overlap (%) 1990–2018	SCI Footprint overlap (%) 2018	SQU Area (km^2)	SQU Footprint overlap (%) 1990–2018	SQU Footprint overlap (%) 2018
Hotspot	15 122	33.57	6.84	58 591	26.47	2.71
90% population	78 404	13.42	2.26	251 879	12.03	1.41
100% population	496 344	4.05	0.90	605 231	6.33	0.61
Known not to exist	3 637 494	0.05	< 0.01			
Unknown	17 375	0.01	0.00			

*****For SCI and SQU, the areas given here represent the areas shown for the annual distribution for scampi and arrow squid provided by MPI at www.nabis.govt.nz. The 'Known not to exist' and 'Unknown' categories combine to equal the area outside the 100% population area within the combined EEZ and Territorial Sea.

7. OTHER COMMERCIAL BOTTOM-CONTACTING FISHING ACTIVITY

7.1 Danish seine

A Danish seine net is defined as "any net or part of a net (including any warp, rope, chain, material, or device used in conjunction with or attached to the net) that — (a) has a buoyancy system on the top edge; and (b) is weighted on the bottom edge; and (c) is operated, without the use of any horizontal net opening device, by surrounding any fish and being drawn over the bed of any waters, or through any waters, to 1 or more vessels" (Fisheries (Auckland and Kermadec Areas Commercial Fishing) Regulations 1986).

Danish seine daily data (recorded on CELRs) were extracted for 1990–2018 as a base dataset for the main summary dataset required for this project; that is, fishing years 2008–2018. Minimal grooming was applied to these data, other than to check target species and to amend a small percentage of duration data and number of daily sets data. Overall, 98% data had 1–5 sets a day, with a mean duration of 6 h a day and a median of 4 h a day. The median number of sets per day (2) was applied to records with zero sets or more than 5 sets per day.

A total of 62 347 daily records from CELR data for 1990–2018 equated to 129 049 Danish seine sets for the main target species which accounted for 96% of the total Danish seine sets (snapper, red gurnard, John dory, flatfish, tarakihi, and red cod) (Table I.1 in Appendix I). During 1990–2018, 70 vessels reported Danish seine sets, and 37 vessels made at least 1000 sets over the time period and accounted for over 94% of the 1990–2018 effort. The annual number of sets in the 1990s was generally between about 4000 and 5700 sets. From 1999 to 2006 fishing years, annual numbers dropped slightly to 3200–3800. In subsequent years, 4000–5200 sets were made a year except in 2018 (3400 sets). These changes over the time period were mainly related to the snapper effort.

Overall, 50% of the sets targeted snapper, 20% targeted red gurnard, 13% were for John dory, 9% for flatfish, and the remainder for tarakihi and red cod. The peak of Danish seine effort for snapper was in the 1990s, at between 2000 and 5000 sets annually. Since then, 1500–2000 sets were made each year. Effort for red gurnard shows periods of higher effort (over 1000 sets annually during the early 2000s and 2009–2014). Flatfish effort was varied across all years, though from the mid-2000s between 500 and 1200 sets were reported annually. Danish seine effort for tarakihi was inconsistent in the 1990s, with less than 100 sets a year from 1991–2006. From 2007, the annual number of sets increased from 200 to a peak in 2014 (at over 600 sets) and then remained relatively steady at about 360 sets a year for 2016–18. Red cod was not a reported target for Danish seine nets until the mid-2000s, and annual effort varied between about 200 and 400 sets a year.

Twenty-six vessels made at least 500 sets during 2008–2018, which equates to over 96% of the total Danish seine effort in those years (50 199 sets). The total effort for the main targets is given by fishing year in Table 21 and by Statistical Area in Tables I.2–I.8. For the main targets in 2008–2018, 20% of the Danish seine effort was in Statistical Area 006 in the Hauraki Gulf, with another 6% in Statistical Area 003 and 4% in Statistical Area 005. In the Bay of Plenty, 16% of total sets for 2008–2018 were from Statistical Area 009, 8% from 008, and 5% from Statistical Area 010. Another 4% were from Statistical Area 047 off the northwest coast of the North Island. Annual effort decreased slightly overall in Statistical Area 006, decreased in 047, whereas it increased in Statistical Area 009 during 2008–2018. The distribution of Danish seine effort for the main target species in 2008–2018 by Statistical Area is shown in Figure I.1.

Statistical Area 038 in Nelson-Marlborough waters accounted for 14% of the total effort for 2008–2018 and Statistical Areas 020 and 022 off the South Island east coast accounted for 8% and 7%, respectively. Annual effort decreased over time in Statistical Area 038, whereas effort fluctuated annually in Statistical Areas 020 and 022.

Statistical Area 006 was the most important fishery area for snapper during 2008–2018 (41% of all snapper sets), with reasonably consistent effort from year to year (Table I.3). Other important snapper areas were Statistical Areas 008–010, with lesser effort in 003 and 005. Red gurnard was targeted mainly in waters around the northern North Island, in 003, 005, 008, and 009 and in 047 off the west coast (Table I.4). Effort in 047 decreased over the 11-y period, as it did in many other areas, though more Danish seine sets were reported towards the end of the time series in Statistical Area 009.

Flatfish effort declined by about 50% over the 11-y period (Table I.5). Almost 80% of the flatfish effort was in Statistical Area 038. The remainder of the flatfish effort was mainly in Statistical Areas 020 and 022. Statistical Areas 020 and 022 were also important for tarakihi, accounting for 53% of the Danish seine sets during 2008–2018. Statistical Area 009 (26%) was the next most important area (Table I.6). Red cod effort has remained reasonably constant throughout 2008–2018 compared with other targets and the effort was almost exclusively targeted in Statistical Areas 020 and 022 (Table I.7). Effort for John dory was concentrated in Statistical Area 006, though towards the end of the time series few sets were made in this area, with an overall decline in effort for this target (Table I.8).

Table 21: The number of Danish seine sets for each of the main targets during 2008–2018. Target species codes are defined in Table 1.

Fishing year	FLA	GUR	JDO	RCO	SNA	TAR	Total
2008	1 199	899	435	406	2 027	207	5 173
2009	968	1 159	257	361	1 851	405	5 001
2010	1 262	1 171	198	308	1 839	436	5 214
2011	613	1 182	277	308	1 798	385	4 563
2012	1 056	1 054	315	176	2 060	502	5 163
2013	740	1 201	285	321	1 745	611	4 903
2014	666	1 022	369	255	1 540	622	4 474
2015	617	772	172	207	1 789	458	4 015
2016	536	813	113	266	2 045	371	4 144
2017	549	828	251	381	1 762	366	4 137
2018	486	686	91	290	1 502	357	3 412
Total	8 692	10 787	2 763	3 279	19 958	4 720	50 199

7.2 Shellfish dredge fisheries

Dredge fisheries for the scallop *Pecten novaezelandiae* and the dredge oyster *Ostrea chilensis* for 1990–2018 and 2008–2018 are summarised in this section (and Appendix J). These data update those described more fully by Baird et al. (2011) and Baird et al. (2015). Gear descriptions of the dredges used in these fisheries are described by Beentjes & Baird (2004).

This dredge effort was reported under the primary method code of "D" on CELR forms. Thus, each record represents the daily number of dredge tows by a vessel within the individual target fishery statistical areas: the west coast North Island scallop fishery, Northland scallop fishery, the Coromandel scallop fishery, the Challenger (Nelson-Marlborough) scallop fishery, and the Chatham Islands scallop fishery, and the Challenger oyster fishery and Foveaux Strait oyster fishery. The fishery areas are shown in Figure J.1.

The primary data grooming on the daily CELR dredge records concentrated on the daily number of tows and the fishery-specific statistical area data and generally follow the grooming by target used by Baird et al. (2011, 2015). These dredge fisheries operate under area-specific fishing years (see Baird et al. 2015), but the requirement for this work was to use the 1 October–30 September fishing year.

Management of these fisheries has changed throughout the time series and for some of the scallop fisheries there are various studies that characterise effort and summarise management changes (for

example, Fisheries New Zealand 2019b, Hartill & Williams 2014, Osborne et al. 2014, and Williams et al. 2014). No such characterisation work was available for the oyster fisheries.

7.2.1 Scallop dredging

Fishery-specific statistical area rules were used to groom the scallop data, and summary distributions of the effort numbers for the scallop fisheries are shown in Figure J.2 in Appendix J. Where the number of dredge tows per day were zero or over 40 tows, the numbers of daily tows were applied to the data, based on medians for each fishery: 16 for west coast North Island, 20 for Northland, 24 for Coromandel, 10 for Chatham, and 18 for the Challenger fishery.

From a total of 91 741 records for 1990–2018 (Table J.1), over 1.7 million dredge tows were reported for scallop fisheries (Table 22). Effort has declined steadily over the 29-y period, with 65% of tows made before 2000, and effort in 2018 totalling 10% of that in 1990. Improved reporting of effort, by individual fishery-specific areas, is evident from 2000 onwards (Table 22). The distribution of scallop effort by fishery area for 1990–2018 is shown in Figure J.3.

Table 22: Number of scallop dredge tows, by fishery, for 1990–2018. The fishery areas are: 'chat' is Chatham Islands; 'coro' is Coromandel; 'nor' is Northland; 'chal' is Challenger; 'wcni' is west coast North Island; and 'other' is effort that could not be assigned to an individual fishery-specific statistical area; some of the 'other' effort was reported as being in a General Statistical Area rather than fishery-specific area (for example, 038 effort that could not be assigned to Challenger fishery-specific areas).

Fishing year	chat	coro	nor	chal	wcni	other	Total
1990	1 093	17 440	35 197	4 775	0	33 835	92 340
1991	1 092	36 867	45 263	12 419	0	18 108	113 749
1992	695	42 586	62 120	22 280	0	22 565	150 246
1993	721	13 385	43 841	31 028	0	12 797	101 772
1994	16	16 666	51 885	68 068	23	2 114	138 772
1995	1 238	20 069	56 098	22 994	2 945	2 584	105 928
1996	1 422	18 519	25 489	58 246	13 249	10 708	127 633
1997	2 429	20 702	19 577	25 276	11 915	10 006	89 905
1998	1 197	17 108	15 342	22 766	12 548	12 452	81 413
1999	273	8 817	8 263	47 062	3 032	16 376	83 823
2000	179	4 230	5 734	35 394	3 320	10 176	59 033
2001	6	8 128	8 420	47 700	590	243	65 087
2002	43	9 282	7 664	60 687	3 998	253	81 927
2003	266	8 618	6 333	56 709	1 496	794	74 216
2004	0	11 164	8 253	32 019	2 076	463	53 975
2005	51	13 257	5 792	20 852	22	30	40 004
2006	0	14 432	6 240	30 843	0	348	51 863
2007	0	16 454	9 163	9 305	0	14	34 936
2008	0	14 719	7 260	6 292	824	52	29 147
2009	0	11 279	8 529	20 486	805	22	41 121
2010	0	9 583	4 288	9 374	2	7	23 254
2011	0	10 694	902	4 107	0	18	15 721
2012	0	7 437	847	7 507	0	15	15 806
2013	0	11 515	58	5 130	0	15	16 718
2014	0	14 256	178	4 837	0	32	19 303
2015	0	6 286	4 686	908	0	33	11 913
2016	0	6 134	3 187	1 657	0	11	10 989
2017	0	3 937	2 313	0	0	0	6 250
2018	0	5 982	3 026	0	0	4	9 012
All	10 721	399 546	455 948	668 721	56 845	154 075	1 745 856

7.2.2 Dredge oyster fisheries

From 41 462 records dredge oyster records for 1990–2018 (Table J.2), about 933 000 dredge tows were reported (Table 23). As with the scallop fisheries, some data were not allocated to fishery-specific areas within a General Statistical Area and these tows could not be assigned to fisheries given in Table 23; Table J.3 summarises the non-fishery-specific data, with almost 65% from the Challenger fishery during 1990–1999.

Foveaux Strait dredge oyster data

This fishery is the main dredge oyster fishery in New Zealand waters (Table 23) and operates between March and August. Effort has increased in recent years after various management interventions (Fisheries New Zealand 2019a), and the number of dredge tows reported in 2018 is similar to that in 1990. The effort distribution is shown in Figure J.2.

Challenger dredge oyster data

The pre-2000 data in 'other' in Table 23 are largely from the Challenger fishery (see Table J.3). There has been minimal oyster dredging activity in this area in recent years.

Table 23: Number of oyster dredge tows, by fishery, for 1990–2018. The fishery areas are: 'chat' is Chatham Islands; 'chal' is Challenger fishery in Statistical Area 038; 'fov' is Foveaux Strait; and 'other' is effort that could not be assigned to an individual fishery-specific statistical area.

Fishing year	chal	chat	fov	other	Total
1990	6 064	0	39 013	2 302	47 379
1991	12 256	0	64 496	1 327	78 079
1992	14 030	0	12 541	3 160	29 731
1993	17 232	0	3 498	7 715	28 445
1994	28 211	0	4 464	1 357	34 032
1995	25 284	0	4 227	6 162	35 673
1996	21 605	0	19 299	10 205	51 109
1997	15 446	0	16 504	11 647	43 597
1998	16 340	0	16 730	12 089	45 159
1999	14 339	2	15 927	10 732	41 000
2000	14 000	0	17 951	496	32 447
2001	9 936	0	17 596	223	27 755
2002	108	2	32 462	25	32 597
2003	14 327	0	19 164	0	33 491
2004	7 920	0	17 565	19	25 504
2005	10 802	0	25 446	0	36 248
2006	10 643	0	19 789	0	30 432
2007	9 348	0	16 225	0	25 573
2008	2 148	0	16 028	0	18 176
2009	613	0	17 610	0	18 223
2010	1 197	0	16 669	4	17 870
2011	1 777	0	16 771	14	18 562
2012	910	0	19 391	18	20 319
2013	230	41	18 996	5	19 272
2014	72	29	24 369	0	24 470
2015	99	0	23 109	11	23 219
2016	29	0	23 865	106	24 000
2017	16	0	32 448	0	32 464
2018	2	0	39 013	0	39 015
All	254 984	74	611 166	67 617	933 841

8. DISCUSSION AND MANAGEMENT IMPLICATIONS

8.1 The all stocks (combined inshore and deepwater) footprint

Comparable tow-by-tow data from different collection methods has enabled generation of an all bottom-contacting trawl footprint for 2008–2018, representing inshore and offshore fishstocks. The combined and deepwater fishstocks during 2008–2018 contacted 294 913 km^2, and this represented 21% of the waters open to trawling and 7% of the combined Territorial Sea and Exclusive Economic Zone. The footprint area declined from about 95 800 km^2 in 2008 to 89 000 km^2 in 2018. The annual inshore footprints were slightly larger (range of 43 145–48 200 km^2) than the Tier 1 annual footprints (40 400–45 250 km^2), but the extent of the overall inshore footprint was smaller than the deepwater Tier 1 footprint and this reflects the more concentrated trawling in the narrow band of depths fished in the continental shelf waters and the smaller gear used by the inshore fleet. This spatial extent of this 2008–2018 footprint indicated that fishing patterns remain constant and that there is very little effort beyond the areas already contacted in earlier years. Due to fishery closures in some years, such as in the ORH 7A fishery, some areas (cells) may appear to be new contact in areas previously fished, whereas other cells did represent areas explored for the first time (in terms of data collection period) as was seen in this area in 2017 (Baird & Mules 2019). Investigation of the contacted cells in each year suggested that the majority of 'new' cells had small swept areas that may represent misplaced tow polygons or the edges of a tow polygon where it contacted the cell.

8.2 Inshore trawl footprint

The distribution of inshore fisheries is based mainly on the data from the TCER forms. These data indicate a steady decrease in the annual number of tows and consequently the annual aggregate and footprint areas over the last 11 years, with 42 900 tows, an aggregate area of 63 850 km^2, and a footprint of 43145 km^2 in 2018. The largest 2008–2018 footprint was from FMA 7 (36 900 km^2), followed by FMA 3 (29 525 km^2), FMA 8/9 (25 880 km^2), FMA 1 (22 220 km^2), FMA 2 (18 595 km^2), and lastly, FMA 5 (8200 km^2). In the northern waters, snapper and tarakihi (and trevally and John dory) contributed most to the total FMA 1 footprint, trevally and tarakihi contributed most to the FMA 8/9 footprint, and tarakihi and red gurnard to the FMA 2 footprint. In FMA 3, the largest footprint contributors were barracouta and tarakihi (with red cod and flatfish also important), and in FMA 7 tarakihi and flatfish contributed the most to the total footprint. Giant stargazer, flatfish, and blue warehou were the main contributors to the FMA 5 2008–2018 footprint.

The data that generated the above estimated areas are limited in their location information in that an end position is not recorded and must be generated to allow creation of the trawl swept area measures (see Methods, Section 2.0). Although the method used to estimate a bearing for a tow in an attempt to get a finish position is sensible (in a situation where important data are lacking), the algorithm used to get a bearing requires a vessel to target the same species in the same area with a series of tows in each trip. The nature of the TCER data is that most vessels undertake short trips from the local port and this limits the number of tows in a trip and therefore a good proportion of trips have one, two, or three tows in a trip; this limits the effort available to estimate a direction for tows, even when the second step of the algorithm is to use nearby tows for the same target species as a guide to generate a bearing. This appears to have the effect of creating some radial patterns as seen at the southern end of FMA 9 in the TAR 1 and TAR 2 plot in Figure F.1.

Furthermore, the application of the duration-speed distance as a trawl distance measure to estimate, in association with the estimated bearing, the endpoint of the tow may result in:

a) trawl lengths that describe trawl tracks that deviate from a straight line and better represent the actual length of a trawl (for example, fishers may follow a contour when trawling);
b) therefore, trawl lengths that are not comparable with the trawl length used for the TCEPR and ERS data which are represented by the straight line between the start and end positions; and

c) trawl lengths that are grossly over-represented because, in the methodology used, these are applied to a reported start position as a straight line following the direction of the estimated end of tow position.

These effects are evident in the mapping of the trawl footprints. In particular, some inshore tows appear to be too long (when drawn as straight lines) and fishing well out of the normal depths of inshore species; and some tows appear to be showing patterns of fishing that are not representative, such as radial patterns in areas where depths would suggest that trawling would be beyond the species depths. It is likely that there is an overestimation of the inshore trawl footprints based mainly on the TCER forms, and that this is represented in the footprint in areas (cells) considered as increased spatial extent for some fishstocks. The introduction of electronic reporting of effort for the inshore vessels should allow various improvements to the inshore trawl footprint (see below). However, without better information on the fishing strategy of these vessels, especially when targeting in restricted depths, the relationship between the duration-speed distance and a straight-line distance will continue to be difficult to describe.

The tow location and tow length data impact on the spatial representation as summarised in the cell-based summaries. Most show a reasonably high degree of cells in each FMA with very little contact, and these are generally representative of the tow ends and often in depths outside the depth range of the target fishstock. Thus, it is likely that the number of 'new' cells, and extent of cells with bottom contact in each FMA, is exaggerated. The ERS data collection from the inshore vessels will allow for more precision in the location of each tow, with the collection of finer scale data for both start and finish positions required for each tow; albeit as a measure of the vessel position, not the trawl door and ground gear position, at the start and end of each tow.

Another important aspect of the generation of the swept area is the doorspread of a tow. In contrast to the larger deepwater vessels, inshore vessels are less likely to have sensor technology that measures the doorspread of each tow. Appendix A presents a brief summary on the doorspread values as recorded by government scientific observers for a variety of vessels and targets, both inshore and offshore. The observers get this information from the vessel skippers or from net plans. The observer data suggest that the generic doorspread values used in this footprint work may be reasonable for most targets, though the range of inshore vessels (and target fisheries) in the commercial dataset is far greater than that covered by observers. For example, there is a lack of observed data on flatfish trawls—and these fishstocks were a large proportion of the inshore data in some areas.

These issues also impact the overlap statistics in the extent of coverage. Caution is necessary when interpreting the outliers in this work. However, the bulk of the data indicate fishing activity in traditional areas each year, with little spread in extent for those cells with persistent bottom contact. We recommend that effort be put into achieving better understanding of the inshore tow length and doorspread data. Depending on the management objective that underpins the footprint work, it would be useful to get a fuller description of the inshore fishing gears used, especially the ground gear, as well as an understanding of fishing strategies, in different regions around New Zealand.

Collection of data through ERS, both from the inshore trawl fleet and from vessels using other bottom-contacting methods, will inevitably provide a more rigorous base dataset to monitor the inshore areas. With the in-house data grooming and GIS database, Fisheries New Zealand has a spatially-enabled dataset that can be readily queried for summary output for fishstocks throughout the inshore waters.

8.2 Deepwater trawl footprint

As with the inshore footprint, the nature of the data and the underlying assumptions mean that these relative measures reflect the fitness of the data and the relevance of the assumptions. An overall summary for 2008–2018 is presented below, followed by a discussion on the relevance of the 2008–2018 footprint as a subset of the full dataset for 1990–2018 and some considerations of the effect of the methods used.

Deepwater Tier 1 and Tier 2 fishstocks contacted about 1% of the combined waters of the Territorial Sea and the 200 n.mile Exclusive Economic Zone each year during 2008–2018, and 4.3% for all years combined. This equated to an overlap of about 13% of the seafloor in waters to 1600 m (under 4% annually). The 2008–2018 deepwater footprint contacted an estimated 177 267 km^2; 86% was from Tier 1 fishstocks. The annual deepwater footprints decreased from about 52 600 km^2 in 2008 to 47 100 km^2 in 2018, despite annual increases in the hoki and scampi footprints throughout 2008–2018. The overall hoki, scampi, and arrow squid footprints equated to 51%, 9%, and 8% of the 2008–2018 footprint, respectively. Declines in annual footprints were estimated for arrow squid, hake, jack mackerels, ling, and oreo species. Barracouta and silver warehou were the main Tier 2 targets, with overall footprints representing 43% and 37% of the 43 250 km^2.

The deepwater footprint for these 11 years represents reasonably stable effort for a sustained period, a level markedly lower than in the 1990s. The 2008–2018 data indicate a continuation of the decreasing trend in swept area since the late 1990s as overall effort declined, primarily as a result of management policies for sustainable fisheries and pressure on the environment. The changes in TACCs for hoki and orange roughy, in particular, have affected the annual footprints in relation to depth zones. Overlap of the deepwater footprint and modelled environmental distributions are provided, as is the extent of footprints in relation to a 25-km^2 grid.

Vessels and effort during 1990–2018. Under this project BEN201801, the full dataset of trawl effort from 1990–2018 was investigated for the deepwater fishstocks as a base for comparison with more recent data (2008–18). For the deepwater component of the bottom-contacting trawl footprint, there have been many changes in the vessel fleets and fisheries management that have affected the measures of swept area during the 29 years of tow-by-tow TCEPR data. Figure 22 shows the Tier 1 annual vessel and tow numbers by vessel length categories used to characterise the effort and to assign the generic doorspread widths (see Appendix A). During the 1990s, larger vessels ('C' and 'D' vessels: 46–104 m in length) dominated the trawling for Tier 1 fishstocks in the early years and, as numbers of the foreign-owned vessels decreased in vessel 'D' category, and the New Zealand domestic fishery built up, the numbers of domestic vessels increased (categories 'A', 'B', and 'C'), as did the number of foreign-owned vessels in the 'C' category.

During the 2000s, under 100 vessels fished Tier 1 fishstocks each year, with most vessels in the 46–82 m category, with decreasing numbers of vessels in groups 'B', 'C', and 'D' to 2007. The increase in numbers of vessels in 2008 is directly related to the introduction of the TCER data collection for small trawlers which enabled the effort by these vessels (category 'A', under 28 m) to be included in the dataset for the footprint analysis. However, despite a doubling of the numbers of category 'A' vessels, the annual number of deepwater tows for these vessels throughout 2008–2018 was only slightly larger than that in earlier years. A core number of vessels undertook most of the 'A' vessel effort each year (in 2008–2018), at about half the level of annual effort by the 'C' category vessels.

From 2008, the vessel makeup of the Tier 1 footprint data is very different from the earlier years. The depleted vessel numbers in all groups except category 'A' indicate that during 2008–2018 the vessel fleets are relatively stable. Some vessel numbers in these data, particularly after 2014, may include some duplicates because some vessels changed registration from being 'foreign' to 'domestic', though effectively using the same gear and crews.

8.3 Possible effects/artefacts of the methodology

This project further illustrated the challenges of how best to represent the footprint. Currently, the footprint is a relative measure for each tow based on a trackline (a straight line that connects the reported start position to either a reported (TCEPR, ERS) or a generated (TCER) end position) to which a generic doorspread value is applied. For the TCER data, the lack of an end of tow position requires the application of a distance measure derived from the reported hours fished per tow and tow speed. This distance may well better represent the track of a tow, as opposed to the 'straight line between two points' trackline. However, when this TCER distance is applied to start and end points, it potentially creates a

longer trackline than would be obtained if both start and end positions were recorded on TCERs. This appears to have had an effect in the extent of the footprint data for TCERs, with tows extending beyond depths that were likely fished. The number of cells with small amounts of footprint at the end of tows may well be over-estimated by this method. The introduction of ERS across the inshore fleet will enable better reconstruction of the trackline. However, the use of a straight line still has its problems in that in many fisheries it represents an unlikely trajectory. Furthermore, the width of the trawls as represented by the generic doorspread values, would benefit from a reality check and this could be achieved by use of summarised industry data collected from those vessels with the necessary electronic gear and further investigation of gear used by inshore fishers.

A new data extract was used for this project, with data from 1990–2018, for all trawl effort, over 2 million tows in total. There may have been some updates to the underlying data, but the methods used in this work were very similar to those used previously (for example, Baird & Mules 2019).

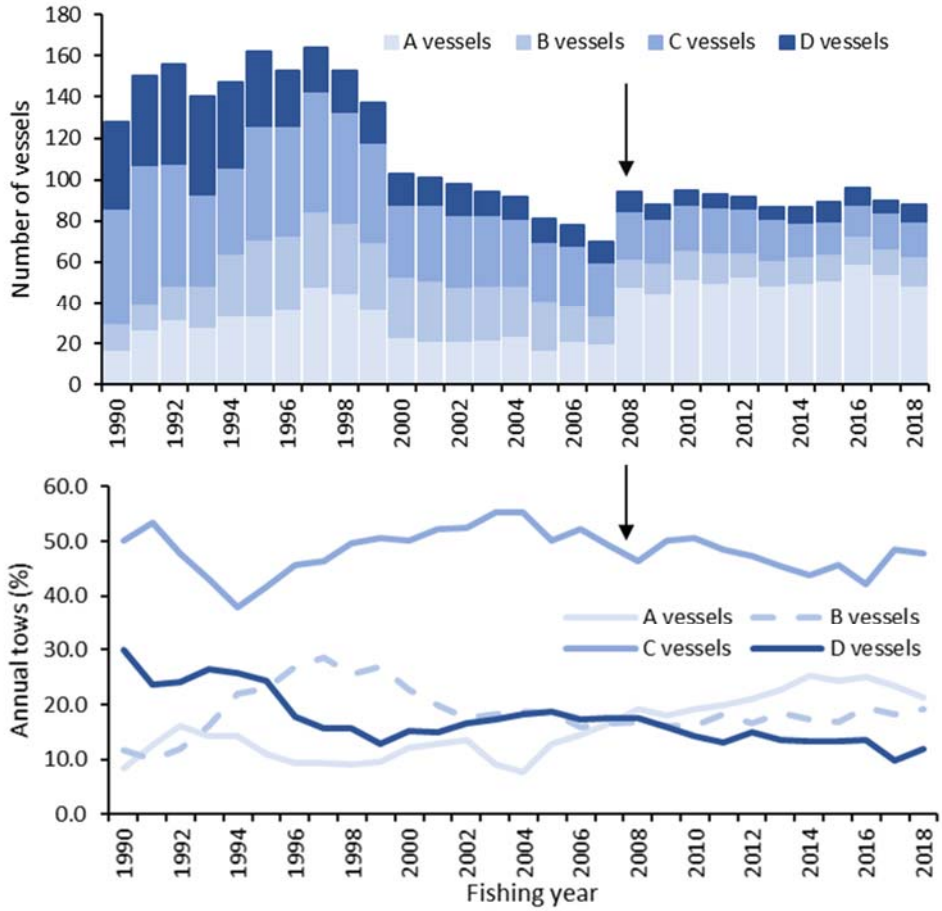

Figure 22: The number of Tier 1 vessels (top barplot) and percentage of Tier 1 bottom-contacting tows (bottom), by vessel length category and by fishing year, for 1990–2018. Black arrows indicate the introduction of the TCER. Note that data for 1990–2007 are from TCEPRs, data from 2008–17 are from TCERs and TCEPRs, and data from 2018 are from TCERs, TCEPRs, and ERS. Length categories are: 'A' vessels, ≤ 28 m; 'B' vessels, > 28 m and ≤ 46 m; 'C' vessels, > 46 m and ≤ 82 m; 'D' vessels, > 82 m (see Appendix A).

9. ACKNOWLEDGMENTS

This project was funded by Fisheries New Zealand, MPI, under project BEN2018-01. Thanks to Richard Ford and Karen Tunley (Fisheries New Zealand), the MPI Spatial Intelligence team, Ian Tuck (NIWA), and members of the Aquatic Environment Working Group for constructive discussion throughout this project. Thanks to Ian Tuck of NIWA and Karen Tunley and Josh van Lier of Fisheries New Zealand for reviews of this document.

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APPENDIX A: DESCRIPTION OF DATA GROOMING AND FINAL DATASET

Note. This appendix covers all the bottom-contacting trawl effort used to generate inshore, deepwater, and combined (all stocks) footprints, for 1990–2018, where relevant.

Grooming routines developed from the methods used by Baird et al. (2011), Black et al. (2013), Baird & Wood (2018), and Baird & Mules (2019) were applied to the MPI EDW database extract via the R Statistical package (R Core Team 2018). The grooming concentrated on the main variables considered necessary for the footprint spatial analysis.

Data for each of the main variables were explored using the vessel/vessel size/target species categories to isolate records with invalid codes or values and any obvious transcription or recording errors and to determine the distribution of variables used to characterise the effort. Where possible these errors were amended. These variables included target species, gear type, position data, tow duration, tow speed, net depth, and bottom depth. Depth data that describe the depth of the gear and the seafloor at the start of fishing were also groomed to identify near-bottom midwater tows and summarise the main depth ranges for each target species.

Observer data were investigated as part of the grooming to determine if there were trawl gear and operation data that might better inform the current grooming.

No data were deleted, other than duplicated records, and new fields were created to accommodate changed and new (derived) values. The grooming process was iterative, with 'corrections' made to one field at a time. Data within a defined range of values for each variable were retained as reported and those outside the range were assigned a median value determined from the data. Similarly, median values were assigned where there were zero values, missing data, or mismatched data (such as gear methods and headline heights for a given target species), based on the reported non-null data for a trip or a vessel. One exception to this was for the tow distance, as measured between reported start and finish positions (see Trawl Length paragraph in this Appendix).

All the trawl effort was retained for the first run of grooming, primarily to allow for checking of the reported target species (a dataset of 2 148 258 tows for all trawl effort during 1990–2018). A summary of the grooming for the main variables is given below. The final grooming run was restricted to the subset of bottom-contacting tows for inshore fishstocks, and deepwater Tier 1 and Tier 2 fishstocks, reported on ERS, TCER, and TCEPR forms (for 1990–2018); that is, tows that used bottom trawl gear or midwater trawl gear for which the reported net depth at the tow start was within 1 metre of the reported bottom depth at the tow start (n = 1 980 546 tows for 1990–2018). This is summarised in Table A.1.

Grooming of the main variables

Target species. Target species codes were checked for validity by comparing the area fished and the gear type used by a vessel on a trip. The full dataset was checked for inconsistencies in the recording of target species data. This was completed before the data were subsetted by inshore and deepwater fishstocks so that 'problem' target species, caused mainly by typological or transcription errors, such as 'SNA' and 'SWA' could be amended. In total, changes to 1877 targets were required (< 0.1% of tows); 77% of these changes were for tows reported as 'SNA' that were deemed to be 'SWA' and 'SWA' tows that were most likely for 'SNA', based on position (tows south of 42° S were considered as 'SWA') and tow depth data. Effort targeted at oreo species under the codes for black oreo, smooth oreo, and spiky oreo ('BOE', 'SSO', 'SOR') were reassigned to the generic code for oreo species ('OEO'). Data for the flatfish species (eight in total) were combined under the code 'FLA'. Generic codes were already assigned to species groups such as jack mackerels, alfonsino, and sea perch.

Gear type. The majority of gear codes were for bottom trawl gear ('BT'), with the remainder reported as midwater trawl ('MW'), and a small number as bottom pair trawl ('BPT') or the Precision Seafood Harvesting technology ('PRB' for bottom trawling and 'PRM' for midwater trawling) (see https://www.mpi.govt.nz/dmsdocument/44359-Precision-Seafood-Harvesting-Final-report) replacing the traditional cod-end. The ground gear (in contact with the seafloor) is likely to be unchanged. Reported gear codes were checked to ensure they matched the reported headline height and wingspread values, with the defining measurements of 10 m as maximum headline height and 40 m as maximum wingspread for 'BT' tows.

For the inshore fishstocks, 1% of the 550 402 'BT' tows were originally 'BPT' and 1% were 'PRB'. All but one of the midwater tows were 'MW'; the one was 'PRM'. For the deepwater Tier 1 fishstocks, 0.2% of the 841 064 'BT' tows were either 'BPT', 'MW', 'PRB', or 'PRM'; and 0.01% were 'BT', 0.03% were 'MPT', and 0.6% were 'PRM'. For the deepwater Tier 2 fishstocks, 0.2% of the 84 412 'BT' tows were originally 'BPT', 0.3% were 'MW', and 0.1% were 'PRB'; and 0.3% of the 16 761 'MW' tows were 'PRM'.

Vessel data. The overall length (in metres) of vessels was used to group similar-sized vessels together, to aid in grooming the data, based on the assumption that similar-sized vessels target certain species, operate in certain areas, and use similar gear. Vessels were assigned to the following categories: 'A' vessels ≤ 28 m, 'B' vessels > 28 m and ≤ 46 m, 'C' vessels > 46 m and ≤ 82 m, and 'D' vessels > 82 m. Overall, 67% of the 174 vessels were in category 'A', 11.5% in category 'B; 15% in 'C', and 7% in 'D'.

Number of nets. The number of nets used per tow was first reported on TCERs and TCEPRs in 2008. A set of data used in the stock assessment of hoki was obtained for use in this project to identify tows most likely to have used twin trawls in the deepwater fleet from the late 1990s (Sira Ballara, NIWA). Both twin-rigged and triple-rigged trawls were used in the scampi fisheries, so depending on the targets, between 1 and 3 nets is sensible. However, this data field continues to be poorly reported on, even in the latest electronic reporting where large numbers of nets were reported on some tows.

For the deepwater Tier 1 tows, about 7% of the original data had between 1 and 3 nets, with most of the remaining records as NAs. Fewer data were useful for the Tier 2 (2.4%) and the inshore data (5%) of the original data were useful. Where there were no records in the *EffortTotalCount* column, it was assumed that a single net was used as part of the bottom trawl rig. Where the target was 'SCI', in the absence of 'number of nets;' data, the reported effort width was used to define a twin-trawl or a triple trawl set-up.

Depths fished. Effort depth and bottom depth data were checked for inconsistencies. Bottom depth and net depth values reported at the start of the tow were used to describe depth ranges for each fishery and to determine which of the midwater tows were within 1 m of the seafloor, and thus be included in the final dataset for the footprint analysis. About 4.4% of the 2008–2018 inshore fishstock depth data had reported tow net depths deeper than bottom depths and the values for these tows were swapped; 3.0% of the 1990–2018 deepwater Tier 1 and 3.6% of the deepwater Tier 2 data were swapped. No further grooming was done on these data.

Tow speed. About 75% of the tow speed values were between 2 and 4.5 kn. The median speed for deepwater Tier 1 fishstocks was 4 kn.; 3.5 kn. for Tier 2 fishstocks; and 2.9 kn. for the inshore fishstocks. Overall, 0.1% of records were amended.

Tow duration. Less than 1% of the final datasets had amendments to the reported duration data, with most amended records for the deepwater targets such as orange roughy, oreo species, black cardinalfish, and alfonsino. Changes were made where records had zero or 'NA' and minimum tow lengths of 0.0833 h were assigned where records were zero—generally short tows for targets such as ORH and OEO. The full range of tow duration data after this grooming was 0.083–24.0 h; and the amended data made very little difference to the overall range, with median of 3.7 h for Tier 1 fishstocks, 2.7 h for Tier 2 fishstocks, and 3.3 h for inshore fishstocks. Almost all the tows longer than 20 h were for HOK, HAK, SQU, and SCI.

Duration data were particularly important in this work in the generation of the tow length and estimation of the end point of TCER tows (85% of the final inshore fishstock dataset). Summary statistics for TCER

duration data are: range of 0.083–24.00 h; the first quartile at 2.7 h, median of 3.4 h, mean of 3.5 h, and third quartile at 4.1 h. Less than 0.1% of these tows were longer in duration than 8 h.

Trawl length. This variable was generated for use in the algorithm used to estimate the end position for TCER tow data, with values based on the groomed tow duration x groomed tow speed and presented as kilometres trawled. The trawl lengths of 1615 TCER tows (0.3% of TCER data) were restricted to 55.56 km: 45% targeted flatfish, 25% were for tarakihi, 10% for red gurnard, and 8% for red cod; 57% were from FMA 3, 13% from FMA 1, 11% from FMA 2, and 6% from FMA 8/9. During 2011–2015, under 100 of these tows each year were amended for trawl length data, and the range for the other years in 2008–2018 was 168–231 tows.

Trawl lengths were also generated based on the distance between the TCEPR and ERS start and end points. Trawl lengths were subjected to the 'long tow' rule such that scampi, arrow squid, and hake tows longer than 70 km were set to 70 km and for all other Tier 1 and Tier 2 target tows, trawl lengths longer than 55.56 km were set to 55.56 km. Several orange roughy fishery areas in northern waters appeared to have long tows across features that were more likely to be short because of the nature of the underwater features). After consulting with fisheries experts, we chose to use the duration-speed data for oreo, orange roughy, black cardinalfish, and alfonsino to generate new tracklines (after Baird & Mules 2019). This may have had an effect of shortening some start-finish position-based tow lengths on the flat fishing areas. The resolution of tow data is not a good match for resolution of the 'seamount' polygon data to identify underwater features, such that position-based tow data may be offset from the location described by the seamount polygons.

Doorspread. The doorspread values were assigned to TCER, TCEPR, and ERS tow data based on vessel size category and the reported number of nets (see Table A.2). The generic doorspread values for the TCER inshore vessels are based on information received from net makers and fishing industry advisers from various regions in the early 2000s. Since October 2007, scientific observers have been collecting data on aspects of the trawl gear, including doorspread. Observers are instructed to "record the design Doorspread in metres. This should be an average value for this trawl system…obtained from net plans or directly from the captain".

Observer data suggest that, in the absence of the doorspread measure by tow, the generic values are reasonable for the larger vessels. A plot of the data by vessel category (A–D) and Fisheries New Zealand classification of vessel type is given in Figure A.1: 'BATM' for the largest foreign trawlers (over 100 m), 'DOM' for domestic vessels, and 'FOV' for foreign other than BATMs. The data for the smallest vessels that fish inshore waters were based on observed effort of a relatively small number of vessels, though a large size range was evident in the A.DOM category and there was wide variation in the doorspread data. In the A vessels range, scampi is the main target for the larger vessels and snapper, tarakihi, and trevally for the vessels less than about 25 m.

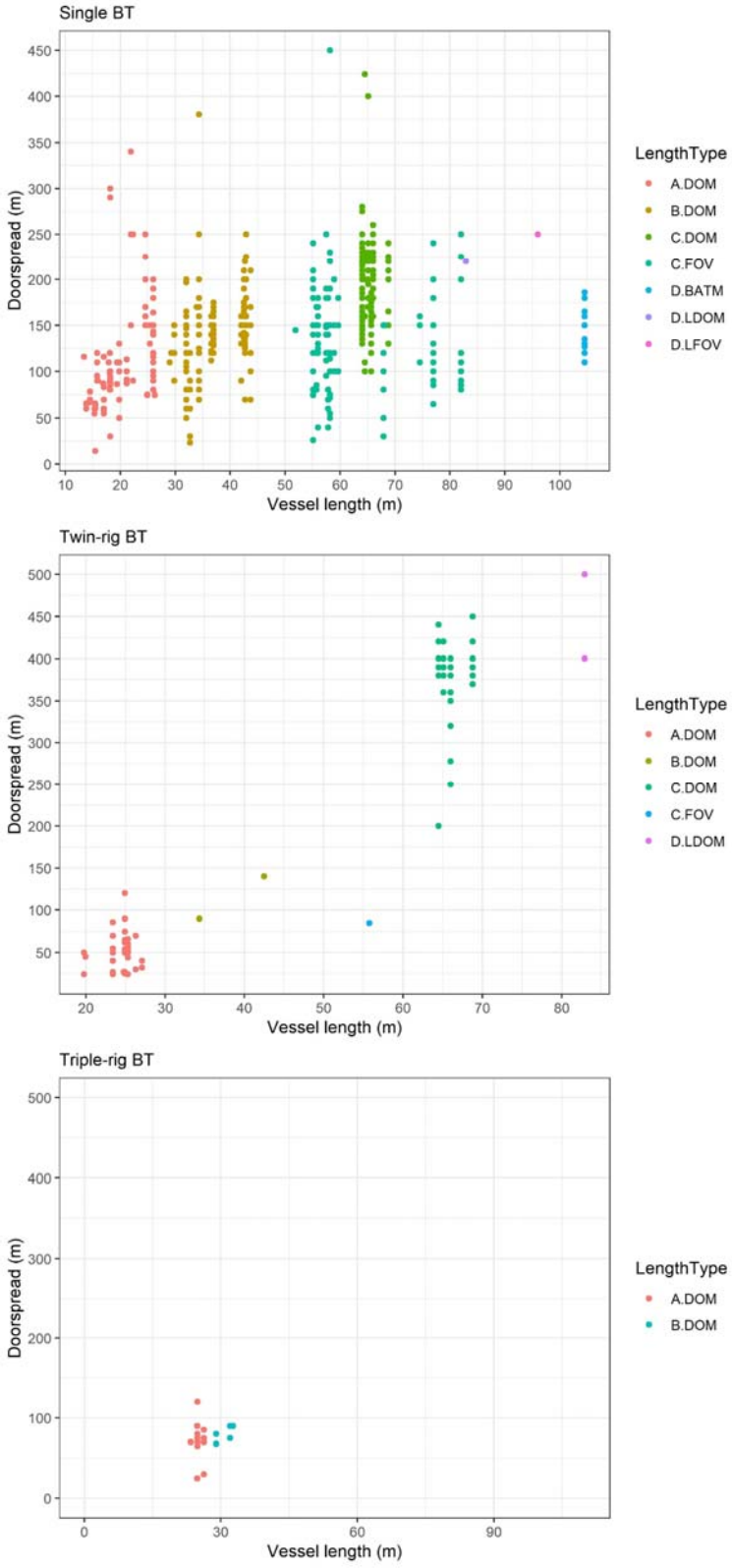

Figure A.1: The range of doorspread values provided by scientific observers on the Trawl Gear Details form, 2008–18. See above for vessels descriptions; note that "D.LDOM" is a large domestic vessels (over 82 m), and "D.LFOV" is a large foreign vessel.

Table A.1: Inshore and deepwater Tier 1 and Tier 2 fishstock data summary for all trawl data collection methods, 1990–2018. The original data summary for 1990–2018 and all trawl fishstocks is presented in (a), the inshore fishstock data summary in (b), and the deepwater fishstock summary in (c). The data in (b) and (c) represent the tow dataset prior to the spatial analysis. (d) summarises the TCER and TCEPR data retained for the spatial analysis (that is, were not "long" tows or tows on the land). NOTE: the number of deepwater vessels may be slightly exaggerated, particularly in recent years, for the TCEPR data because of the change of licensing of the previously foreign-owned fleet which resulted in name changes for those vessels that continued to fish in the New Zealand EEZ.

(a)

Original data (1990–2018)

Number of tows in the original full data extract for all targets = 2 148 258

Number of bottom-contacting tows for all inshore and deepwater Tier 1 & Tier 2 fishstocks reported on TCER, TCEPR, and ERS = 1 740 164 tows

(b)

Final dataset for all inshore fishstocks, 2008–18 [*n* = 561 416 tows]

Total TCER tows = 477 641 tows

Number of TCER trawl vessels = 235 vessels

Number of TCER = 71 200 trips

Main target for TCER = BAR, ELE, FLA, GUR, JDO, KAH, LEA, MOK, RSK, SCH, SKI, SNA, SPD, SPO, SSK, STA, TAR, TRE, WAR

Total TCEPR tows = 81 573 tows

Number of TCEPR trawl vessels = 63 vessels

Number of TCEPR trips = 5438 trips

Main target for TCEPR = BAR, ELE, FLA, GUR, JDO, KAH, LEA, MOK, SCH, SKI, SNA, SPD, SPO, STA, TAR, TRE, WAR

Total ERS tows = 2202 tows

Number of ERS trawl vessels = 16 vessels

Number of ERS trips = 137 trips

Target for ERS = BAR, ELE, FLA, GUR, JDO, LEA, SCH, SKI, SNA, SPO, STA, TAR, TRE, WAR

(c)

Final dataset for deepwater Tier 1 and Tier 2 fishstocks, 1990–2018 [*n* = 1 178 476 tows]

Total TCER tows = 29 568 tows

Number of TCER trawl vessels = 100 vessels

Number of TCER = 7553 trips

Main target for TCER = BAR, BYX, CDL, FRO, HAK, HOK, JMA, LDO, LIN, OEO, ORH, RBY, RIB, SCI, SKI, SPD, SPE, SQU, SWA, WWA

Total TCEPR tows = 1 128 519 tows

Number of TCEPR trawl vessels = 489 vessels

Number of TCEPR trips = 35 950 trips

Main target for TCEPR = BAR, BYX, CDL, EMA, FRO, GSH, HAK, HOK, JMA, LDO, LIN, OEO, ORH, PRK, PTO, RBT, RBY, RIB, SBW, SCI, SKI, SPD, SPE, SQU, SWA, WWA

Total ERS tows = 20 389 tows

Number of ERS trawl vessels = 38 vessels

Number of ERS trips = 569 trips

Target for ERS = BAR, BYX, CDL, FRO, HAK, HOK, JMA, LIN, OEO, ORH, RBT, RBY, SBW, SCI, SPE, SQU, SWA, WWA

Table A.2: The vessel size categories and doorspread values assigned to TCER, TCEPR, and ERS tow data for the swept area analysis. Target codes are defined in Tables 1 and 2. 'BATM' for the largest foreign trawlers (over 100 m), 'DOM' for domestic vessels, and 'FOV' for foreign other than BATMs.

Type	Length	Category	No. of nets	Target	Doorspread (m)
DOM	≤ 28 m	A	1	All	70
DOM	> 28, ≤ 46 m	B	1	All	90
DOM	≤ 46 m	A, B	2	SCI	50
DOM			3	SCI	70
DOM, FOV	> 46, ≤ 82 m	C	1	All except HAK, HOK, LIN, SWA	150
DOM, FOV			1	HAK, HOK, LIN, SWA	200
DOM, FOV			2	BT for HAK, HOK, LIN, SWA	400
DOM, FOV, BATM	> 82 m	D	1	ALL	200

APPENDIX B: EXTENT OF ENVIRONMENTAL LAYERS AND FISHERY AREAS

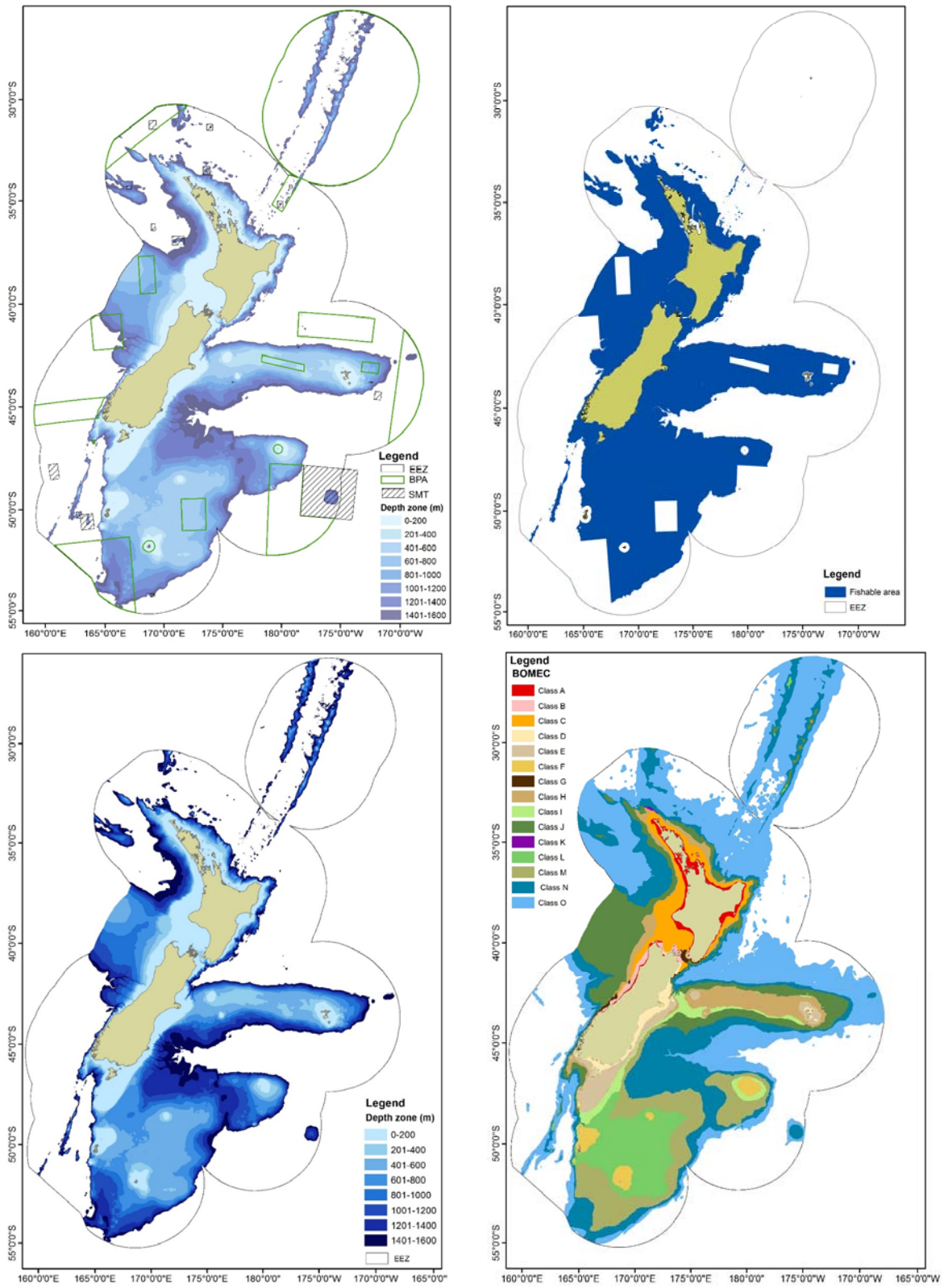

Figure B.1: The extent of the waters down to 1600 m with the overlap of Benthic Protection Areas (BPA) and seamount closed areas (SMT) (top left), the 'fishable' area with areas closed to bottom trawling (including cable lanes, marine farms, and marine reserves) removed (top right), 200-m depth zones to 1600 m depth (bottom left), and waters delineated by the Benthic-optimised Marine Environment Classification (BOMEC) distribution (right) to 3000 m depth (see Leathwick et al. 2012).

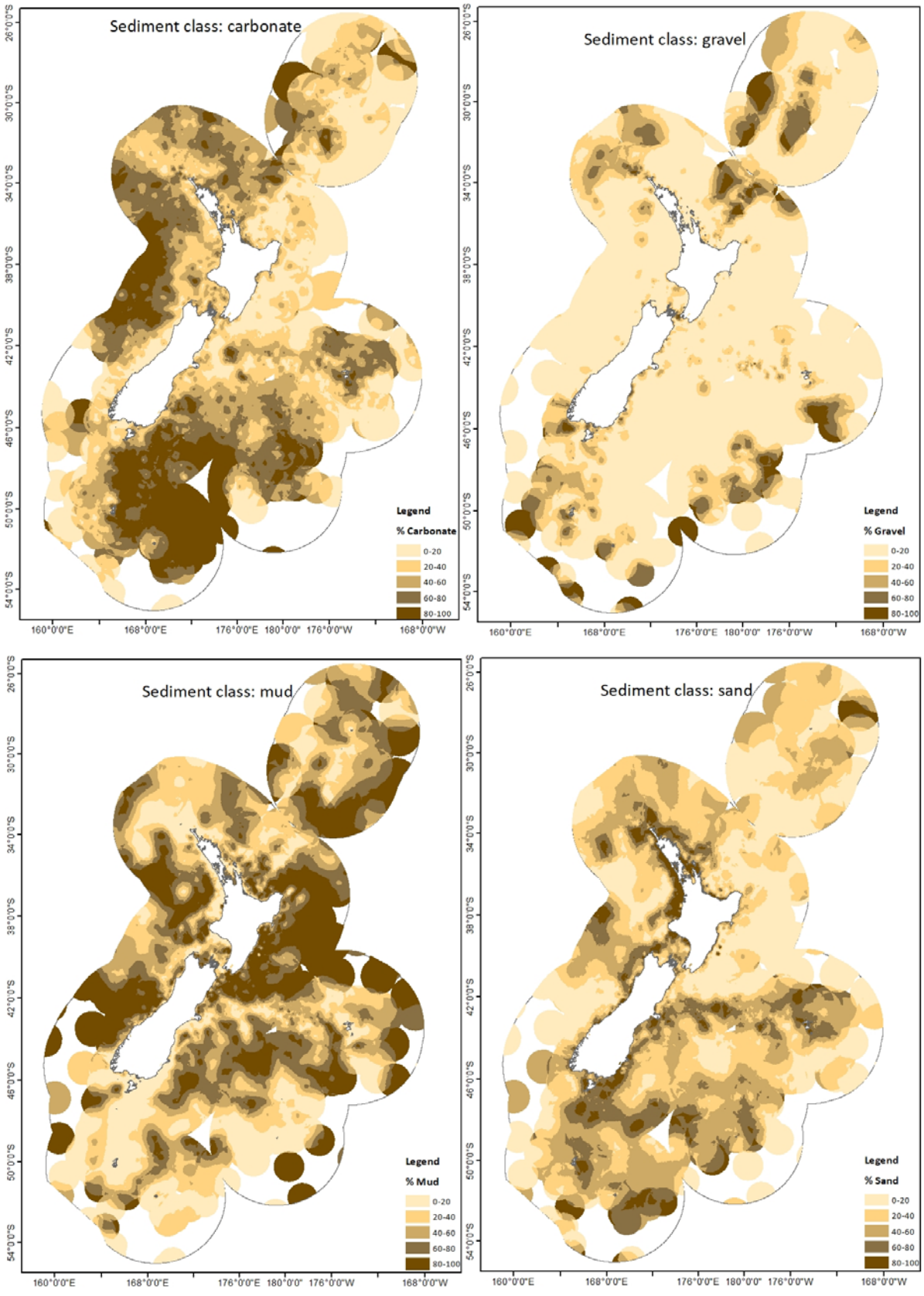

Figure B.2: The interpolated distribution (%) of carbonate, gravel, mud, and sand based on the nzSEABED database (after Bostock et al. 2019a, 2019b).

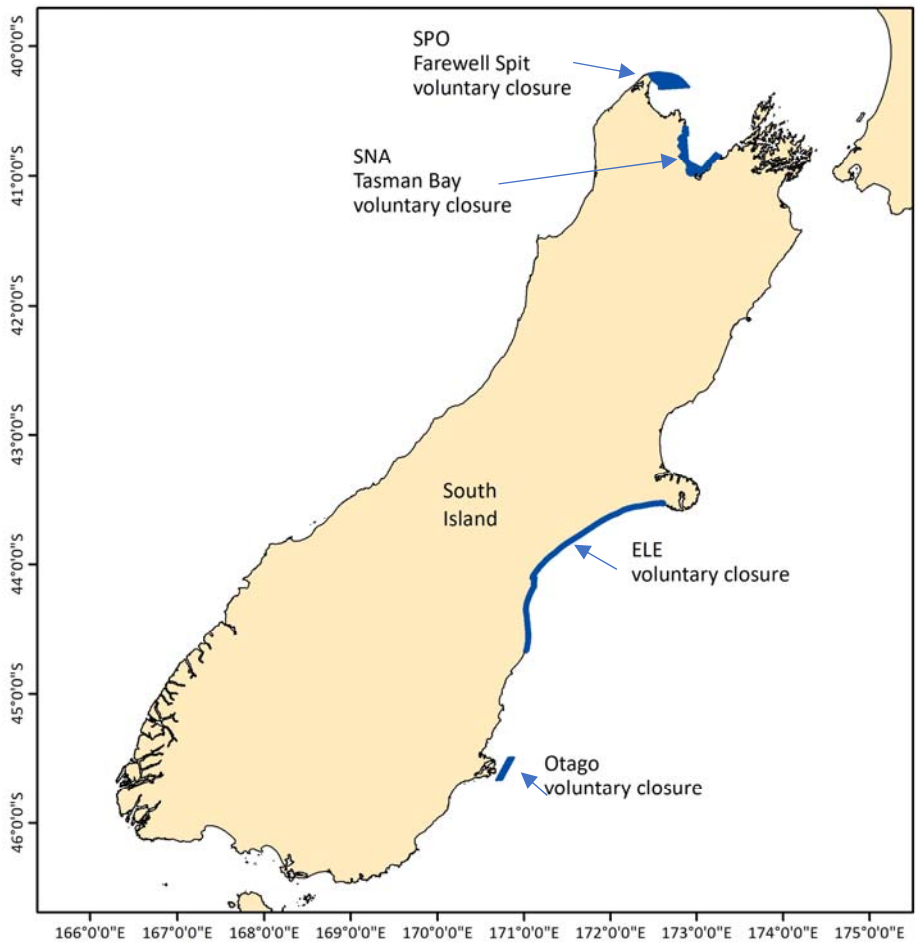

Figure B.3: Location of the four voluntary closure areas off the South Island coast.

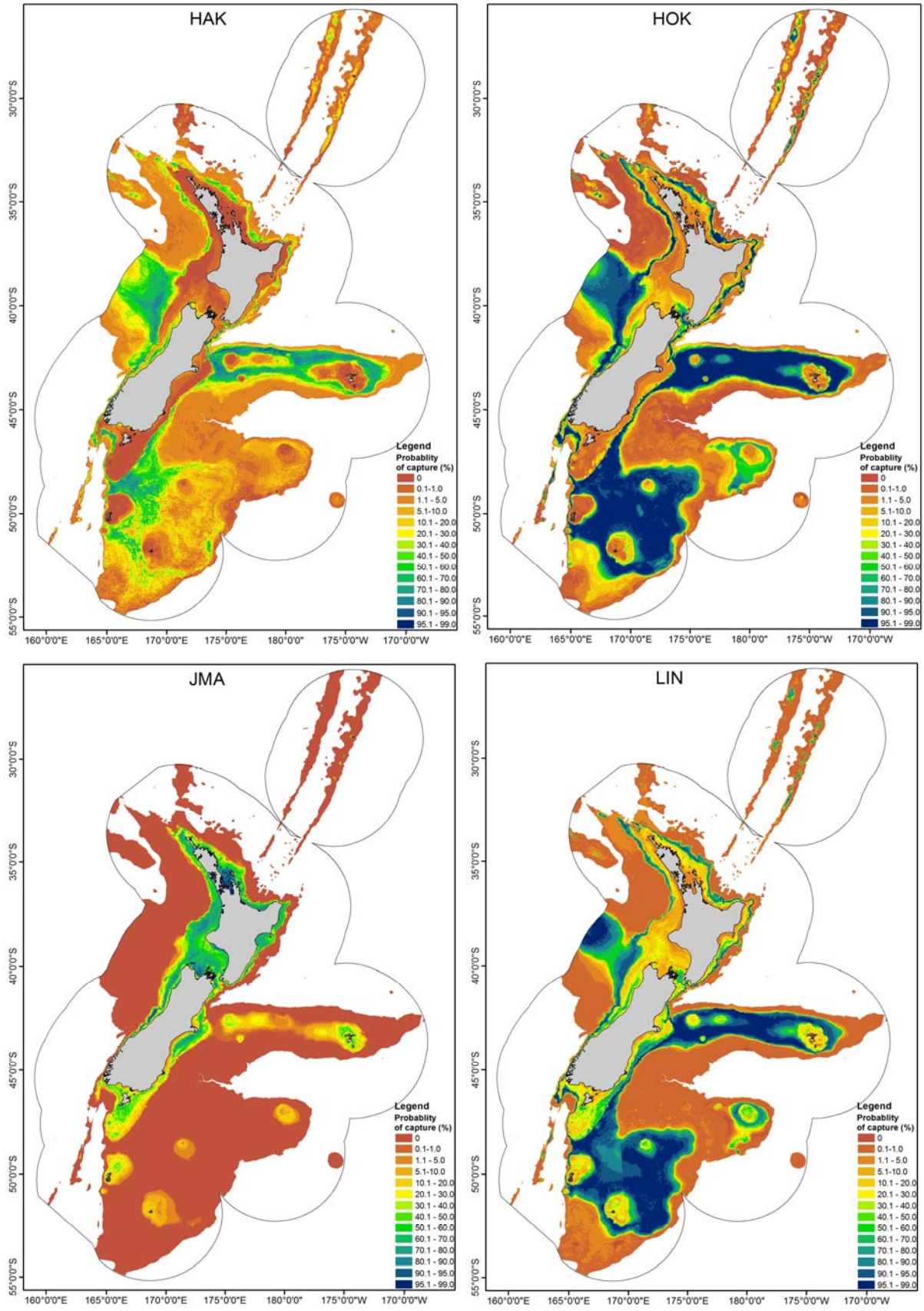

Figure B.4a: The extent of the predicted distribution of the preferred habitat for hake top (left) and hoki (top right), for jack mackerels (bottom left), and ling (bottom right) (after Leathwick et al. 2006), where the preferred habitat represents the probability of capture of that species in a standardised trawl in waters down to 1950 m depth.

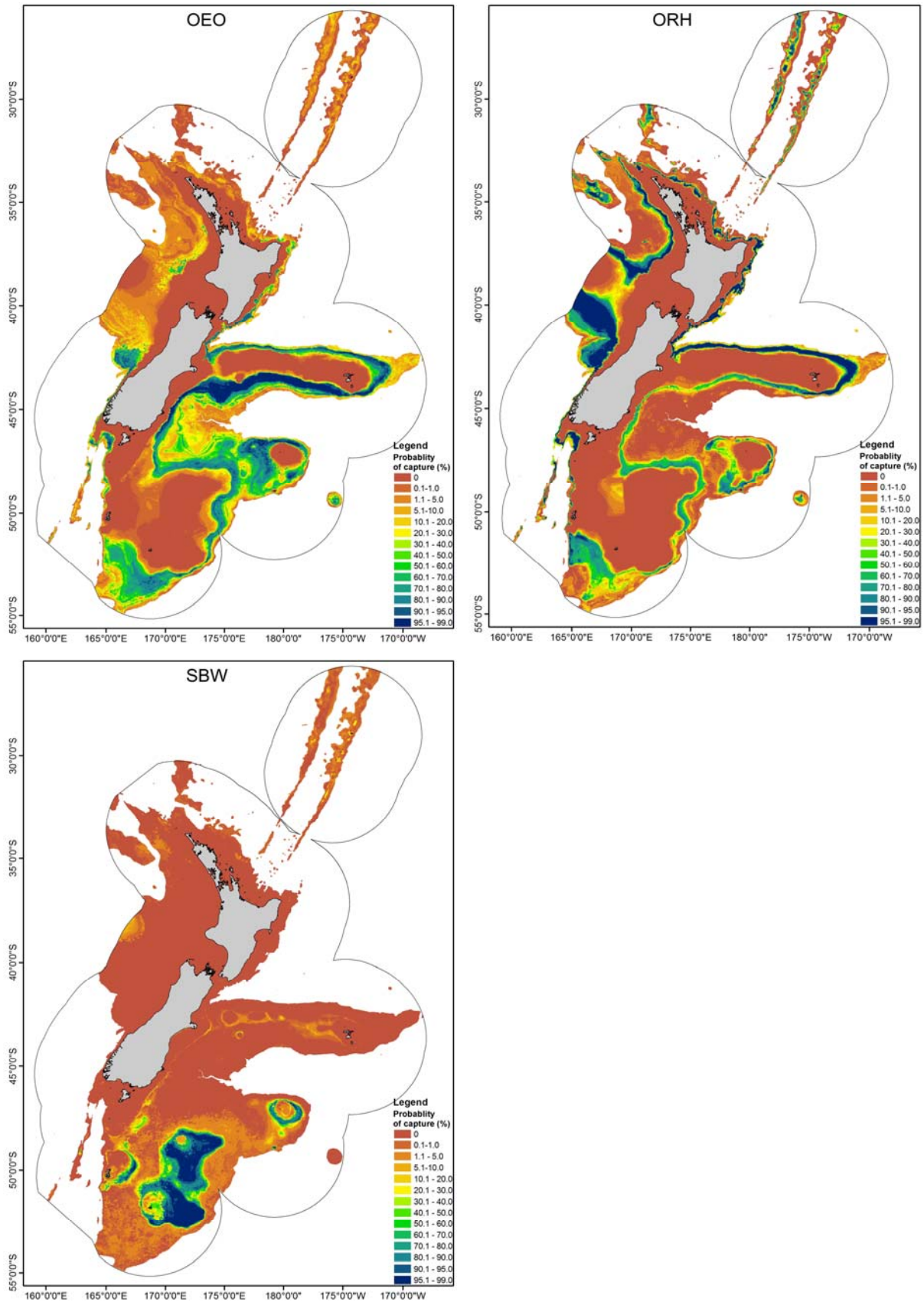

Figure B.4b: The extent of the predicted distribution of the preferred habitat for oreo species (top left), orange roughy (top right), and southern blue whiting (after Leathwick et al. 2006), where the preferred habitat represents the probability of capture of that species in a standardised trawl down to 1950 m depth.

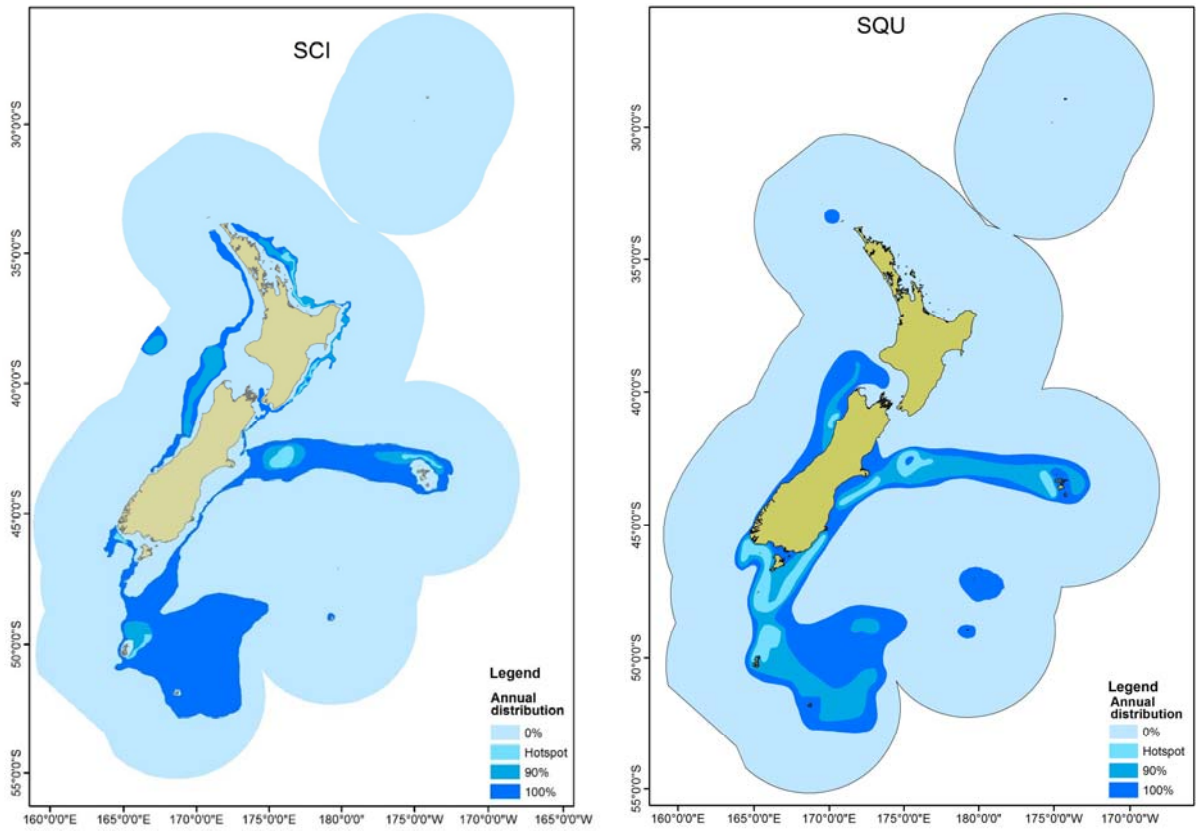

Figure B.4c: The extent of the annual distribution of scampi (left) and arrow squid (right) (from www.nabis.govt.nz).

APPENDIX C: BOTTOM-CONTACTING FISHING EFFORT FOR INSHORE AND DEEPWATER TARGET SPECIES

Inshore target data are given in Tables C.1–C.4 and for deepwater targets in Tables C.5–C.7.

Inshore targets

The numbers of bottom-contacting tows for all inshore bottom-contacting targets during the 2008–18 fishing years are given in Table C.2. These 561 416 tows contributed to the total inshore footprint and, as such represent the groomed base data from 294 vessels for the inshore spatial analysis in GIS. The majority of these tows were from fishstocks that are included in Table 1 as the FMA-based set used to describe the mixed trawl fishery effort in FMAs 1, 2, 3, 5, 7, and 8/9 as requested by Fisheries New Zealand (listed in Table 6). In total, 98% of the inshore tow data are included in the FMA-based mixed trawl fishery summary.

Table C.1: Number of bottom-contacting tows reported for inshore fishstocks, by fishing year for 2008–2018. Target species codes are defined in Table 1.

Code	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
BAR	921	1 162	1 234	1 199	1 212	1 510	1 314	1 384	1 150	1 544	2 177	14 807
BCO	9	0	10	1	9	12	4	1	3	4	0	53
BNS	104	68	67	37	20	2	1	3	16	17	2	337
ELE	646	697	862	678	793	658	605	791	649	660	650	7 689
FLA	17 769	17 186	19 716	15 344	17 193	17 020	15 923	13 396	15 008	14 768	12 350	175 673
FRO	0	0	0	1	0	0	0	0	0	0	1	2
GSH	173	565	705	806	488	515	419	247	99	92	69	4 178
GUR	4 905	4 956	6 892	6 416	6 769	7 616	7 367	6 279	6 087	5 404	6 028	68 719
HPB	44	40	45	32	14	28	15	46	53	66	79	462
JDO	2 103	1 941	2 070	1 654	1 420	1 746	2 040	1 972	1 607	2 143	1 492	20 188
JMA	0	0	1	2	1	1	1	1	1	0	0	8
KAH	5	0	3	10	4	3	22	8	13	8	0	76
LEA	67	87	224	155	324	193	134	81	34	57	30	1 386
LIN	198	216	196	147	109	145	164	141	166	217	168	1 867
MOK	72	79	62	143	85	106	94	96	76	116	137	1 066
PAD	64	8	9	33	17	0	2	0	0	0	0	133
POR	0	0	0	0	0	0	1	0	1	0	0	2
QSC	98	206	97	21	42	398	7	14	30	96	97	1 106
RCO	3 043	2 909	2 996	2 900	2 627	2 359	2 572	1 611	1 822	2 066	1 197	26 102
RSK	3	8	72	65	29	124	228	237	78	249	227	1 320
RSN	4	0	0	0	0	0	2	1	0	2	0	9
SCH	76	101	69	107	101	105	88	75	90	133	220	1 165
SKI	107	124	168	215	83	133	186	82	159	165	147	1 569
SNA	4 155	4 449	4 141	4 205	4 255	3 978	3 707	3 520	3 038	2 821	3 188	41 457
SPD	123	174	127	74	63	9	11	26	0	14	0	621
SPO	13	68	132	114	170	146	233	203	196	189	336	1 800
SSK	0	0	0	0	0	5	0	1	0	0	0	6
STA	1 396	1 414	1 989	1 879	1 616	1 555	1 682	1 600	1 807	1 454	1 547	17 939
TAR	11 461	12 441	12 967	12 814	11 849	11 418	12 757	11 460	10 138	10 984	9 544	127 833
TRE	3 039	3 271	3 175	3 712	2 593	2 739	2 592	2 306	2 512	2 712	2 226	30 877
TRU	0	0	1	0	0	0	0	0	0	0	0	1
WAR	1 064	1 040	1 040	1 242	1 357	1 243	1 129	1 410	1 333	1 117	990	12 965
All	51 662	53 210	59 070	54 006	53 243	53 767	53 300	46 992	46 166	47 098	42 902	561 416

Table C.2: Number of inshore tows, by data collection method and fishing year, for 2008–2018. ERS is Electronic Reporting System, TCE is Trawl Catch Effort Return, and TCP is Trawl Catch Effort Processing Return. The number of vessels in each year is also given.

Fishing year	Commercial data collection method				No. of vessels
	ERS	TCE	TCP	All	
2008	0	42 606	9 056	51 662	217
2009	0	44 206	9 004	53 210	196
2010	0	50 181	8 889	59 070	202
2011	0	45 584	8 422	54 006	209
2012	0	45 286	7 957	53 243	192
2013	0	46 896	6 871	53 767	183
2014	0	45 434	7 866	53 300	180
2015	0	40 258	6 734	46 992	170
2016	0	39 907	6 259	46 166	171
2017	0	40 193	6 905	47 098	162
2018	2 202	37 090	3 610	42 902	152
All	2 202	477 641	81 573	561 416	294

Table C.3: Number of inshore tows, split by target and Fishery Management Area for the FMA-based mixed trawl fishery groups (and also for FMA 4), 2008–2018. Target species codes are defined in Table 1. Note: some fishstocks straddle more than one FMA; for example, BAR 1 covers FMAs 1, 2, and 3. Targets included in the FMA-based groups are in bold

	FMAs for the mixed trawl fishery groups							
Target	FMA1	FMA2	FMA3	FMA5	FMA7	FMA89	FMA4	All
BAR	**214**	**535**	**14 058**	**0**	**0**	**0**	0	**14 807**
BCO	0	0	33	15	5	0	0	53
BNS	6	213	10	10	16	1	81	337
ELE	**0**	**0**	**6 828**	**626**	**235**	**0**	0	**7 689**
FLA	**9**	**11 836**	**73 726**	**23 562**	**65 858**	**680**	2	**175 673**
FRO	2	0	0	0	0	0	0	2
GSH	0	81	395	0	3 683	19	0	4178
GUR	**2 526**	**33 858**	**4 845**	**1 144**	**11 761**	**14 569**	16	**68 719**
HPB	3	4	368	15	68	3	1	462
JDO	**14 298**	**151**	**1**	**0**	**2 859**	**2 879**	0	**20 188**
JMA	6	2	0	0	0	0	0	8
KAH	**27**	**29**	**1**	**0**	**3**	**16**	0	**76**
LEA	**138**	**2**	**51**	**43**	**715**	**437**	0	**1 386**
LIN	661	894	312	0	0	0	0	1 867
MOK	**1**	**563**	**9**	**0**	**222**	**270**	1	**1 066**
PAD	0	0	133	0	0	0	0	133
POR	2	0	0	0	0	0	0	2
QSC	0	0	1 106	0	0	0	0	1 106
RCO	**0**	**292**	**16 245**	**147**	**9 418**	**0**	0	**26 102**
RSK	**0**	**0**	**1 317**	**0**	**3**	**0**	0	**1 320**
RSN	4	0	0	0	0	5	0	9
SCH	**34**	**8**	**165**	**3**	**285**	**668**	2	**1 165**
SKI	**652**	**884**	**0**	**0**	**0**	**0**	33	**1 569**
SNA	**31 582**	**2 289**	**13**	**14**	**3 991**	**3 568**	0	**41 457**
SPD	**0**	**14**	**603**	**0**	**4**	**0**	0	**621**
SPO	**0**	**1**	**0**	**0**	**0**	**126**	1 673	**1 800**
SSK	**0**	**0**	**6**	**0**	**0**	**0**	0	**6**
STA	**0**	**2**	**1 828**	**11 802**	**4 253**	**0**	54	**17 939**
TAR	**19 200**	**49 721**	**16 788**	**829**	**27 965**	**11 479**	1 851	**127 833**
TRE	**12 790**	**461**	**1**	**0**	**245**	**17 380**	0	**30 877**
TRU	0	0	0	0	0	1	0	1
WAR	**1**	**2 105**	**2 734**	**1 397**	**6 510**	**217**	1	**12 965**
Total	82 156	103 945	141 576	39 607	138 099	52 318	3 715	561 416
FMA	**81 472**	**102 751**	**139 219**	**39 567**	**134 327**	**52 289**	0	**549 625**

Table C.4: Number of inshore tows included in the FMA-based mixed trawl fishery data, by fishing year for 2008–2018. Target species codes are defined in Table 1.

Code	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	All
BAR	921	1 162	1 234	1 199	1 212	1 510	1 314	1 384	1 150	1 544	2 177	14 807
ELE	646	697	862	678	793	658	605	791	649	660	650	7 689
FLA	17 769	17 186	19 716	15 344	17 193	17 020	15 923	13 396	15 008	14 768	12 348	175 671
GUR	4 905	4 951	6 892	6 416	6 769	7 616	7 356	6 279	6 087	5 404	6 028	68 703
JDO	2 103	1 941	2 070	1 654	1 420	1 746	2 040	1 972	1 607	2 143	1 492	20 188
KAH	5	0	3	10	4	3	22	8	13	8	0	76
LEA	67	87	224	155	324	193	134	81	34	57	30	1 386
MOK	72	79	62	142	85	106	94	96	76	116	137	1 065
RCO	3 043	2 909	2 996	2 900	2 627	2 359	2 572	1 611	1 822	2 066	1 197	26 102
RSK	3	8	72	65	29	124	228	237	78	249	227	1 320
SCH	76	100	69	106	101	105	88	75	90	133	220	1 163
SKI	95	119	165	214	82	126	185	81	159	163	147	1 536
SNA	4 155	4 449	4 141	4 205	4 255	3 978	3 707	3 520	3 038	2 821	3 188	41 457
SPD	123	174	127	74	63	9	11	26	0	14	0	621
SPO	1	1	4	6	1	0	5	16	26	32	35	127
SSK	0	0	0	0	0	5	0	1	0	0	0	6
STA	1 388	1 414	1 970	1 854	1 616	1 555	1 680	1 600	1 807	1 454	1 547	17 885
TAR	11 018	12 311	12 666	12 615	11 843	11 418	12 399	11 240	10 105	10 839	9 528	125 982
TRE	3 039	3 271	3 175	3 712	2 593	2 739	2 592	2 306	2 512	2 712	2 226	30 877
WAR	1 064	1 040	1 040	1 242	1 357	1 243	1 129	1 410	1 333	1 117	989	12 964
Total	50 493	51 899	57 488	52 591	52 367	52 513	52 084	46 130	45 594	46 300	42 166	549 625

Deepwater targets

Table C.5: Number of deepwater tows for Tier 1 target fishstocks, 1990–2018. Target species codes are given in Table 2.

Year	HAK	HOK	JMA	LIN	OEO	ORH	SBW	SCI	SQU	Tier 1
1990	243	8 166	2 235	698	2 120	6 235	963	2 189	8 314	31 163
1991	68	13 390	1 589	1 010	2 595	5 070	1 387	4 087	10 314	39 510
1992	553	15 686	2 709	661	1 284	6 617	2 373	5 793	7 501	43 177
1993	979	16 818	2 662	554	2 020	9 930	487	5 340	7 314	46 104
1994	572	13 505	2 820	425	1 630	13 822	450	5 194	9 380	47 798
1995	761	17 575	2 058	241	1 812	14 438	188	3 891	10 180	51 144
1996	531	21 904	2 016	387	3 071	9 841	353	3 492	9 519	51 114
1997	479	25 438	1 613	332	3 477	8 210	341	3 586	9 892	53 368
1998	460	27 870	3 287	332	3 185	10 331	813	3 488	7 903	57 669
1999	706	24 273	2 529	362	3 428	10 823	784	4 072	7 245	54 222
2000	421	25 320	1 696	467	3 402	8 326	553	4 615	5 323	50 123
2001	564	23 949	1 591	308	3 258	5 204	460	4 777	6 850	46 961
2002	811	22 105	2 377	414	2 715	4 594	834	6 545	7 038	47 433
2003	914	21 769	2 502	385	2 500	4 958	361	4 542	8 055	45 986
2004	1 620	17 213	1 880	369	2 271	4 849	471	3 696	7 942	40 311
2005	1 413	11 328	1 894	665	2 357	4 545	399	4 647	9 523	36 771
2006	1 255	9 223	2 251	1 000	2 028	4 642	315	4 865	7 784	33 363
2007	1 223	8 469	2 005	1 346	2 110	3 972	342	5 133	4 824	29 424
2008	1 533	7 897	1 974	2 023	2 477	3 689	429	4 802	3 986	28 810
2009	1 700	7 117	1 588	1 175	2 167	3 558	613	3 974	3 619	25 511
2010	812	8 556	1 908	996	2 541	2 922	740	4 248	3 772	26 495
2011	798	8 367	1 259	955	1 897	1 889	694	4 446	4 189	24 494
2012	644	8 997	1 524	838	1 659	1 593	495	4 508	3 473	23 731
2013	680	9 397	1 383	1 002	1 278	1 592	389	4 537	2 625	22 883
2014	779	10 372	1 333	965	1 259	2 033	311	4 421	2 048	23 521
2015	933	10 180	955	984	1 260	2 347	454	4 423	1 933	23 469
2016	479	9 504	897	976	795	3 125	348	5 209	2 863	24 196
2017	535	9 978	786	1 010	699	2 983	307	4 707	2 592	23 597
2018	247	10 822	923	994	841	3 415	341	4 558	2 814	24 955
All	22 713	425 188	54 244	21 874	62 136	165 553	16 995	129 785	178 815	1 077 303

Table C.6: Number of deepwater tows for Tier 2 target fishstocks, 1990–2018. Target species codes are given in Table 2.

Fishing year	BAR	BYX	CDL	EMA	FRO	GSH	LDO	PRK	PTO	RBT	RBY	RIB	SKI	SPD	SPE	SWA	WWA	All
1990	1 745	200	106	0	1	1	0	0	0	0	2	0	155	31	14	932	182	3 369
1991	1 505	246	385	11	3	0	0	0	0	0	6	0	68	28	14	604	43	2 913
1992	1 213	344	171	1	2	0	0	0	0	1	39	0	109	7	32	724	16	2 659
1993	1 503	368	203	1	7	0	9	4	0	0	78	0	153	0	40	931	4	3 301
1994	1 053	619	386	7	1	0	2	0	0	0	53	0	24	0	42	851	8	3 046
1995	1 779	689	569	0	28	0	0	0	0	0	97	0	19	0	42	1 081	3	4 307
1996	1 645	728	942	0	0	0	0	0	320	0	74	0	20	1	17	829	0	4 576
1997	1 245	774	946	10	0	0	0	0	0	0	39	0	26	5	9	396	1	3 451
1998	1 083	668	720	0	24	0	0	0	0	0	26	0	16	0	46	354	7	2 944
1999	769	1 299	908	46	112	0	0	0	0	0	46	0	0	0	2	219	63	3 464
2000	816	880	1 086	0	10	0	0	0	0	0	81	0	16	0	0	346	74	3 309
2001	960	736	743	0	73	0	0	0	13	0	126	0	0	0	2	285	94	3 032
2002	1 032	568	766	0	75	1	27	0	0	0	84	0	0	37	81	531	234	3 436
2003	964	919	1 134	7	4	0	3	0	0	0	49	0	21	0	302	240	336	3 979
2004	611	747	592	0	3	0	0	0	0	0	66	0	3	3	138	124	307	2 594
2005	776	986	778	9	4	0	0	0	0	1	119	7	0	8	9	404	355	3 456
2006	579	1 295	999	35	11	0	0	0	0	13	152	11	1	39	32	606	247	4 020
2007	955	830	1 041	14	4	1	0	0	0	4	112	0	0	12	161	801	215	4 150
2008	2 197	647	540	15	0	0	28	0	0	6	98	0	9	170	124	1 123	223	5 180
2009	1 318	776	417	24	0	0	7	0	0	18	65	0	10	243	32	1 057	325	4 292
2010	1 027	935	526	1	0	0	39	0	0	9	201	0	17	246	157	745	205	4 108
2011	922	878	387	4	0	0	59	0	0	3	174	0	71	150	221	834	117	3 820
2012	1 160	787	379	25	0	4	47	0	0	21	114	0	82	114	46	615	153	3 547
2013	1 117	257	228	6	0	11	106	0	0	39	122	0	74	52	192	695	156	3 055
2014	1 182	523	311	0	3	5	46	0	0	34	112	0	37	72	145	727	244	3 441
2015	1 165	516	195	0	2	1	73	0	0	17	104	1	47	86	326	630	101	3 264
2016	1 032	417	148	0	11	3	64	0	0	5	252	0	40	0	298	579	103	2 952
2017	1 113	456	116	0	12	0	42	0	0	13	142	0	19	1	220	607	111	2 852
2018	920	489	82	0	13	0	55	0	0	2	100	2	12	0	295	599	87	2 656
1990–2018	33 386	19 577	15 804	216	403	27	607	4	333	186	2 733	21	1 049	1 305	3 039	18 469	4 014	101 173

Table C.7: Number of deepwater tows, by stock, data collection method, and fishing year, for 1990–2018. ERS is Electronic Reporting System, TCE is Trawl Catch Effort Return, and TCP is Trawl Catch Effort Processing Return. The numbers of vessels in each year (based on unique vessel key) are also given.

	Tier 1 fishstocks					Tier 2 fishstocks					All deepwater
Fishing year	ERS	TCE	TCP	All	No. vessels	ERS	TCE	TCP	All	No. vessels	Total vessels
1990	0	0	31 163	31 163	127	0	0	3 369	3 369	50	127
1991	0	0	39 510	39 510	147	0	0	2 913	2 913	53	148
1992	0	0	43 177	43 177	151	0	0	2 659	2 659	58	151
1993	0	0	46 104	46 104	137	0	0	3 301	3 301	64	138
1994	0	0	47 798	47 798	143	0	0	3 046	3 046	75	148
1995	0	0	51 144	51 144	158	0	0	4 307	4 307	82	162
1996	0	0	51 114	51 114	150	0	0	4 576	4 576	85	156
1997	0	0	53 368	53 368	160	0	0	3 451	3 451	75	168
1998	0	0	57 669	57 669	150	0	0	2 944	2 944	74	152
1999	0	0	54 222	54 222	134	0	0	3 464	3 464	75	139
2000	0	0	50 123	50 123	103	0	0	3 309	3 309	62	112
2001	0	0	46 961	46 961	101	0	0	3 032	3 032	60	105
2002	0	0	47 433	47 433	98	0	0	3 436	3 436	57	104
2003	0	0	45 986	45 986	94	0	0	3 979	3 979	55	101
2004	0	0	40 311	40 311	92	0	0	2 594	2 594	50	95
2005	0	0	36 771	36 771	81	0	0	3 456	3 456	57	87
2006	0	0	33 363	33 363	77	0	0	4 020	4 020	53	80
2007	0	0	29 424	29 424	70	0	0	4 150	4 150	50	72
2008	0	1 378	27 432	28 810	94	0	1 685	3 495	5 180	80	112
2009	0	1 035	24 476	25 511	88	0	1 263	3 029	4 292	81	107
2010	0	1 396	25 099	26 495	95	0	1 292	2 816	4 108	89	115
2011	0	1 206	23 288	24 494	93	0	1 197	2 623	3 820	88	114
2012	0	1 297	22 434	23 731	92	0	1 181	2 366	3 547	79	104
2013	0	1 486	21 397	22 883	87	0	1 489	1 566	3 055	78	101
2014	0	1 753	21 768	23 521	87	0	1 420	2 021	3 441	83	105
2015	0	1 658	21 811	23 469	89	0	1 197	2 067	3 264	78	103
2016	0	1 721	22 475	24 196	96	0	1 071	1 881	2 952	72	105
2017	0	1 448	22 149	23 597	90	0	835	2 017	2 852	73	97
2018	18 909	1 575	4 471	24 955	88	1 480	985	191	2 656	63	96
1990–2018	18 909	15 953	1 042 441	1 077 303	547	1 480	13 615	86 078	101 173	359	568

APPENDIX D: INSHORE SWEPT AREA SUMMARIES, 2008–2018

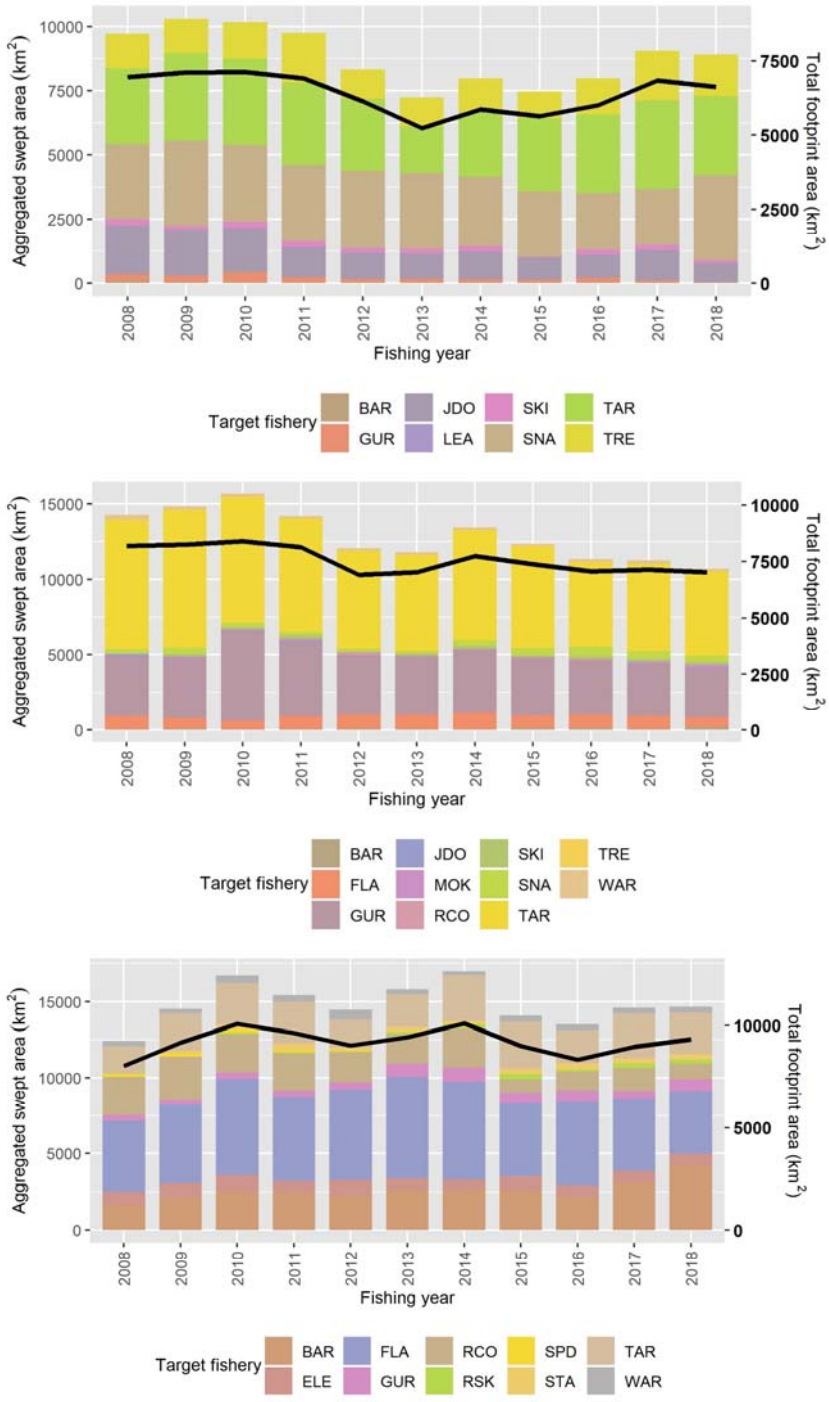

Figure D.1: Aggregate swept area (km^2) estimated from mixed inshore target fisheries (bars) and the total trawl footprint (km^2) (black line), by fishing year for 2008–2018, for FMA 1 (top), FMA 2 (centre), and FMA 3 (bottom).

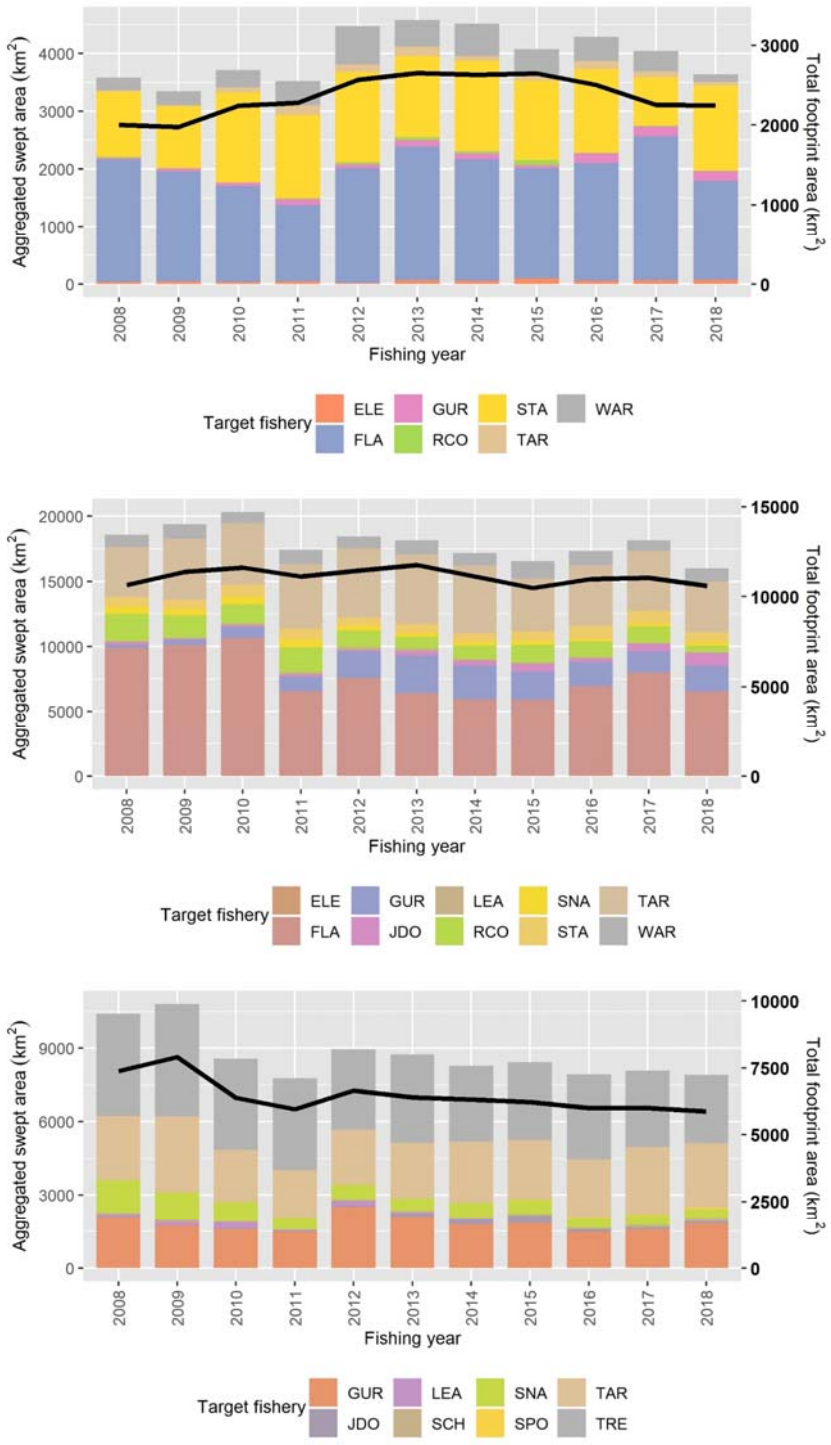

Figure D.1 — *continued*: Aggregate swept area (km^2) estimated from mixed inshore target fisheries (bars) and the total trawl footprint (km^2) (black line), by fishing year for 2008–2018, for FMA 5 (top), FMA 7 (centre), and FMA 8/9 (bottom).

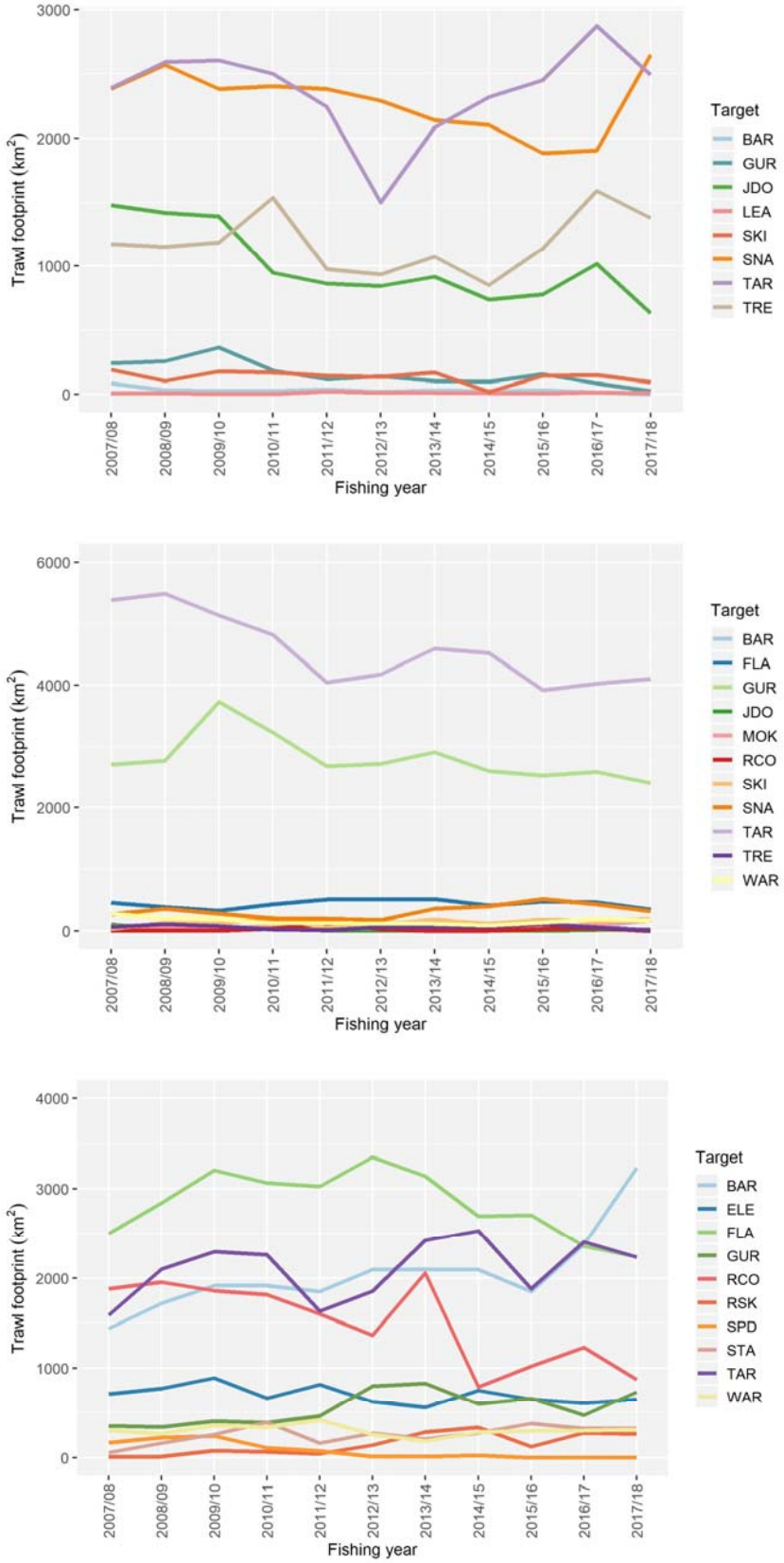

Figure D.2: Trawl footprint (km^2) estimated from FMA 1 (tip), FMA 2 (centre), and FMA 3 mixed inshore target fisheries, by fishing year for 2008–2018.

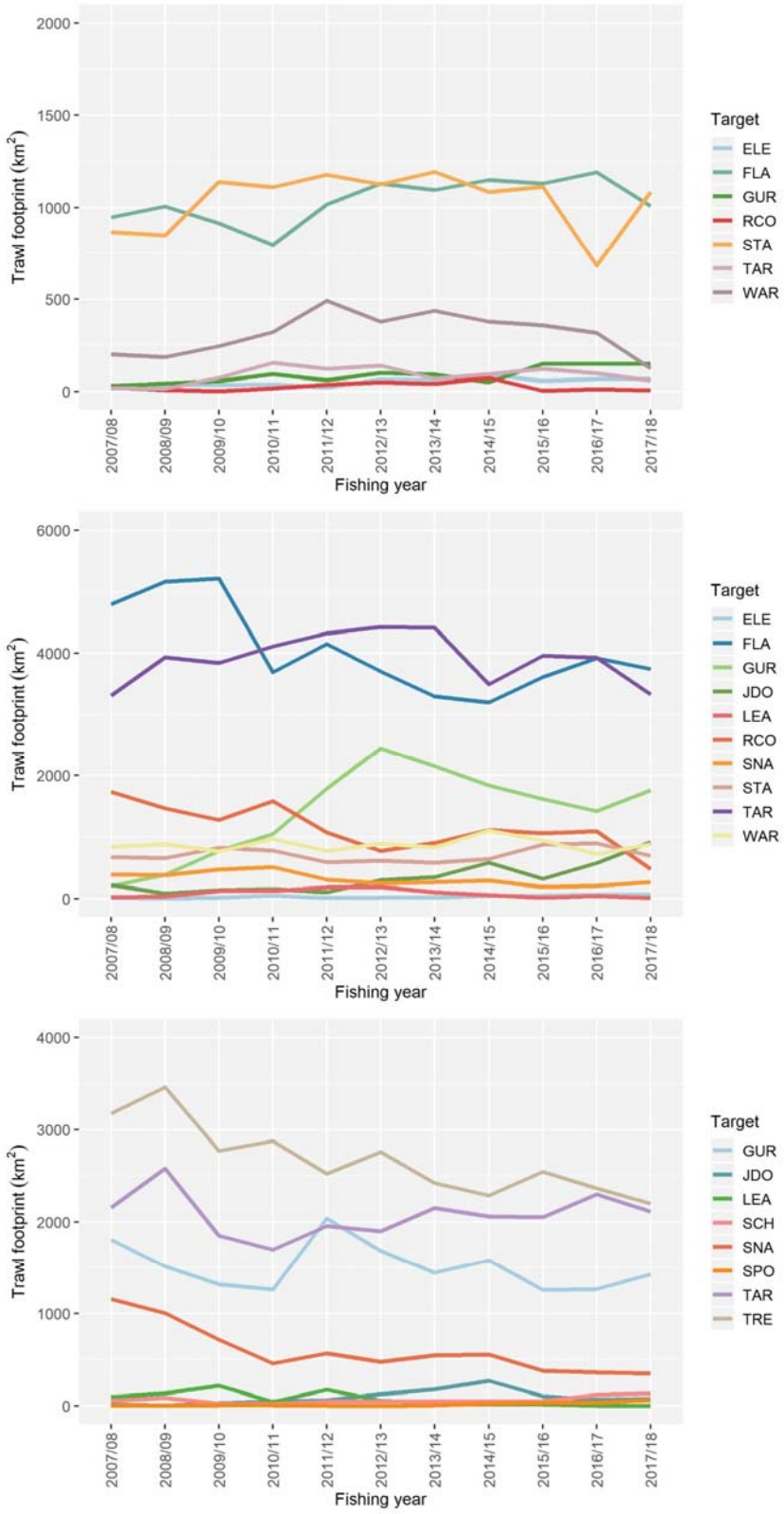

Figure D.2 — *continued*: Trawl footprint (km^2) estimated from FMA 8 and FMA 9 (combined) mixed inshore target fisheries, by fishing year for 2008–2018.

Table D.1: Aggregate swept area (km^2) estimated from FMA 1 inshore trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 1.

Fishing year	BAR1	GUR1	JDO1	LEA1	SKI1	SNA1	TAR1	TRE1	Total
2008	88.2	260.4	1 892.1	3.5	243.4	2 928.7	2 939.4	1 356.7	9 712.4
2009	29.3	273.1	1 774.8	7.0	147.5	3 318.2	3 405.2	1 328.7	10 283.8
2010	24.7	398.6	1 726.5	3.0	242.7	2 989.0	3 358.7	1 408.6	10 151.8
2011	24.5	200.4	1 168.5	2.8	236.0	2 982.3	3 201.9	1 932.8	9 749.2
2012	38.1	122.4	1 000.9	22.5	165.0	3 009.9	2 833.2	1 128.0	8 320.0
2013	17.7	151.8	980.9	11.4	176.5	2 956.9	1 822.9	1 106.8	7 224.9
2014	31.6	108.4	1 075.1	10.6	202.4	2 712.0	2 514.7	1 324.9	7 979.7
2015	23.6	101.2	870.5	8.0	18.3	2 550.1	2 860.8	1 037.9	7 470.4
2016	30.6	176.5	898.5	5.6	196.4	2 203.3	3 063.0	1 410.1	7 984.0
2017	14.1	86.7	1 174.3	14.9	202.8	2 182.0	3 446.9	1 925.5	9 047.2
2018	0.0	23.9	748.1	7.9	104.9	3 318.5	3 074.6	1 619.1	8 897.0
Total	322.4	1 903.4	13 310.2	97.2	1 935.9	31 150.9	32 521.3	15 579.1	96 820.4

Table D.2: Aggregate swept area (km^2) estimated from FMA 2 inshore trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 1.

Fishing year	BAR1	FLA2	GUR2	JDO2	MOK1	RCO2	SCH2	SKI2	SNA2	SPO2	TAR2	TRE2	WAR2	Total
2008	41.5	889.9	3 924.8	117.2	79.3	8.0	0.1	30.1	291.3	0.0	8 522.0	63.8	305.4	14 273.4
2009	96.8	700.2	4 003.5	25.2	69.1	5.7	0.0	151.6	404.8	0.0	9 054.7	108.7	222.5	14 842.8
2010	34.3	588.0	5 996.8	22.8	39.3	5.8	0.0	125.9	296.o	0.0	8 285.5	78.8	196.0	15 669.2
2011	21.4	874.3	4 988.9	65.8	80.4	34.8	0.3	233.1	210.9	1.4	7 515.6	20.8	143.3	14 191.0
2012	59.9	958.6	3 934.2	4.5	52.9	138.9	3.6	52.0	196.5	0.0	6 482.7	7.1	140.2	12 031.1
2013	49.3	955.3	3 869.0	2.4	39.6	31,0	0.0	118.2	176.2	0.0	6 334.2	66.7	139.0	11 780.9
2014	33.7	1 108.1	4 178.7	8,0	41.6	0.0	0.0	191.2	419.4	0.0	7 242.2	56.7	153.4	13 433.0
2015	124.6	828.6	3 825.3	0.7	56.8	0.7	5.0	122.9	460.3	0.0	6 734.4	66.5	103.8	12 329.6
2016	118.2	887.8	3 602.2	2.3	51.7	33.7	0.0	190.2	658.7	0.0	5 518.3	113.6	154.3	11 331.0
2017	69.0	851.6	3 472.2	16.3	112.6	42.0	1.7	175.0	503.3	0.0	5 740.7	55.8	218.2	11 258.4
2018	182.4	666.7	3 270.2	23.1	180.9	0.0	0.0	206.3	391.2	0.0	5 590.4	12.8	179.5	10 703.5
Total	831.1	9 309.1	45 065.8	288.3	804.2	300.6	10.7	1 596.5	4 008.6	1.4	77 020.7	651.3	1 955.6	141 843.9

Table D.3: Aggregate swept area (km^2) estimated from FMA 3 inshore trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 1.

Fishing year	BAR1	ELE3	FLA3	GUR3	RCO3	RSK3	SPD3	SSK3	STA3	TAR3	WAR3	Total
2008	1 664.2	832.6	4 660.1	396.6	2 514.2	5.2	164.7	0.0	54.1	1 776.6	347.6	12 415.9
2009	2 149.2	896.8	5 146.7	357.9	2 829.2	12.9	225.3	0.0	166.5	2 447.0	290.5	14 522.0
2010	2 541.4	1 044.5	6 331.6	425.4	2 521.3	95.2	251.2	0.0	276.0	2 731.3	482.6	16 700.5
2011	2 428.7	770.3	5 554.1	413.6	2 444.8	73.7	106.9	0.0	447.5	2 737.4	436.7	15 413.7
2012	2 288.0	975.1	5 936.9	499.9	1 994.6	40.8	76.1	0.0	176.3	1 835.8	636.2	14 459.7
2013	2 652.1	728.1	6 667.4	860.7	1 951.1	144.0	11.1	6.3	293.2	2 163.1	320.6	15 797.7
2014	2 624.9	670.4	6 431.5	951.3	2 532.8	305.2	13.3	0.0	214.5	2 999.1	224.8	16 967.8
2015	2 606.3	899.9	4 859.1	655.2	874.2	353.3	25.5	1.0	320.2	3 088.8	415.0	14 098.5
2016	2 170.9	777.3	5 500.8	716.3	1 243.8	129.7	0.0	0.0	429.5	2 158.7	383.6	13 510.6
2017	3 136.3	724.7	4 739.9	515.8	1 523.0	308.4	0.0	0.0	343.8	2 945.9	378.8	14 616.6
2018	4 261.6	735.3	4 129.6	800.3	993.6	282.2	0.0	0.0	342.3	2 746.7	383.3	14 674.9
Total	28 523.6	9 055.0	59 957.7	6 593.0	21 422.6	1 750.6	874.1	7.3	3 063.9	27 630.4	4 299.7	163 178.0

Table D.4: Aggregate swept area (km^2) estimated from FMA 5 inshore trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 1.

Fishing year	ELE5	FLA3	GUR3	RCO3	STA5	TAR5	WAR3	Total
2008	33.7	2 125.7	32.0	21.5	1 124.5	18.9	218.8	3 575.1
2009	40.6	1 913.7	48.0	7.5	1 075.6	14.3	239.8	3 339.5
2010	35.6	1 667.6	60.2	0.9	1 553.6	89.0	301.0	3 707.9
2011	40.6	1 332.5	103.4	17.8	1 436.0	172.2	416.3	3 518.8
2012	21.4	1 988.7	67.0	36.5	1 561.7	133.3	655.2	4 463.8
2013	66.9	2 321.8	110.6	51.2	1 399.3	164.3	460.4	4 574.5
2014	60.9	2 109.1	99.5	40.5	1 562.8	77.1	560.1	4 510.0
2015	96.8	1 914.0	52.6	84.6	1 381.3	95.7	442.9	4 067.9
2016	57.7	2 040.9	172.3	3.6	1 447.7	140.4	421.8	4 284.4
2017	67.9	2 497.7	166.0	12.2	837.5	103.3	355.2	4 039.8
2018	71.3	1 721.7	171.5	6.2	1 466.4	65.0	135.2	3 637.3
Total	593.4	21 633.4	1 083.1	282.5	14 846.4	1 073.5	4 206.7	43 719.0

Table D.5: Aggregate swept area (km^2) estimated from FMA 7 inshore trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 1.

Fishing year	ELE7	FLA7	GUR7	JDO7	LEA2	RCO7	SNA7	SPD7	STA7	TAR7	WAR7	total
2008	14.3	9 893.6	209.0	229.3	26.2	2 142.9	535.7	0	733.2	3 838.1	963.9	18 586.2
2009	5.5	10 112.1	404.0	87.7	34.9	1 729.5	498.4	0	693.8	4 703.0	1 119.2	19 388.1
2010	16.8	10 624.4	837.8	141.7	130.9	1 469.1	580.6	2.4	910.8	4 775.8	837.1	20 327.4
2011	52.1	6 494.0	1 139.8	173.7	123.0	1 927.8	626.6	0	836.0	4 943.7	1 133.6	17 450.3
2012	12.4	7 548.1	2 063.4	108.3	200.2	1 262.3	375.9	0	627.6	5 322.1	928.0	18 448.3
2013	15.4	6 376.7	2 913.4	328.3	192.9	931.1	277.3	0	695.3	5 344.9	1 077.9	18 153.2
2014	17.1	5 935.5	2 569.0	382.7	106.6	1 040.6	310.9	0	627.3	5 236.6	950.7	17 177.0
2015	45.5	5 866.9	2 147.7	637.4	57.6	1 370.8	333.6	0	693.5	4 048.6	1 343.3	16 544.9
2016	47.8	6 906.6	1 833.1	332.7	14.9	1 243.8	210.7	0	989.1	4 658.5	1 113.4	17 350.6
2017	63.7	7 920.8	1 603.1	628.8	44.0	1 254.1	234.2	1.5	969.9	4 627.1	818.4	18 165.6
2018	60.7	6 470.1	1 999.9	996.4	7.9	507.2	306.0	0	753.4	3 887.3	995.9	15 984.8
Total	351.3	84 148.8	17 720.2	4 047.0	939.1	14 879.2	4 289.9	3.9	8 529.9	51 385.7	11 281.4	197 576.4

Table D.6: Aggregate swept area (km^2) estimated from FMA 8 and FMA 9 inshore trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 1.

Fishing year	GUR1	GUR8	JDO1	KAH8	LEA2	SCH8	SNA8	SPO8	TAR1	TAR8	TRE7	Total
2008	1 456.5	615.8	15.6	1.7	109.5	57.7	1 343.6	3.4	2 026.7	587.3	4 185.2	10 403.0
2009	884.2	842.9	3.3	0.0	145.9	92.0	1 136.1	1.9	2 128.6	967.0	4 598.3	10 800.2
2010	599.0	1 001.8	28.4	0.0	257.1	25.9	792.6	6.4	1 081.2	1 042.2	3 736.7	8 571.3
2011	649.7	815.2	46.2	0.0	40.5	18.8	484.8	7.7	1 117.1	828.6	3 764.7	7 773.3
2012	1 777.3	717.3	60.6	0.0	202.8	48.7	605.4	2.1	1 290.5	973.1	3 273.1	8 950.9
2013	1 427.8	666.5	135.7	0.0	55.2	47.8	508.2	0.0	1 444.9	849.2	3 609.3	8 744.6
2014	1 190.5	598.7	189.5	3.9	35.7	52.3	590.8	8.4	1 622.1	892.9	3 081.0	8 265.8
2015	1 246.6	593.9	291.8	4.6	18.0	48.0	585.6	23.9	1 686.9	750.1	3 186.2	8 435.6
2016	1 075.5	391.5	105.2	11.5	15.2	51.2	398.6	32.1	1 610.9	764.0	3 477.1	7 932.8
2017	1 252.8	304.6	65.5	14.5	3.5	125.2	379.7	36.0	2 189.7	595.8	3 119.1	8 086.4
2018	1 303.3	519.3	78.5	0.0	0.0	139.0	370.3	63.0	1 923.0	712.2	2 797.3	7 905.9
Total	12 863.2	7 067.5	1 020.3	36.2	883.4	706.6	7 195.7	184.9	18 121.6	8 962.4	38 828.0	95 869.8

Table D.7: Trawl footprint (km^2) for the inshore FMA 1 trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 1.

Fishing year	BAR1	GUR1	JDO1	LEA1	SKI1	SNA1	TAR1	TRE1	Total
2008	82.3	239.3	1 477.9	3.5	189.7	2 383.5	2 392.1	1 173.2	6 962.3
2009	28.9	256.7	1 416.6	7.0	102.0	2 569.7	2 590.9	1 150.5	7 110.8
2010	24.6	361.7	1 391.1	3.0	176.1	2 381.6	2 605.6	1 184.0	7 130.4
2011	24.4	184.7	946.0	2.8	168.0	2 405.1	2 501.5	1 538.5	6 913.7
2012	37.8	114.7	861.7	21.4	142.5	2 380.7	2 244.6	976.3	6 147.1
2013	17.5	140.6	843.4	11.3	134.5	2 291.9	1 501.1	932.9	5 243.5
2014	31.2	101.6	914.6	10.5	169.2	2 139.0	2 083.1	1 071.7	5 875.6
2015	23.2	95.3	735.1	7.9	17.9	2 103.4	2 319.9	850.7	5 643.6
2016	30.5	156.1	777.5	5.6	143.9	1 881.6	2 451.2	1 137.6	6 017.0
2017	14.1	82.7	1 015.7	14.6	150.1	1 904.3	2 874.6	1 589.1	6 844.9
2018	0.0	23.4	628.5	7.9	94.2	2 648.5	2 491.2	1 377.1	6 626.8
Total	301.9	1 322.9	5 379.9	93.6	673.2	10 950.4	11 839.4	6 871.5	22 221.6

Table D.8: Trawl footprint (km^2) for the inshore FMA 2 trawl fisheries, by fishing year 2008–2018. Target species codes are given in Table 1.

Fishing year	BAR1	FLA2	GUR2	JDO2	MOK1	RCO2	SCH2	SKI2	SNA2	SPO2	TAR2	TRE2	WAR2	Total
2008	40.8	448.0	2 709.0	104.2	75.8	8.0	0.1	29.2	262.5	0.0	5382.1	62.3	272.1	8193.8
2009	93.5	375.5	2 777.6	25.0	63.4	5.7	0.0	132.8	348.9	0.0	5486.9	106.2	203.2	8257.2
2010	33.4	320.5	3 732.8	22.4	38.9	3.7	0.0	113.8	269.2	0.0	5137.3	77.8	183.9	8408.1
2011	20.9	425.0	3 231.9	59.9	73.5	34.1	0.3	204.2	196.3	1.4	4818.2	20.6	122.2	8131.4
2012	58.2	499.4	2 685.7	4.5	46.7	114.3	3.6	46.6	186.2	0.0	4046.9	7.1	125.9	6912.0
2013	47.5	501.2	2 724.5	2.4	34.9	27.3	0.0	110.6	167.4	0.0	4179.0	65.0	116.1	7029.9
2014	33.5	509.1	2 912.8	8.0	34.4	0.0	0.0	173.5	352.4	0.0	4596.3	56.4	116.9	7747.6
2015	122.1	403.6	2 606.1	0.7	54.4	0.7	5.0	116.6	387.9	0.0	4525.3	65.5	88.2	7385.8
2016	109.8	470.2	2 534.0	2.3	48.8	32.0	0.0	170.8	508.2	0.0	3922.6	111.2	132.5	7051.8
2017	67.3	452.8	2 594.3	15.8	102.2	40.0	1.7	156.8	422.1	0.0	4029.1	53.1	189.2	7128.4
2018	174.6	340.7	2 407.9	20.3	170.7	0.0	0.0	186.0	310.4	0.0	4103.7	12.7	163.4	7027.4
Total	769.1	1 401.0	8 946.0	238.4	589.1	253.0	10.6	1 043.2	2 287.7	1.4	14 842.2	611.0	1 134.3	18 595.66

Table D.9: Trawl footprint (km^2) for the inshore FMA 3 trawl fisheries, by fishing year 2008–2018. Target species codes are given in Table 1.

Fishing year	BAR1	ELE3	FLA3	GUR3	RCO3	RSK3	SPD3	SSK3	STA3	TAR3	WAR3	Total
2008	1 440.4	710.2	2 500.4	354.1	1 881.6	5.2	162.1	0	53.5	1 589.3	301.5	8 039.0
2009	1 718.5	773.2	2 842.9	341.0	1 956.4	12.9	219.5	0	157.9	2 101.3	264.7	9 176.0
2010	1 916.0	889.0	3 204.9	402.3	1 859.4	76.4	240.1	0	254.3	2 294.6	356.8	10 075.7
2011	1 917.5	662.8	3 064.2	386.2	1 814.7	65.0	105.4	0	390.2	2 259.5	335.3	9 641.7
2012	1 851.7	813.7	3 027.3	463.2	1 599.6	40.0	73.9	0	158.2	1 630.1	415.4	9 031.6
2013	2 096.2	621.4	3 351.2	799.7	1 365.9	137.9	11.0	6.1	270	1 853.5	257.3	9 423.3
2014	2 094.8	555.6	3 138.9	828.1	2 054.7	282.7	13.2	0	203.2	2 422.6	181.4	10 101.7
2015	2 095.6	751.5	2 692.8	596.8	790.1	336.5	25.1	1	273	2 532.1	283.6	9 001.4
2016	1 852.5	649.2	2 706.1	659.9	1 020.9	122.1	0.0	0	379.2	1 882.7	293.6	8 332.3
2017	2 378.5	604.0	2 357.2	471.8	1 230.2	274.8	0.0	0	323.2	2 405.5	299.8	8 956.8
2018	3 230.1	649.4	2 239.2	730.2	872.4	262.4	0.0	0	324.2	2 237.2	314.4	9 325.5
Total	12 098.2	4 494.2	9 371.9	4 382.6	9 909.4	1 441.0	819.2	7.2	2270.7	12 238.2	1 867.5	29 525.0

Table D.10: Trawl footprint (km^2) for the inshore FMA 5 trawl fisheries, by fishing year 2008–2018. Target species codes are given in Table 1.

Fishing year	ELE5	FLA3	GUR3	RCO3	STA5	TAR5	WAR3	Total
2008	32.5	947.3	30.2	21.5	866.7	18.2	200.9	2 002.0
2009	37.3	1 005.7	43.4	7.4	849.2	14.1	185.3	1 974.1
2010	33.8	914.6	56	0.9	1 138.9	72.4	244.4	2 240.8
2011	39.4	796.0	92.2	16.4	1 111.5	153.6	321.0	2 281.2
2012	21	1 017.4	59.7	35.5	1 178.1	121.6	491.3	2 567.9
2013	63.7	1 130.8	98.5	48.8	1 126.1	139.3	376.9	2 652.5
2014	59.6	1 096.8	89.9	40.1	1 193.9	68.5	436.0	2 630.9
2015	91.5	1 151.3	50	73.4	1 085.0	92.1	376.4	2 646.6
2016	56.5	1 131.5	150.1	3.6	1 113.2	120.3	358.3	2 504.4
2017	66	1 191.9	148.4	12.2	683.5	97.9	316.1	2 251.1
2018	68.6	1 009.3	148.5	6.2	1 084.0	58.5	124.4	2 246.8
Total	502.7	3 185.9	721.4	258.4	4 486.2	755.1	1 825.4	8 188.6

Table D.11: Trawl footprint (km^2) for the inshore FMA 7 trawl fisheries, by fishing year 2008–2018. Target species codes are given in Table 1.

Fishing year	ELE7	FLA7	GUR7	JDO7	LEA2	RCO7	SNA7	SPD7	STA7	TAR7	WAR7	Total
2008	14.2	4794.4	202.4	218.1	24.8	1734.8	391.5	0.0	675.3	3 311.9	839.2	10 651.1
2009	5.5	5158.8	383.7	80.5	34.8	1466.9	379	0.0	650.0	3 934.2	882.7	11 367.1
2010	16.6	5213.1	768.7	132.5	123.1	1273.4	467.6	2.4	821.8	3 841.2	762.8	11 611.9
2011	49.1	3696.9	1046.5	156.7	119.8	1584.5	508.8	0.0	779.9	4 112.6	967.9	11 120.6
2012	12.3	4150.8	1784.7	104.6	183.2	1073.6	307.6	0.0	585.8	4 325.1	773.6	11 445.9
2013	15.4	3705.0	2446.7	301.6	186.5	767.6	247.8	0.0	614.6	4 429.6	885.5	11 756.7
2014	14.8	3300.7	2152.6	341.3	101.9	898.3	268.6	0.0	580	4 417.6	830.1	11 117.2
2015	45.0	3204.5	1835.6	577.8	56.7	1111.2	289.2	0.0	639.8	3 496.4	1 105.5	10 471.8
2016	47.0	3614.0	1612.7	315.7	14.9	1058.5	189.9	0.0	873.9	3 964.6	938.3	10 967.2
2017	62.5	3922.1	1421.7	571.9	42.8	1091.0	206.0	1.5	897.4	3 927.5	720.2	11 054.7
2018	60.2	3744.6	1759.0	915.6	7.8	475.4	268.2	0.0	689	3 336.2	883.8	10 602.2
Total	330.8	12 210.9	9 178.2	2 953.7	780.1	7 795.5	2 079.4	3.8	5 440.8	21 992.6	6 102.3	36 898.6

Table D.12: Trawl footprint (km^2) for the inshore FMA 8 and FMA 9 trawl fisheries, by fishing year 2008–2018. Target species codes are given in Table 1.

Fishing year	GUR1	GUR8	JDO1	KAH8	LEA2	SCH8	SNA8	SPO8	TAR1	TAR8	TRE7	Total
2008	1 269.8	541.0	15.3	1.7	94.5	55.0	1 157.1	3.4	1 694.8	463.3	3 175.7	7 384.4
2009	776.5	743.1	3.3	0.0	135.3	86.6	1 004.0	1.9	1 719.6	863.5	3 456.7	7 912.7
2010	494.2	825.2	28.4	0.0	215.5	25.4	714.6	6.4	984.1	870.9	2 772.6	6 387.3
2011	552.9	708.3	45.4	0.0	39.8	18.8	456.1	7.5	970.4	726.5	2 877.7	5 956.5
2012	1 419.3	628.3	57.2	0.0	174.3	48.2	565.8	2.1	1 120.2	835.6	2 523.0	6 663.0
2013	1 104.2	583.3	123.7	0.0	52.8	46.7	474.4	0.0	1 147.8	748.8	2 760.9	6 408.0
2014	921.5	525.3	177.2	3.9	34.7	51.5	544.7	8.4	1 356.4	797.4	2 424.3	6 319.8
2015	1 050.0	528.9	267.2	4.6	17.2	47.6	554.8	23.5	1 394.3	668.4	2 287.1	6 219.5
2016	895.8	359.1	101.6	11.5	15.2	49.5	378.3	30.9	1 372.8	682.1	2 547.1	6 001.6
2017	981.6	283.1	62.8	14.4	3.5	116.1	362.2	33.9	1 772.3	530.1	2 364.5	6 003.6
2018	970.2	458.1	76.0	0.0	0.0	132.7	349.3	61.6	1 539.6	574.4	2 200.0	5 873.6
Total	5 538.4	3 818.8	819.3	36.1	641.8	602.1	4 721.7	175.3	7 514.5	4781.4	11 138.7	25 877.4

APPENDIX E: INSHORE CELL-BASED SUMMARIES, 2008–2018

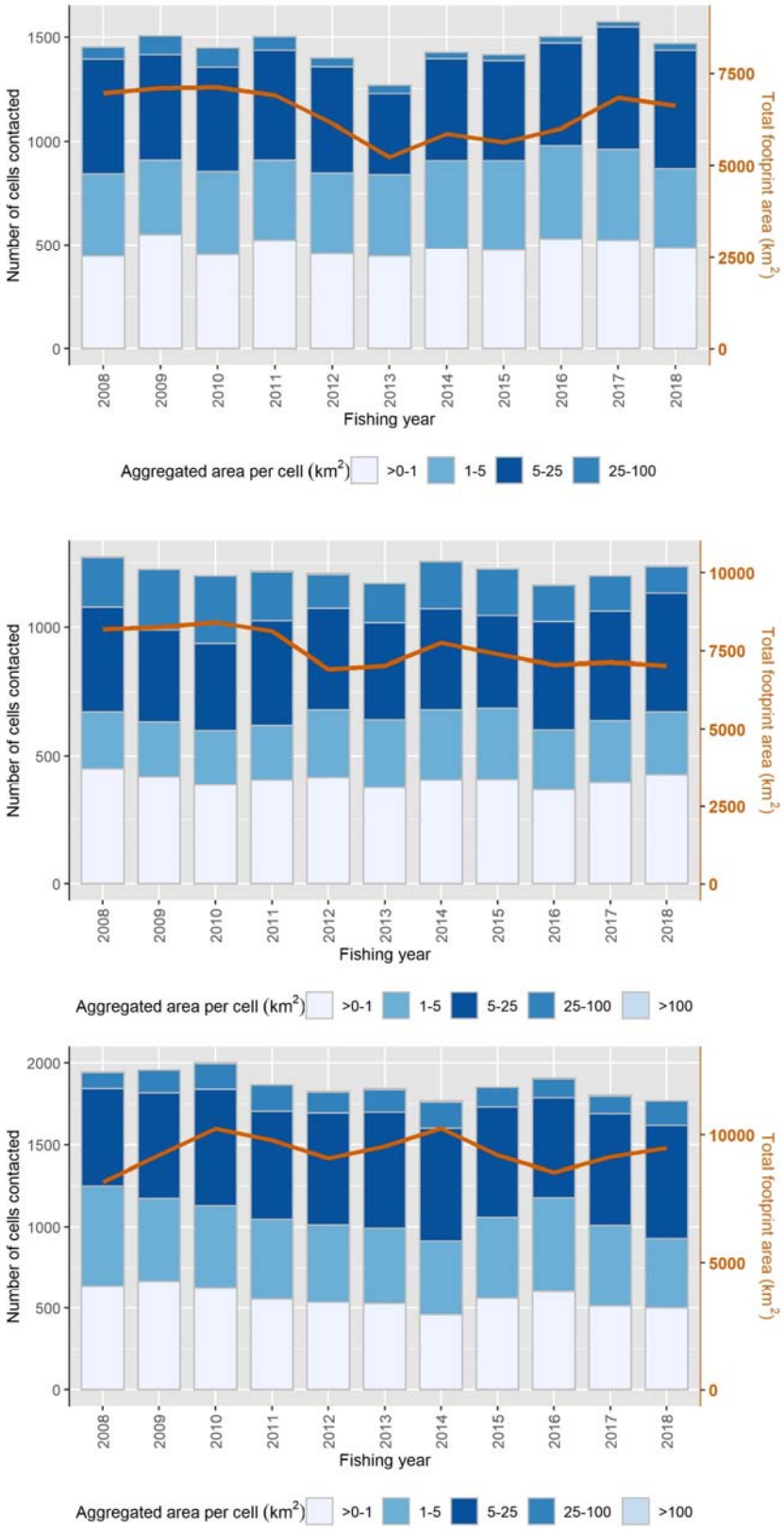

Figure E.1: Number of cells with trawl contact (binned by the annual aggregate swept area (km^2) per cell) for inshore trawl fisheries (bars), and the total trawl footprint (km^2) (line), by fishing year for 2008 to 2018, for FMA 1 (top), FMA 2 (centre), and FMA 3 (bottom).

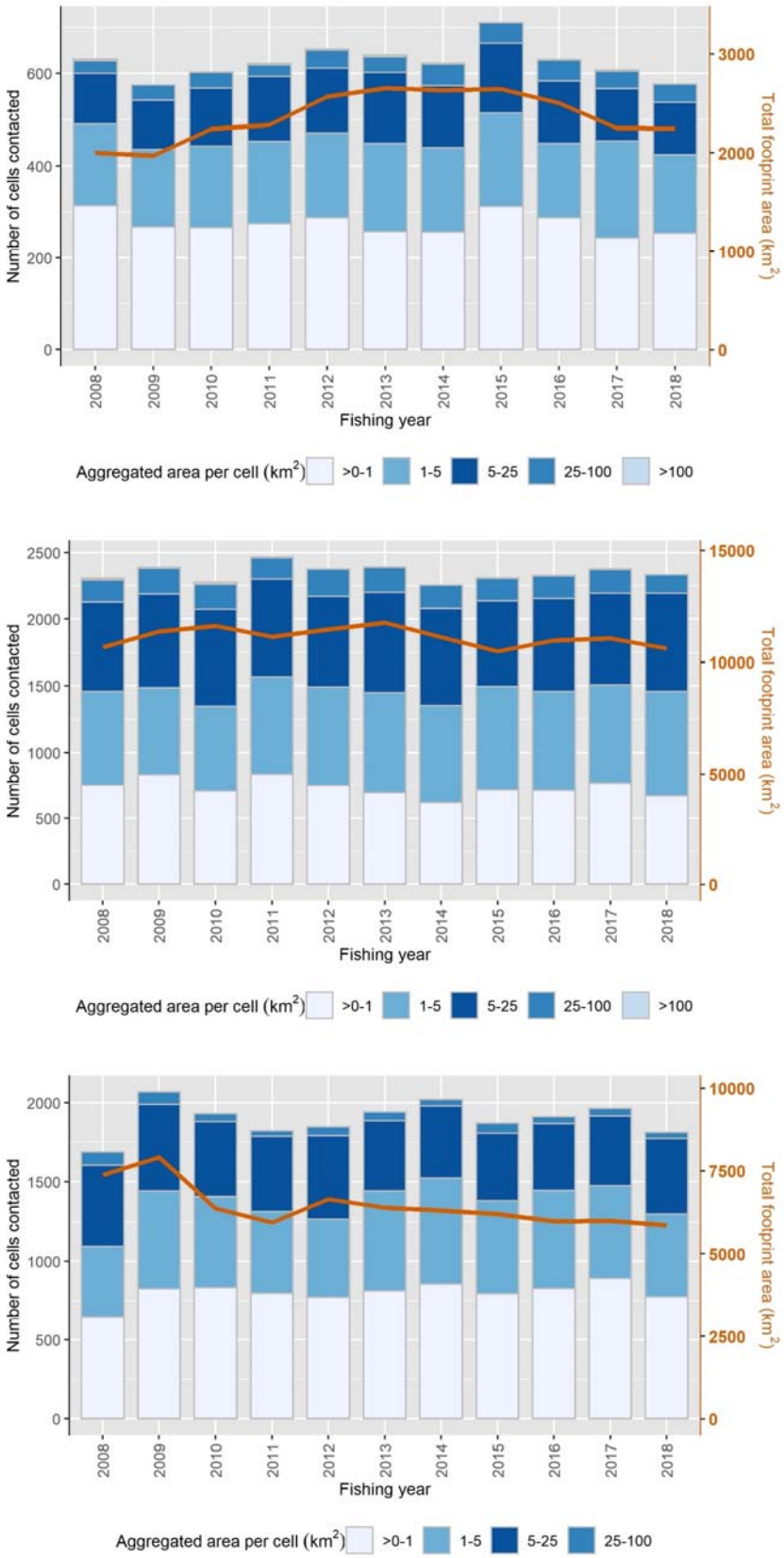

Figure E.1: — *continued.* Number of cells with trawl contact (binned by the annual aggregate swept area (km^2) per cell) for inshore trawl fisheries (bars), and the total trawl footprint (km^2) (line), by fishing year for 2008 to 2018, for FMA 5 (top), FMA 7 (centre), and FMA 8/9 (bottom).

Table E.1: Number of cells contacted by FMA 1 inshore trawl fisheries, by fishing year for 2008 to 2018. Target species codes are given in Table 1.

Fishing year	BAR1	GUR1	JDO1	LEA1	SKI1	SNA1	TAR1	TRE1	Total
2008	102	256	613	16	152	900	1 073	822	1 451
2009	55	272	560	26	54	911	1 039	764	1 505
2010	65	367	607	14	92	880	1 071	712	1 448
2011	57	248	483	12	65	927	1 057	704	1 501
2012	94	172	446	37	93	948	950	597	1 399
2013	51	157	467	36	75	834	830	583	1 269
2014	80	117	521	38	144	857	968	614	1 427
2015	79	158	425	31	44	890	1 008	575	1 414
2016	60	121	485	18	73	837	1 041	622	1 501
2017	38	149	570	26	94	881	1 209	708	1 573
2018	0	60	374	33	58	995	1 005	710	1 469
Total	383	725	1 069	155	305	1 602	1 858	1 348	2 117

Table E.2: Number of cells contacted by FMA 2 inshore trawl fisheries, by fishing year for 2008 to 2018. Target species codes are given in Table 1.

Fishing year	BAR1	FLA2	GUR2	JDO2	MOK1	RCO2	SCH2	SKI2	SNA2	SPO2	TAR2	TRE2	WAR2	Total
2008	101	166	704	112	98	26	1	59	224	0	1 157	134	230	1 274
2009	226	171	694	52	145	25	0	116	313	0	1 105	231	198	1 225
2010	75	103	751	48	83	12	0	140	221	0	1 051	166	189	1 201
2011	76	159	761	55	96	74	2	240	199	6	1 038	72	94	1 219
2012	131	196	687	26	76	108	14	82	195	0	1 094	27	112	1 210
2013	91	191	697	10	46	65	0	136	167	0	1 050	148	85	1 171
2014	94	187	735	29	59	1	0	183	263	0	1 075	165	100	1 257
2015	207	128	675	5	108	6	16	149	197	0	1 109	136	102	1 228
2016	185	152	697	13	88	73	1	141	313	0	1 029	226	143	1 164
2017	131	120	751	50	156	95	8	166	275	0	1 034	132	164	1 201
2018	272	118	702	57	261	0	0	209	305	0	1 080	46	179	1 238
Total	655	437	1 227	172	433	240	36	528	592	6	1 689	568	435	1 774

Table E.3: Number of cells contacted by FMA 3 inshore trawl fisheries, by fishing year for 2008 to 2018. Target species codes are given in Table 1.

Fishing year	BAR1	ELE3	FLA3	GUR3	RCO3	RSK3	SPD3	SSK3	STA3	TAR3	WAR3	Total
2008	888	458	890	332	997	20	335	0	146	990	311	1 796
2009	956	606	833	389	984	46	397	0	288	1 035	366	1 870
2010	965	603	920	408	1 067	105	349	0	422	1 028	240	1 904
2011	980	549	827	399	1 040	116	236	0	403	1 076	250	1 830
2012	998	576	830	413	1 057	110	124	0	264	939	241	1 784
2013	992	467	823	586	946	209	41	13	359	932	257	1 787
2014	1 048	448	781	591	1 148	347	48	0	332	1 048	175	1 739
2015	1 098	500	788	478	869	431	73	5	314	1 174	242	1 808
2016	992	489	771	585	791	203	0	0	468	1 147	251	1 869
2017	1 073	423	762	459	979	252	0	0	457	1 149	245	1 759
2018	1 243	543	700	575	911	356	0	0	494	1 006	266	1 726
Total	1 854	1 098	1725	991	1 705	732	790	18	1143	1 918	911	2 936

Table E.4: Number of cells contacted by FMA 5 inshore trawl fisheries, by fishing year for 2008 to 2018. Target species codes are given in Table 1.

Fishing year	ELE5	FLA3	GUR3	RCO3	STA5	TAR5	WAR3	Total
2008	75	254	53	44	351	36	170	631
2009	61	303	55	16	343	36	96	575
2010	61	252	86	4	383	65	128	603
2011	86	292	113	28	369	157	147	621
2012	49	280	77	51	400	134	205	653
2013	116	278	100	64	416	127	125	640
2014	106	288	117	75	385	93	178	622
2015	127	304	78	94	375	146	230	710
2016	113	332	115	10	370	100	162	630
2017	129	300	134	34	337	122	192	607
2018	126	282	119	13	367	72	79	577
Total	294	548	250	257	741	361	461	1 155

Table E.5: Number of cells contacted by FMA 7 inshore trawl fisheries, by fishing year for 2008 to 2018. Target species codes are given in Table 1.

Fishing year	ELE7	FLA7	GUR7	JDO7	LEA2	RCO7	SNA7	SPD7	STA7	TAR7	WAR7	Total
2008	39	1 255	349	284	68	1 018	266	0	517	1 484	639	2 284
2009	24	1 273	501	149	87	890	236	0	465	1 693	613	2 354
2010	32	1 254	761	205	137	906	309	11	559	1 634	604	2 258
2011	116	1 022	862	178	177	849	319	0	579	1 862	684	2 442
2012	27	1 110	992	225	156	773	223	0	526	1 805	562	2 353
2013	53	1 060	1 052	410	182	601	268	0	508	1 822	654	2 364
2014	42	899	994	365	116	613	272	0	517	1 842	617	2 245
2015	108	850	896	594	105	639	219	0	505	1 701	635	2 289
2016	89	919	892	434	52	679	225	0	623	1 681	674	2 311
2017	155	922	900	484	83	658	196	6	618	1 730	563	2 362
2018	163	1 008	941	762	20	573	216	0	569	1 674	665	2 310
Total	397	2 109	1 739	1 162	304	1 785	621	17	1 152	2 939	1 442	3 416

Table E.6: Number of cells contacted by FMA 8 and FMA 9 inshore trawl fisheries, by fishing year for 2008 to 2018. Target species codes are given in Table 1.

	GUR1	GUR8	JDO1	KAH8	LEA2	SCH8	SNA8	SPO8	TAR1	TAR8	TRE7	Total
2008	555	344	38	6	67	62	593	11	661	327	929	1 687
2009	478	433	13	0	126	90	566	9	714	619	1038	2 068
2010	345	449	88	0	132	45	492	20	625	583	954	1 931
2011	383	436	116	0	86	59	448	15	557	520	983	1 823
2012	512	413	97	0	120	117	516	10	567	525	900	1 848
2013	521	439	186	0	93	91	413	0	605	512	904	1 942
2014	474	413	287	8	57	99	343	31	752	601	894	2 020
2015	554	377	330	15	30	92	471	44	706	528	740	1 871
2016	451	354	186	34	41	65	405	90	723	550	824	1 911
2017	472	308	126	34	14	138	463	61	719	465	871	1 965
2018	451	378	135	0	0	147	393	101	676	412	805	1 811
Total	962	826	612	86	278	298	1 224	212	1 410	1 281	1 874	3 248

Table E.7: Number of cells for 2008–2012 and number of new cells in subsequent years estimated from the FMA-based mixed inshore target fisheries, and the associated aggregate area and footprint in those new cells, by fishing year for 2008 to 2018.

Fishing year	FMA	No. cells	No. new cells	Aggregate area (km^2)	Footprint area (km^2)	Fishstock	No. cells	No. new cells	Aggregate area (km^2)	Footprint Area (km^2)
2008–12	FMA 1	1900				2008–12	FMA 5	955		
2013			28	7.1	7.1	2013		58	38.8	36.5
2014			43	11.7	11.7	2014		29	8.3	8.3
2015			31	7.7	7.7	2015		69	78.6	74.6
2016			37	12.2	12.2	2016		22	4.1	4.1
2017			66	19.6	19.6	2017		9	1.3	1.3
2018			23	6.4	6.4	2018		13	5.5	5.3
2008–12	FMA 2	1624				2008–12	FMA 7	3131		
2013			15	3.0	3.0	2013		89	29.6	29.5
2014			47	12.3	12.3	2014		33	39.6	37.1
2015			31	8.8	8.8	2015		36	11.4	11.4
2016			18	4.9	4.9	2016		52	15.1	15.1
2017			22	4.7	4.6	2017		59	16.8	16.8
2018			21	5.0	5.0	2018		24	8.4	8.4
2008–12	FMA 3	2636				2008–12	FMA 8/9	2772		
2013			79	27.6	27.4	2013		134	53.5	53.2
2014			77	48.4	40.3	2014		155	62.4	62.0
2015			94	27.2	27.2	2015		41	11.3	11.1
2016			105	30.6	30.3	2016		79	24.2	24.2
2017			24	4.5	4.5	2017		90	34.2	34.1
2018			30	8.8	8.8	2018		19	6.1	6.1

Table E.8: Total number of cells contacted and summary data for the annual number of bottom-contacting tows per cell, for FMA-based inshore fishstocks, 2008–2018.

Fishing year	No. cells	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
2008	9 201	1	3	12	31.6	38	571
2009	9 743	1	2	11	31.4	39	694
2010	9 394	1	3	13	34.6	41	697
2011	9 483	1	3	13	31.5	40	750
2012	9 302	1	3	14	31.8	38	608
2013	9 223	1	3	13	32.1	39	717
2014	9 349	1	4	14	32.3	40	707
2015	9 364	1	3	12	29.4	36	524
2016	9 396	1	3	12	28.9	34	592
2017	9 512	1	3	12	29.6	36	634
2018	9 160	1	3	13	28.8	38	472
2008–18	14 674	1	4	33	218.5	253	5 741

Table E.9: Summary data for the annual aggregate swept area per cell (km^2), for FMA-based inshore fishstocks, 2008–2018. The minimum values ranged between 1 and 2 m^2.

Fishing year	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
2008	< 0.0001	0.2	0.5	2.3	1.7	141.8
2009	< 0.0001	0.2	0.5	2.4	1.7	119.8
2010	< 0.0001	0.2	0.5	2.4	1.7	141.1
2011	< 0.0001	0.2	0.5	2.2	1.6	122.8
2012	< 0.0001	0.2	0.5	2.2	1.7	128.8
2013	< 0.0001	0.2	0.5	2.2	1.7	157.0
2014	< 0.0001	0.2	0.5	2.2	1.7	120.9
2015	< 0.0001	0.2	0.5	2.1	1.6	112.1
2016	< 0.0001	0.2	0.5	2.1	1.6	135.7
2017	< 0.0001	0.2	0.5	2.1	1.7	130.6
2018	< 0.0001	0.2	0.5	2.0	1.6	96.1
2008–18	< 0.0001	0.2	0.5	2.2	1.7	157.0

APPENDIX F: SNA 1, TAR 1, AND TAR 2 SUMMARIES, 2008–2018

Table F.1: The SNA 1 estimated footprint, by depth zone and fishing year for 2008–2018. Allocation of the footprint in each depth zone is based on the overlay of the footprint on the 250-m gridded bathymetry (Mitchell et al. 2012) where the depth value is the depth at the midpoint of each cell (see Figure B.1).

Fishing	Depth zone (m)								
year	200	400	600	800	1000	1200	1400	1600	0–1600
2008	2 332.9	28.5	9.2	7.1	2.4	1.3	2.1	0	2 383.5
2009	2 518.5	24.7	6.5	10.9	2.9	3.2	2.6	0.4	2 569.7
2010	2 348.7	19.4	10.2	2.4	0.5	0.4	0	0	2 381.6
2011	2 369.0	16.2	11.2	2.6	2.1	1.9	1.4	0.6	2 405.1
2012	2 336.3	25.5	9.0	5.0	0.7	1.2	2.4	0.7	2 380.7
2013	2 266.7	15.0	6.1	0.9	1.6	0.8	0.7	0.0	2 291.9
2014	2 111.3	14.2	4.9	2.4	2.6	1.1	1.6	0.8	2 139.0
2015	2 062.4	25.2	7.5	5.6	0.7	0.4	0.6	1.0	2 103.4
2016	1 841.5	18.5	9.1	5.3	4.0	0.7	1.1	1.5	1 881.6
2017	1 874.7	22.7	3.3	3.3	0.3	0	0	0	1 904.3
2018	2 591.9	39.0	9.4	2.7	1.2	2.1	1.2	1.0	2 648.5
All	10 524.6	241.6	84.6	47.8	19.2	12.9	13.6	6.0	10 950.4

Table F.2: The TAR 1 estimated footprint, by depth zone and fishing year for 2008–2018.

Fishing	Depth zone (m)								
year	200	400	600	800	1000	1200	1400	1600	0–1600
2008	3 187.3	744.3	85.2	31.2	17.4	10.8	9.7	1.1	4 086.9
2009	3 220.2	933.5	86.0	25.9	13.0	10.4	12.4	9.2	4 310.5
2010	2 652.8	776.4	98.0	29.0	12.1	5.6	8.7	7.1	3 589.6
2011	2 419.7	881.5	94.7	36.7	15.3	9.3	6.8	8.0	3 471.9
2012	2 522.9	701.7	77.9	24.5	13.4	9.4	8.5	6.6	3 364.8
2013	2 009.6	531.0	67.2	18.3	7.6	6.3	5.9	3.0	2 648.9
2014	2 541.5	740.9	69.8	34.3	23.1	13.1	10.7	6.0	3 439.5
2015	2 536.6	1 056.7	72.3	23.5	14.6	5.6	3.3	1.6	3 714.2
2016	2 507.2	1 132.3	106.9	39.5	17.7	10.8	6.3	3.3	3 824.0
2017	3 287.3	1 176.4	101.2	28.1	22.4	14.9	10.0	6.5	4 646.8
2018	2 630.7	1 268.7	79.6	29.6	9.4	6.5	3.8	2.5	4 030.8
All	13 494.8	4 562.6	720.0	296.3	160.7	100.0	84.7	54.4	19 473.5

Table F.3: The TAR 2 estimated footprint, by depth zone and fishing year for 2008–2018.

Fishing	Depth zone (m)								
year	200	400	600	800	1000	1200	1400	1600	0–1600
2008	4 948.9	249.6	65.2	40.2	26.5	27.2	14.7	9.9	5 382.1
2009	5 164.9	160.9	58.2	34.8	23.4	21.6	13.6	9.4	5 486.9
2010	4 859.8	150.0	51.6	27.3	14.2	17.7	10.0	6.7	5 137.3
2011	4 521.0	161.0	53.5	33.1	17.2	15.5	9.4	7.6	4 818.2
2012	3 672.7	162.9	67.7	48.1	38.5	31.2	16.4	9.3	4 046.9
2013	3 864.1	144.6	61.4	40.2	24.2	19.6	16.6	8.5	4 179.0
2014	4 206.1	203.8	73.3	49.2	28.6	16.8	12.1	6.3	4 596.3
2015	4 205.3	151.1	63.2	42.3	24.2	17.4	11.9	9.8	4 525.3
2016	3 619.1	147.4	69.6	41.5	21.2	15.8	6.2	1.8	3 922.6
2017	3 715.8	162.7	66.6	35.9	21.8	11.9	9.1	5.3	4 029.1
2018	3 768.1	179.8	61.7	40.1	22.5	14.5	10.3	6.8	4 103.7
All	12 596.0	979.7	389.9	286.2	215.2	186.5	115.0	73.7	14 842.2

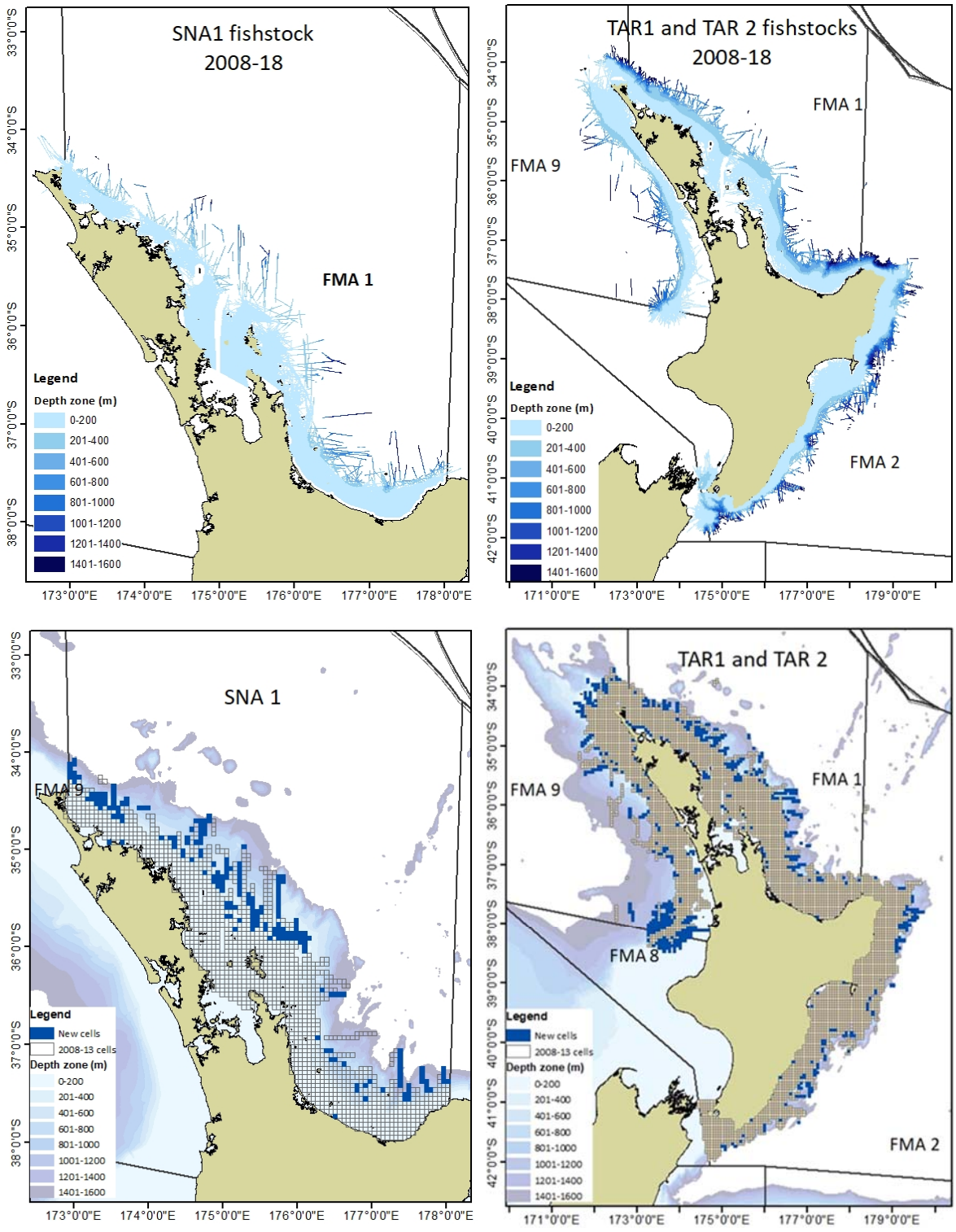

Figure F.1: Distribution of the SNA 1 trawl footprint (left) and TAR 1 and TAR 2 footprints (right), for 2008–2018.

APPENDIX G: DEEPWATER TRAWL FOOTPRINT AND AGGREGATE SWEPT AREA

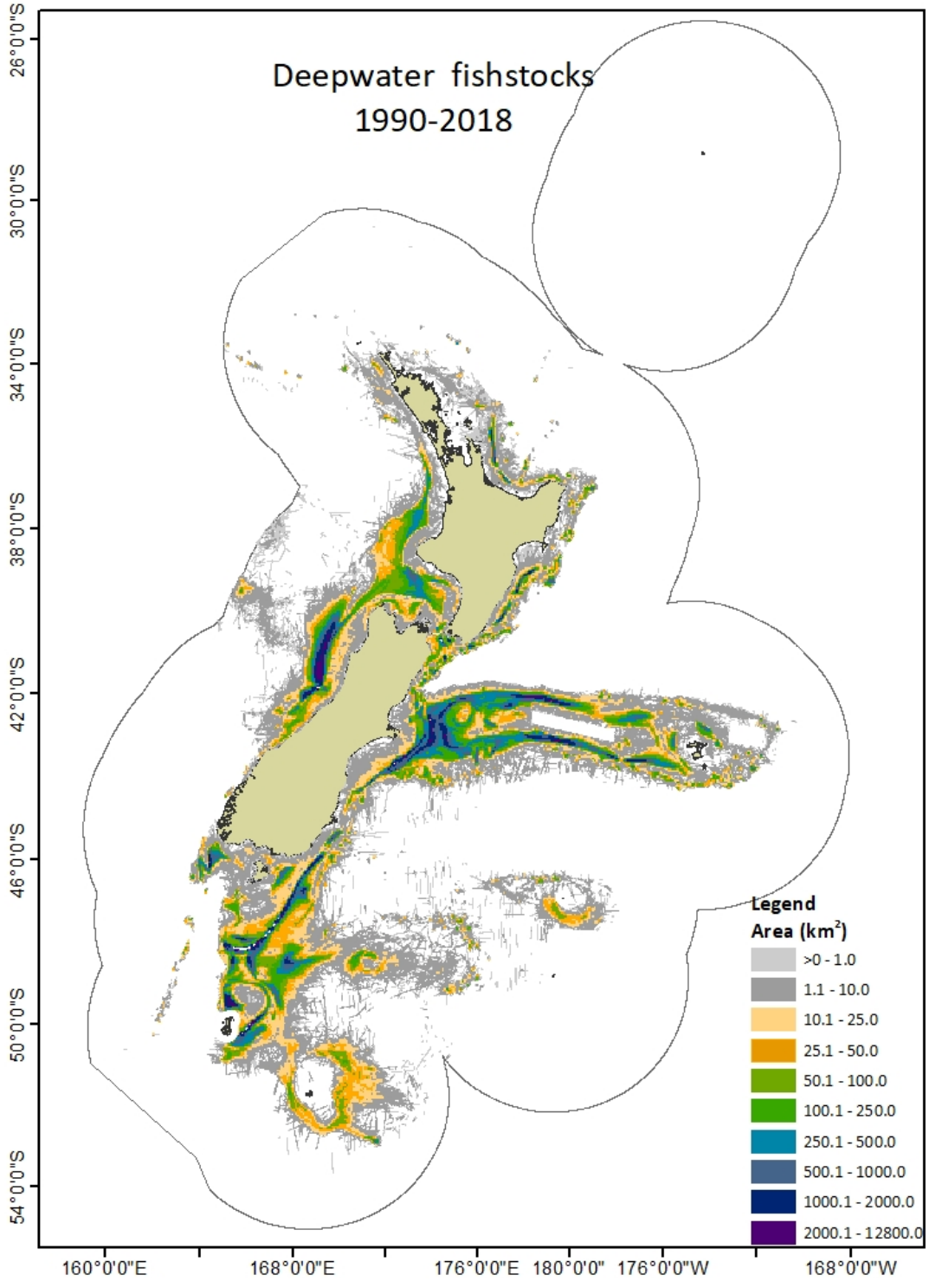

Figure G.1: Distribution of the deepwater fishstock aggregate swept area, summed by 25-km^2 cell, for 1990–2018.

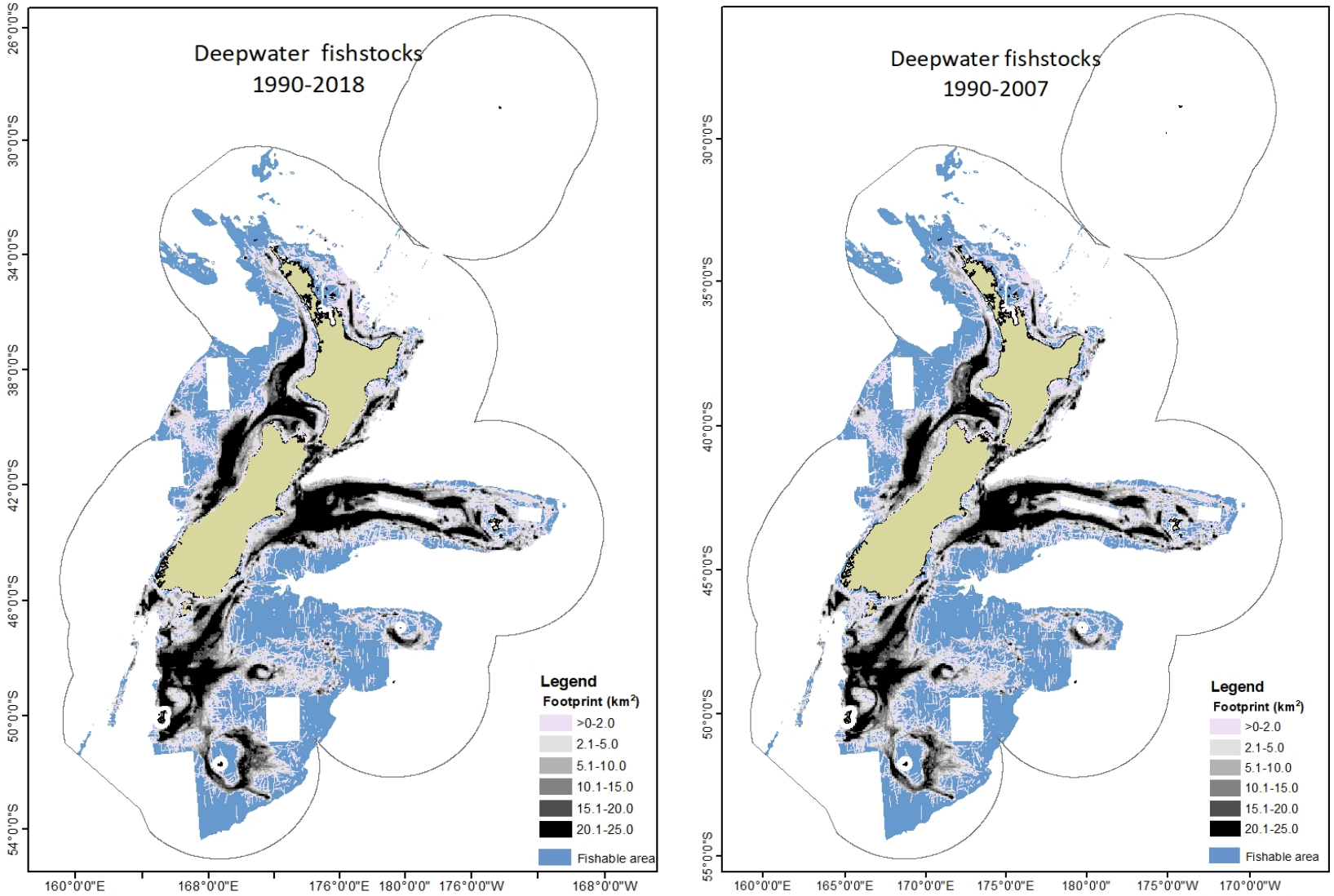

Figure G.2: The spatial distribution for the deepwater Tier 1 and Tier 2 fishstocks combined for 1990–2018 (left) and for 1990–2007 (right).

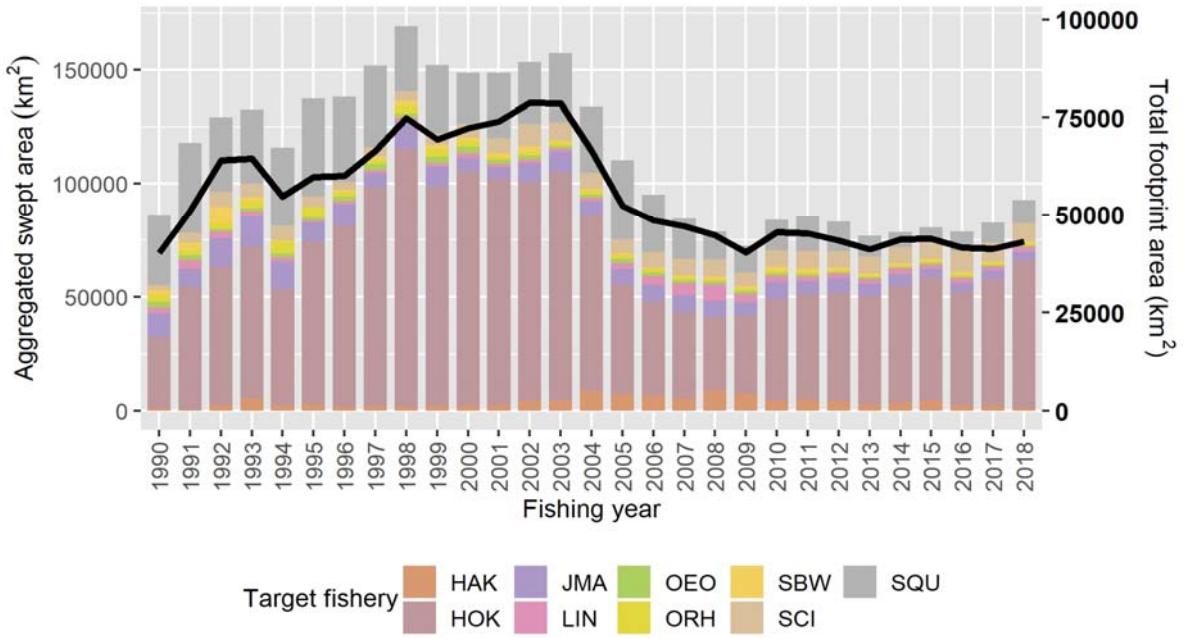

Figure G.3: Aggregate swept area (km^2) estimated from deepwater Tier 1 target fisheries (bars) and the total trawl footprint (km^2) (black line), by fishing year for 1990–2018.

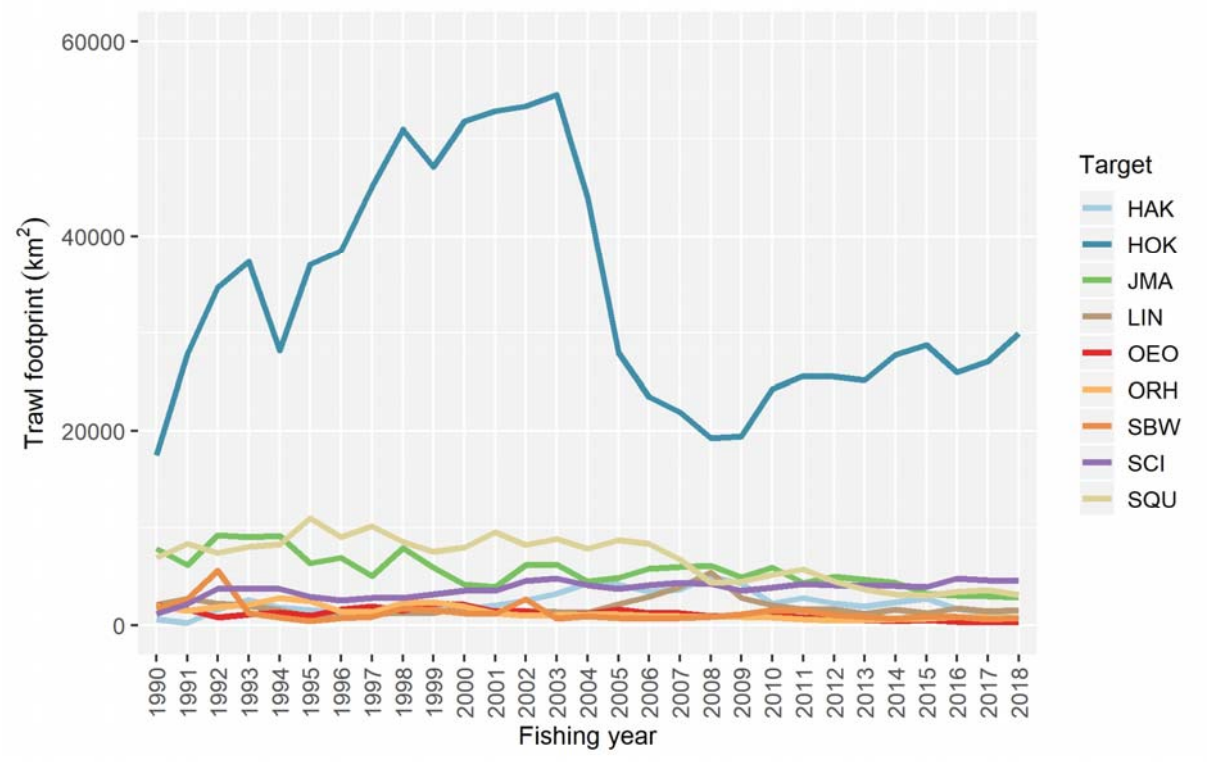

Figure G.4: Trawl footprint (km^2) estimated from deepwater Tier 1 target fisheries, by fishing year for 1990–2018.

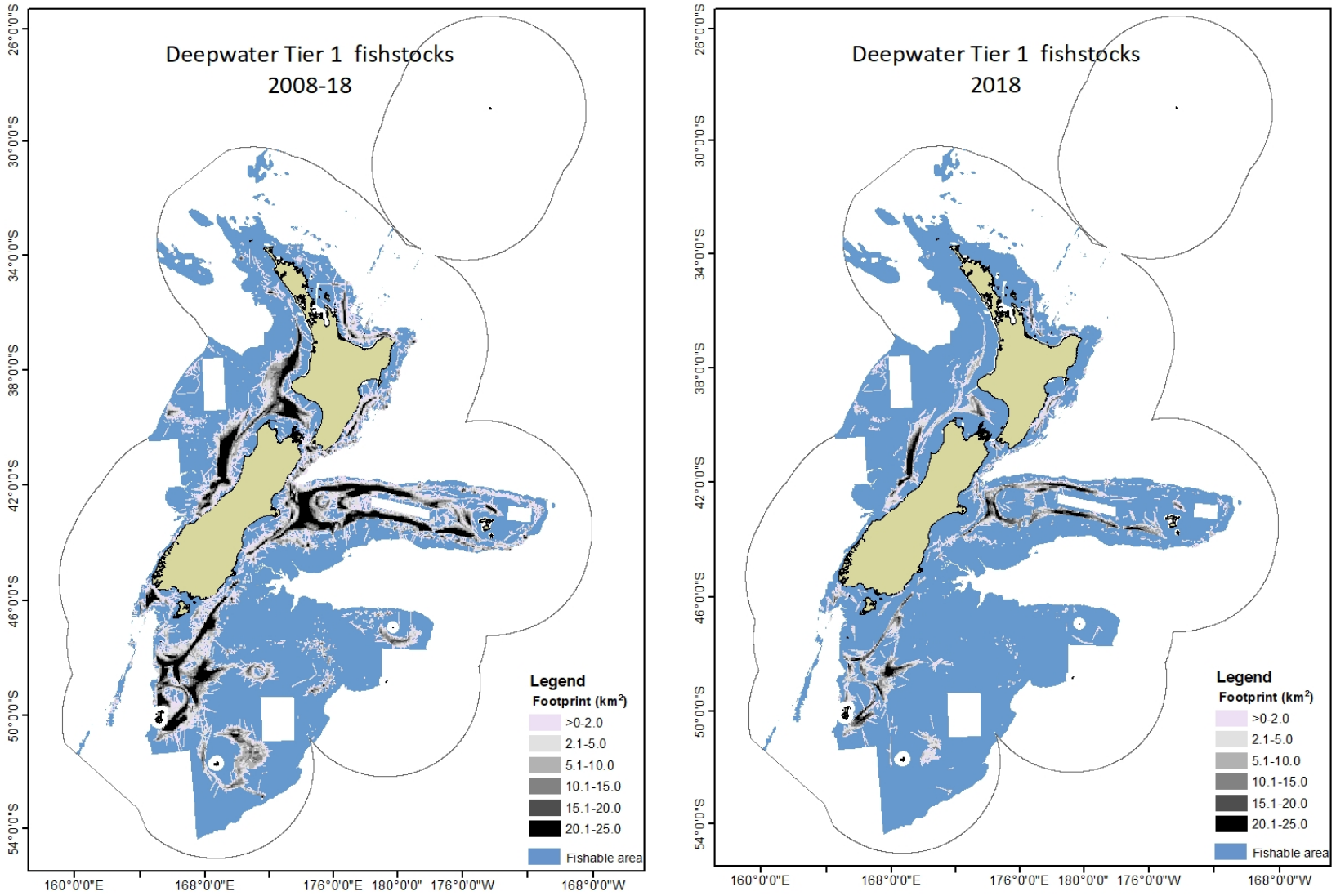

Figure G.5: The spatial distribution for the deepwater Tier 1 fishstocks for 2008–2018 (left) and for 2018 (right).

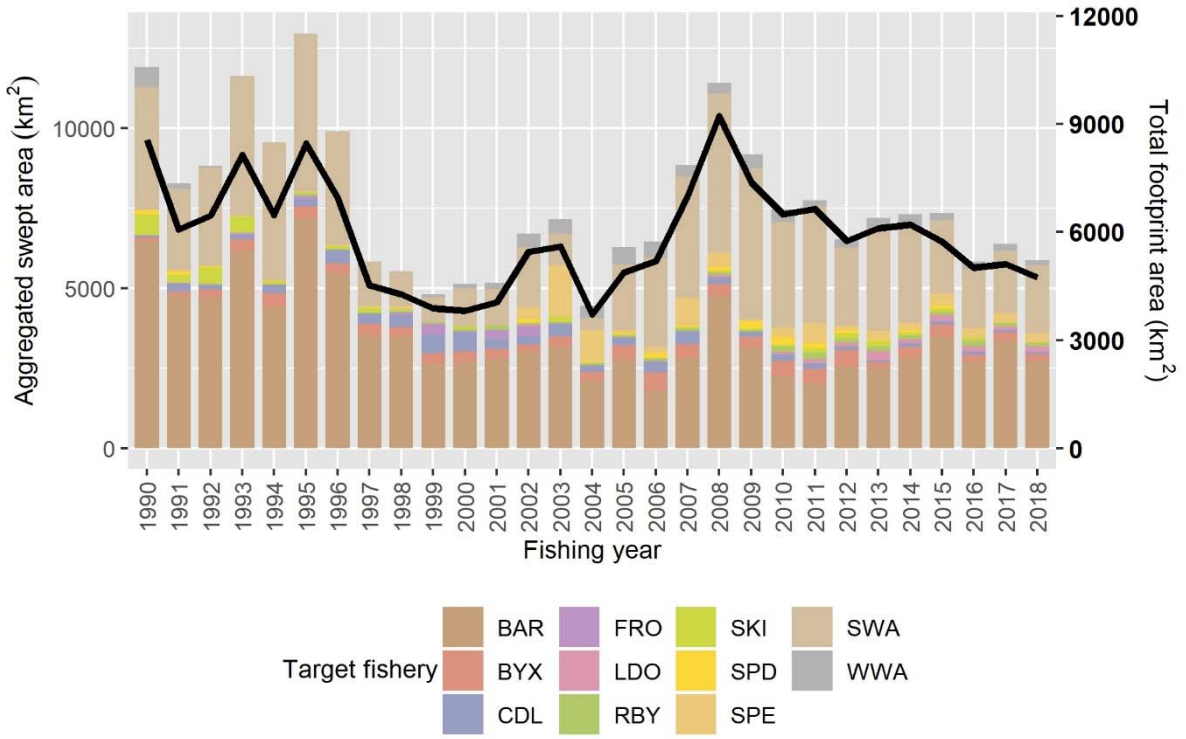

Figure G.6: Aggregate swept area (km^2) estimated for the main deepwater Tier 2 target fishstocks (bars) and the total trawl footprint (km^2) (black line), by fishing year for 1990 to 2018.

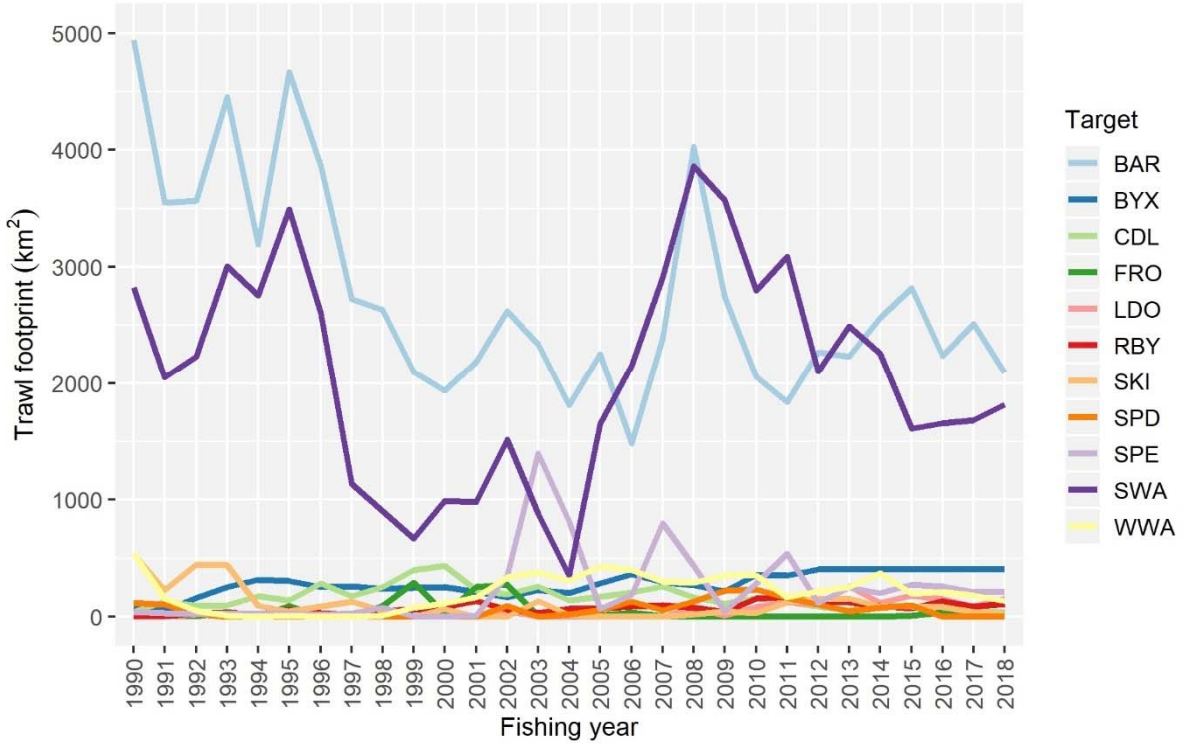

Figure G.7: Trawl footprint (km^2) estimated for the main deepwater Tier 2 target fishstocks, by fishing year for 1990 to 2018.

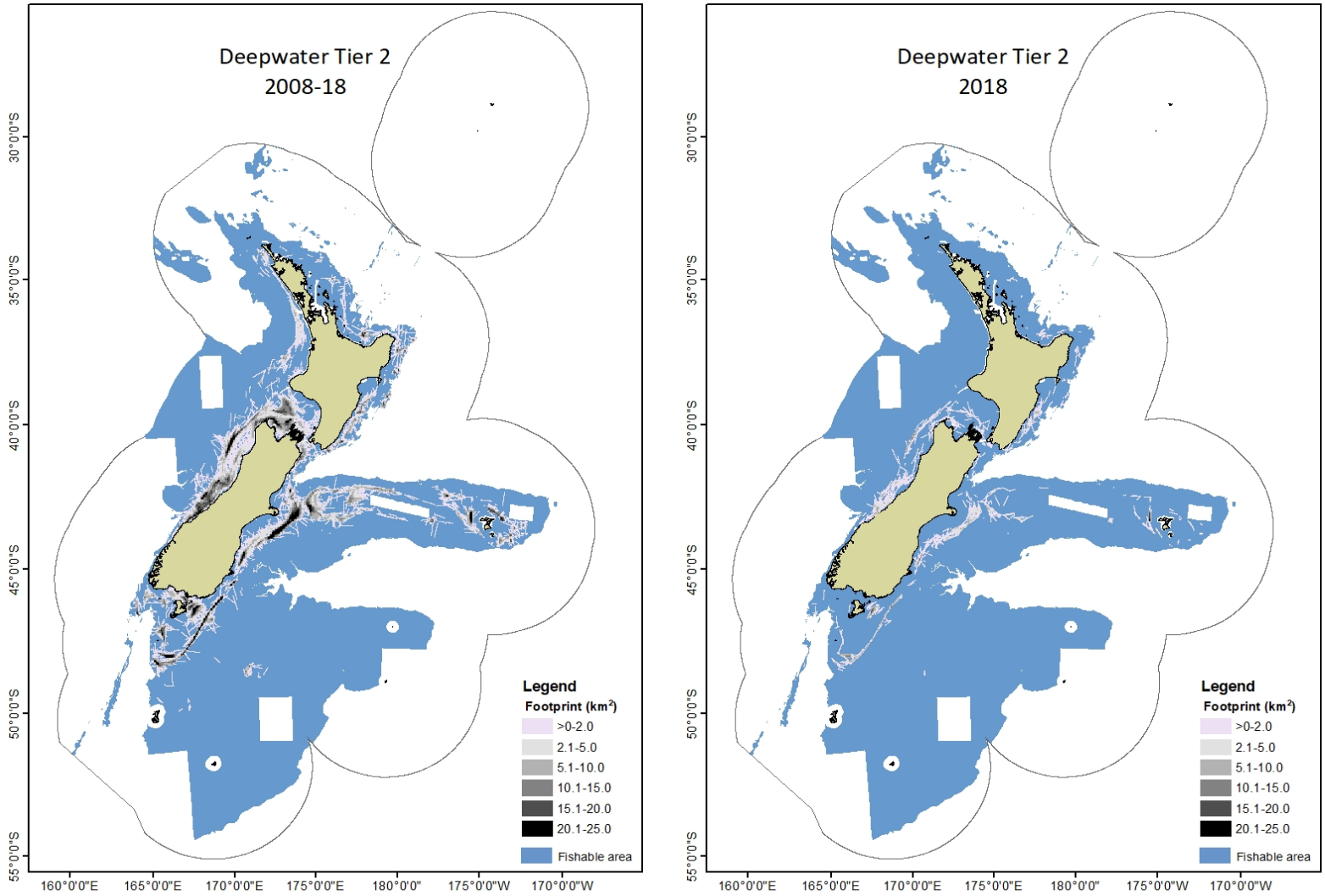

Figure G.8: The spatial distribution for the deepwater Tier 2 fishstocks for 2008–2018 (left) and for 2018 (right).

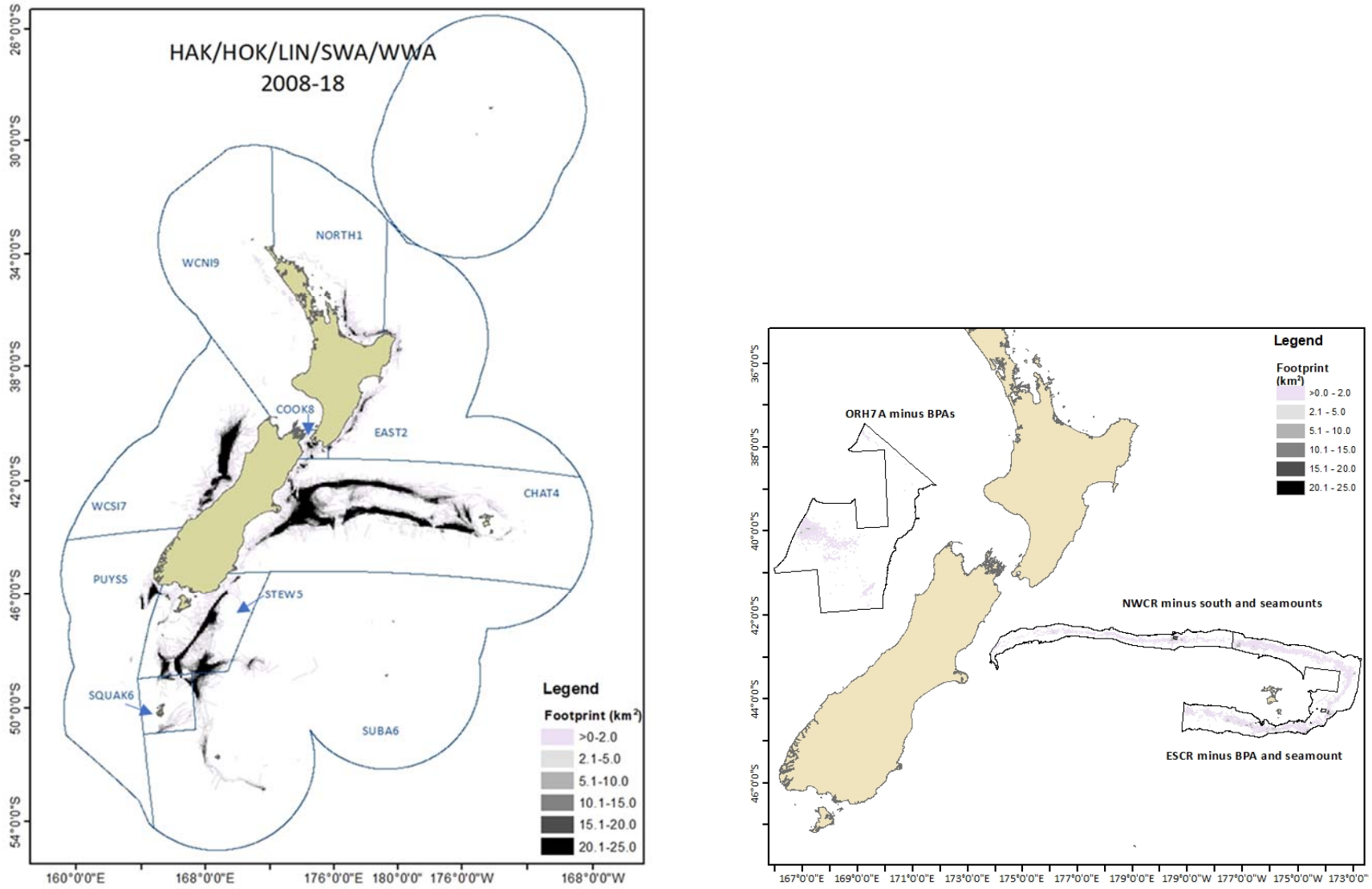

Figure G.9: Bycatch Assessment Areas (green) (from Anderson & Edwards 2018) used to analyse the HAK/HOK/LIN/SWA/WWA mixed fishery, relative to Fishery Management Areas (black) (left) and areas used to summarise ORH/OEO fisheries in ORH 7A, NWCR, and ESCR and the 2008–2018 footprint (right).

Table G.1: Number of bottom-contacting tows, footprint (km^2), aggregate area (km^2), number of cells contacted, and number of new cells contacted in following years for deepwater trawl fisheries, by fishing year for 1990–2018.

Fishing year	No. tows	Footprint (km^2)	Aggregate (km^2)	No. cells	New cells
1990	34 532	46 148.4	98 067.3	12 881	
1991	42 423	54 946.7	126 175.4	14 179	5 378
1992	45 836	68 254.1	138 037.7	15 929	4 305
1993	49 405	69 847.8	144 394.5	15 591	2 623
1994	50 844	58 728.9	125 411.2	14 586	1 544
1995	55 451	64 971.7	150 287.5	15 010	1 359
1996	55 690	64 405.7	148 201.1	14 865	1 453
1997	56 819	69 265.5	157 838.7	15 057	1 195
1998	60 613	77 274.8	174 810.0	16 314	1 502
1999	57 686	71 493.2	157 000.0	15 782	1 303
2000	53 432	74 724.4	153 891.8	15 853	1 207
2001	49 993	77 030.8	153 718.0	15 989	683
2002	50 869	82 492.4	160 129.0	17 847	1 116
2003	49 965	82 790.5	164 563.0	17 211	654
2004	42 905	69 527.9	138 014.4	14 884	322
2005	40 227	55 676.1	116 572.2	13 774	486
2006	37 383	51 832.8	101 651.6	13 085	255
2007	33 574	52 050.9	93 493.8	12 620	235
2008	33 990	52 570.7	90 312.4	13 638	188
2009	29 803	46 555.3	81 831.6	12 560	173
2010	30 603	50 680.6	91 439.5	12 864	121
2011	28 314	50 640.6	93 000.1	12 551	119
2012	27 278	48 074.8	89 890.3	11 639	80
2013	25 938	46 186.9	84 214.0	10 937	62
2014	26 962	48 631.7	86 062.4	11 754	66
2015	26 733	48 396.9	88 071.6	11 452	104
2016	27 148	45 950.2	84 709.8	11 331	94
2017	26 449	45 528.4	89 154.9	11 363	97
2018	27 611	47 092.9	98 507.5	10 788	87
Total	1 178 476	351 231.5	3 479 451.2	39 692	

Table G.2: Aggregate swept area (km^2) estimated from deepwater Tier 1 target fisheries, by fishing year for 2008–2018. Target species codes are given in Table 2.

Fishing year	HAK	HOK	JMA	LIN	OEO	ORH	SBW	SCI	SQU	Total
2008	8 852.1	32 065.4	7 265.7	7 136.9	1 272.1	1 125.3	998.1	7 582.2	12 502.6	78 800.6
2009	7 399.6	34 228.6	5 799.8	3 693.1	1 248.0	1 096.1	1 249.2	5 947.4	11 873.5	72 535.4
2010	4 437.7	44 343.9	7 720.3	2 542.0	1 397.4	974.0	1 747.4	7 174.1	13 621.1	83 957.9
2011	5 046.2	46 253.5	5 428.7	2 135.4	1 011.9	758.0	1 746.1	7 773.0	15 099.6	85 252.4
2012	4 071.4	47 580.2	6 300.6	2 061.2	903.1	640.0	1 139.7	7 367.1	13 189.7	83 253.2
2013	2 836.2	47 168.0	5 680.0	2 114.5	668.2	679.2	1 018.7	7 480.1	9 212.4	76 857.3
2014	3 552.4	51 011.8	5 327.1	2 464.0	561.8	761.2	775.3	7 220.9	6 952.1	78 626.7
2015	4 413.2	53 750.5	3 950.1	2 028.7	716.1	836.5	1 090.3	7 395.1	6 502.9	80 683.4
2016	2 433.5	49 872.8	3 538.2	2 355.0	473.0	1 157.0	960.4	9 388.3	8 678.4	78 856.6
2017	1 960.9	55 898.8	3 482.9	2 009.3	347.7	1 028.7	671.6	8 282.4	9 066.1	82 748.4
2018	866.7	65 149.0	3 573.8	2 405.2	484.6	1 082.8	821.3	8 098.7	10 140.2	92 622.3
Total	45 869.9	527 322.5	58 067.3	30 945.3	9 083.7	10 139.1	12 218.3	83 709.4	116 838.5	894 193.9

Table G.3: Trawl footprint (km^2) for deepwater Tier 1 trawl fisheries, by fishing year for 2008–2018. Target species codes are given in Table 2.

Fishing year	HAK	HOK	JMA	LIN	OEO	ORH	SBW	SCI	SQU	All
2008	4 960.6	19 224.0	6 124.8	5 418.6	956	850.3	860.8	4 239.0	4 374.0	44 903.9
2009	4 297.4	19 408.9	4 915.5	2 806.0	1 015.6	891.3	1 142.2	3 562.6	4 511.2	40 417.8
2010	2 240.8	24 283.2	5 909.2	2 084.0	1 092.2	825.0	1 574.7	3 879.5	5 190.6	45 588.7
2011	2 817.3	25 569.4	4 386.5	1 651.5	830.6	647.1	1 480.1	4 240.5	5 760.5	45 247.1
2012	2 267.7	25 523.1	4 979.0	1 618.6	722.7	522.7	1 040.3	4 107.2	4 520.2	43 405.8
2013	1 933.2	25 177.0	4 656.2	1 212.7	562.5	539.6	851.8	4 078.2	3 664.4	41 222.5
2014	2 373.4	27 792.3	4 387.6	1 647.5	472.9	634.0	687.2	4 038.2	3 171.1	43 752.8
2015	2 747.5	28 796.3	3 261.0	1 242.8	593.1	673.9	957.0	3 956.2	3 087.7	43 879.6
2016	1 717.6	25 991.2	3 049.2	1 738.8	405.8	905.2	866.6	4 784.8	3 455.2	41 694.2
2017	1 333.3	27 067.6	2 974.8	1 421.2	315.4	839.3	610.6	4 590.1	3 638.6	41 353.2
2018	709.4	29 983.1	2 890.3	1 536.0	385.8	755.7	744.3	4 534.7	3 107.5	43 215.4
All	10 544.4	78 307.5	22 200.9	14 068.3	4 882.1	5 323.2	9 036.3	12 569.4	13 962.7	152 412.6

Table G.4: Aggregate swept area (km^2) estimated from deepwater Tier 2 trawl fisheries, by fishing year for 2008–2018. There was no recorded effort for PRK or PTO during these years and less than 6 km^2 for RIB; these targets are not included in this table. Target species codes are described in Table 2.

Fishing year	BAR	BYX	CDL	EMA	FRO	GSH	LDO	RBT	RBY	SKI	SPD	SPE	SWA	WWA	Total
2008	4 770.2	351.8	215.5	60.1	0.0	0.0	77.6	21.9	85.2	21.3	135.6	461.2	4 964.1	344.7	11 509.2
2009	3 155.4	324.3	144.8	61.5	0.0	0.0	13.1	45.4	43.6	47.3	242.2	46.5	4 727.8	444.3	9 296.2
2010	2 245.5	471.1	207.9	1.5	0.0	0.0	90.4	29.0	167.6	35.4	262.8	293.5	3 284.6	392.5	7 481.8
2011	2 020.7	463.9	161.8	5.4	0.0	0.0	140.7	7.0	191.6	138.0	175.7	602.4	3 660.4	179.4	7 747.0
2012	2 526.6	532	112.3	50.1	0.0	16.1	111.8	35.1	134.6	160.1	113.0	124.2	2 448.2	269.8	6 633.9
2013	2 508.3	168.9	69.8	11.1	0.0	46.6	289.0	109.4	141.9	164.6	52.8	281.1	3 205.5	307.5	7 356.5
2014	2 830.9	338.2	106.9	0.0	2.2	20.2	130.3	105.3	112.2	90.1	82.4	230.2	2 926.5	458.9	7 434.3
2015	3 491.3	370.0	95.8	0.0	11.4	4.7	201.5	31.0	89.2	94.3	101.9	380.4	2 286.3	228.5	7 386.3
2016	2 664.6	252.3	63.6	0.0	40.7	12.2	161.1	5.6	177.9	86.2	0.0	305.5	1 851.0	229.5	5 850.2
2017	3 326.5	280.2	72.3	0.0	25.2	0.0	93.3	31.0	94.3	45.5	0.7	288.9	1 942.4	206.3	6 406.6
2018	2 723.9	215.2	46.4	0.0	23.2	0.0	164.6	12.7	114.6	20.6	0.0	287.8	2 117.8	153.0	5 879.8
Total	32 263.9	3 767.9	1 297.1	189.7	102.7	99.8	1 473.4	433.4	1 352.7	903.4	1 167.1	3 301.7	33 414.6	3 214.4	82 981.8

Table G.5: Trawl footprint (km^2) for deepwater Tier 2 trawl fisheries, by fishing year for 2008 to 2018. Target species codes are described in Table 2.

Fishing year	BAR	BYX	CDL	EMA	FRO	GSH	LDO	RBT	RBY	RIB	SKI	SPD	SPE	SWA	WWA	Total
2008	4 025.4	270.7	167.2	58..7	–	–	72.3	21.6	77.1	–	21.2	128.2	434.5	3 862.1	292.7	9 211.0
2009	2 744.0	218.2	114.0	58.6	–	–	13.1	43.9	42.0	–	47.1	225.6	46.0	3 568.2	355.0	7 376.0
2010	2 053.9	357.5	162.9	1.5	–	–	86.3	28.7	155.6	–	32.7	231.9	285.3	2 796.5	353.5	6 488.2
2011	1 836.6	352.5	130.3	5.3	–	–	126.5	7.0	171.0	–	126.8	160.2	542.8	3 090.0	164.7	6 650.8
2012	2 267.1	406.0	90.7	47.6	–	15.9	102.2	34.8	122.8	–	150.4	103.1	122.5	2 103.6	219.2	5 743.7
2013	2 232.8	144.3	58.9	11.1	–	44.1	258.0	106.3	127.5	–	157.4	48.7	250.0	2 493.8	256.2	6 111.2
2014	2 562.6	270.9	89.8	–	2.1	19.5	121.5	101.3	93.9	–	87.5	78.0	202.4	2 259.6	373.1	6 212.7
2015	2 820.3	293.1	85.0	–	11.0	4.7	183.4	30.8	73.6	0.4	89.4	97.1	273.2	1 607.3	200.3	5 740.1
2016	2 238.3	210.4	54.0	–	38.9	11.7	148.8	5.6	136.1	–	83.1	–	261.6	1 654.4	214.9	5 012.7
2017	2 514.4	224.1	56.0	–	24.4	–	90.1	30.6	89.8	–	44.7	0.7	214.5	1 680.6	181.7	5 114.1
2018	2 092.3	154.0	34.8	–	23.0	–	156.3	12.7	107.5	5.5	20.0	–	217.2	1 815.9	137.7	4 748.0
Total	18 620.4	1 952.4	670.5	175.7	98.7	84.3	989.7	408.1	887.4	5.9	738.4	834.8	2 271.0	16 064.0	1 958.1	43 252.6

Table G.6: Number of bottom-contacting tows from combined deepwater Tier 1 targets HAK/HOK/LIN/SWA/WWA for each Bycatch Assessment Area (see Figure G.9), by fishing year for 2008–2018.

Fishing year	CHAT4	COOK8	EAST2	NORTH1	PUYS5	SQUAK6	STEW5	SUBA6	WCNI9	WCSI7	Total
2008	5 891	1 160	148	146	305	98	2 042	374	65	2 768	12 997
2009	5 327	1 058	221	138	233	73	1 893	288	57	2 296	11 584
2010	5 203	890	200	286	229	28	1 988	137	17	2 531	11 509
2011	4 879	686	288	202	359	88	1 570	234	20	2 890	11 216
2012	4 982	728	223	220	333	43	1 787	114	40	2 878	11 348
2013	4 618	981	232	283	242	53	2 220	256	39	3 148	12 072
2014	4 493	1 230	470	240	299	134	2 477	337	29	3 539	13 248
2015	4 741	1 026	268	256	263	131	2 405	186	22	3 670	12 968
2016	4 868	1 047	277	220	332	72	1 438	84	13	3 455	11 806
2017	4 797	919	355	234	271	87	1 818	193	26	3 758	12 458
2018	4 619	939	389	234	195	114	2 062	482	33	3 848	12 915
Total	54 418	10 664	3 071	2 459	3 061	921	21 700	2 685	361	34 781	134 121

Table G.7: Aggregate swept area (km^2) estimated from combined deepwater Tier 1 targets HAK/HOK/LIN/SWA/WWA for each Bycatch Assessment Area (see Figure G.9), by fishing year for 2008–2018.

Fishing year	CHAT4	COOK8	EAST2	NORTH1	PUYS5	SQUAK6	STEW5	SUBA6	WCNI9	WCSI7	Total
2008	28 538.2	1 218.1	182.8	142.6	1 063.8	703.5	6 782.4	2 026.1	2.1	12 949.2	53 608.8
2009	28 864.1	1 064.1	324.2	148.6	552.5	613.5	8 302.2	1 706.5	10.6	9 115.6	50 701.9
2010	32 291.4	937.4	275.5	386.3	498.4	365.1	9 535.2	1 032.2	9.7	9 840.5	55 171.7
2011	31 149.4	717.3	584.6	385.1	818.9	938.7	8 970.2	2 342.0	5.4	11 740.9	57 652.5
2012	32 508.8	778.6	301.7	470.3	904.9	315.8	9 215.6	837.4	46.6	11 154.8	56 534.5
2013	31 729.8	1 144.0	387.8	507.0	633.3	370.3	10 123.4	1 075.3	11.4	9 835.6	55 817.9
2014	28 609.2	1 358.6	785.4	402.7	972.3	1 039.2	13 418.0	2 296.5	7.4	12 050.8	60 940.1
2015	32 148.4	1 119.5	427.5	451.3	579.7	987.8	13 127.7	1 414.4	2.1	12 909.3	63 167.7
2016	34 104.8	1 186.2	433.8	291.2	1 089.9	572.4	6 542.7	1 038.9	1.4	11 799.9	57 061.2
2017	33 033.7	1 095.1	425	393.4	632.8	524.6	8 773.5	1 196.5	2.7	16 222.2	62 299.5
2018	34 443.7	934.5	568.1	626.7	489.1	1 089.8	11 768.2	3 453.6	3.3	17 949.6	71 326.6
Total	347 421.5	11 553.4	4 696.4	4 205.2	8 235.6	7 520.7	106 559.1	18 419.4	102.7	135 568.4	644 282.4

Table G.8: Trawl footprint (km^2) estimated from the combined deepwater Tier 1 fisheries for HAK/HOK/LIN/SWA/WWA for each Bycatch Assessment Area (see Figure G.9), for the 2008–2018 fishing years.

Fishing year	CHAT4	COOK8	EAST2	NORTH1	PUYS5	SQUAK6	STEW5	SUBA6	WCNI9	WCSI7	Total
2008	17 480.2	424.5	154.9	134.5	787.9	403.8	4 170.9	1 292.7	2.1	6 531.9	31 383.5
2009	15 968.8	374.1	255.7	142.1	430.3	363.0	4 778.9	1 090.5	10.6	4 932.1	28 346.0
2010	17 494.5	407.7	246.6	351.3	410.0	236.6	5 368.2	721.4	9.4	4 811.6	30 057.3
2011	17 191.2	319.1	417.7	354.0	572.0	386.3	5 352.6	1 264.3	5.4	5 428.8	31 291.3
2012	17 167.6	294.8	267.9	402.9	669.2	240.6	5 219.8	649.3	46.1	5 130.3	30 088.3
2013	16 651.4	398.1	323.8	429.2	476.5	247.7	5 230.7	855.1	11.4	4 909.6	29 533.6
2014	15 435.6	447.5	573.0	358.7	603.8	588.3	7 333.4	1 691.2	7.1	5 738.7	32 777.4
2015	16 731.9	401.0	338.9	377.2	466.3	597.9	6 916.0	1 018.5	1.8	6 369.5	33 218.9
2016	17 549.3	341.3	357.0	255.5	749.2	363.7	4 339.2	657.3	1.3	5 541.8	30 155.7
2017	16 205.3	382.5	332.9	320.4	464.6	413.3	5 502.2	920.9	2.7	5 899.0	30 443.8
2018	16 565.0	283.8	483.6	479.8	359.7	607.9	6 281.2	1 863.0	3.3	6 033.7	32 961.0
Total	50 839.9	1 383.1	2 327.8	2 109.0	2 348.2	2 129.0	18 510.0	5 922.1	100.6	14 874.3	100 544.0

Table G.9: The number of tows, number of contacted cells, and the aggregate swept area (km^2) and footprint (km^2) estimated from the combined orange roughy and oreo fisheries for each orange roughy assessment area (see Figure G.9), for 2008–2018 fishing years.

	ESCR				NWCR				ORH 7A			
Fishing year	No. tows	No. cells	Aggregate area (km^2)	Footprint (km^2)	No. tows	No. cells	Aggregate area (km^2)	Footprint (km^2)	No. tows	No. cells	Aggregate area (km^2)	Footprint (km^2)
2008	2 283	491	724.3	533.1	278	93	88.6	62.4	0	–	–	–
2009	2 254	528	684.3	529.7	179	119	60.0	53.5	65	54	23.5	23.1
2010	1 665	456	573.5	463.0	271	166	78.7	70.5	78	54	26.9	26.7
2011	715	223	255.4	221.6	9	12	4.4	4.3	112	53	49.8	47.2
2012	871	275	398.2	328.7	6	8	1.6	1.6	105	54	42.4	39.2
2013	824	221	369.7	313.9	9	10	3.0	3.0	152	64	50.0	47.8
2014	940	271	398.0	320.0	221	122	68.8	55.9	132	56	38.2	36.5
2015	971	251	511.5	416.4	279	117	93.6	68.1	703	231	230.9	189.1
2016	1 281	314	371.6	282.9	404	182	125.6	101.9	433	171	150.7	136.7
2017	1 189	300	372.1	280.8	461	204	132.7	113.3	518	293	180.2	168.6
2018	1 260	305	430.2	260.0	397	166	143.6	108.2	353	171	123.6	115.7
All	14 253	854	5 089.0	2 307.1	2 514	416	800.5	477.1	2 651	457	916.0	682.1

APPENDIX H: CELL SUMMARIES FOR DEEPWATER FISHSTOCKS, 1990–2018

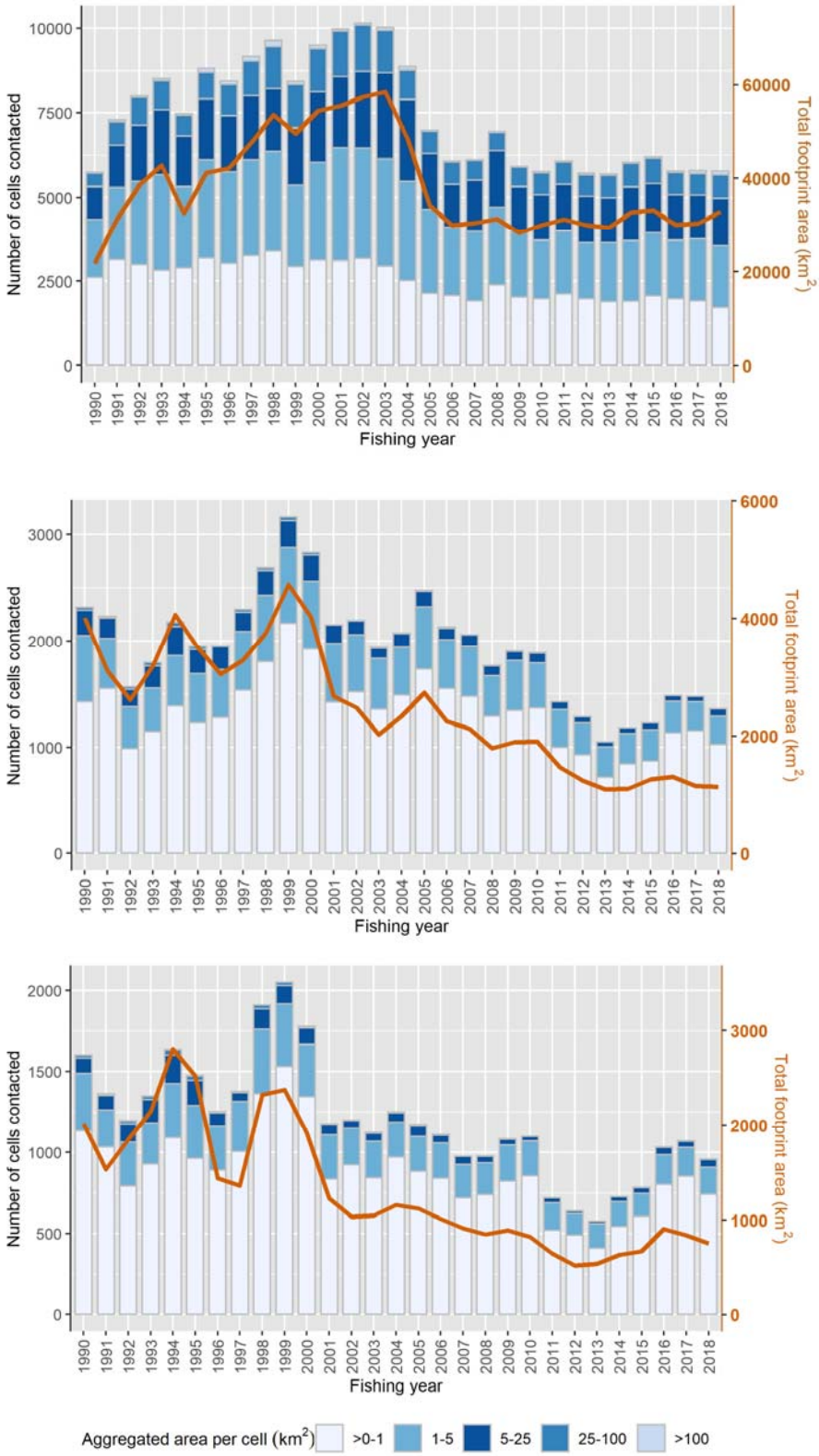

Figure H.1: Number of cells with trawl contact (binned by the annual aggregate swept area (km^2) per cell) for the HAK/HOK/LIN/SWA/WWA fishery (top), the ORH/OEO fishery (centre), and the ORH (bottom) trawl fisheries (bars), and the total trawl footprint (km^2) (line), by fishing year for 1990–2018.

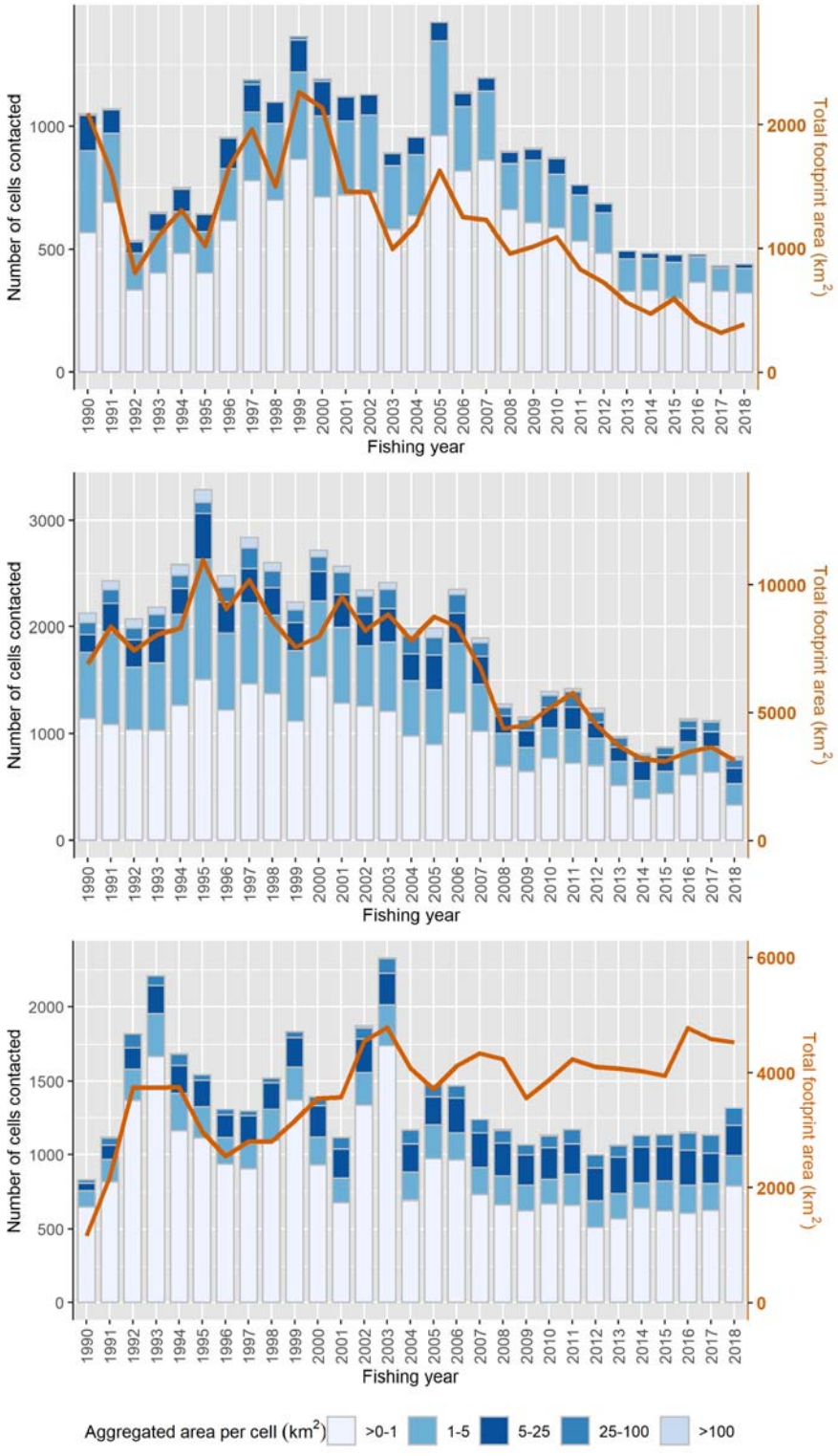

Figure H.1: — *continued*. Number of cells with trawl contact (binned by the annual aggregate swept area (km^2) per cell) for OEO fisheries (top), the SQU fisheries (centre), and the SCI fisheries (bottom) (bars), and the total trawl footprint (km^2) (line), by fishing year for 1990–2018.

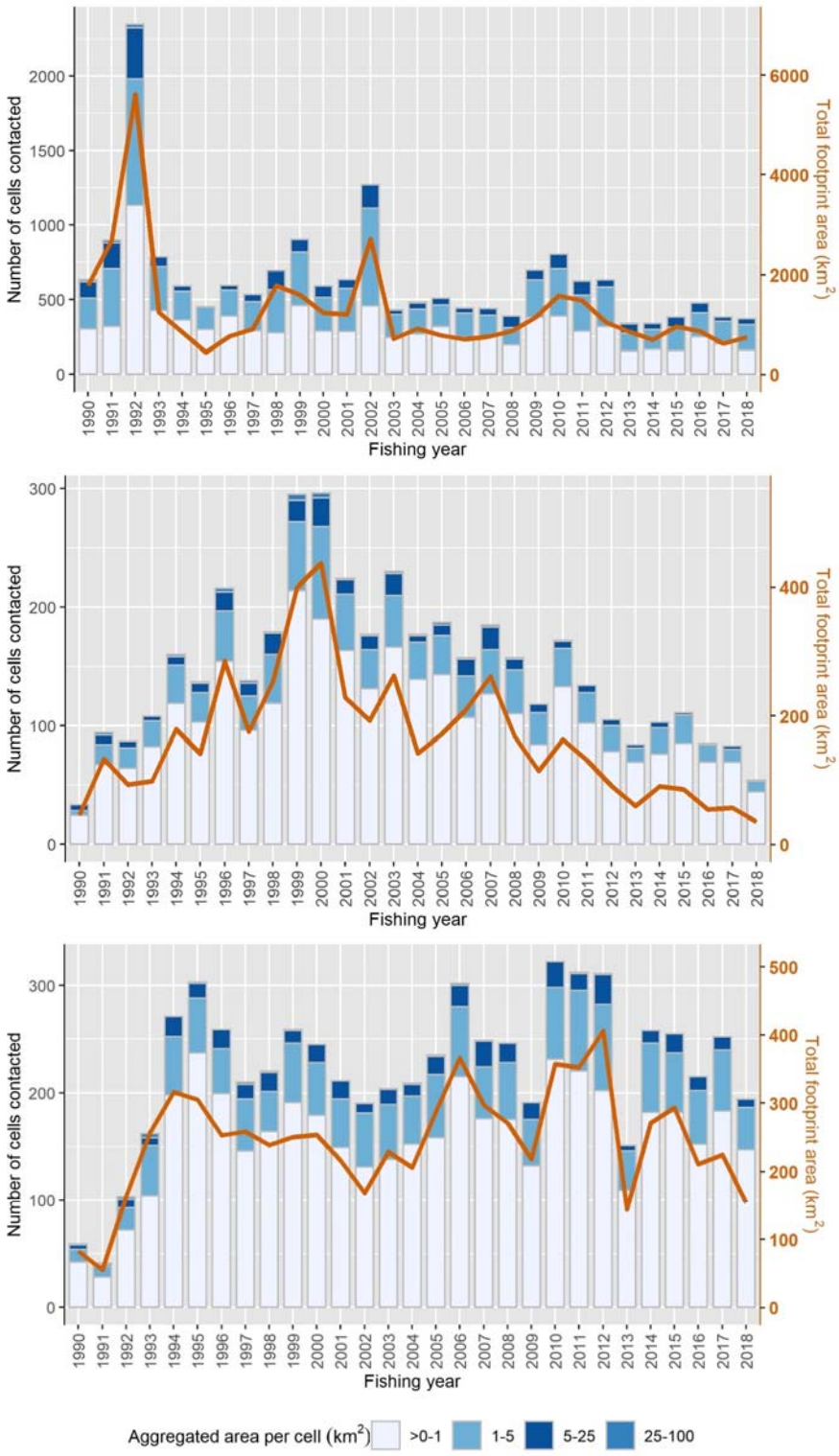

Figure H.1: — *continued*. Number of cells with trawl contact (binned by the annual aggregate swept area (km^2) per cell) for SBW fisheries (top), the CDL fisheries (centre), and the BYX trawl fisheries (bottom) (bars), and the total trawl footprint (km^2) (line), by fishing year for 1990–2018.

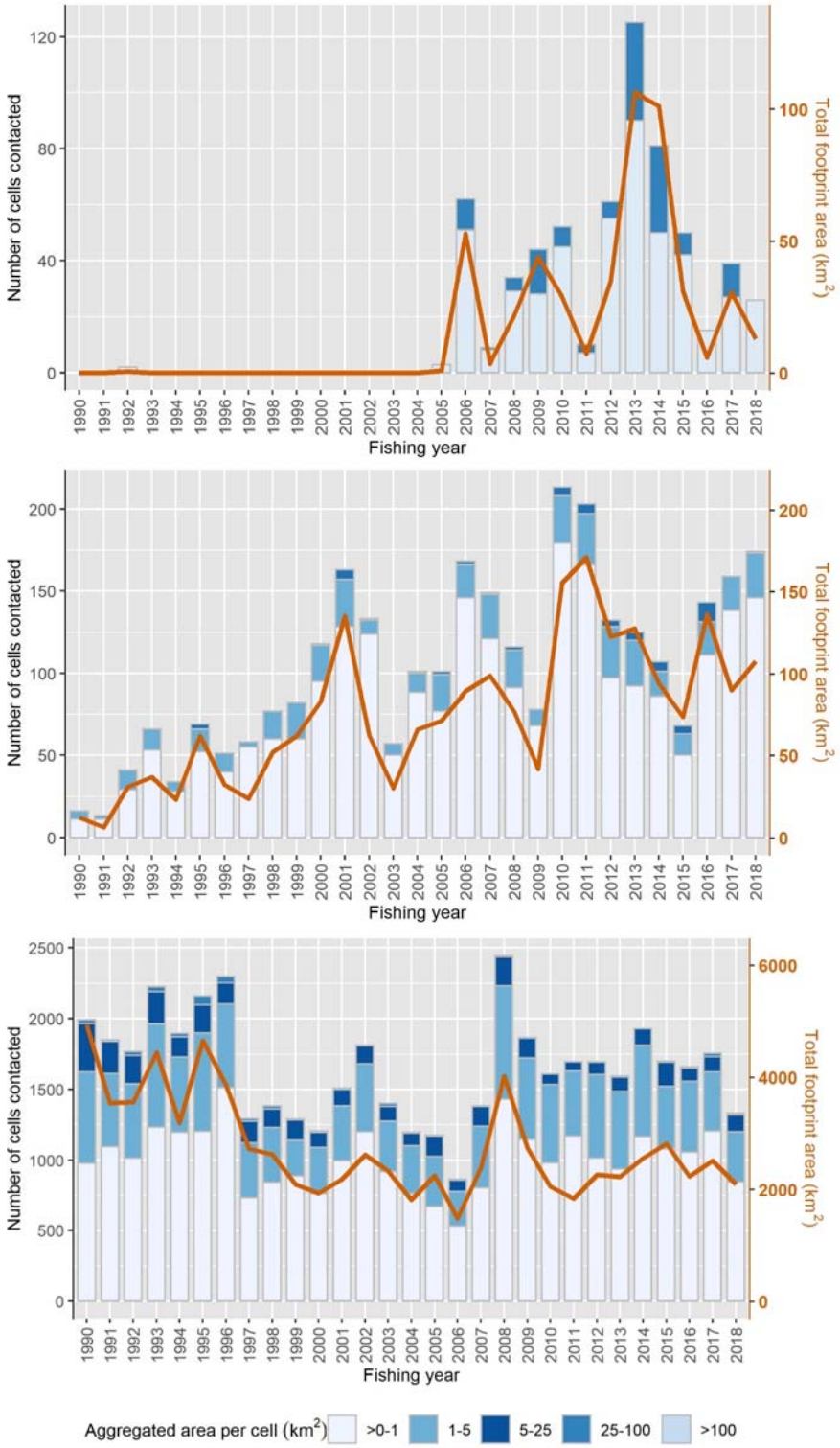

Figure H.1: — *continued*. Number of cells with trawl contact (binned by the annual aggregate swept area (km^2) per cell) for RBT fisheries (top), RBY fisheries (centre), and deepwater BAR trawl fisheries (bottom) (bars), and the total trawl footprint (km^2) (line), by fishing year for 1990–2018.

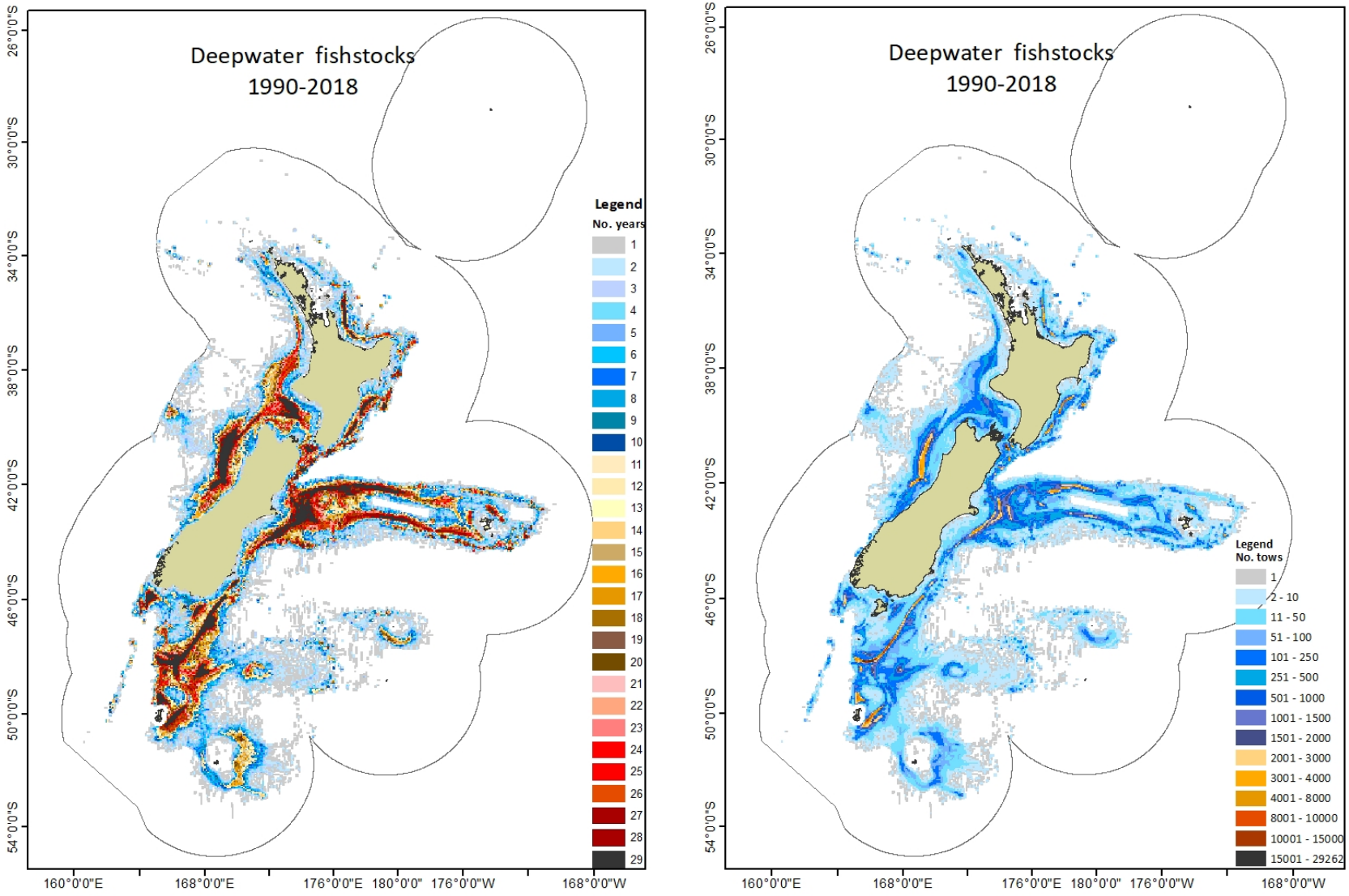

Figure H.2: Number of years a 25-km^2 cell was contacted by deepwater fishstocks (left) and the number of tows per cell (right), for 1990–2018 fishing years.

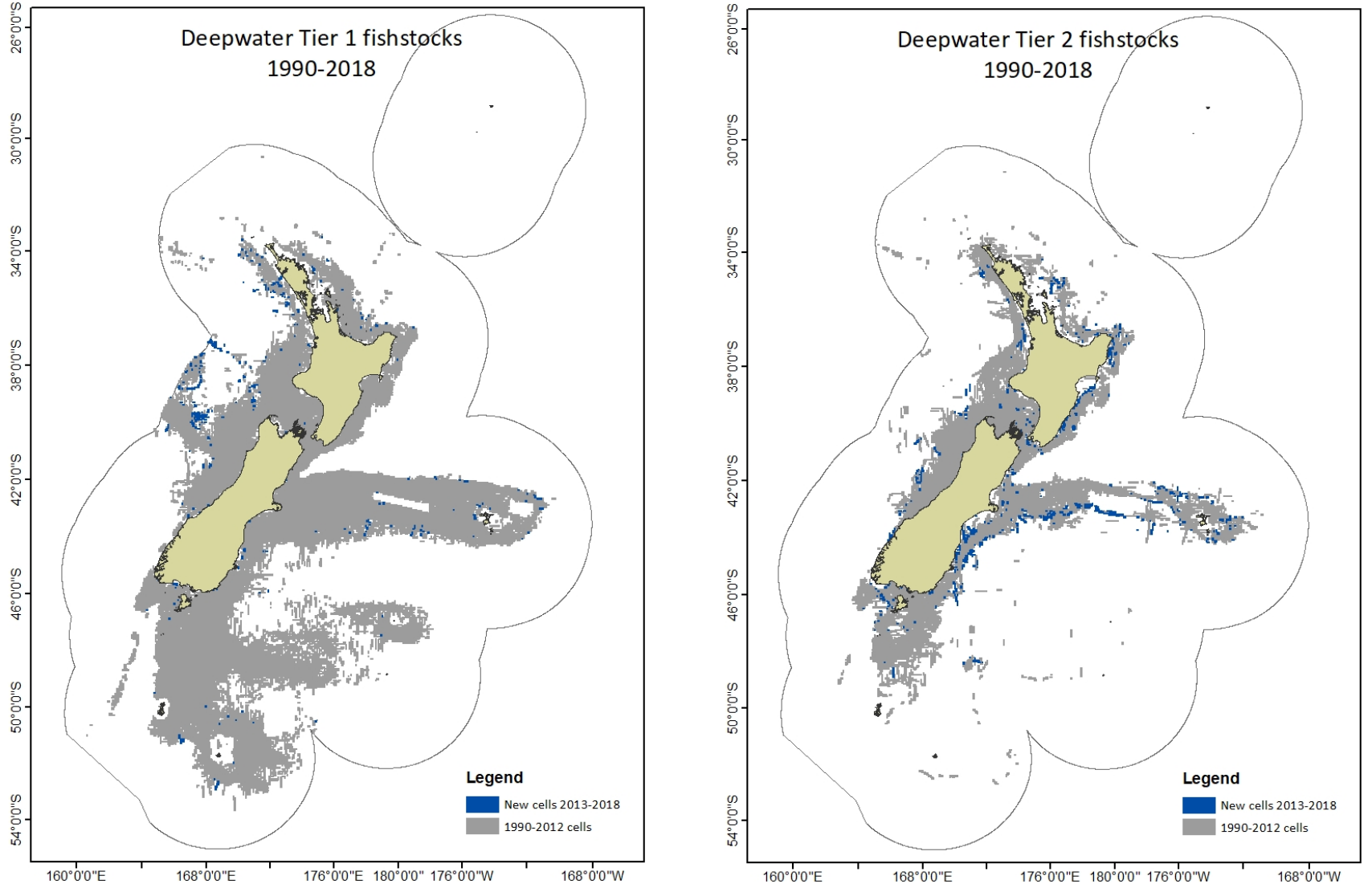

Figure H.3 Distribution of 25-km^2 cells contacted during 1990–2012 and those contacted in 2013–2018 only, for Deepwater Tier 1 fishstocks (left) and Tier 2 fishstocks (right).

Table H.1: Number of cells contacted by deepwater Tier 1 target fisheries, by fishing year for 2008–2018. Target species codes are described in Table 2.

Fishing year	HAK	HOK	JMA	LIN	OEO	ORH	SBW	SCI	SQU	Total
2008	1093	4583	1814	2229	897	978	388	1168	1277	11407
2009	1178	4065	1620	1464	910	1083	697	1065	1156	10611
2010	532	4313	1606	1587	871	1098	803	1131	1390	11026
2011	657	4678	1447	1162	761	719	628	1170	1417	10418
2012	481	4498	1414	893	686	640	633	999	1238	9718
2013	516	4565	1467	777	492	577	341	1064	971	9163
2014	603	4831	1554	908	483	727	339	1130	804	9611
2015	643	5079	1236	763	476	784	384	1135	870	9619
2016	497	4539	1207	893	478	1033	478	1151	1138	9546
2017	373	4668	1124	827	431	1071	383	1132	1131	9518
2018	280	4671	1123	889	438	958	371	1318	777	9363
Total	2128	10903	3172	4289	2165	2872	1817	3397	3376	22 606

Table H.2: Number of cells contacted by the combined deepwater Tier 1 targets HAK/HOK/LIN/SWA/WWA effort in each Bycatch Assessment Area (see Figure G.9), by fishing year for 2008–2018.

Fishing year	CHAT4	COOK8	EAST2	NORTH1	PUYS5	SQUAK6	STEW5	SUBA6	WCNI9	WCSI7	Total
2008	5 065	157	169	151	293	253	1 762	502	7	1 741	6 955
2009	4 180	149	189	185	191	168	1 771	430	28	1 327	5 923
2010	3 801	193	209	282	271	97	1 534	291	22	1 415	5 765
2011	3 699	152	297	308	314	107	1 624	446	14	1 346	6 078
2012	3 149	113	334	306	223	141	1 375	283	95	1 288	5 721
2013	2 962	177	332	266	227	112	1 431	417	28	1 385	5 693
2014	2 796	194	387	270	207	211	1 762	594	17	1 490	6 050
2015	3 107	167	327	286	216	221	1 544	375	9	1 535	6 500
2016	3 200	145	306	214	250	163	1 453	234	6	1 389	5 777
2017	2 728	197	322	201	194	175	1 533	483	6	1 382	5 792
2018	2 906	108	436	251	177	171	1 435	573	9	1 129	5 778
Total	5 755	311	682	656	339	514	2 505	1 230	194	1 701	13 762

Table H.3: Number of cells contacted by deepwater Tier 2 target fisheries, by fishing year for 2008–2018. There was no effort reported for PRK or PTO during these fishing years. Effort for RIB contacted 18 cells and this is included in the overall total given below. Target species codes are described in Table 2.

Fishing year	BAR	BYX	CDL	EMA	FRO	GSH	LDO	RBT	RBY	SKI	SPD	SPE	SWA	WWA	Total
2008	2 444	246	157	89	0	0	58	34	116	49	169	411	1 882	253	5 094
2009	1 867	191	118	69	0	0	29	44	78	80	200	119	1 534	326	4 067
2010	1 608	322	172	3	0	0	94	52	213	39	205	437	1 399	250	4 264
2011	1 696	312	134	6	0	0	129	10	203	125	152	415	1 591	171	4 366
2012	1 695	311	105	67	0	19	101	61	132	154	110	194	1 257	147	3 825
2013	1 592	151	84	19	0	30	190	125	125	172	78	244	1 240	202	3 577
2014	1 928	258	103	0	5	16	130	81	107	119	102	254	1 250	271	4 129
2015	1 699	255	111	0	16	10	159	50	68	109	131	202	1 032	197	3 633
2016	1 658	215	85	0	41	9	162	15	143	108	0	280	1 151	225	3 677
2017	1 754	252	83	0	28	0	107	39	159	61	4	220	1 118	174	3 593
2018	1 331	194	54	0	35	0	177	26	174	41	0	201	1 160	140	3 161
Total	4 664	994	382	178	105	42	421	346	672	432	351	1 277	4 702	989	11 091

Table H.4: The number of new cells, and the aggregate area and footprint area estimated for the new cells, contacted by deepwater Tier 1 fishstock trawls, 1990–2018. 'New cells' are those contacted in a fishing year but not contacted in previous years (i.e., 'new cells' in 2013 are those contacted in 2013 but not contacted in 1990–2012; 'new cells' in 2014 are those contacted in 2014 but not in 1990–2013). The total new cells for Tier 1 targets and Tier 2 targets are also given.

Fishing year	Target (no. cells for 1990–2012)	No. new cells	Aggregate (km^2)	Footprint (km^2)
1990–2012: HAK (*n* =4578)				
2013		47	41.8	38.9
2014		19	7.3	7.2
2015		24	7.2	7.2
2016		22	9.3	9.3
2017		10	4.7	4.7
2018		8	1.9	1.9
1990–2012: HOK (*n* = 23 490)				
2013		43	26.7	26.7
2014		51	24.3	24.3
2015		48	24.4	24.4
2016		42	22.3	22.3
2017		22	13.1	13.1
2018		27	13.1	13.1
1990–2012: JMA (*n* = 6985)				
2013		33	12.6	12.5
2014		17	9.8	9.8
12015		36	14.2	14.2
2016		10	3.1	3.0
2017		20	5.7	5.7
2018		7	1.7	1.7
1990–2012: LIN (*n* = 7031)				
2013		74	31.3	31.3
2014		62	44.2	39.2
2015		37	17.9	17.9
2016		90	43.4	41.4
2017		37	16.0	15.5
2018		88	57.9	55.8
1990–2012: OEO (*n* = 5598)				
2013		13	2.7	2.7
2014		9	3.8	3.8
2015		28	32.1	24.3
2016		19	8.0	8.0
2017		11	2.4	2.4
2018		16	6.5	5.8
1990–2012: ORH (*n* = 6848)				
2013		26	7.4	7.3
2014		26	8.5	8.1
2015		86	22.6	22.5
2016		78	24.3	24.0
2017		69	19.2	18.7
2018		36	8.4	8.3

Table H.4: — *continued.*

Fishing year	Target (no. cells for 1990–2012)	No. new cells	Aggregate (km^2)	Footprint (km^2)	Fishing year	Target (no. cells for 1990–2012)	No. new cells	Aggregate (km^2)	Footprint (km^2)
1990–2012: SBW (*n* = 4317)					1990–2012: SQU (*n* = 9235)				
2013		3	2.9	2.9	2013		21	8.6	8.6
2014		2	0.6	0.6	2014		24	31.9	30.8
2015		11	9.3	9.1	2015		13	6.5	6.3
2016		2	0.8	0.8	2016		55	27.1	26.5
2017		4	1.9	1.9	2017		46	17.2	17.2
2018		1	0.4	0.4	2018		9	3.1	3.1
1990–2012: SCI (*n* = 7337)									
2013		50	12.1	12.1					
2014		71	16.0	15.7					
2015		66	15.3	15.3					
2016		39	11.2	11.0					
2017		59	34.0	29.6					
2018		154	69.4	57.7					
1990–2012: Tier 1 (*n* = 37 716)					**1990–2012: Tier 2 (*n* = 16 023)**				
2013		60	30.2	30.1	2013		189	125.5	122.6
2014		55	21.0	20.9	2014		221	159.7	155.2
2015		95	30.6	29.9	2015		138	58.6	58.4
2016		82	27.5	27.5	2016		150	62.2	61.1
2017		82	36.6	33.0	2017		146	76.2	74.1
2018		96	21.7	21.6	2018		86	42.4	41.2

APPENDIX I: DANISH SEINE FISHERIES EFFORT, 1990–2018

Table I.1: The number of Danish seine sets reported on CELR forms, 1990–2018, for the main target species (96% of the total sets).

Fishing year	FLA	GUR	JDO	RCO	SNA	TAR	Total
1990	0	49	60	0	2 371	0	2 480
1991	15	329	95	0	3 566	16	4 021
1992	19	470	258	2	4 945	36	5 730
1993	215	997	386	0	3 068	2	4 668
1994	457	790	499	0	3 654	5	5 405
1995	196	542	743	0	3 775	7	5 263
1996	52	692	995	0	3 597	3	5 339
1997	45	987	1 565	0	2 288	30	4 915
1998	30	981	945	0	2 005	64	4 025
1999	12	911	1 527	0	1 197	90	3 737
2000	4	1 034	1 344	0	1 417	80	3 879
2001	37	1 042	1 282	0	1 064	62	3 487
2002	0	1 213	652	0	1 352	60	3 277
2003	152	879	497	6	1 574	63	3 171
2004	267	666	558	97	1 948	74	3 610
2005	398	521	426	123	1 779	61	3 308
2006	440	707	693	252	1 522	35	3 649
2007	510	756	843	176	1 542	224	4 051
2008	1 199	899	435	406	2 027	207	5 173
2009	968	1 159	257	361	1 851	405	5 001
2010	1 262	1 171	198	308	1 839	436	5 214
2011	613	1 182	277	308	1 798	385	4 563
2012	1 056	1 054	315	176	2 060	502	5 163
2013	740	1 201	285	321	1 745	611	4 903
2014	666	1 022	369	255	1 540	622	4 474
2015	617	772	172	207	1 789	458	4 015
2016	536	813	113	266	2 045	371	4 144
2017	549	828	251	381	1 762	366	4 137
2018	486	686	91	290	1 502	357	3 412
All	11 541	24 353	16 131	3 935	62 622	5 632	124 214

Table I.2: Number of Danish seine sets for the main species dataset (snapper, red gurnard, flatfish, John dory, tarakihi, and red cod) in each Statistical Area, by fishing year for 2008–2018. These species account for 96% of the total number of sets. 'Unk' means the Statistical Area was not known. Statistical Areas are shown in Figure I.1.

Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
001	0	3	0	0	1	3	0	0	0	0	0	7
002	38	28	33	20	7	22	18	9	3	1	3	182
003	338	233	338	227	313	265	325	224	213	203	158	2 837
004	2	0	12	2	14	2	4	4	1	0	3	44
005	152	245	331	143	234	227	158	144	124	45	66	1 869
006	1 280	852	837	776	1187	814	883	891	957	976	772	10 225
007	8	3	9	0	0	0	5	4	5	1	2	37
008	414	417	377	388	362	461	468	453	351	349	249	4 289
009	395	640	809	761	524	786	618	731	893	883	823	7 863
010	97	103	152	418	293	377	223	286	311	271	198	2 729
011	4	1	3	31	11	8	0	0	0	0	0	58
012	10	0	57	131	175	118	0	2	0	4	0	497
013	24	0	13	47	216	19	0	49	103	93	94	658
014	0	0	0	0	0	0	0	1	0	0	17	18
015	0	1	0	0	0	0	0	0	0	0	0	1
016	0	15	0	0	0	0	0	0	0	0	0	15
017	20	15	7	5	28	17	19	0	0	0	0	111
018	4	14	3	15	27	15	15	0	7	8	0	108
020	482	440	354	381	383	495	323	218	445	350	232	4 103
021	6	0	0	0	0	0	0	0	0	0	0	6
022	354	312	253	271	352	342	472	249	183	286	262	3 336
024	0	0	0	3	4	0	0	0	0	0	0	7
030	0	3	0	0	0	0	0	0	3	0	0	6
033	0	0	0	0	2	0	0	0	0	0	0	2
034	0	0	0	0	0	0	0	2	0	0	0	2
035	0	21	8	36	3	0	3	0	2	1	0	74
036	0	0	1	1	0	1	0	0	0	0	0	3
037	5	6	8	3	11	0	0	3	0	0	0	36
038	906	778	1141	446	725	580	504	538	431	481	413	6 943
039	79	61	16	49	44	31	5	0	3	0	0	288
040	4	25	0	1	0	0	0	0	0	0	0	30
041	35	88	2	2	24	9	15	0	0	0	0	175
042	69	139	8	116	44	84	80	46	0	4	23	613
044	0	0	0	0	0	0	0	0	1	0	0	1
045	59	95	34	101	89	78	96	25	1	60	22	660
046	24	89	23	25	0	10	23	27	0	0	1	222
047	349	361	375	159	87	137	194	79	31	48	30	1 850
101	2	0	0	0	0	0	0	0	0	0	0	2
106	2	0	3	0	0	0	0	2	3	0	2	12
107	0	4	0	0	0	0	0	1	0	1	1	7
201	0	0	0	0	0	0	3	0	0	0	0	3
608	0	0	0	3	0	0	0	0	0	0	0	3
Unk	11	9	7	2	3	2	20	27	73	72	41	267
Total	5 173	5 001	5 214	4 563	5 163	4 903	4 474	4 015	4 144	4 137	3 412	50 199

Table I.3: The number of Danish seine sets for snapper, by Statistical Area for 2008–2018. Statistical Areas are shown in Figure I.1.

Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
001	0	2	0	0	1	3	0	0	0	0	0	6
002	13	14	2	0	0	0	4	9	3	1	3	49
003	219	147	165	102	120	79	87	71	86	92	73	1 241
004	1	0	1	0	0	0	3	0	1	0	0	6
005	76	144	163	40	112	59	70	67	65	27	55	878
006	897	598	641	535	917	603	589	807	922	928	764	8 201
007	0	3	8	0	0	0	2	2	5	1	0	21
008	339	354	239	191	218	198	236	241	237	181	108	2 542
009	391	464	446	539	385	488	395	374	409	286	344	4 521
010	78	61	97	258	232	291	136	181	255	175	117	1 881
011	0	1	0	18	5	1	0	0	0	0	0	25
012	3	0	19	55	57	15	0	0	0	2	0	151
013	0	0	6	3	10	2	0	0	0	0	0	21
015	0	1	0	0	0	0	0	0	0	0	0	1
020	0	0	0	0	0	0	0	12	3	0	0	15
036	0	0	1	0	0	0	0	0	0	0	0	1
038	0	34	11	20	0	0	0	0	0	0	0	65
041	0	0	2	0	0	0	0	0	0	0	0	2
042	0	4	2	0	0	1	0	0	0	1	0	8
044	0	0	0	0	0	0	0	0	1	0	0	1
045	2	9	3	3	0	4	0	0	1	1	1	24
047	0	2	26	32	0	0	0	0	0	0	0	60
101	2	0	0	0	0	0	0	0	0	0	0	2
106	0	0	0	0	0	0	0	1	1	0	1	3
107	0	4	0	0	0	0	0	1	0	1	1	7
201	0	0	0	0	0	0	3	0	0	0	0	3
Unk	6	9	7	2	3	1	15	23	56	66	35	223
Total	2 027	1 851	1 839	1 798	2 060	1 745	1 540	1 789	2 045	1 762	1 502	19 958

Table I.4: The number of Danish seine sets for red gurnard, by Statistical Area for 2008–2018. Statistical Areas are shown in Figure I.1.

Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
001	0	1	0	0	0	0	0	0	0	0	0	1
002	23	4	17	13	0	4	5	0	0	0	0	66
003	93	73	126	100	117	172	226	146	119	109	80	1 361
004	1	0	8	0	0	0	0	3	0	0	3	15
005	66	77	153	97	98	133	74	67	40	18	8	831
006	13	7	17	0	9	3	10	4	0	1	0	64
007	0	0	0	0	0	0	0	1	0	0	2	3
008	40	53	108	157	123	205	149	104	86	132	60	1 217
009	2	55	217	119	44	158	68	163	375	296	268	1 765
010	0	42	36	145	24	47	43	50	38	57	59	541
011	0	0	3	13	6	7	0	0	0	0	0	29
012	5	0	38	76	109	92	0	2	0	2	0	324
013	21	0	7	44	206	17	0	49	103	93	94	634
014	0	0	0	0	0	0	0	1	0	0	17	18
017	12	10	3	5	21	17	19	0	0	0	0	87
018	0	7	3	2	17	12	11	0	0	0	0	52
020	4	0	0	3	0	0	0	0	6	0	4	17
022	5	0	0	0	0	2	3	0	4	6	12	32
033	0	0	0	0	2	0	0	0	0	0	0	2
035	0	0	0	1	2	0	0	0	0	0	0	3
037	5	5	8	3	11	0	0	0	0	0	0	32
038	0	3	2	4	1	3	0	2	0	0	0	15
039	79	43	16	28	34	16	5	0	0	0	0	221
040	4	25	0	1	0	0	0	0	0	0	0	30
041	35	88	0	2	16	9	15	0	0	0	0	165
042	69	135	6	116	38	83	80	46	0	2	23	598
045	53	86	31	98	89	74	96	25	0	59	21	632
046	24	89	23	25	0	10	23	27	0	0	1	222
047	344	356	349	127	87	137	194	79	31	48	30	1 782
106	0	0	0	0	0	0	0	1	1	0	0	2
608	0	0	0	3	0	0	0	0	0	0	0	3
Unk	1	0	0	0	0	0	1	2	10	5	4	23
Total	899	1 159	1 171	1 182	1 054	1 201	1 022	772	813	828	686	10 787

Table I.5: The number of Danish seine sets for flatfish, by Statistical Area for 2008–2018. Statistical Areas are shown in Figure I.1.

Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
003	0	0	4	0	3	0	0	0	0	0	0	7
005	0	0	0	0	4	0	0	0	0	0	0	4
006	1	0	0	0	0	0	0	0	0	0	0	1
007	8	0	0	0	0	0	0	0	0	0	0	8
010	0	0	0	0	0	0	1	0	3	0	0	4
013	3	0	0	0	0	0	0	0	0	0	0	3
016	0	15	0	0	0	0	0	0	0	0	0	15
017	0	0	4	0	7	0	0	0	0	0	0	11
020	206	159	101	97	181	117	95	42	87	53	69	1 207
022	76	10	17	38	115	30	63	34	7	14	4	408
024	0	0	0	0	4	0	0	0	0	0	0	4
030	0	3	0	0	0	0	0	0	3	0	0	6
034	0	0	0	0	0	0	0	2	0	0	0	2
035	0	21	8	35	1	0	3	0	2	1	0	71
036	0	0	0	0	0	1	0	0	0	0	0	1
037	0	1	0	0	0	0	0	3	0	0	0	4
038	905	741	1 128	422	722	577	504	536	431	481	413	6 860
039	0	18	0	21	5	15	0	0	3	0	0	62
041	0	0	0	0	8	0	0	0	0	0	0	8
042	0	0	0	0	6	0	0	0	0	0	0	6
Total	1 199	968	1 262	613	1 056	740	666	617	536	549	486	8 692

Table I.6: The number of Danish seine sets for John dory, by Statistical Area for 2008–2018. Statistical Areas are shown in Figure I.1.

Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
003	19	3	1	5	4	1	4	0	2	0	5	44
005	10	7	12	4	14	35	14	10	19	0	3	128
006	369	247	179	241	261	208	284	79	35	47	8	1958
007	0	0	1	0	0	0	3	1	0	0	0	5
008	12	0	0	4	2	6	30	24	2	5	20	105
009	1	0	2	20	4	30	23	29	40	175	44	368
010	19	0	0	2	27	5	11	29	8	22	10	133
036	0	0	0	1	0	0	0	0	0	0	0	1
038	0	0	0	0	2	0	0	0	0	0	0	2
039	0	0	0	0	1	0	0	0	0	0	0	1
042	0	0	0	0	0	0	0	0	0	1	0	1
106	2	0	3	0	0	0	0	0	1	0	0	6
Unk	3	0	0	0	0	0	0	0	6	1	1	11
Total	435	257	198	277	315	285	369	172	113	251	91	2 763

Table I.7: The number of Danish seine sets for red cod, by Statistical Area for 2008–2018. Statistical Areas are shown in Figure I.1.

Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
017	8	5	0	0	0	0	0	0	0	0	0	13
018	0	4	0	1	3	0	0	0	0	4	0	12
020	236	229	187	173	102	177	97	124	211	233	129	1 898
021	6	0	0	0	0	0	0	0	0	0	0	6
022	155	123	121	131	71	144	158	83	55	144	161	1 346
024	0	0	0	3	0	0	0	0	0	0	0	3
038	1	0	0	0	0	0	0	0	0	0	0	1
Total	406	361	308	308	176	321	255	207	266	381	290	3 279

Table I.8: The number of Danish seine sets for tarakihi, by Statistical Area for 2008–2018. Statistical Areas are shown in Figure I.1.

Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
002	2	10	14	7	7	18	9	0	0	0	0	67
003	7	10	42	20	69	13	8	7	6	2	0	184
004	0	0	3	2	14	2	1	1	0	0	0	23
005	0	17	3	2	6	0	0	0	0	0	0	28
006	0	0	0	0	0	0	0	1	0	0	0	1
008	23	10	30	36	19	52	53	84	26	31	61	425
009	1	121	144	83	91	110	132	165	69	126	167	1 209
010	0	0	19	13	10	34	32	26	7	17	12	170
011	4	0	0	0	0	0	0	0	0	0	0	4
012	2	0	0	0	9	11	0	0	0	0	0	22
018	4	3	0	12	7	3	4	0	7	4	0	44
020	36	52	66	108	100	201	131	40	138	64	30	966
022	118	179	115	102	166	166	248	132	117	122	85	1 550
039	0	0	0	0	4	0	0	0	0	0	0	4
045	4	0	0	0	0	0	0	0	0	0	0	4
047	5	3	0	0	0	0	0	0	0	0	0	8
106	0	0	0	0	0	0	0	0	0	0	1	1
Unk	1	0	0	0	0	1	4	2	1	0	1	10
Total	207	405	436	385	502	611	622	458	371	366	357	4 720

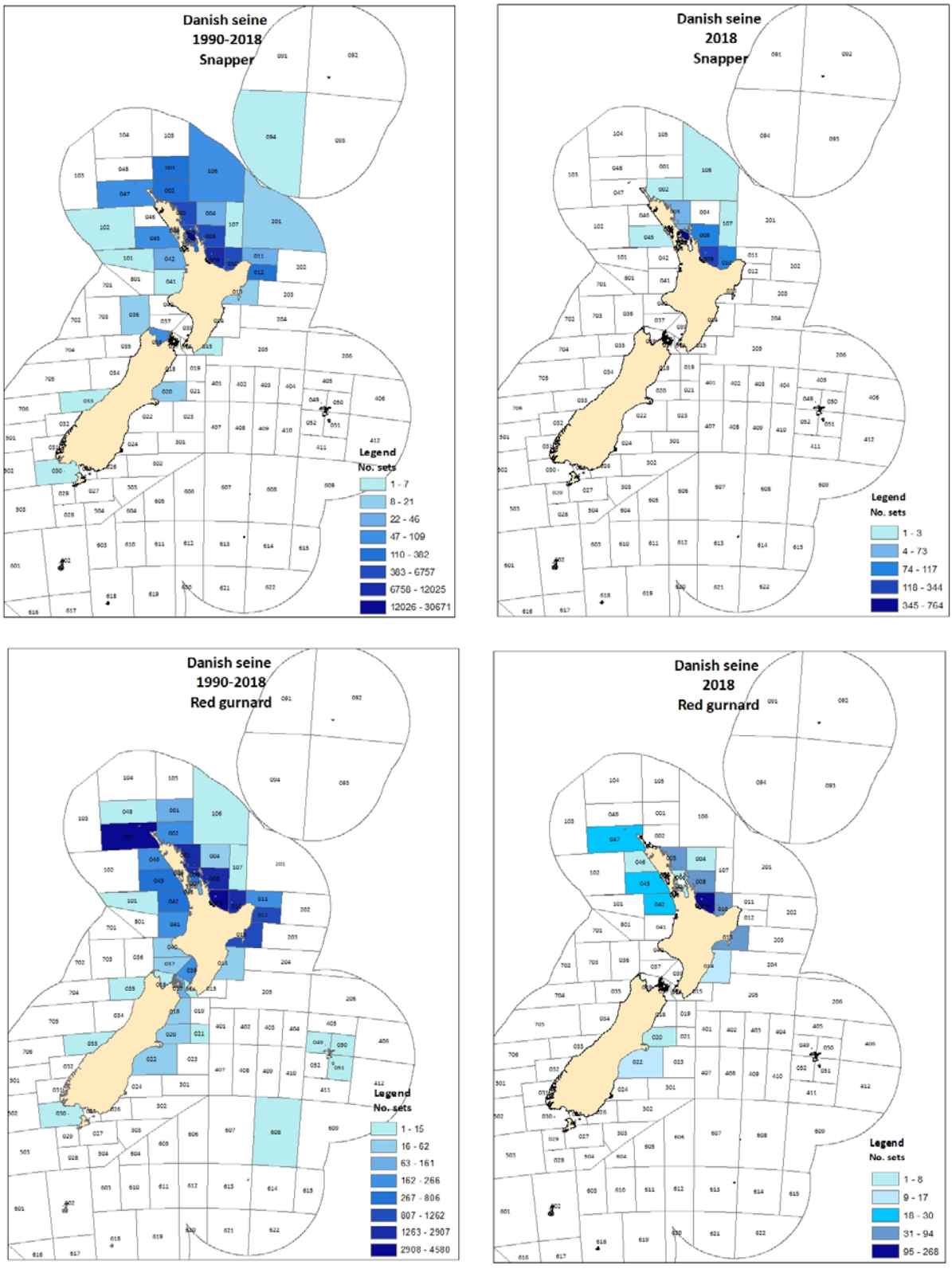

Figure I.1: The number of snapper (top) and red gurnard (bottom) Danish seine sets for 1990–2018 (left) and for 2018 (right), by Statistical Area. [Continued on next 2 pages]

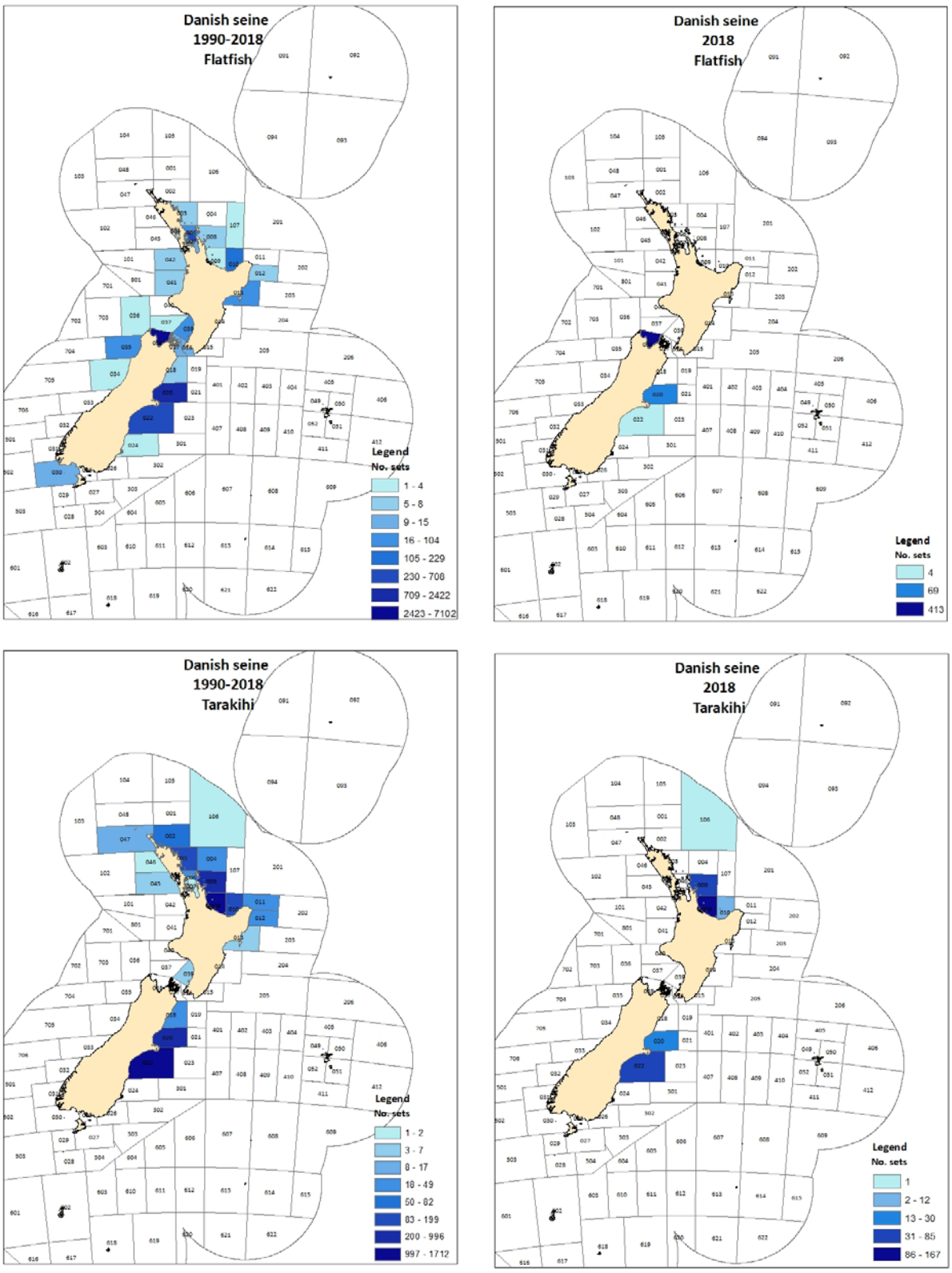

Figure I.1: — *continued*. The number of flatfish (top) and tarakihi (bottom) Danish seine sets for 1990–2018 (left) and for 2018 (right), by Statistical Area.

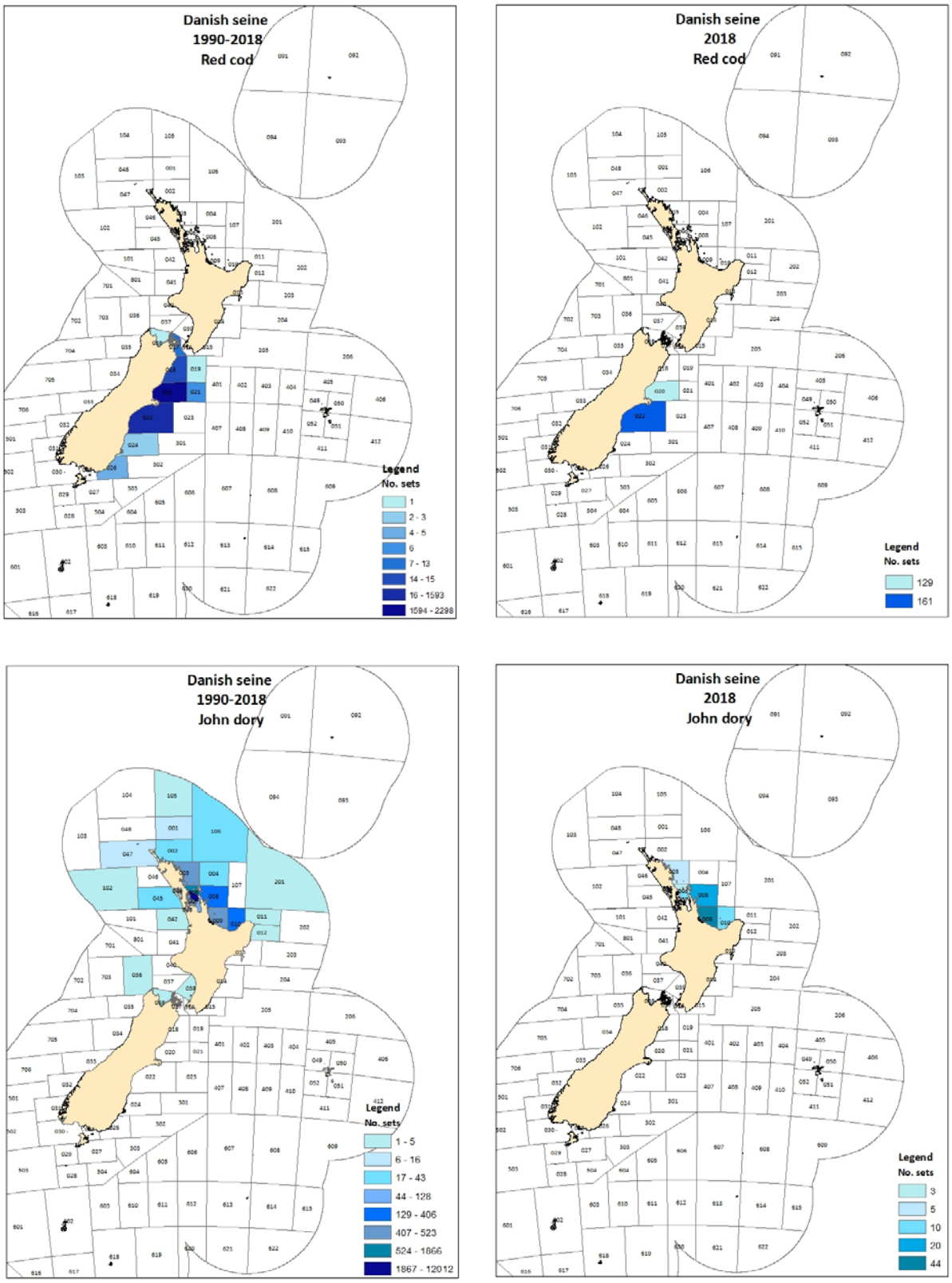

Figure I.1: — *continued.* The number of red cod (top) and John dory (bottom) Danish seine sets for 1990–2018 (left) and for 2018 (right), by Statistical Area.

APPENDIX J: SHELLFISH DREDGE EFFORT, 1990–2018

Table J.1: The number of CELR records for scallop dredge effort during 1990–2018, by main scallop fishery areas: 'chat' for Chatham Islands, 'coro' for the Coromandel fishery, 'nor' for the Northland fishery, 'chal' for Challenger fishery, and 'wcni' for the west coast North Island. 'Other' is scallop effort not in the five fishery-specific area.

Fishing year	chat	coro	nor	chal	wcni	other	Total
1990	113	760	1 593	356	0	1 873	4 695
1991	126	1 636	2 173	1 450	0	954	6 339
1992	80	1 761	2 883	1 575	0	1 203	7 502
1993	79	578	2 019	2 160	0	637	5 473
1994	1	761	2 700	4 181	2	129	7 774
1995	103	842	2 984	1 395	164	155	5 643
1996	134	822	1 350	3 199	1 041	723	7 269
1997	240	837	1 029	1 392	655	534	4 687
1998	150	693	759	1 207	632	611	4 052
1999	54	360	420	2 616	146	932	4 528
2000	36	158	274	1 916	168	530	3 082
2001	3	372	441	2 640	31	14	3 501
2002	12	365	407	3 239	286	11	4 320
2003	19	429	350	2 738	81	32	3 649
2004	0	597	447	1 675	112	28	2 859
2005	7	639	365	1 008	1	8	2 028
2006	0	640	417	1 401	0	27	2 485
2007	0	683	409	501	0	8	1 601
2008	0	544	349	345	42	9	1 289
2009	0	458	518	1 009	42	2	2 029
2010	0	398	233	461	1	5	1 098
2011	0	538	47	203	0	11	799
2012	0	525	45	385	0	8	963
2013	0	687	4	228	0	12	931
2014	0	614	11	260	0	17	902
2015	0	320	196	51	0	13	580
2016	0	350	174	109	0	6	639
2017	0	310	122	0	0	0	432
2018	0	392	197	0	0	3	592
All	1 157	18 069	22 916	37 700	3 404	8 495	91 741

Table J.2: The number of CELR records for oyster dredge effort during 1990–2018, by main oyster fishery areas: 'chat' for Chatham Islands, 'fov' for the Foveaux Strait fishery and 'chal' for the Challenger fishery. 'Other' is oyster effort not in the three fishery-specific areas. Areas are shown in Figure I.2.

Fishing year	chat	fov	chal	other	Total
1990	0	1 020	531	201	1 752
1991	0	1 585	996	112	2 693
1992	0	344	1 056	208	1 608
1993	0	110	1 208	509	1 827
1994	0	157	1 921	74	2 152
1995	0	147	1 807	432	2 386
1996	0	633	1 421	597	2 651
1997	0	650	1 018	692	2 360
1998	0	652	1 028	668	2 348
1999	1	605	878	595	2 079
2000	0	703	916	30	1 649
2001	0	582	607	12	1 201
2002	1	982	7	1	991
2003	0	622	937	0	1 559
2004	0	664	492	1	1 157
2005	0	841	697	0	1 538
2006	0	737	743	0	1 480
2007	0	644	584	0	1 228
2008	0	549	124	0	673
2009	0	616	38	0	654
2010	0	614	73	4	691
2011	0	720	111	2	833
2012	0	847	53	1	901
2013	5	835	14	2	856
2014	5	852	5	0	862
2015	0	711	9	1	721
2016	0	726	4	6	736
2017	0	863	1	0	864
2018	0	1 011	1	0	1 012
Total	12	20 022	17 280	4 148	41 462

Table J.3: Number of dredge tows for 'other', where there is no fishery-specific statistical area given, in oyster dredge data, 1990–2018. 'Unk' is unknown area.

Area	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2004	2010	2011	2012	2013	2015	2016	Total
1	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
2	0	0	4	0	0	138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	142
3	0	6	0	0	0	14	0	0	20	0	0	0	0	0	0	0	0	0	0	0	40
4	0	0	0	0	0	0	0	8	6	0	0	0	0	0	0	0	0	0	0	0	14
5	0	0	64	0	0	0	0	11	13	58	0	0	0	0	0	0	0	0	0	0	146
6	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
7	50	0	0	63	212	970	3698	2933	597	2242	33	65	25	0	0	0	0	0	0	0	10888
8	0	0	0	0	0	0	70	0	0	0	0	0	0	0	0	0	0	0	0	0	70
9	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	40
10	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
14	0	0	0	12	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	31
15	0	0	0	0	0	20	0	0	25	0	20	0	0	0	0	0	0	0	0	0	65
17	33	141	0	12	0	17	0	0	0	1240	0	0	0	0	4	1	0	0	0	106	1554
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5
22	0	0	0	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70
25	0	0	829	32	44	0	168	255	374	273	127	56	0	0	0	0	0	0	11	0	2169
26	0	0	0	0	48	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	66
27	0	0	0	0	0	0	0	0	36	81	0	0	0	0	0	0	0	0	0	0	117
32	0	0	0	0	0	0	0	0	73	0	0	0	0	0	0	0	0	0	0	0	73
33	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	27
35	13	0	0	44	0	0	0	20	44	21	0	0	0	0	0	0	0	0	0	0	142
36	0	0	0	0	0	0	32	14	0	0	33	0	0	0	0	0	0	0	0	0	79
37	0	0	10	155	0	169	31	36	12	30	0	0	0	0	0	0	0	0	0	0	443
38	2118	1055	1319	6988	827	4513	2893	6628	10484	6707	153	102	0	19	0	0	0	0	0	0	43806
46	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
48	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0	44
49	0	0	0	0	0	0	56	0	0	0	0	0	0	0	0	0	0	0	0	0	56
1J	0	0	814	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	887
1L	0	0	0	0	226	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	226
7O	17	119	15	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	158
7R	0	6	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
205	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
206	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
938	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	21
Unk	41	0	71	229	0	296	3237	1656	361	59	130	0	0	0	0	13	18	0	0	0	6111
Total	2302	1327	3160	7715	1357	6162	10205	11647	12089	10732	496	223	25	19	4	14	18	5	11	106	67617

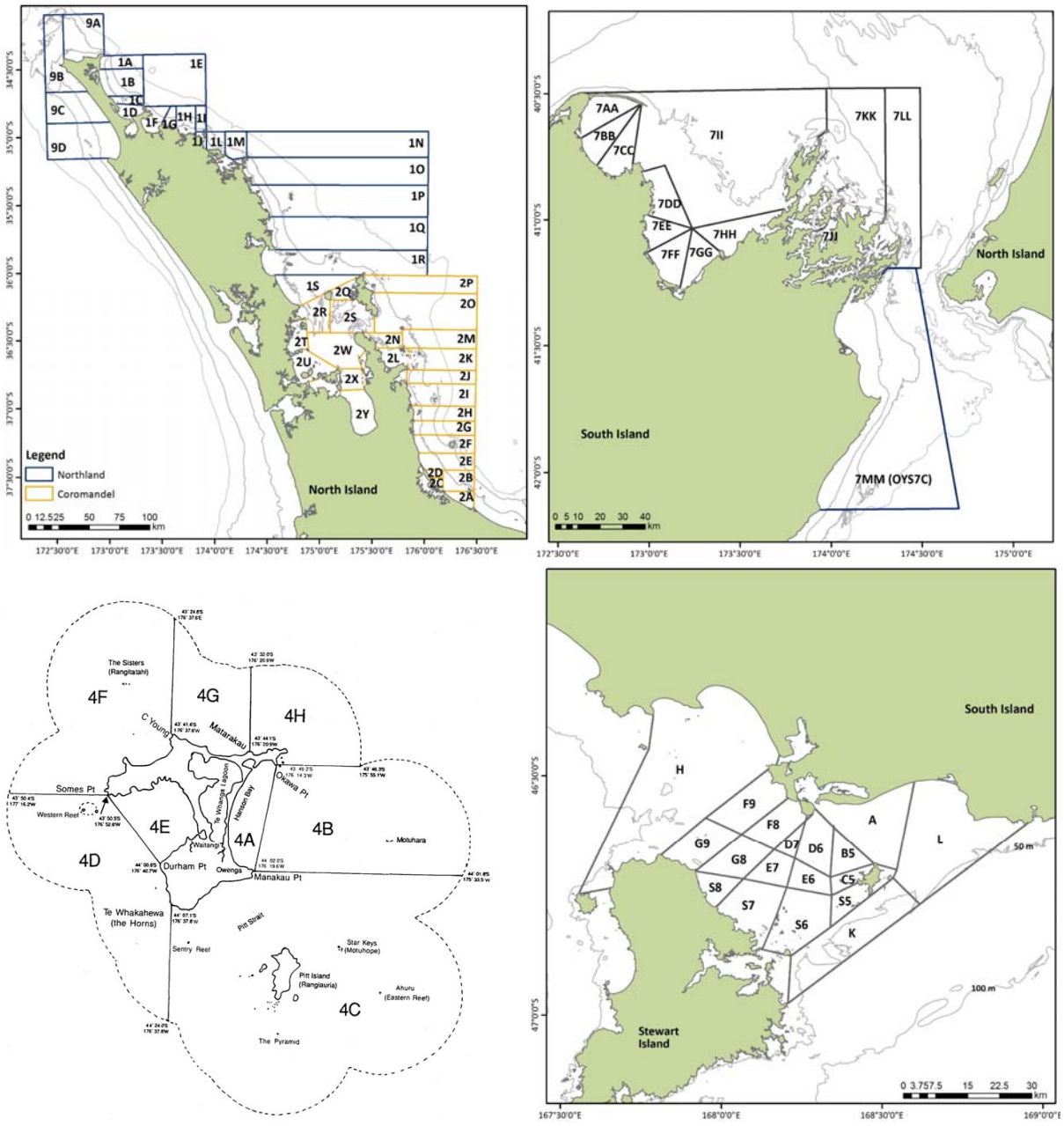

Figure J.1: West coast North Island scallop fishery (areas 9A–9D), Northland fishery (1A–1S); and Coromandel fishery (2A–2Y) (top left); Challenger scallop and oyster fishery (areas 7AA–7MM) (top right); Chatham Islands scallop fishery area (areas 4A–4H) (bottom left); and the Foveaux Strait oyster fishery (bottom right).

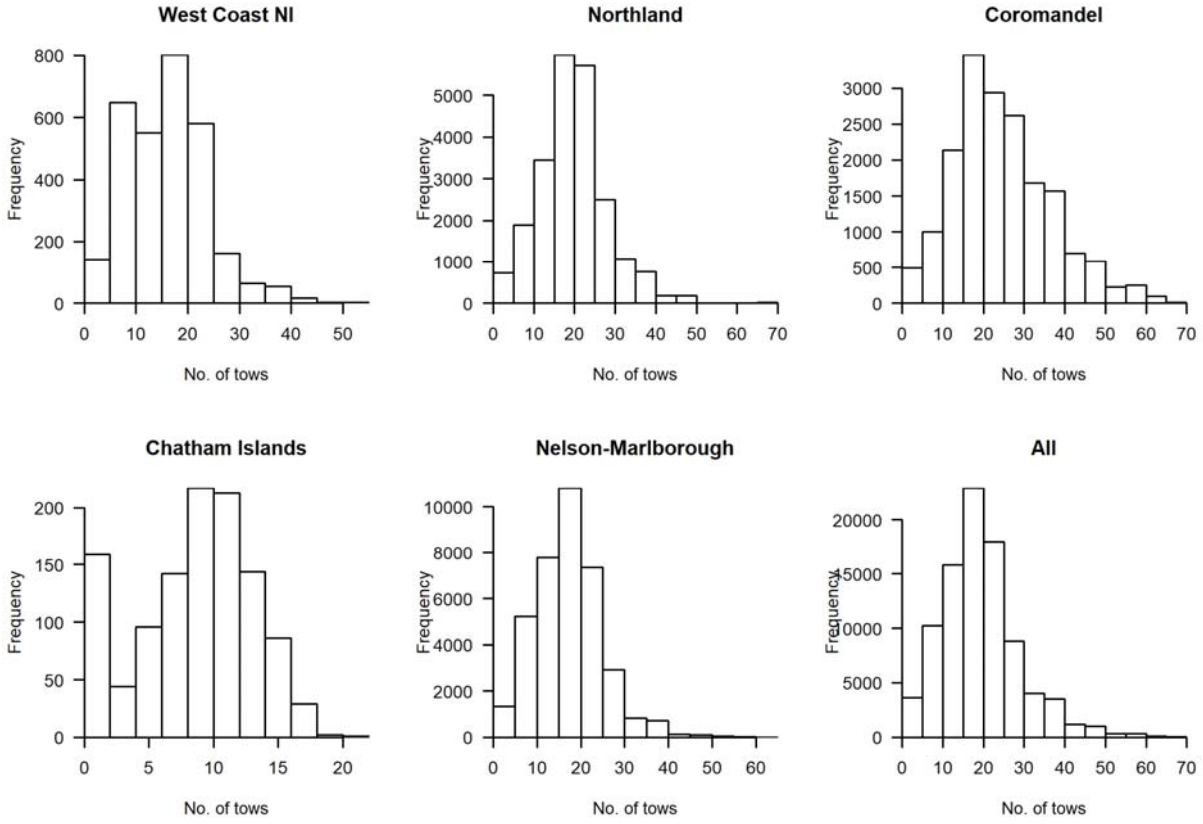

Figure J.2: Frequency distribution of the number of scallop dredge tows per day, for each fishery, 1990–2018. These data represent the original data before this variable was groomed.

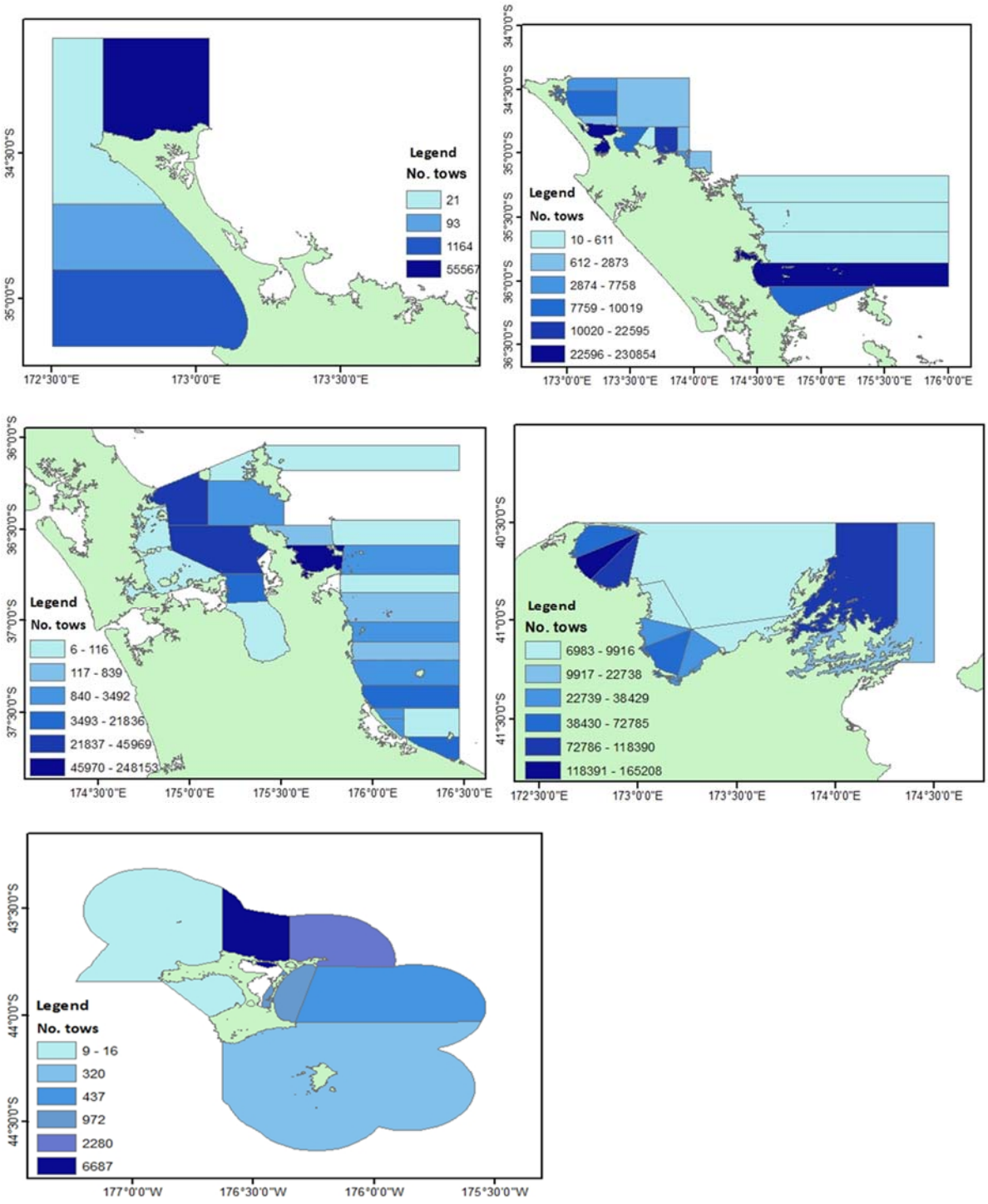

Figure J.3: Numbers of scallop tows for the west coast North Island fishery (upper left); Northland fishery (upper right), Coromandel fishery (centre left), and the Challenger (centre right), and Chatham Islands (lower left) for 1990–2018. See Table 22 for years of operation for each fishery and Figure J.1 for fishery specific area codes.

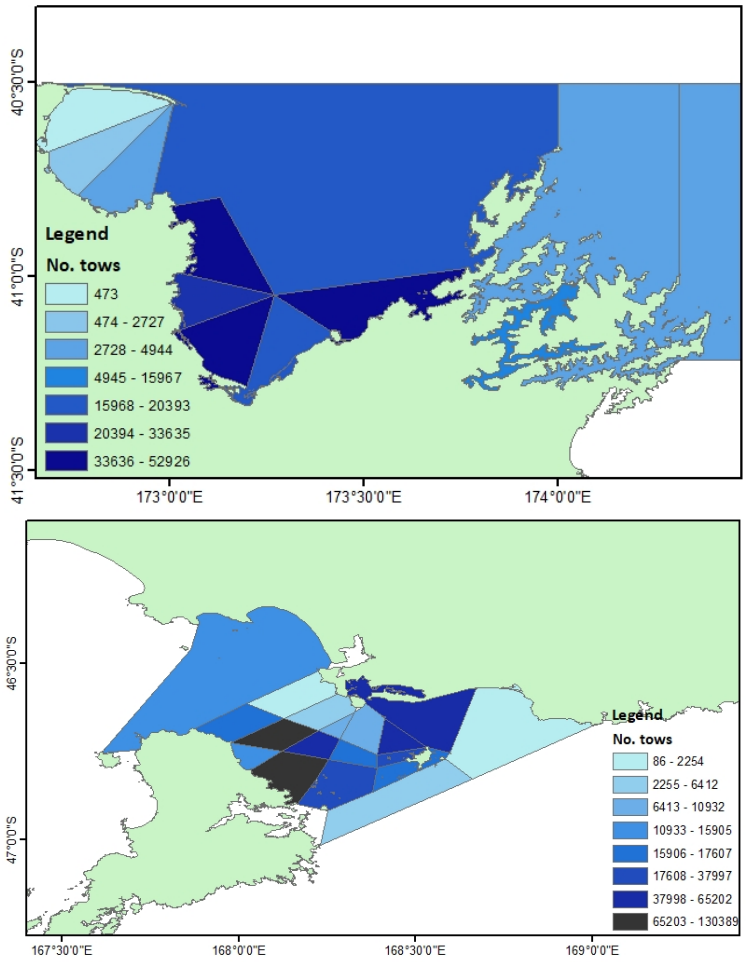

Figure J.4: Numbers of oyster tows for the Challenger fishery (upper) and Foveaux Strait fishery (lower) for 1990–2018. See Table 23 for years of operation for each fishery and Figure J.1 for fishery specific area codes.