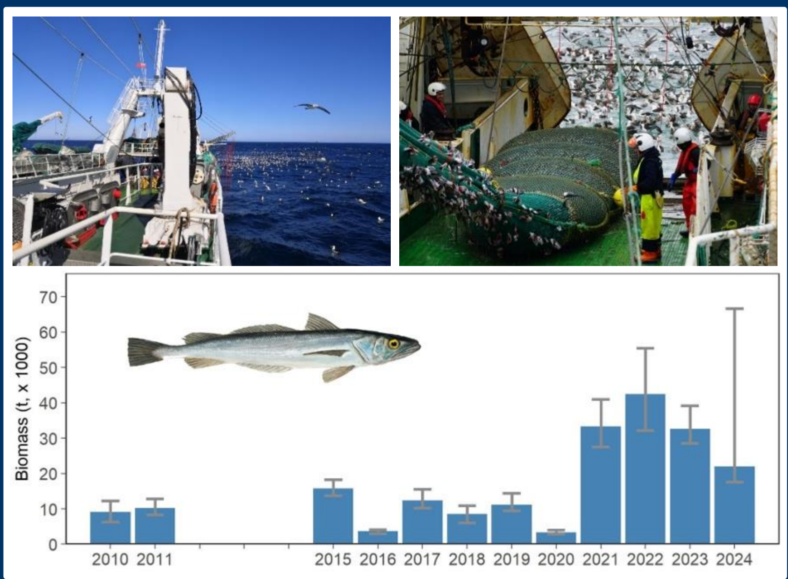
February bottom trawl survey biomasses of fishery species in Falkland Islands waters, 2010–2024



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Reviewed and approved on 19 April 2024 by:

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February bottom trawl survey biomasses of fishery species in Falkland Islands waters, 2010–2024

1. Summary

Survey biomass assessments of 11 commercial stocks (Argentine shortfin squid, banded whiptail grenadier, common hake, hoki, kingclip, Patagonian squid, red cod, rock cod, southern blue whiting, southern hake, and toothfish) were carried out covering the area of the north and west of the Falkland Islands Interim Conservation and Management Zone (FICZ), the north in the Falkland Islands Outer Conservation Zone (FOCZ), and the 'Loligo box'. The assessments were based on catch data of 1,648 bottom trawls conducted during the February parallel groundfish and calamari pre-season surveys in 2010, 2011, and 2015 to 2024.

Rock cod and southern hake had declining trends in biomass from 2010 to 2020, with slow increase from 2021 to 2024. Rock cod and southern hake had statistically significant lower biomass in 2024 compared with 2010, and their biomasses in 2024 were 15%, and 45% of their biomasses in 2010, respectively. Red cod had a declining trend from 2010 to 2020, but no significant changes in biomass after 2020. Argentine shortfin squid, banded whiptail grenadier, common hake, hoki, kingclip, Patagonian squid, southern blue whiting, and toothfish did not have statistically significant trends from 2010 to 2024.

Most stocks assessed in Falkland Islands waters are targeted across several nations' Exclusive Economic Zones, and for some stocks the Falkland Islands contribute a small proportion of the reported total shared catch in the Southwest Atlantic and Southeast Pacific. Declines in biomass of some of these stocks may also be in part due to fishing pressure outside Falkland Islands waters. However, Falkland Islands fisheries contribute a major proportion of the reported total shared catch for some stocks (i.e., rock cod and red cod), and pertinent management decisions made at the Falkland Islands Fisheries Department (FIFD) are relevant for the sustainability of those stocks.

In February 2024, the highest densities of the Argentine shortfin squid, common hake, kingclip, red cod, and rock cod were to the north-west in the FICZ and FOCZ. The highest densities of southern blue whiting were detected to the north-east in the FICZ. Banded whiptail grenadier, hoki, southern hake, and toothfish were mainly aggregated to the south-west in the FICZ. Patagonian squid were caught around Falkland Islands waters but mainly to the south in the FICZ.

2. Introduction

The Falkland Islands shelf is located within the Patagonian large marine ecosystem, one of the most productive fishing areas in the world (Arkhipkin et al. 2012). The Patagonian large marine ecosystem is comprised of a southern temperate ecosystem in the north and a sub-Antarctic ecosystem in the south, divided by a boundary that runs from the south-west to the north-east through the Falkland Islands (Boltovskoy 1999). The temperate ecosystem lies within waters of subtropical origin, transported onto the shelf by the Brazil Current and mixed with temperate shelf waters. Several productive zones are revealed in this ecosystem, mainly due to the existence of tidal mixing oceanographic fronts, as well as seasonal fronts originating from cold fresh water inflows into the Strait of Magellan. The sub-Antarctic ecosystem lies within waters of sub-Antarctic origin transported onto the shelf by the Falkland Current (Peterson & Whitworth 1989). The Falkland Current diverges from the main stream of the Antarctic Circumpolar Current in the Drake Passage and turns northwards. The Falkland Current splits at the continental slope south of the Falkland Islands into a weak branch and a stronger branch that flow around the west and east of the Islands, respectively (Bianchi et al. 1982). These oceanographic features affect the distribution and abundance of marine species; for instance, Argentine shortfin squid (*Illex argentinus*) and hoki (*Macruronus magellanicus*) migrate to frontal zones for feeding and back to non-frontal zones for spawning (Agnew 2002). In contrast, migrations of deep-water fish such as toothfish (*Dissostichus eleginoides*) into the shelf are favoured by intrusions of sub-Antarctic waters (Laptikhovsky et al. 2008; Arkhipkin & Laptikhovsky 2010).

Squids and fishes around the Falkland Islands have been targeted by international fishing fleets over decades. However, catch data by species only started to be recorded systematically from the year 1987 (Falkland Islands Government 1989). Total catches reached a maximum of 462,487 t in 2015, in part due to the unusual large intrusion of *I. argentinus* in Falkland Islands waters from April to May 2015 (Winter 2015) that resulted in record catches (332,862 t) for this species that year (Falkland Islands Government 1989, 2024).

Finfish license allocations in the Falkland Islands used to be set by Total Allowable Effort (TAE) calculated as a function of the catchability of an index species that represents the main target of the fishery. This approach worked under the assumption of consistent relationships among catch, effort, and biomass. The first index species for finfish TAE was southern blue whiting (*Micromesistius australis*). However, with declining catches of southern blue whiting and increasing catches of rock cod (*Patagonotothen ramsayi*), the index species was re-examined (Payá et al. 2010) and switched in 2011 from southern blue whiting to rock cod in order to set effort allocation. Catches of rock cod decreased since 2010 (Falkland Islands Government 2024; Ramos & Winter 2023a) whereas catches of common hake (*Merluccius hubbsi*) increased, and reached a maximum catch in 2022 (62,624 t; Falkland Islands Government 2024). The use of an index species to manage all Falkland Islands commercial species was thus considered unreliable, and the Falkland Islands Government mandated assessing each individual commercial stock. An important step to achieve this goal is to estimate the abundance and distribution of each commercial stock in the Falkland Islands Conservation Zones (FICZ and FOCZ) based on commercial and scientific surveys.

Scientific surveys are key sources of fisheries independent data that benefit from a standardised sampling plan and constant catchability (Hilborn & Walters 1992; Alglave et al. 2022; Gallo et al. 2022). The Falkland Islands Fisheries Department (FIFD) has carried out parallel groundfish and calamari (*Doryteuthis gahi*) pre-season surveys every February since 2010, except for 2012, 2013, and 2014. The groundfish surveys are conducted along the north, west and south-west in Falkland Islands waters. The calamari pre-season surveys are conducted along the 'Loligo Box' to the east of the Falkland Islands. The original objective of these February parallel demersal surveys was to provide a synchronous biomass estimate of rock cod on the entire Falklands fishing grounds (Winter et al. 2010), which has since been expanded to provide information on other commercial stocks. It is noted, however, that Falkland Islands waters represent only part of the range for most stocks examined, and for some migratory stocks February is not a time of peak abundance, i.e., common hake (Arkhipkin et al. 2015), kingclip (*Genypterus blacodes*; Arkhipkin et al. 2012), and southern blue whiting (Barabanov 1982). Stations to the south-west in the FICZ have also not been sampled equally in all years, which may influence biomass estimates for stocks that occur in that area during February, such as banded whiptail grenadier (*Coelorinchus fasciatus*), hoki, southern blue whiting, and toothfish.

This report summarizes catch data jointly from the groundfish survey and the calamari pre-season survey, to estimate the biomass of key stocks in Falkland Islands waters since 2010. Previous index species (southern blue whiting and rock cod), and main commercial species are included in this report.

3. Methods

3.1. Trawl stations and biological sampling

Concurrent groundfish and calamari pre-season research surveys were carried out during February 2010–2011 and 2015–2024 on board chartered fishing trawlers to cover the Falkland Islands fishing zone (Fig. 1). All trawls were bottom trawls; GPS latitude, GPS longitude, net vertical opening, trawl door spread, and trawl speed were recorded on the ship's bridge during the progress of each trawl.

All species from the catch of each trawl station were sorted by FIFD scientific personnel and the vessel's factory crew. FIFD scientific personnel recorded the total catch of each species assessed by a combination of weighing on an electronic balance to the nearest 0.01 kg and factory production records. Random samples of up to 100 individuals of each species were measured to the lowest 1 cm for finfish and to the lowest 0.5 cm for squids. Dorsal mantle length was measured for Argentine shortfin squid and Patagonian squid (*Doryteuthis gahi*). Total length was measured for common hake, kingclip, red cod (*Salilota australis*), rock cod, southern blue whiting, southern hake (*Merluccius australis*), and toothfish. Pre-anal length was measured for banded whiptail grenadier and hoki. In this report, catches and length frequencies were assessed for eleven species that represent important commercial targets in the Falkland Islands and other nations' fishing zones (Table I; Appendix I).

The duration of each trawl was approximately 60 min on the bottom during groundfish surveys, and 120 min on the bottom during calamari pre-season surveys. Characteristics of the trawl nets, trawl performance, and biological sampling during groundfish (Brickle & Laptikhovsky 2010; Arkhipkin et al. 2011, 2019; Gras et al. 2015, 2016, 2017, 2018; Randhawa et al. 2020; Trevizan et al. 2021, 2022, 2023; Ramos et al. 2024) and calamari pre-season (Arkhipkin et al. 2010; Winter et al. 2011, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023; Chemshirova et al. 2024) surveys can be consulted in detail in their respective survey reports. These surveys were designed to be consistent in the number and position of stations across years. However, there were variations in the number of stations mainly to the south-west of the FICZ for specific purposes of the February 2018 and 2020 groundfish surveys (Gras et al. 2018; Randhawa et al. 2020). In February 2022, a total of 42 stations were conducted instead of the usual > 80 stations due to the survey being shortened because of COVID-19 quarantine requirements of the vessel's crew (Trevizan et al. 2022).

Table I. Main commercial species assessed in groundfish and calamari pre-season surveys in Falkland Islands waters during February 2010–2011 and 2015–2024. Geographic distributions taken from http://www.fao.org/fishery/species/search/en

Common name	**Scientific name**	**Distribution**
Argentine shortfin squid	*Illex argentinus*	Southwest Atlantic: Brazil, Uruguay, Argentina, Falkland Islands.
Banded whiptail grenadier	*Coelorinchus fasciatus*	Southwest Atlantic: Brazil, Uruguay, Argentina, Falkland Islands. Southern Pacific: Chile, Australia, New Zealand. Southern Indian: Africa, Australia.
Common hake	*Merluccius hubbsi*	Southwest Atlantic: Brazil, Uruguay, Argentina, Falkland Islands.
Hoki	*Macruronus magellanicus*	Southwest Atlantic: Argentina, Falkland Islands. Southeast Pacific: Chile.
Kingclip	*Genypterus blacodes*	Southwest Atlantic: Brazil, Uruguay, Argentina, Falkland Islands. Southern Pacific: Chile, Australia, New Zealand.
Patagonian squid	*Doryteuthis gahi*	Southwest Atlantic: Argentina, Falkland Islands. Southern Pacific: Peru, Chile.
Red cod	*Salilota australis*	Southwest Atlantic: Argentina, Falkland Islands. Southeast Pacific: Chile.
Rock cod	*Patagonotothen ramsayi*	Southwest Atlantic: Argentina, Falkland Islands.
Southern blue whiting	*Micromesistius australis*	Southwest Atlantic: Argentina, Falkland Islands. Southeast Pacific: Chile. Southern Ocean: South Georgia, South Shetland, South Orkney Islands.
Southern hake	*Merluccius australis*	Southwest Atlantic: Argentina, Falkland Islands. Southern Pacific: Chile, New Zealand.
Toothfish	*Dissostichus eleginoides*	Southwest Atlantic: Argentina, Falkland Islands. Southeast Pacific: Chile. Southwest Pacific: Macquarie Island. Southern Ocean: South Georgia.

3.2. Abundance calculations

Station and catch data were recorded during the surveys, checked and uploaded to the FIFD database, from which the data were available for analyses. Trawls were excluded if not quantifiable for the following reasons: 1) the trawl doors did not open properly, 2) the net broke during the trawl, or 3) if the net was quickly filled with medusae, which resulted in the trawl being interrupted (Appendix I).

Biomass densities per species at each trawl station were calculated as the species catch weight divided by the trawl station area (net horizontal opening × distance covered). For calamari pre-season surveys, net horizontal opening was derived from the distance between trawl doors (Seafish 2010). For groundfish surveys, the triangulation method that derives net horizontal opening from the distance between trawl doors is unsuitable because the geometry of the net is different. Since 2016, groundfish survey net horizontal opening has instead been measured directly from Marport sensors fitted to the extremities of the survey vessel's trawl net wings. If net horizontal opening was not recorded due to failure of the Marport sensors, it was calculated from door spread, net vertical opening and trawl speed using a generalized additive model.

Yearly trawl biomass densities were extrapolated to the survey area combining the finfish zone (122,493.7 km^2) and 'Loligo Box' (31,296.9 km^2), partitioned into grids of 5×5 km^2. Position coordinates of trawls were converted to WGS 84 projection in UTM sector 21, and extrapolation was calculated using inverse distance weighting. The basic inverse distance weighting algorithm assigns a value *u* to any grid location *x* that is the weighted average of a known scattered set of points x_i according to the inverse of the *i* points' distances from the grid location *x*:

$$u(\mathrm{x}) = \begin{cases} \dfrac{\sum_{i=1}^{N} w_i(\mathrm{x}) u_i}{\sum_{i=1}^{N} w_i(\mathrm{x})}, & \text{if } d(\mathrm{x}, \mathrm{x_i}) \neq 0 \\ u_i, & \text{if } d(\mathrm{x}, \mathrm{x_i}) = 0 \end{cases}$$

where

$$w_i(\mathrm{x}) = \frac{1}{d(\mathrm{x}, \mathrm{x_i})^p}$$

The power parameter *p* (a positive real number) adjusts the weight of points x_i as a function of distance (x, x_i); higher values of *p* put higher influence on the points x_i closest to a given interpolated point *x*. For this survey analysis, an empirical approach to selecting *p* was used running the inverse distance weighting algorithm with *p* values from 1 to 25 by 0.25, and for each *p* calculating the aggregate of log proportional differences between the empirical values of density at every trawl and the interpolation at every trawl from all other trawls. The lowest aggregate of log proportional differences corresponded to the best *p* value. Because some points may be more clustered than others, an isolation parameter was assigned attributing more weight to points x_i in proportion to being further away from any other point x_j. Isolation parameters (*s*) per yearly survey were calculated as the standardized mean of distances between each point x_i and all other points x_j:

$$s(\mathrm{x_i}) = \overline{d(\mathrm{x_i}, \mathrm{x_j})}$$

An additional weighting factor was included to adjust for trawl differences in area coverage. Survey trawls are generally standardized (60 min duration in groundfish surveys and 120 min in calamari pre-season surveys), but may be shortened on immediate notice for reasons that include unmanageably large concentrations of fish accumulating in the net. Such instances will result in the trawl being stopped just when its biomass density is maximized, rather than being stopped independently of the biomass density, and thereby create a potential bias of the density estimate at that location. For shoaling fish in sparse, highly aggregated distributions, the effect can be substantial (i.e., hoki; Appendix II in Ramos & Winter 2022a). However, the trawl itself is not an error record that should be invalidated and removed from the data set. To mitigate the potential bias effect, swept area of each trawl was taken as a proportional weighting parameter so that a shortened trawl covering, for example, only half as much ground would have only half as much weight. Like the isolation parameters $s(\mathrm{x_i})$, the area parameters $a(\mathrm{x_i})$ were standardized (divided by their mean among all trawls), then $s(\mathrm{x_i})$ and $a(\mathrm{x_i})$ were added together and divided again by their sum to give a factor centred on 1. The revised inverse distance weighting factor is:

$$w_i(\mathrm{x}) = \left(\frac{\left(\dfrac{s(\mathrm{x_i}) + a(\mathrm{x_i})}{\overline{\left(s(\mathrm{x_i}) + a(\mathrm{x_i})\right)}} \right)}{d(\mathrm{x}, \mathrm{x_i})} \right)^p$$

Distance $d(x, x_i)$ is inherently calculated as Euclidean (straight-line) distance. However, the survey area surrounds the Falkland Islands and between two remote points a fish or ship would have to travel a real distance longer than straight-line; circumnavigating the landmass. Therefore, an axial loop was drawn through the survey area (Fig. 1), and $d(x, x_i)$ was defined as the longer of either the Euclidean distance between x and x_i, or the distance on the axial loop between its two points respectively closest to x and x_i (Winter 2019).

As an extrapolation algorithm, calculated biomass over a given area will depend on the spatial distribution of surveyed densities, not just their total or average value. Accordingly, the biomass is considered an estimate.

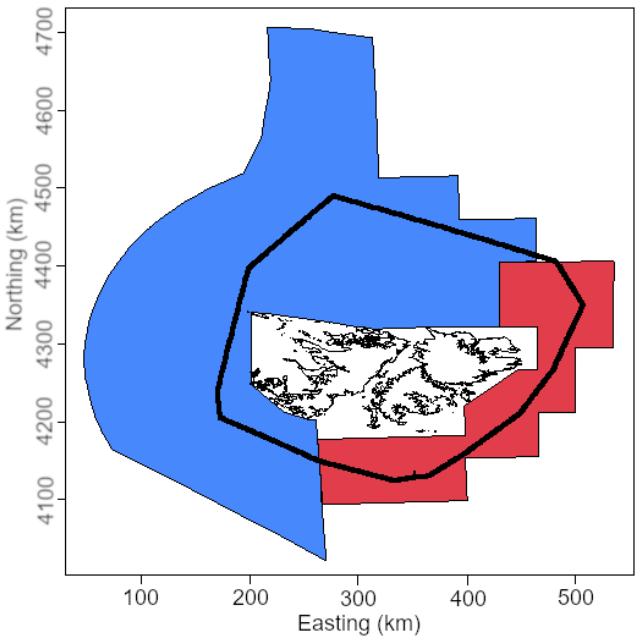

Fig. 1. Groundfish (blue) and calamari pre-season (red) survey areas, with axial loop (black line) used to define relative distances for the inverse distance weighting algorithm.

Uncertainty of the biomass estimate was calculated by a hierarchical bootstrap algorithm. Survey trawls and their catches were first randomly re-sampled with replacement for 10,000 iterations, whereby each year's groundfish survey and parallel calamari pre-season survey were re-sampled separately so that both 'halves' of the survey area retained about the same relative coverage. Second, each re-sampled trawl was given a random uniform re-assignment of its coordinate position between start latitude and longitude and end latitude and longitude. Third, the isolation parameters were re-calculated for the randomized set of trawl data, and the inverse distance weighted algorithm re-applied. One iteration might thus re-sample any trawl twice or more, but each would have a slightly different position. The 95% confidence intervals of the 10,000 bootstrap iterations were used to infer uncertainty.

LOESS (span = 1.0, C.I. = 0.95) was implemented to examine changes in biomass through time from the yearly estimates.

4. Results

4.1. Trawls

A total of 1,648 bottom trawls were carried out during the February groundfish and calamari pre-season surveys from 2010–2011 and 2015–2024; a range of 79 to 97 trawls are usually carried out during groundfish surveys per year, and 52 to 64 trawls are carried out during calamari pre-season surveys per year. In 2024, a total of 84 trawls were carried out during the groundfish survey, and 64 trawls were carried out during the calamari pre-season survey (Appendix I).

4.2. Abundance, distribution and size structure

Biomass estimates and catches of each commercial stock assessed during the February parallel demersal surveys 2010–2024 are summarized in Table II and in Appendix II, respectively. Biomass histograms from 10,000 bootstrap iterations of each commercial stock are in Appendix III. Biomass trends of each commercial stock assessed over the same period of time are shown in Appendix IV. The density spatial distributions of each stock during the February 2024 parallel demersal surveys are in Appendix V.

Table II. Biomass calculations (t) of main commercial species during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters. The 95% confidence intervals are indicated in parentheses.

Year	Argentine shortfin squid	Banded whiptail grenadier	Common hake	Hoki
2010	8633.92 (3510.35–13384.35)	66622.68 (40514.45–98311.11)	9124.06 (6280.46–12219.25)	278980.21 (188264.88–457666.96)
2011	9294.45 (6777.82–12564.25)	43482.30 (20547.39–73607.37)	10180.24 (8330.32–12809.67)	221132.74 (172507.38–281186.26)
2015	210513.16 (129839.58–365643.99)	60434.68 (35864.88–77202.47)	15758.48 (13700.90–18213.42)	134733.17 (44674.67–179592.78)
2016	201.73 (146.47–263.11)	34897.77 (8500.93–55042.45)	3661.91 (2974.25–4175.68)	158388.16 (79371.74–222823.65)
2017	11830.16 (7412.76–18225.10)	36736.93 (19596.89–43533.35)	12419.11 (10191.95–15538.58)	28882.54 (16801.50–38817.08)
2018	45086.43 (30158.94–64394.07)	34256.01 (27633.27–43657.43)	8534.38 (6048.05–10877.41)	141953.50 (92768.34–204228.49)
2019	60076.25 (40113.04–93531.22)	21976.99 (9186.12–36085.96)	11151.32 (9483.58–14419.93)	41864.81 (5779.47–166317.90)
2020	148081.91 (89302.24–196203.10)	25225.42 (8358.90–43250.89)	3340.09 (2846.51–3971.84)	75402.28 (20203.23–143531.23)
2021	42780.70 (20466.20–68912.67)	68844.80 (32834.53–85342.42)	33281.79 (27502.33–40938.52)	245890.30 (92470.50–431476.19)
2022	5823.75 (2397.40–30856.33)	49558.54 (25192.54–102067.28)	42420.98 (32223.84–55471.45)	144782.83 (12362.55–248962.54)
2023	10483.67 (7614.37–15619.55)	34369.51 (22666.50–46028.90)	32616.58 (28532.20–39221.03)	131715.33 (37696.82– 212465.82)
2024	61986.65 (52241.58–81690.59)	36692.12 (20129.73–49562.23)	21981.6 (17585.78–66611.91)	46549.50 (22017.84–77799.87)

Table II. *continued*

Year	Kingclip	Patagonian squid	Red cod	Rock cod
2010	21274.04 (13705.30–28607.34)	184615.48 (160421.18–239516.37)	95050.09 (18335.99–158897.80)	817086.43 (519306.26–1306091.27)
2011	41485.02 (28424.85–63121.38)	47236.55 (39537.83–62533.45)	166617.50 (39230.31–258711.16)	884741.55 (716079.56–1064218.58)
2015	76722.26 (30150.81–124958.88)	112296.69 (82994.09–164421.27)	106244.23 (45278.81–160780.36)	350913.41 (269667.68–432687.92)
2016	24782.64 (13955.05–39613.42)	41292.65 (34357.75–53300.16)	102789.02 (28384.22–149860.74)	232429.14 (177911.14–306135.45)
2017	18831.90 (11873.32–28544.00)	182113.39 (145101.61–234454.73)	59568.95 (22863.35–86532.41)	141469.65 (113896.56–176351.05)
2018	14788.92 (11069.78–21527.00)	63154.37 (44073.52–96689.36)	57422.88 (19277.51–117355.42)	90679.85 (63308.48–122537.23)
2019	20869.45 (14764.62–28127.04)	214492.39 (188175.67–259467.94)	83005.12 (35235.62–119480.37)	45669.16 (29040.32–66668.90)
2020	14531.98 (10052.06–26304.43)	91415.65 (80832.08–126778.53)	21889.98 (10993.21–32014.04)	19079.02 (11656.70–27065.20)
2021	21216.07 (12901.88–35823.59)	119433.40 (98119.16–165138.90)	35217.39 (22852.74–51663.11)	59670.41 (45689.57–66885.68)
2022	43437.30 (14738.11–80447.75)	167439.23 (131702.50–235968.93)	81176.73 (34162.13–129660.26)	93177.17 (58753.11–131454.56)
2023	35880.61 (18884.19–58232.85)	190506.92 (156060.20–262829.20)	38861.12 (20178.92–56206.64)	64729.11 (51235.90–78204.69)
2024	16597.44 (11950.68–27609.68)	206976.96 (181079.58–288983.91)	47937.57 (20903.51–70057.72)	122995.42 (87911.52–164719.01)

Table II. *continued*

Year	Southern blue whiting	Southern hake	Toothfish
2010	68447.18 (25380.63–91314.04)	5096.76 (3910.63–6443.37)	9492.17 (7096.05–11727.84)
2011	154691.35 (42459.43–357267.81)	5223.77 (3445.99–8095.63)	10588.19 (7859.83–13377.29)
2015	35307.57 (12197.06–80184.05)	2961.07 (1750.69–4350.03)	3730.91 (1359.57–4477.02)
2016	113986.55 (25096.46–204263.77)	1971.72 (1204.90–2963.73)	7472.12 (5373.64–10194.34)
2017	54456.87 (1375.47–65699.77)	1829.09 (1021.33–2478.36)	9316.94 (5662.92–11183.99)
2018	57963.36 (17839.34–69597.20)	1453.02 (978.54–1947.08)	8633.46 (6276.48–10886.50)
2019	5856.24 (205.30–34084.93)	425.70 (88.45–577.12)	6173.70 (3162.82–7794.58)
2020	4989.54 (26.73–15435.54)	593.71 (230.37–868.25)	2499.29 (1621.34–3392.18)
2021	13567.47 (3616.43–25713.15)	1943.34 (919.34–2941.07)	4395.03 (2825.50–4845.25)
2022	19200.92 (877.49–48977.89)	920.22 (574.62–1471.85)	3877.36 (2080.95–5151.07)
2023	39575.05 (9904.22–67656.97)	1247.99 (629.48–2028.57)	3350.25 (1991.62–4590.57)
2024	67202.42 (21635.73–134012.68)	2281.6 (1734.88–5932.60)	4284.69 (3078.91–5092.08)

4.2.1. Argentine shortfin squid (*Illex argentinus*)

On average, 91% of the total Argentine shortfin squid catches were from groundfish surveys in any year. The highest catch was reported in 2015 (32 t) and the lowest catch in 2016 (0.1 t), with the catch of 2024 (17 t) being higher than the average (9 t) (Fig. 2; Appendix II). The maximum biomass was estimated in 2015 (210,513 t) whereas the lowest biomass was estimated for 2016 (202 t). Above-average biomass was calculated for 2024 (61,987 t), increasing for two consecutive years since 2022 (Fig. 2; Table II). Argentine shortfin squid biomass in 2010 (8,634 t) was 14% of its biomass in 2024 but did not have a significant inter-annual trend for the period 2010 to 2024 (Appendix IV).

In 2024, this species was distributed to the north-west of West Falkland, with the highest densities near the limit of the FICZ (6,162 kg/km^2; Fig. 3). This may be an indication of patches of higher abundance beyond the west limit of the FICZ at the time of the surveys, just before this species starts migrating into Falkland Islands waters. Across years, the Argentine shortfin squid was mainly distributed through the north and west in the FICZ, with the highest density in the time series reported to the north of East Falkland during 2015 (74,426 kg/km^2; Appendix VI).

Length frequency histograms show a range of sizes of *I. argentinus* from 5 cm to 36.5 cm across years. At least two length-groups were detected every year. The modal dorsal mantle length of the smaller group was nearly 9.5 cm, and the modal dorsal mantle length of the larger group ranged from 18 cm to 25 cm. In 2024, the main length-group was detected at about 23 cm dorsal mantle length, with females being larger than males. One juvenile was collected with dorsal mantle length of 7.5 cm (Fig. 4).

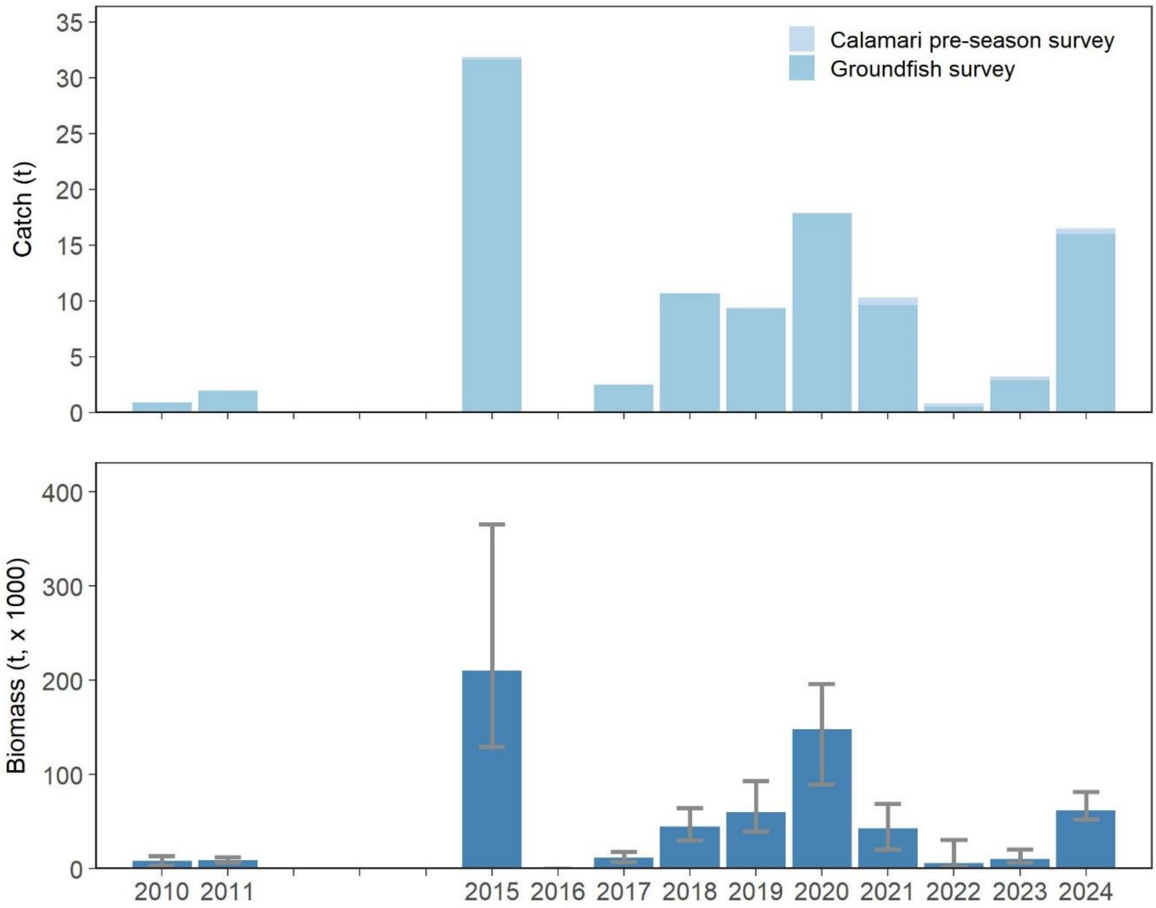

Fig. 2. Catch (t), and mean biomass (t) ± 95% confidence intervals of the Argentine shortfin squid (*Illex argentinus*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

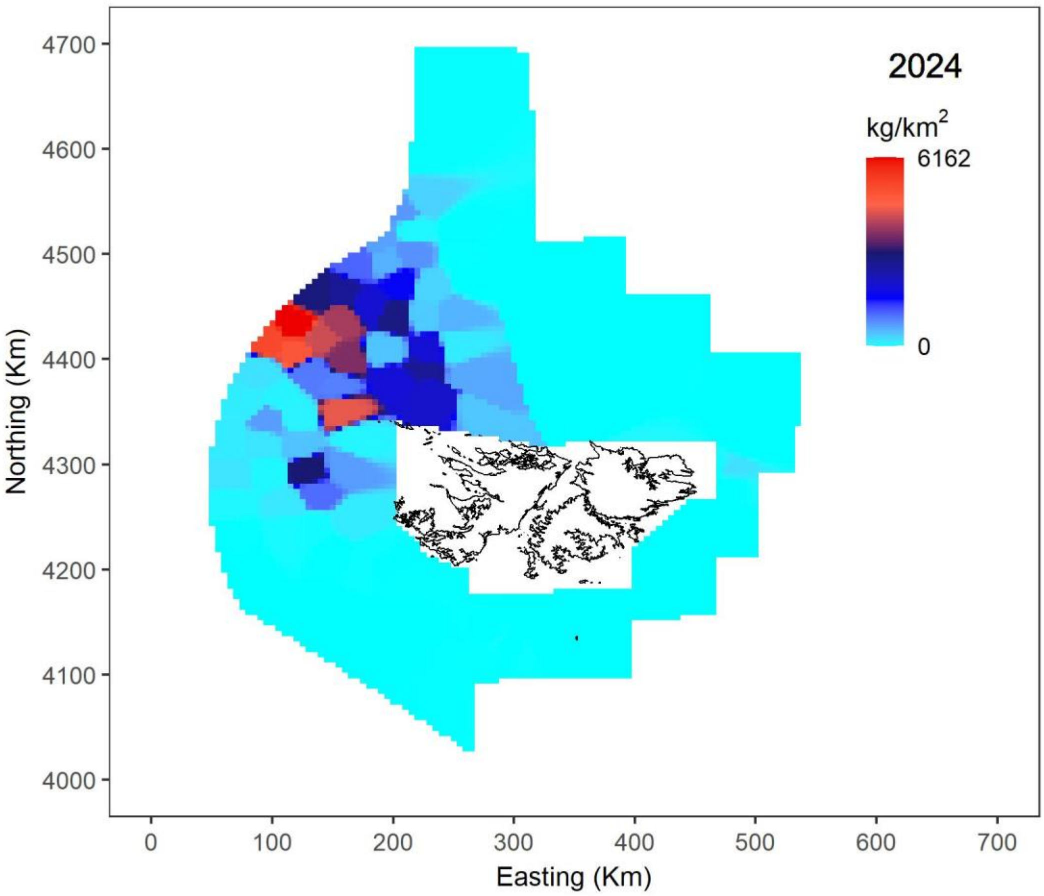

Fig. 3. Distribution and abundance of the Argentine shortfin squid (*Illex argentinus*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

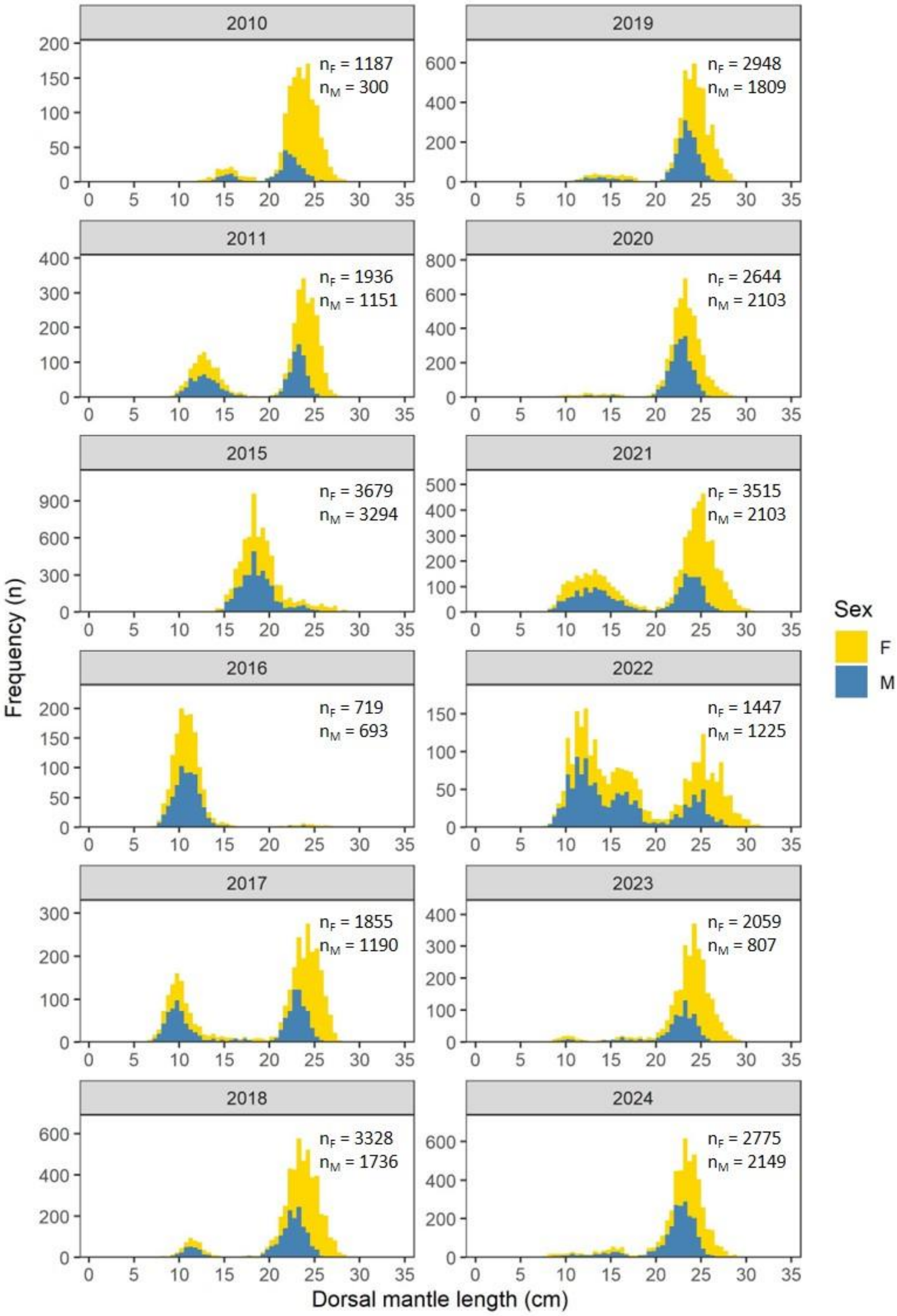

Fig. 4. Length-frequency distribution of Argentine shortfin squid (*Illex argentinus*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.2. Banded whiptail grenadier (*Coelorinchus fasciatus*)

Patterns of catch and biomass across years were variable, likely due to the small catches and patchy distributions of this species, which also reflects in wide biomass confidence intervals (Table II). On average, 90% of the total banded whiptail grenadier catches were from groundfish surveys. Total catches of banded whiptail grenadier ranged between 2.5 t and 8 t, with the catch in 2024 (4 t) being below the average (5 t) of the time series (Fig. 5; Appendix II). The biomass of banded whiptail grenadier ranged from 21,977 t in 2019 to 68,845 t in 2021, with no evident trend through time. The biomass in February 2024 was calculated at 36,692 t, which is below the average (42,758 t) of the time series and is 55% of its biomass in 2010 (66,623 t) (Fig. 5; Table II; Appendix IV).

Banded whiptail grenadier was distributed to the south-west of West Falkland during 2024, with the maximum density calculated at 2,846 kg/km^2 (Fig. 6). Across years, there was a consistent pattern of distribution to the south-west of West Falkland with the highest density calculated for 2011 (9,127 kg/km^2; Appendix VII).

Length frequency histograms of banded whiptail grenadier show a range of sizes from 2 cm to 20 cm pre-anal length. One mode was evident every year and remained constant through time, i.e., 9–10 cm pre-anal length for females and for males, with females often being larger than males (Fig. 7).

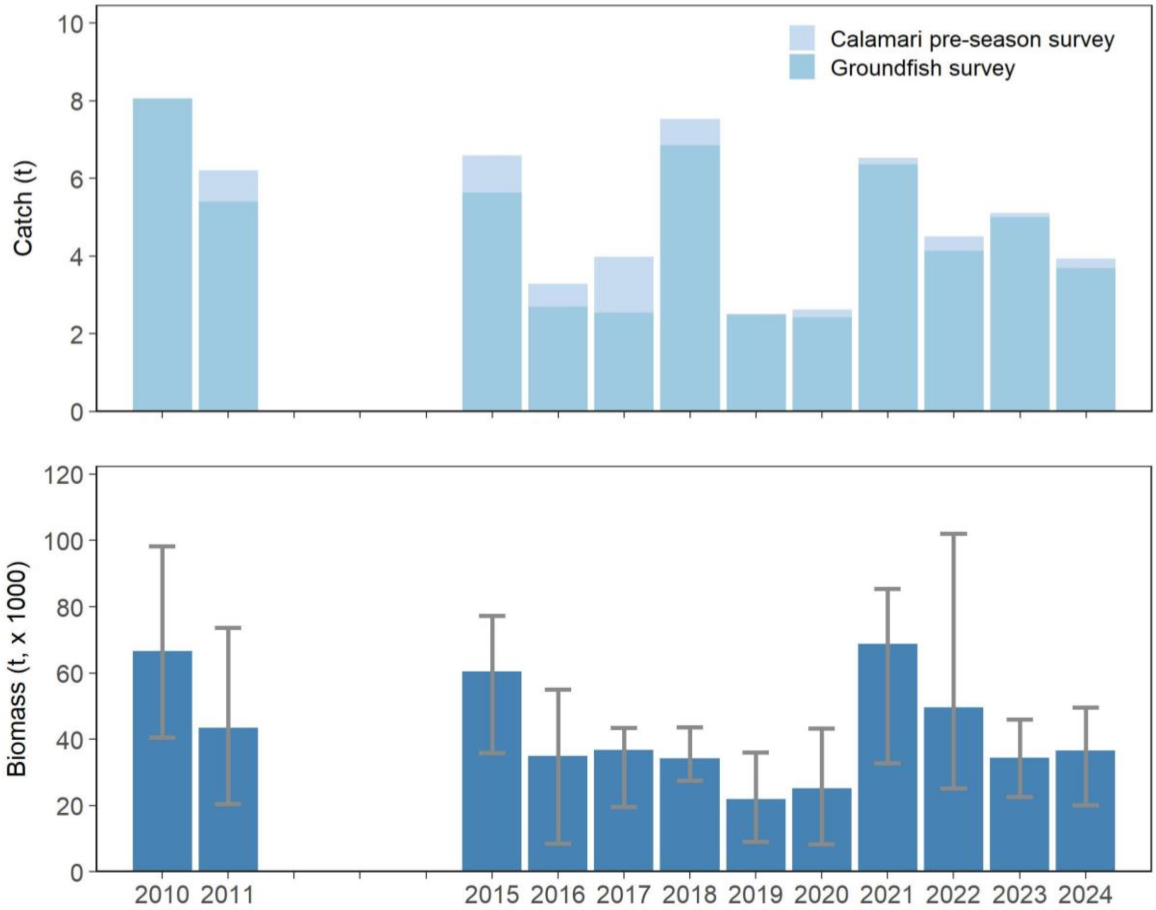

Fig. 5. Catch (t), and mean biomass (t) ± 95% confidence intervals of banded whiptail grenadier (*Coelorinchus fasciatus*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

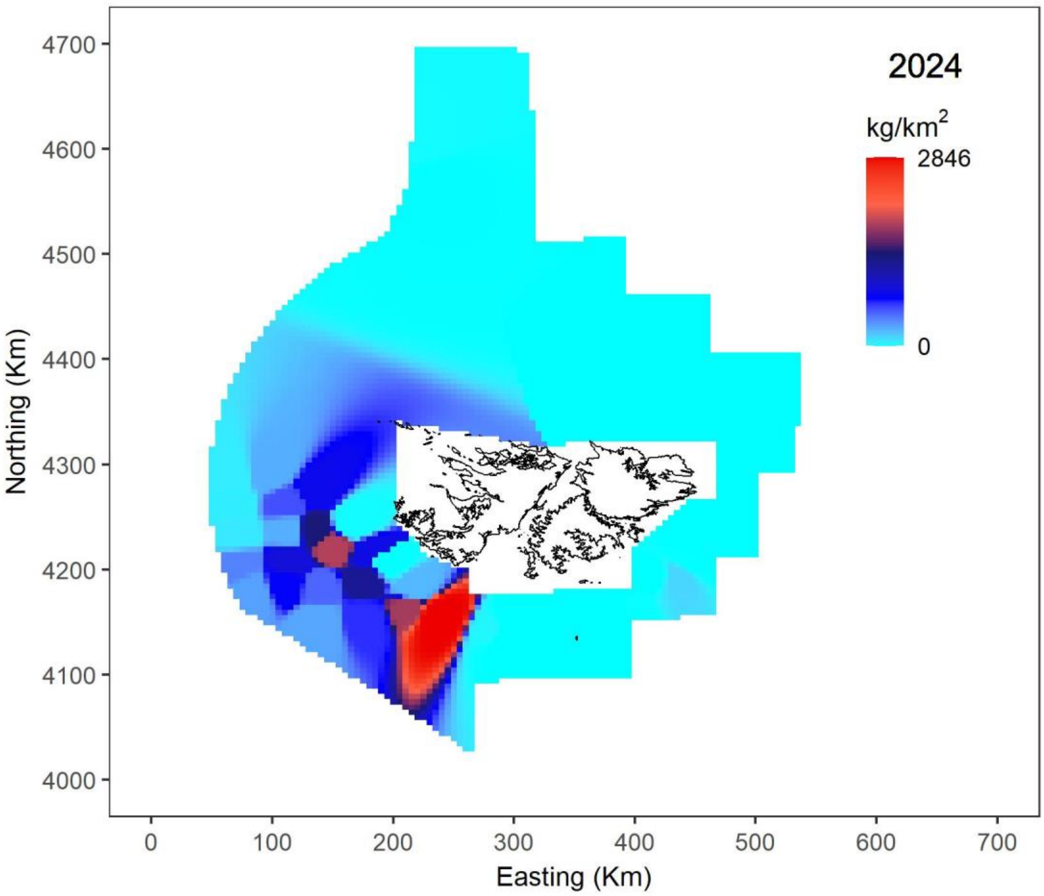

Fig. 6. Distribution and abundance of banded whiptail grenadier (*Coelorinchus fasciatus*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

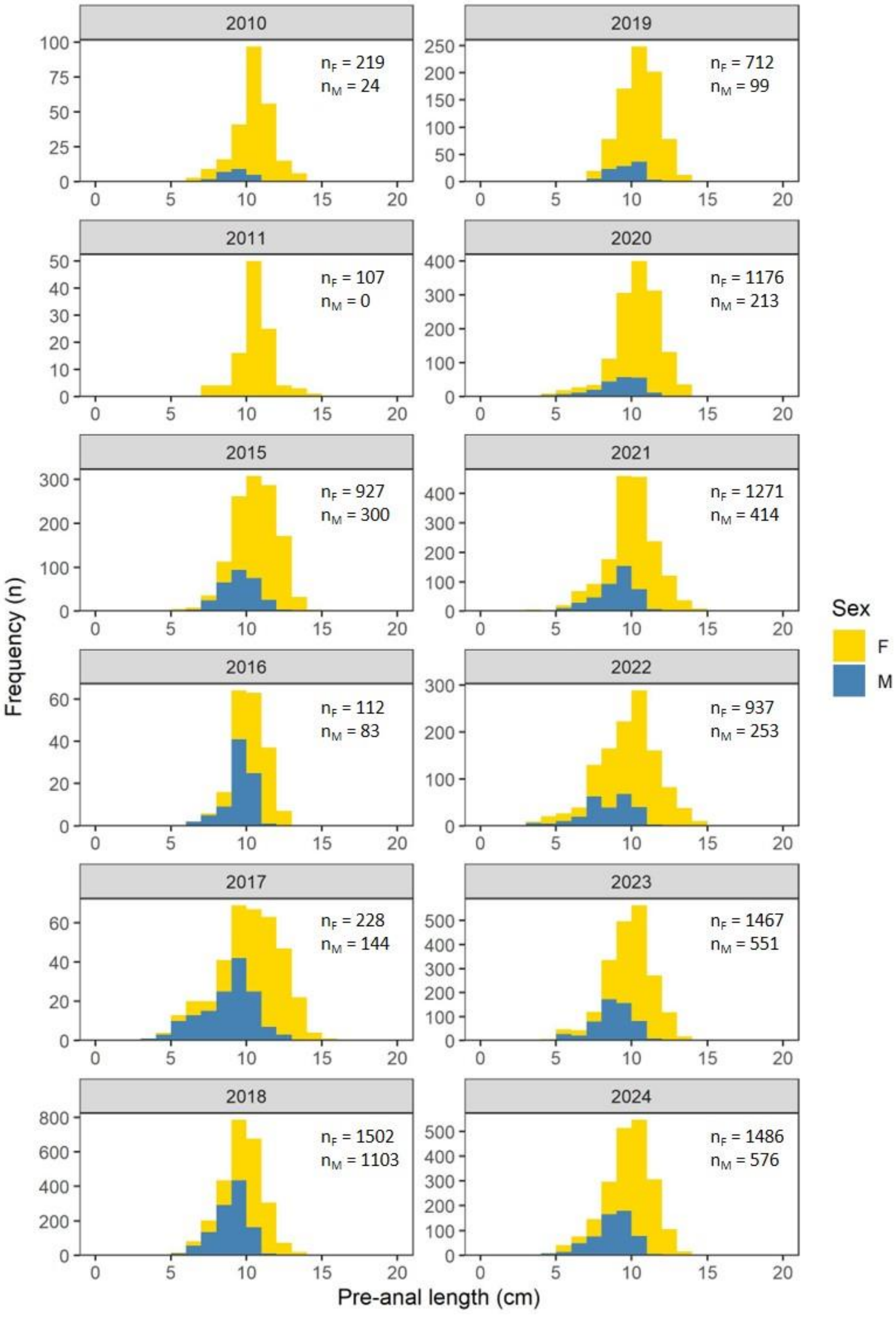

Fig. 7. Length frequency of banded whiptail grenadier (*Coelorinchus fasciatus*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.3. Common hake (*Merluccius hubbsi*)

Common hake were mainly caught in groundfish surveys through the time series, averaging 99% of the surveys' total common hake catch. Catches reached a maximum in 2023 (8.6 t). Common hake catch in 2024 (6 t) was the third highest and was above the average (3.6 t) of the time series (Fig. 8; Appendix II). The biomass of common hake was calculated at 9,124 t in 2010, reached its highest value in 2022 (42,421 t), and declined for two consecutive years with 21,981 t calculated for February 2024 (Fig. 8; Table II). The recent biomass decrease resulted in a statistically non-significant trend in biomass from 2010 to 2024 (Appendix IV).

In 2024, common hake was mainly distributed to the north-west of West Falkland with the highest density estimated at 4,241 kg/km^2 (Fig. 9). Migration of common hake into Falkland Islands waters is likely driven by specific oceanographic conditions, and takes place in February when the surveys are being conducted. Hence, changes in oceanographic conditions may result in year-to-year abundance variability for this species during February in Falkland Islands waters that may not be proportional to overall population abundance. Across years, high densities were detected to the north-west offshore or near the north-west limit of the FICZ, with the highest density calculated for 2024 (4,241 kg/km^2; Appendix VIII).

Length frequency histograms show a wide range of common hake sizes, from 13 cm to 95 cm total length, across the time series. Common hake >60 cm total length have been rare since 2015. In 2024, one length-group was detected, with modal length at 41 cm total length for females. A small number of males were detected with no evident modal length (Fig. 10).

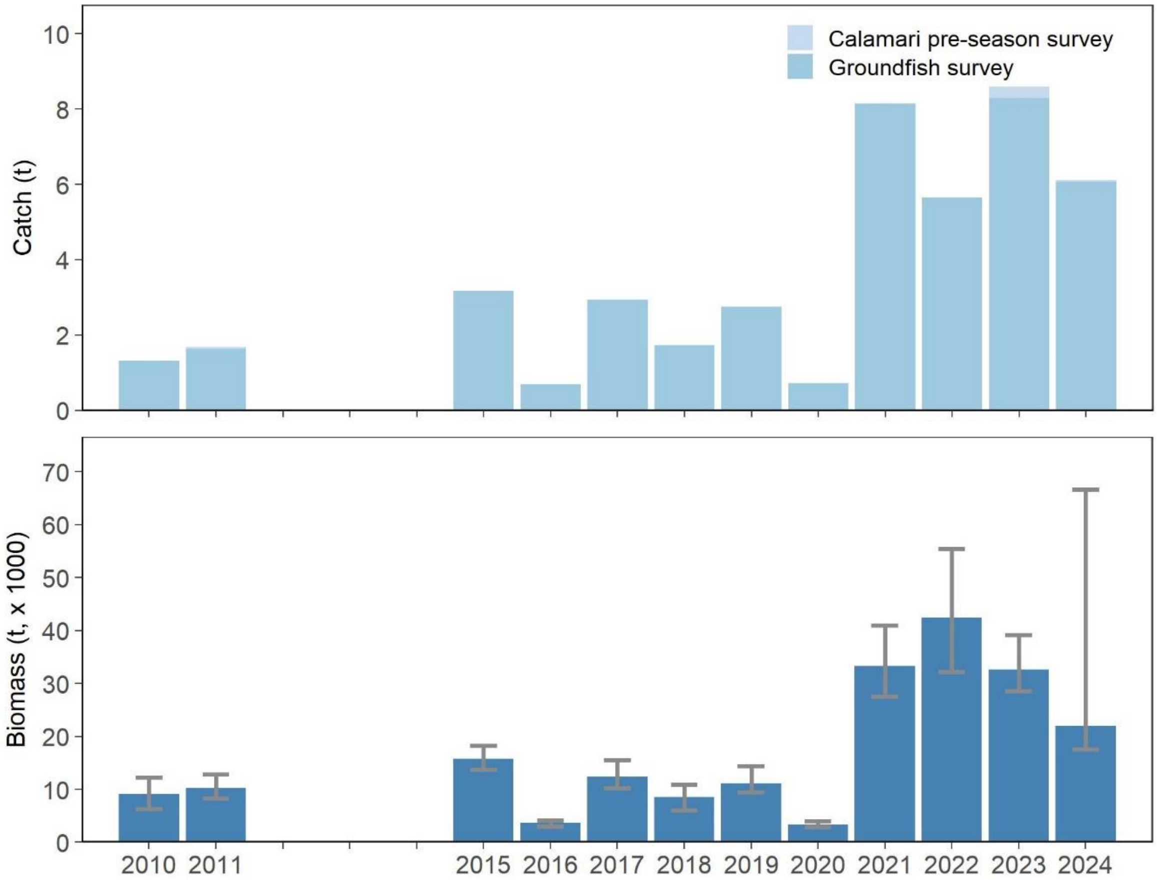

Fig. 8. Catch (t), and mean biomass (t) ± 95% confidence intervals of common hake (*Merluccius hubbsi*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

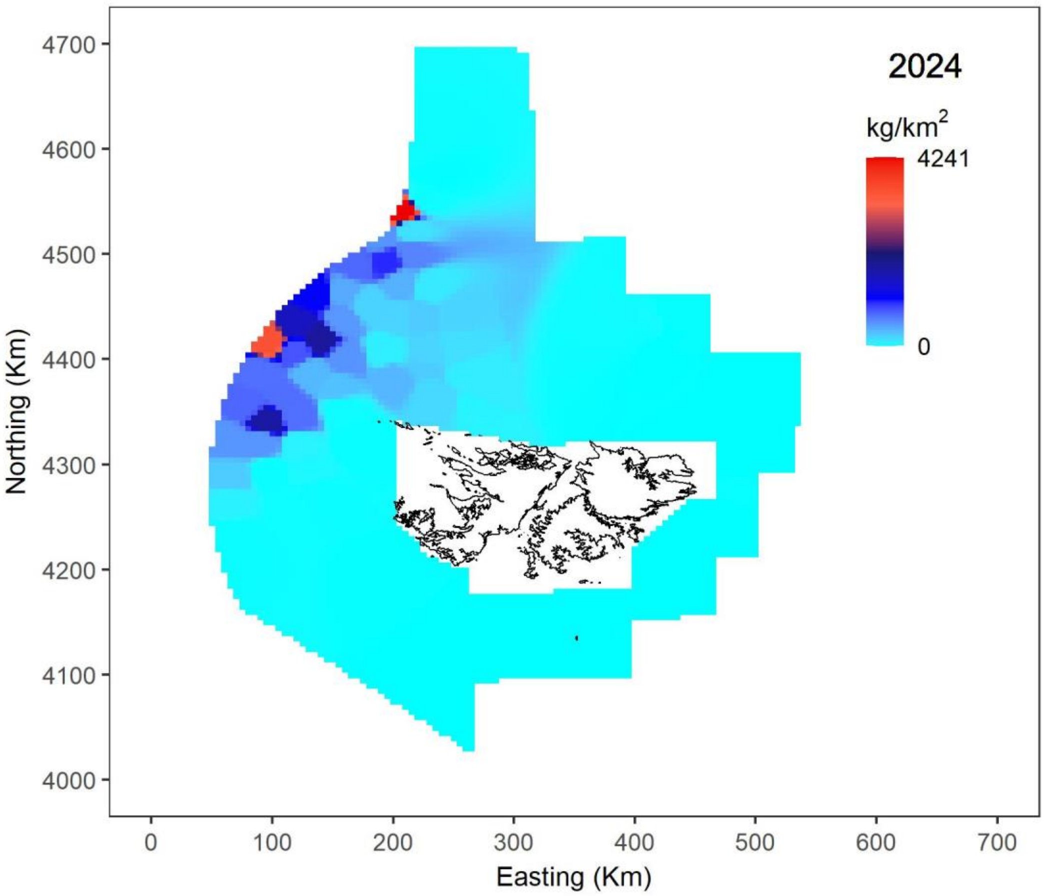

Fig. 9. Distribution and abundance of common hake (*Merluccius hubbsi*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

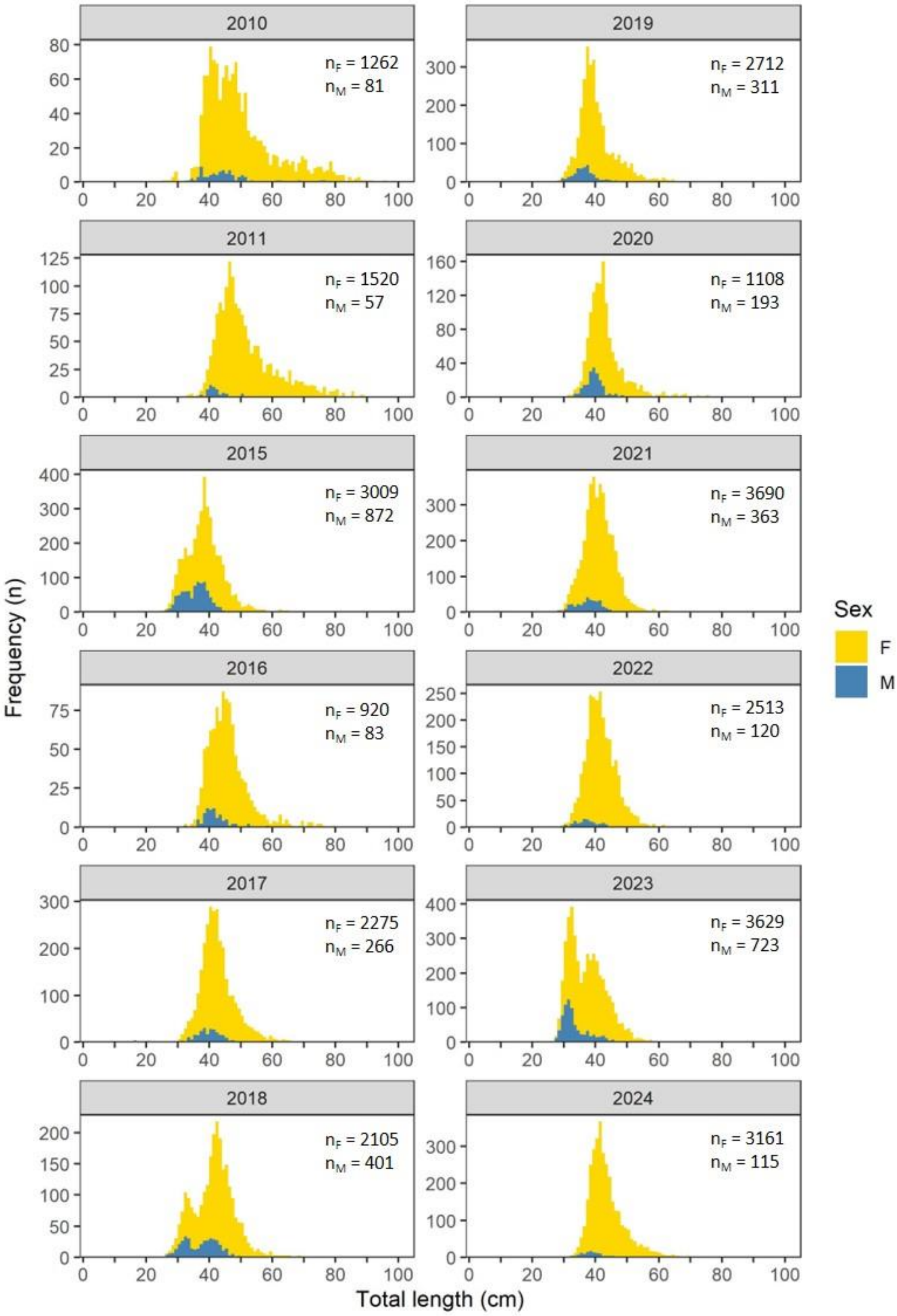

Fig. 10. Length frequency of common hake (*Merluccius hubbsi*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.4. Hoki (*Macruronus magellanicus*)

Hoki catch was nearly evenly split between groundfish and calamari pre-season surveys in 2010, 2011, and 2015, 2016. However, hoki catches were taken predominantly in groundfish surveys from 2017 to 2023 at an average of 97% of the combined surveys' total hoki catch. But in 2024, hoki catch was higher in the calamari pre-season survey, at 73% of the total (Fig. 11). The highest catch was reported in 2010 (79.8 t), and the lowest catch in 2017 (3.7 t); catch in 2024 (21 t) was below the average of 28 t (Appendix II). The highest biomass in the time series was calculated for 2010 (278,980 t), and the lowest was calculated for 2017 (28,883 t). The biomass in 2024 was the third lowest (46,550 t) and it was below the average (137,523 t) of the time series; hoki biomass in 2024 was 17% of its biomass in 2010 (Fig. 11; Table II); however, there was no significant trend in biomass from 2010 to 2024 (Appendix IV).

In 2024, hoki was found to the south-west edge of the FICZ with the highest density calculated at 6,830 kg/km^2 (Fig. 12). The distribution of hoki has been patchy and variable from year to year. From 2010 to 2015, hoki occurred over the entire FICZ and FOCZ but its distribution was localized mainly to the south-west of West Falkland from 2016 to 2024 (Appendix IX); the highest density in the time series occurred to the south-west limit of the FICZ in 2021 (146,193 kg/m^2).

Length frequency histograms show a range of sizes from 11 cm to 46 cm pre-anal length across the time series. The largest animals (≥ 35 cm pre-anal length) were less frequent since 2018. Several length-groups were present each year but these cannot be identified with certainty given the overlap in sizes. In 2024, the modal length of the largest length-group was 27–28 cm pre-anal length for females and for males. Smaller length-groups were detected at about 19 cm pre-anal length (Fig. 13).

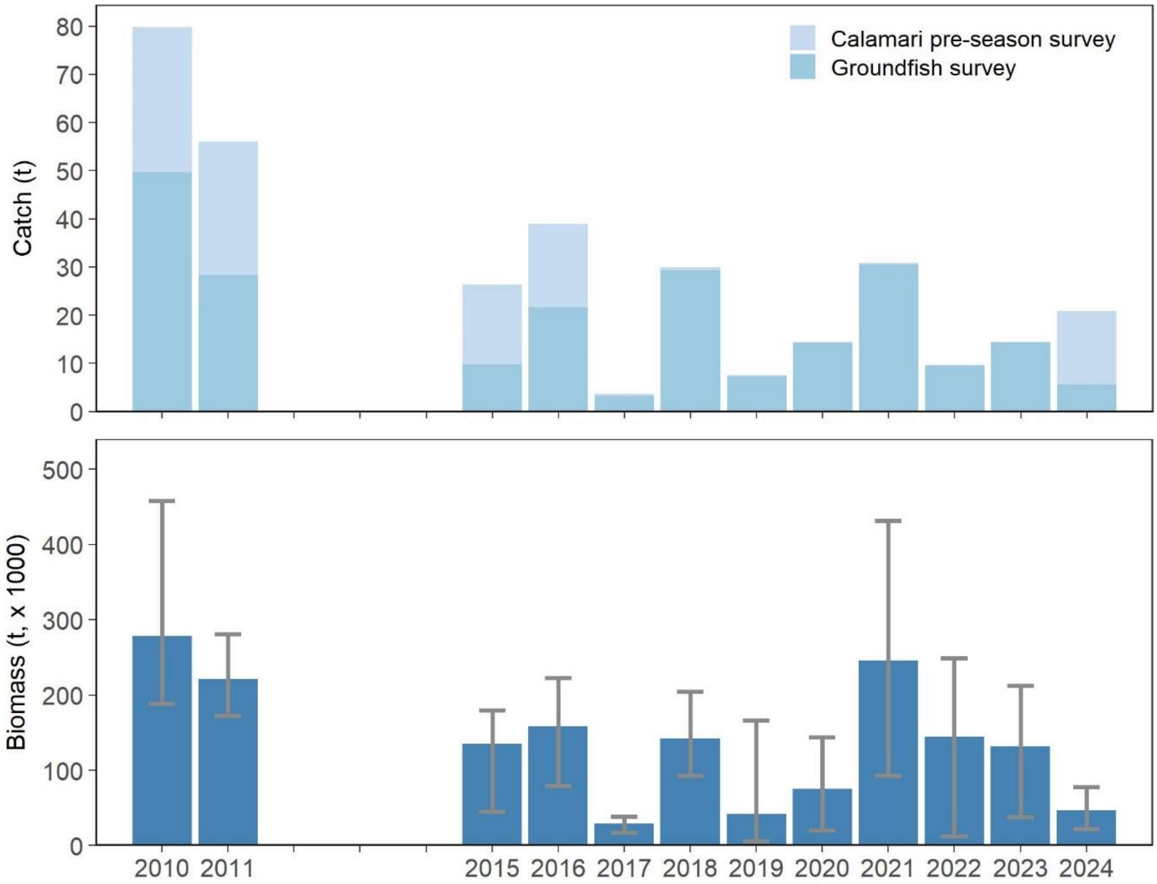

Fig. 11. Catch (t), and mean biomass (t) ± 95% confidence intervals of hoki (*Macruronus magellanicus*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

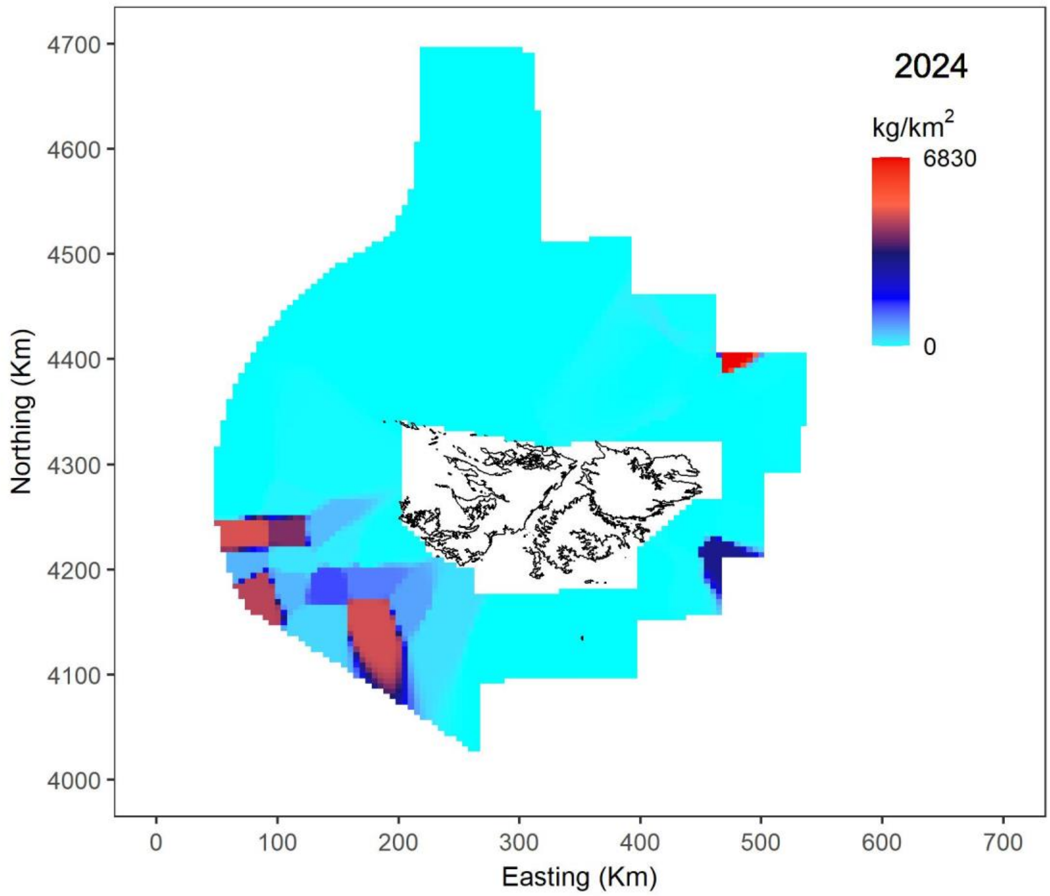

Fig. 12. Distribution and abundance of hoki (*Macruronus magellanicus*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

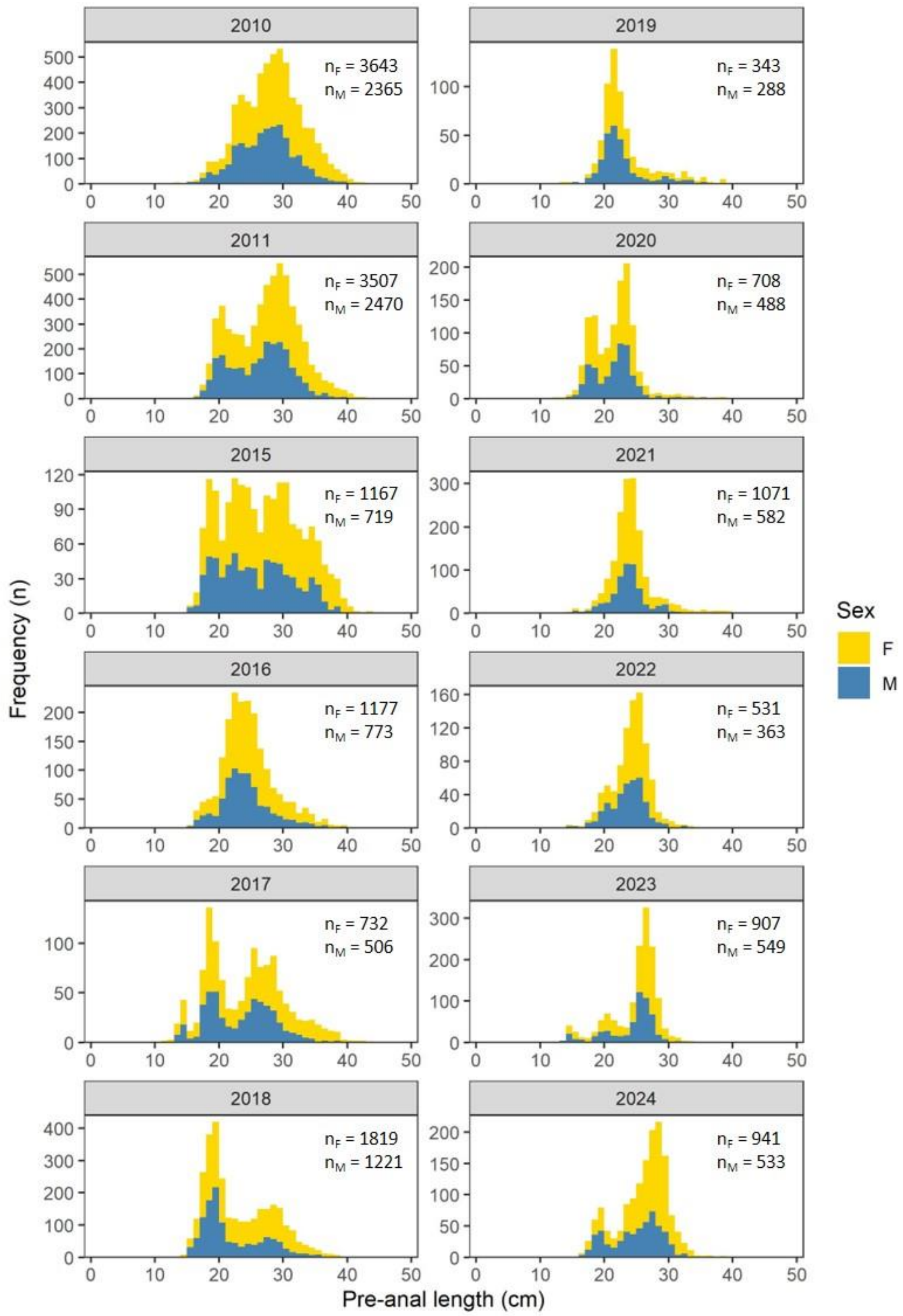

Fig. 13. Length frequency of hoki (*Macruronus magellanicus*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.5. Kingclip (*Genypterus blacodes*)

Most kingclip were caught in groundfish surveys (average of 94% of the total kingclip catch across years) compared with calamari pre-season surveys. The highest catch of kingclip occurred in 2015 (14.7 t), whereas the lowest catch in the time series occurred in 2022 (2.8 t). Kingclip catch in 2024 was reported at 5 t, below the average (6 t) of the time series (Fig. 14; Appendix II). Kingclip biomass in 2015 was the highest (76,722 t) in the time series, and the lowest biomass was calculated for 2020 (14,532 t). In 2024, the biomass of kingclip (16,597 t) was the third lowest and below the average (29,201 t) of the time series; kingclip biomass in 2024 was 78% of its biomass in 2010 (21,274 t) (Fig. 14; Table II). There was no statistically significant trend in biomass from 2010 to 2024 (Appendix IV).

In 2024, the highest density (2,525 kg/km^2) of kingclip occurred to the north-west near the limit of the FICZ; a small but highly dense aggregation was also detected to the north-east in the FICZ (Fig. 15). Throughout the time series, kingclip was dispersed around the FICZ and FOCZ, except for the south-east. The highest density in the time series was 32,777 kg/km^2 to the north-west in 2015 (Appendix X).

Length frequency histograms show a wide range of kingclip sizes across the time series, from 23 cm to 136 cm total length. In 2024, two length-groups were detected. The smaller length-group with modal length at about 61 cm total length, and the larger group with modal length at 80–84 cm total length; females were on average larger than males (Fig. 16).

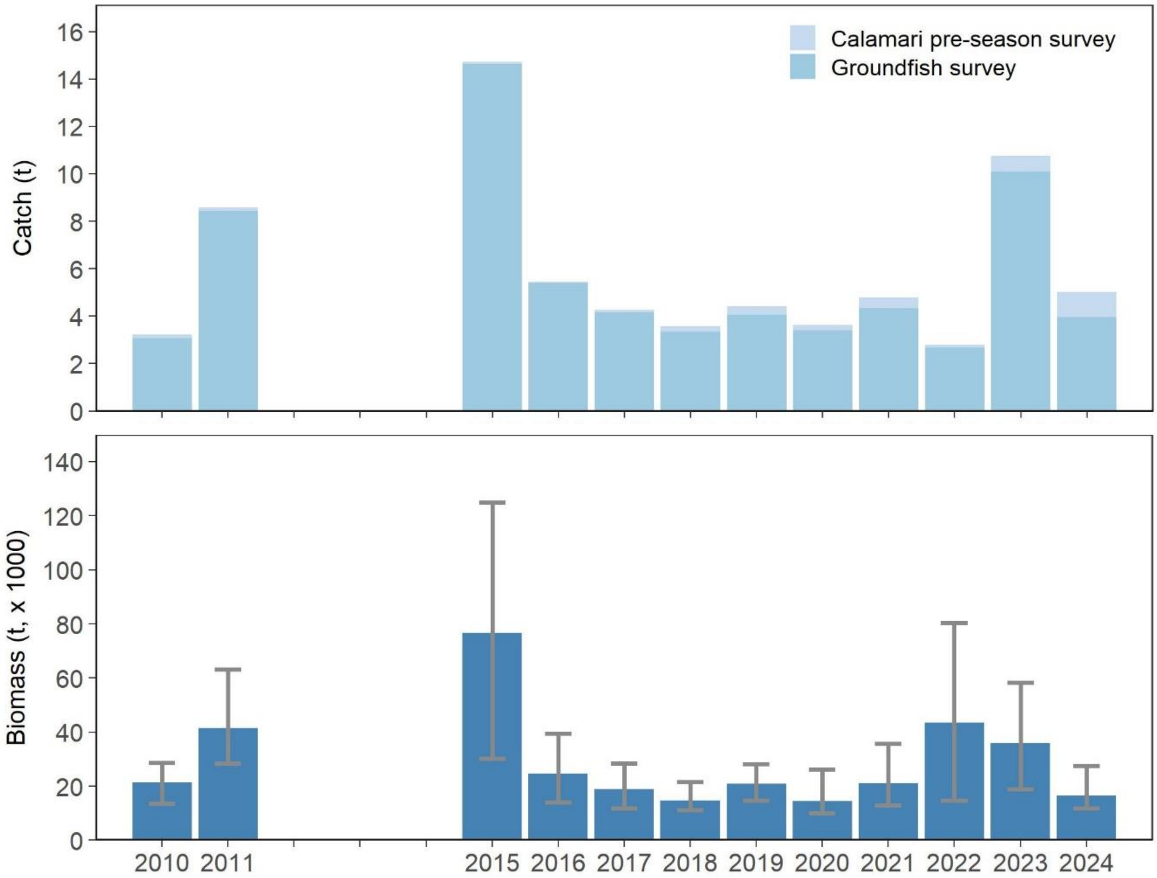

Fig. 14. Catch (t), and mean biomass (t) ± 95% confidence intervals of kingclip (*Genypterus blacodes*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

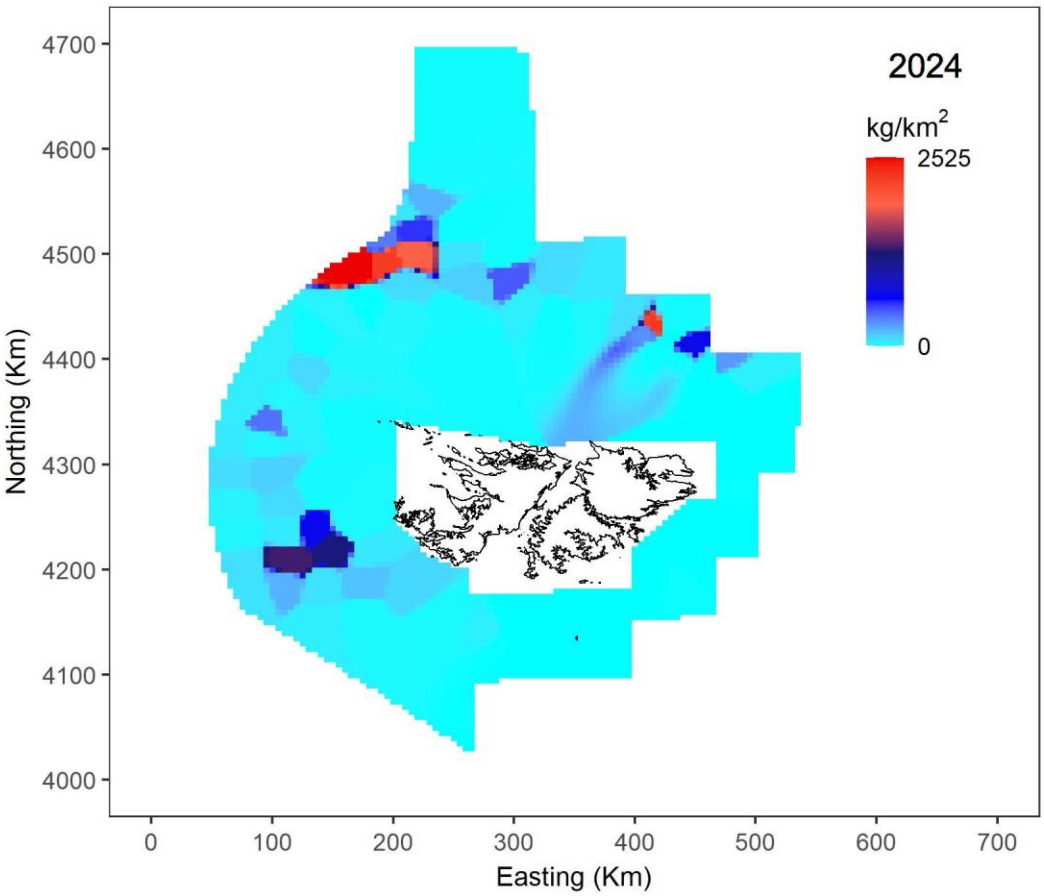

Fig. 15. Distribution and abundance of kingclip (*Genypterus blacodes*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

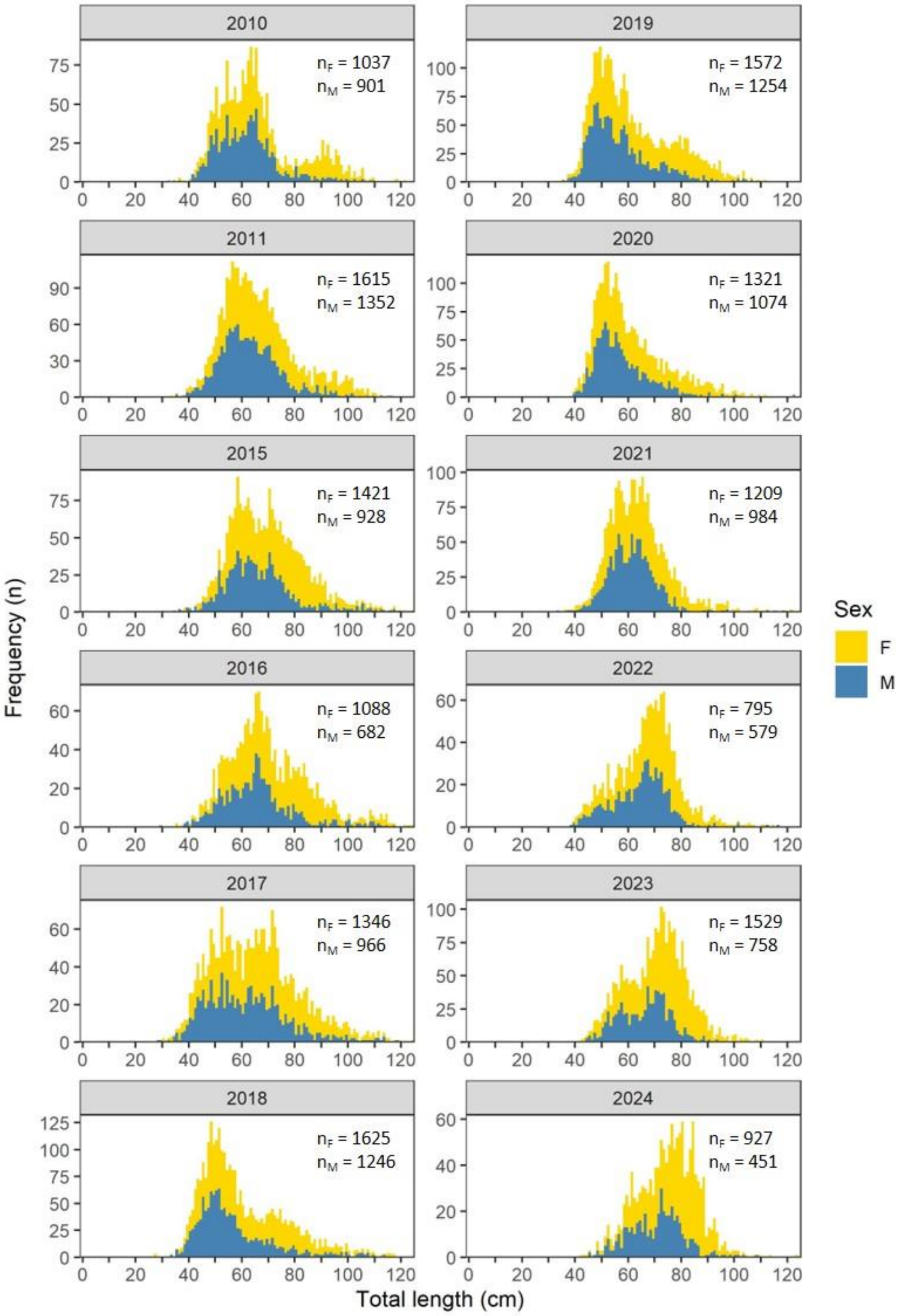

Fig. 16. Length frequency of kingclip (*Genypterus blacodes*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.6. Patagonian squid (*Doryteuthis gahi*)

On average, 98% of the total Patagonian squid catches were from calamari pre-season surveys. The highest total catch of Patagonian squid in the time series occurred in 2024 (683 t), due to high catches during the calamari pre-season survey (Fig. 17; Appendix II). The highest biomass in the time series was estimated in 2019 with 214,492 t, and the lowest was calculated for 2016 (41,293 t). The biomass in February 2024 (206,977 t) was the second highest in the time series and was above the average (135,081 t) of the time series, increasing for the fourth consecutive year since 2020 (Fig. 17; Table II). However, there was no statistically significant trend in biomass from 2010 to 2024 (Appendix IV).

Patagonian squid were mainly found to the south and south-east of East Falkland. In 2024, the maximum density was 28,499 kg/km^2 to the south of East Falkland (Fig. 18), and the highest density throughout the time series was reported in 2023 (Appendix XI).

Length-frequency histograms show a wide range of Patagonian squid sizes, from 2.5 cm to 36 cm, across the time series. Two length-groups were evident only in some years. In 2024, the modal length was at about 10 cm dorsal mantle length (Fig. 19).

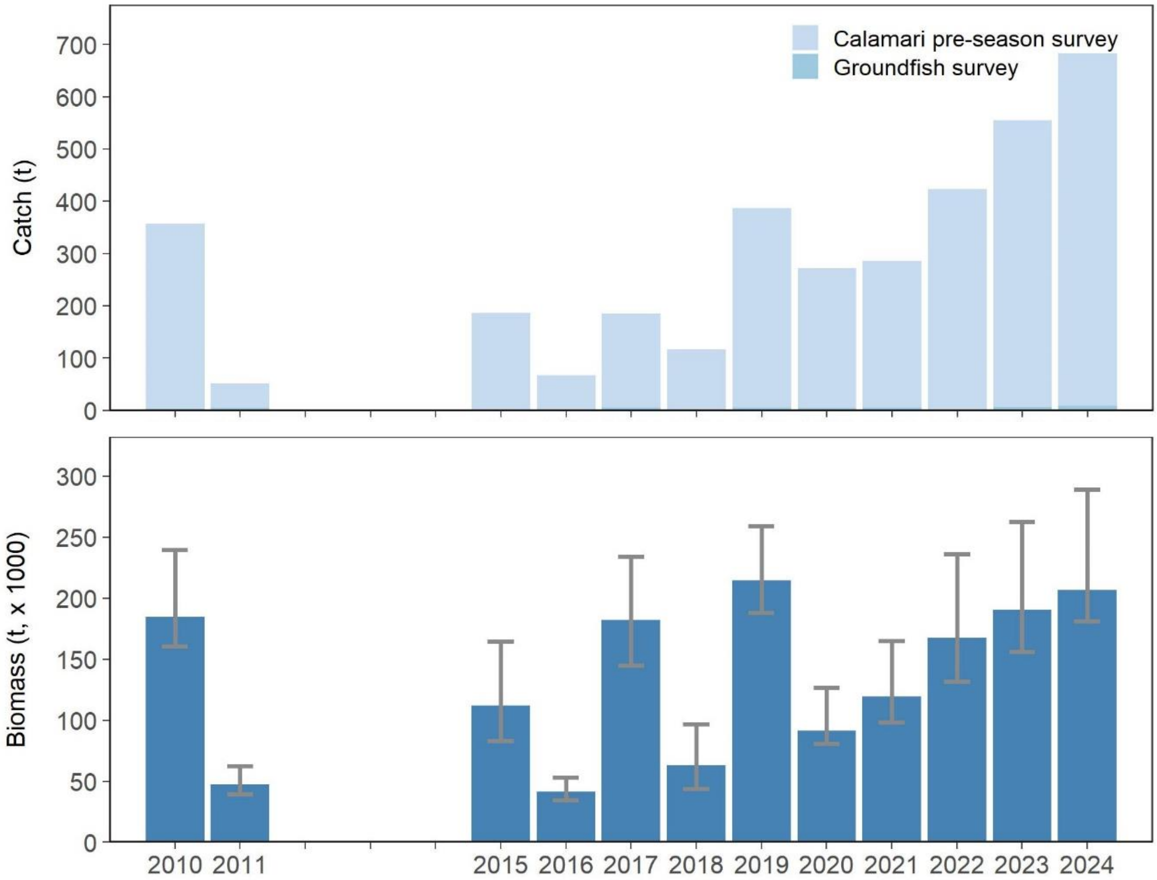

Fig. 17. Catch (t), and mean biomass (t) ± 95% confidence intervals of the Patagonian squid (*Doryteuthis gahi*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

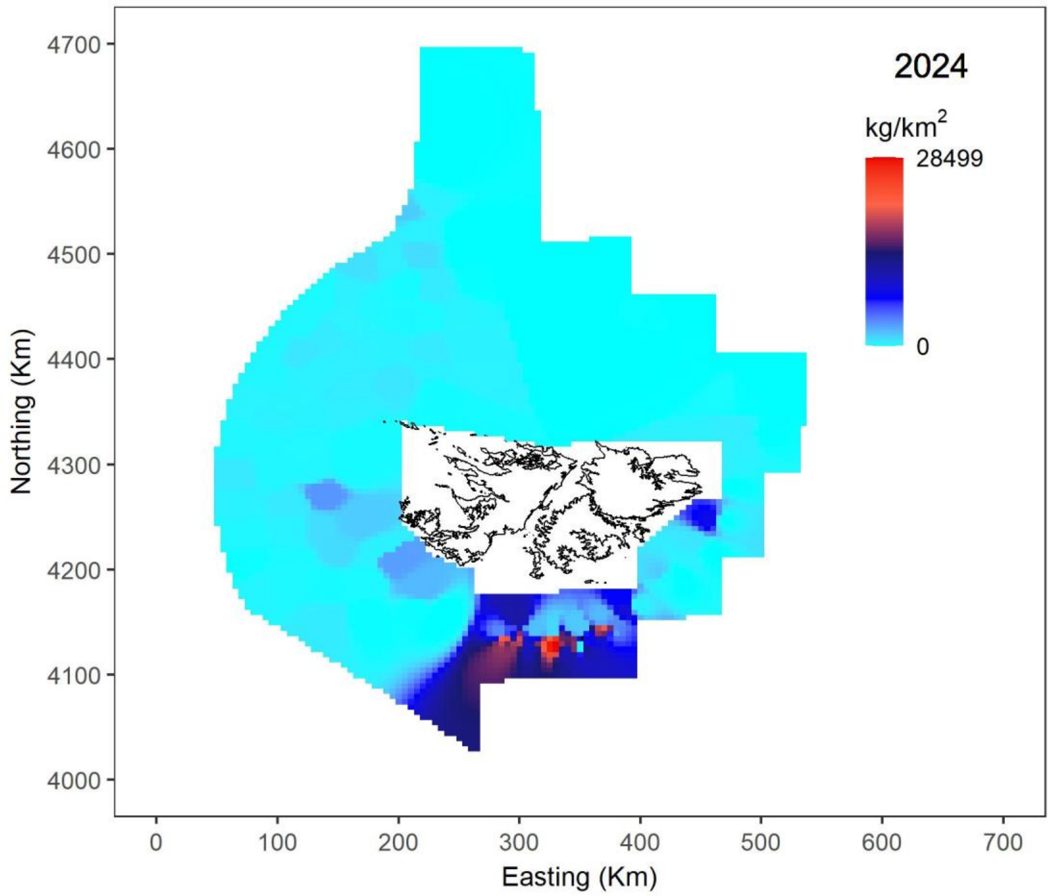

Fig. 18. Distribution and abundance of the Patagonian squid (*Doryteuthis gahi*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

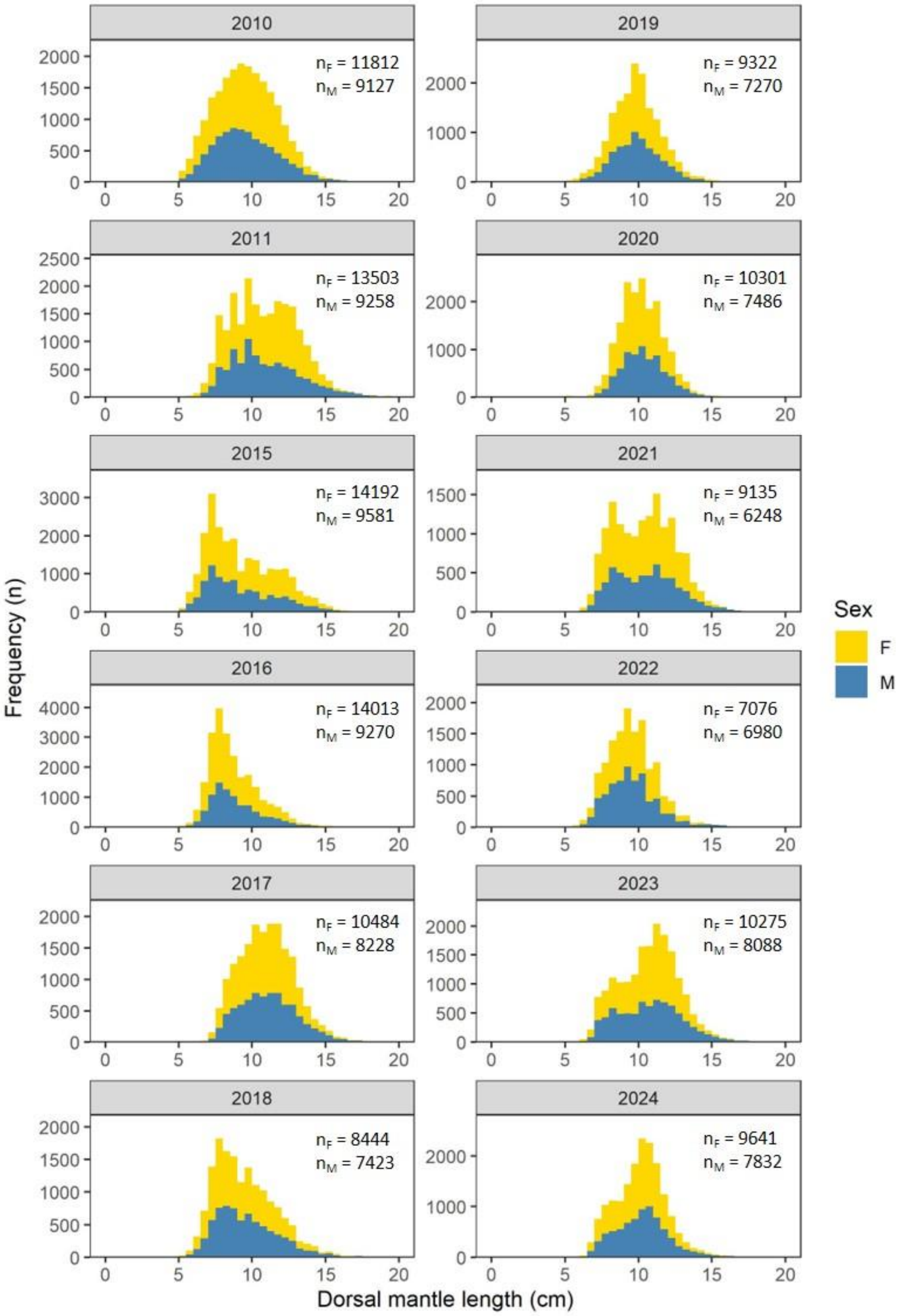

Fig. 19. Length frequency of the Patagonian squid (*Doryteuthis gahi*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.7. Red cod (*Salilota australis*)

Red cod was predominantly caught in groundfish surveys (average of 90% of the total red cod catch across years) compared with calamari pre-season surveys. Catches declined from 2011 and reached the lowest value in 2020 (3.7 t). Catches increased consecutively from 2020 to 2023, then declined again in 2024 (6.4 t), which was below the average (13 t) of the time series (Fig. 20; Appendix II). Red cod biomass was highest in 2011 (166,618 t). Biomass decreased the following years to 21,890 t in 2020, the lowest biomass calculated in the time series. In 2024, the biomass of red cod was calculated at 47,938 t, which is below the average (74,648 t) of the time series, and it was 50% of its biomass in 2010 (95,050 t) (Fig. 20; Table II). Biomass had a statistically significant declining trend from 2010 to 2020, but recent variability resulted in no statistically significant difference in biomass between 2010 and 2024 (Appendix IV).

In 2024, the highest densities occurred near the north-west limit of the FICZ (7,036 kg/km^2), although there were also high densities to the south-west in the FICZ (Fig. 21). Through the time series, red cod was found mainly along the west of West Falkland, and the highest density in the time series was 38,175 kg/km^2 in 2016 (Appendix XII).

Length frequency histograms show a wide range of red cod sizes across the time series (i.e., 4–85 cm total length) due to the presence of several length-groups. Poor recruitment to the fishery occurred in 2010, 2018, and since 2020; individuals recruited to the fishery had modal lengths between 15 cm and 19 cm total length across years. In 2024, three length-groups were detected. The modal lengths of the smaller, medium, and larger length-group were at about 17 cm, 26 cm, and 40–43 cm total length, respectively (Fig. 22).

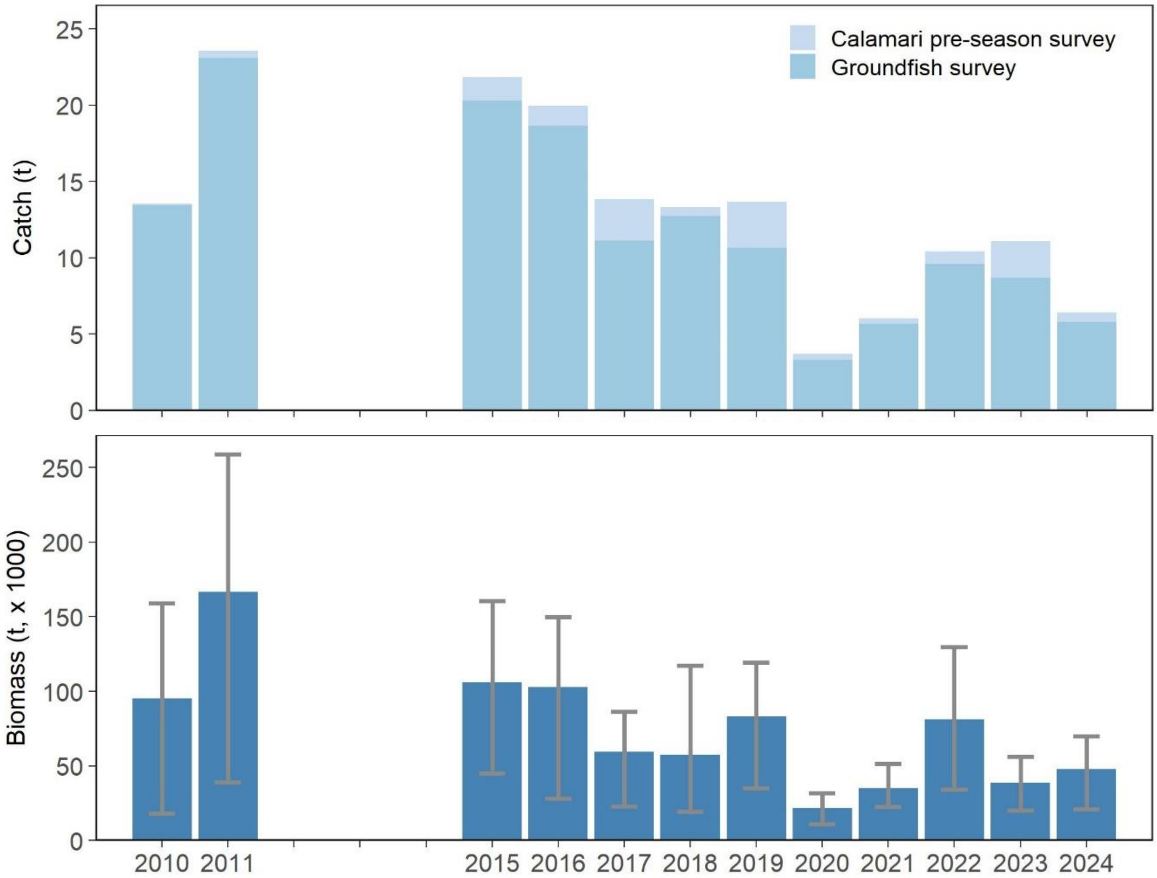

Fig. 20. Catch (t), and mean biomass (t) ± 95% confidence intervals of red cod (*Salilota australis*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

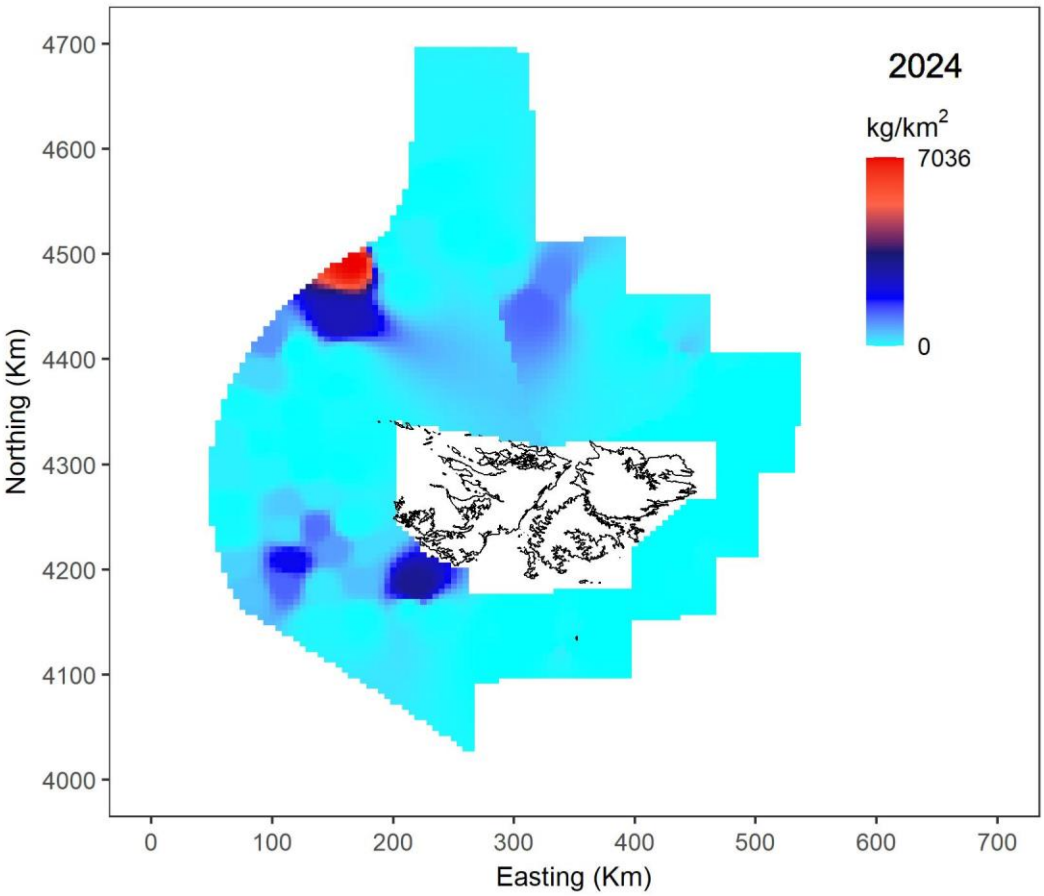

Fig. 21. Distribution and abundance of red cod (*Salilota australis*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

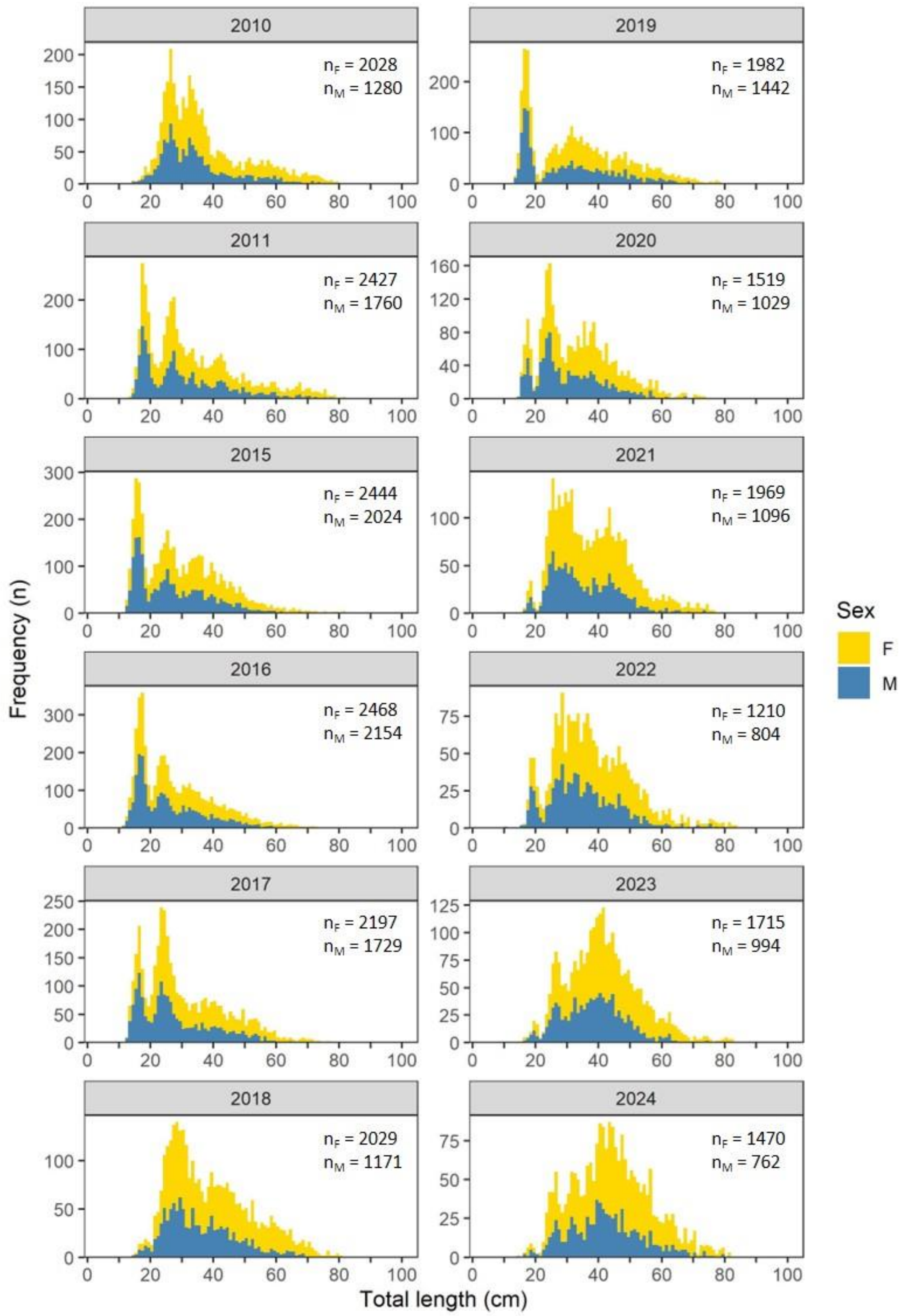

Fig. 22. Length frequency of red cod (*Salilota australis*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.8. Rock cod (*Patagonotothen ramsayi*)

Since 2011 the majority of rock cod have been reported from calamari pre-season surveys, with an average of 73%. The highest catch of rock cod was reported in 2011 (249.4 t) and the lowest catch in 2020 (11 t). A total of 169 t of rock cod were caught in 2024, which is the third highest and above the average (94 t) of the time series (Fig. 23; Appendix II). The biomass of rock cod in 2024 (122,995 t) is below the average (243,553 t) of the time series. Rock cod biomass had a statistically significant decline from 2010 (817,086 t) to 2024, with its biomass in 2024 being 15% of its biomass in 2010 (Fig. 23; Table II; Appendix IV).

In 2024, rock cod occurred in high densities (21,812 kg/km^2) to the north-west in the FICZ (Fig. 24). Rock cod had a patchy distribution around the Falkland Islands throughout the time series, and the highest density in the time series was calculated for 2011 to the north-east of East Falkland (602,147 kg/km^2; Appendix XIII).

Sizes of rock cod ranged widely throughout the time series (i.e., 4–43 cm). In some years, at least two length-groups were detected. In 2024, modal length was 13 cm total length for a smaller length-group and 19 cm total length for a larger length-group, with individuals smaller than in 2023 (Fig. 25). In 2024, 22 juveniles were collected in a range of sizes between 4.5 cm and 9 cm total length.

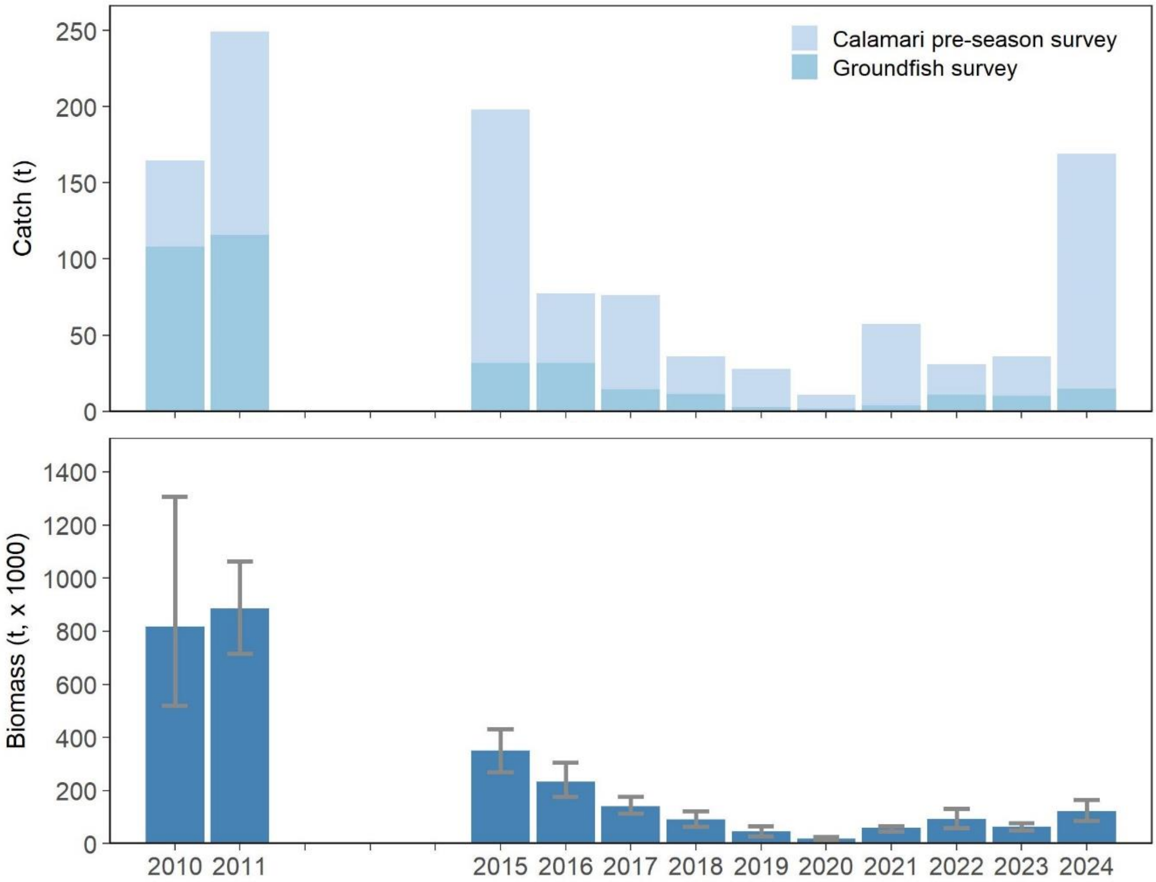

Fig. 23. Catch (t), and mean biomass (t) ± 95% confidence intervals of rock cod (*Patagonotothen ramsayi*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

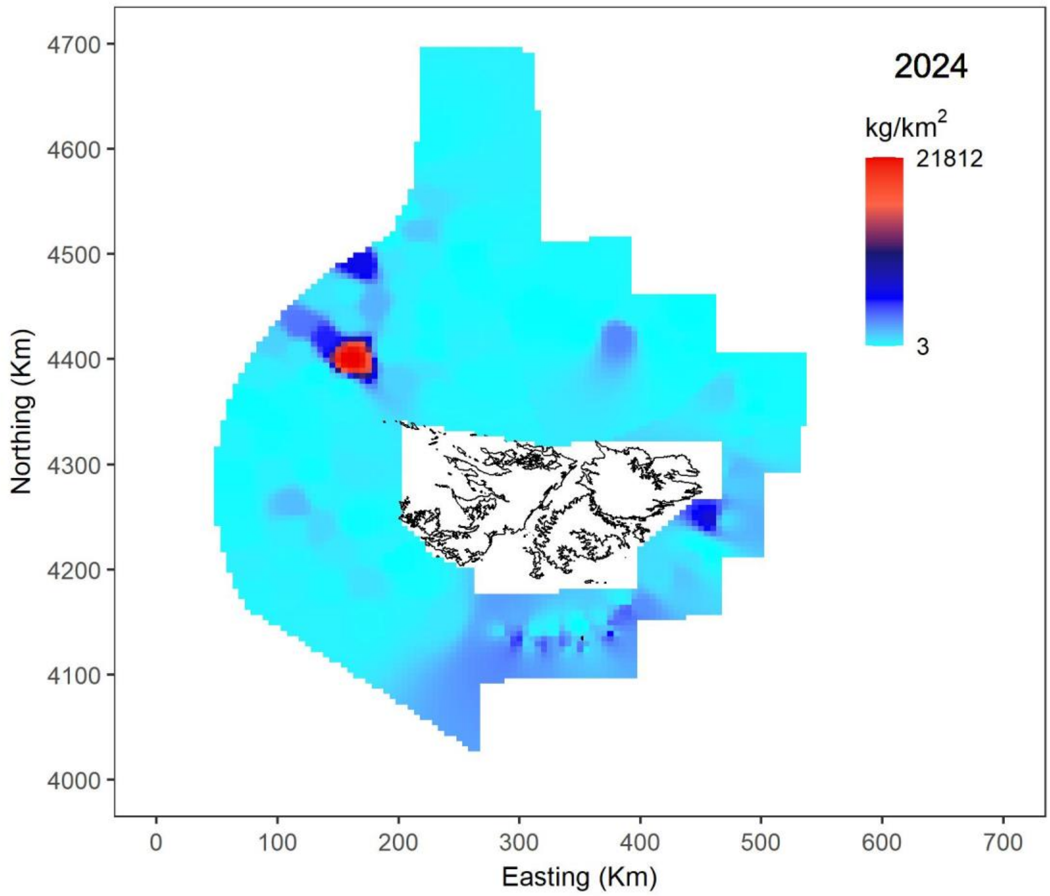

Fig. 24. Distribution and abundance of rock cod (*Patagonotothen ramsayi*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

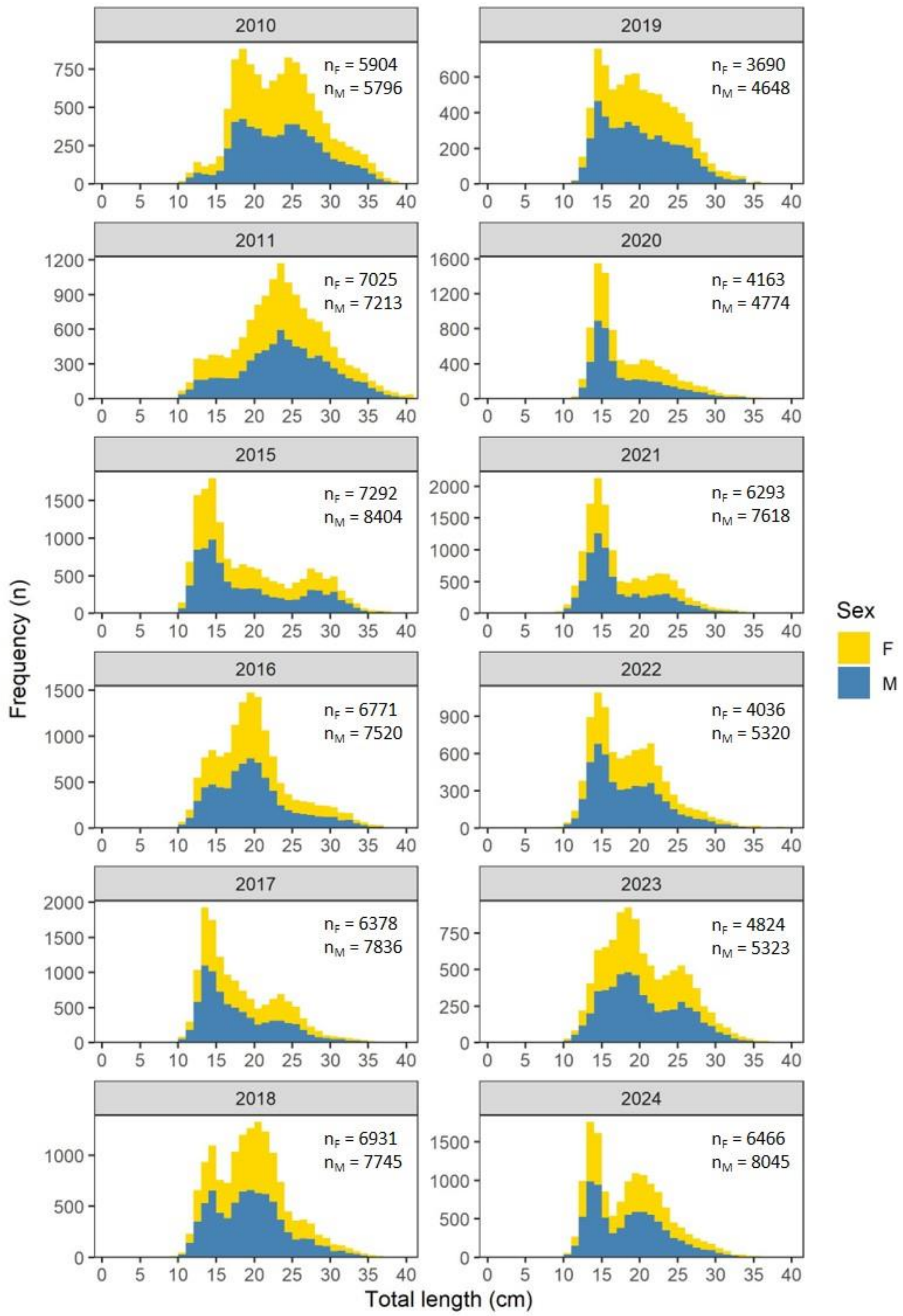

Fig. 25. Length frequency of rock cod (*Patagonotothen ramsayi*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.9. Southern blue whiting (*Micromesistius australis*)

Southern blue whiting were mainly caught in the calamari pre-season surveys compared with the groundfish surveys, at an average of 94% of the surveys' total southern blue whiting catch across years. The highest catch was reported in 2024 (119.8 t) and the lowest catch in 2022 (3.3 t), with the average being 32.9 t (Fig. 26; Appendix II). The highest biomass was estimated for 2011 (154,691 t), and the lowest biomass was estimated for 2020 (4,990 t). However, biomass increased since 2020, and was 67,202 t in 2024 (Fig. 26; Table II), which is above the average (52,937 t) of the time series. Southern blue whiting biomass in 2024 was 98% of its biomass in 2010 (68,447 t), and there was no significant difference in biomass between 2010 and 2024 (Appendix IV).

In 2024, southern blue whiting occurred to the south-west and to the east in the FICZ, with the highest density (47,812 kg/km^2) occurring to the north-east (Fig. 27). Throughout the time series, southern blue whiting occurred mainly to the south of the FICZ and to the north-east of East Falkland, with the highest density calculated for 2016 to the south of East Falkland (203,954 kg/km^2; Appendix XIV).

Southern blue whiting was caught in small numbers through the time series; total length ranged from 6 cm to 72 cm, and a small length-group with total length at 23–25 cm was present across years. In 2024, a total of 2,377 individuals were sampled, and allowed detecting three length-groups. The small group with modal length at 23 cm total length, the medium group with modal length at 30 cm total length, and the large length-group with modal length at 53 cm total length (Fig. 28).

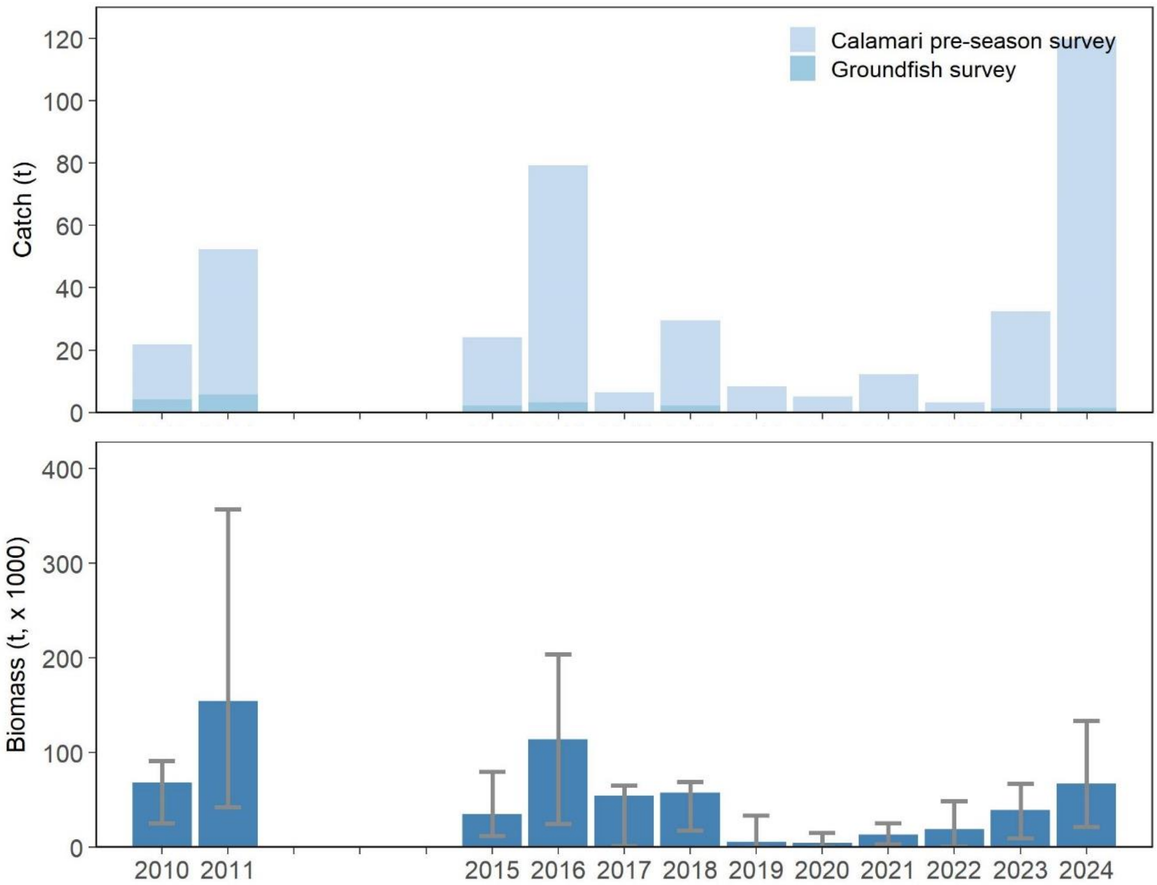

Fig. 26. Catch (t), and mean biomass (t) ± 95% confidence intervals of southern blue whiting (*Micromesistius australis*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

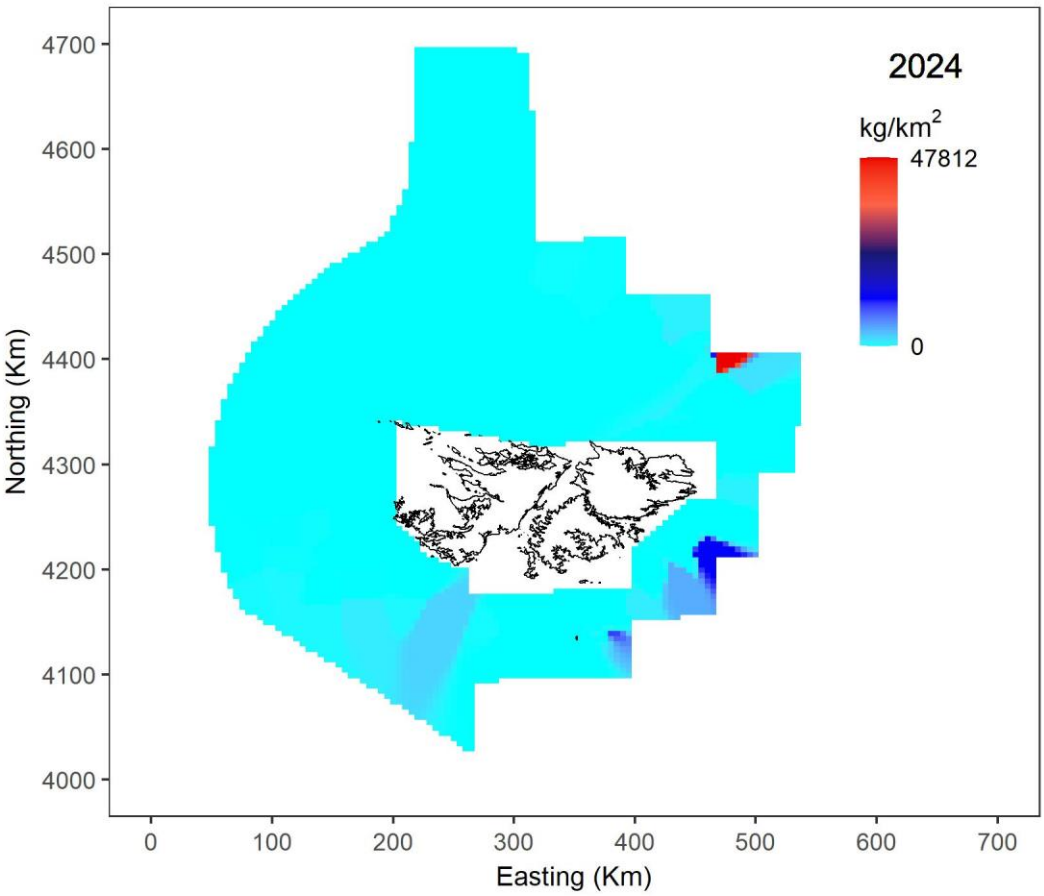

Fig. 27. Distribution and abundance of southern blue whiting (*Micromesistius australis*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

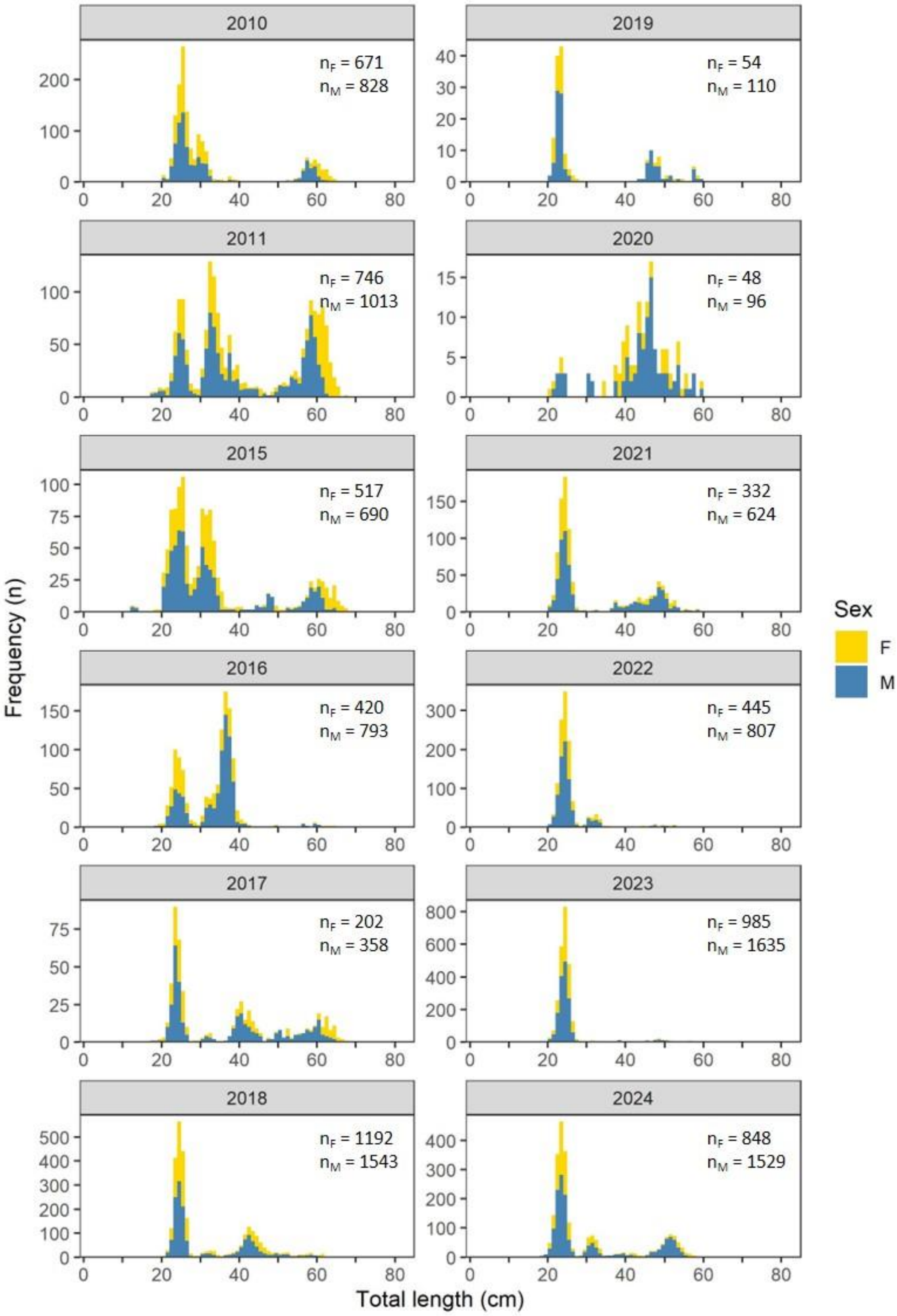

Fig. 28. Length frequency of southern blue whiting (*Micromesistius australis*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.10. Southern hake (*Merluccius australis*)

On average, 91% of the surveys' total southern hake catch was from the groundfish survey across years. The highest catch in the time series was reported in 2010 (822 kg) and the lowest catch was reported in 2019 (51 kg). A total of 321 kg of southern hake were caught in 2024, which is similar to the average (320 kg) of the time series (Fig. 29; Appendix II). The highest biomass was calculated for 2011 (5,224 t) and the lowest biomass was calculated for 2019 (426 t). The biomass of southern hake in February 2024 was calculated at 2,282 t, which is just above the average (2,162 t) of the time series; southern hake biomass in 2024 was 45% of its biomass in 2010 (5,097 t) (Fig. 29; Table II). Biomass decreased significantly from 2010 to 2020, and remained significantly below the maximum estimates as of 2024 (Appendix IV).

In 2024, the highest densities of southern hake were detected to the south-west of West Falkland (223 kg/km^2; Fig. 30), a consistent spatial distribution pattern through the time series. The highest density of southern hake was reported in 2011 (923 kg/km^2; Appendix XV).

Southern hake is caught in small numbers in Falkland Islands waters; hence the small number of samples. Length frequency histograms show range of sizes from 29 cm to 106 cm throughout the time series, with a modal length at approximately 65 cm total length for females (Fig. 31).

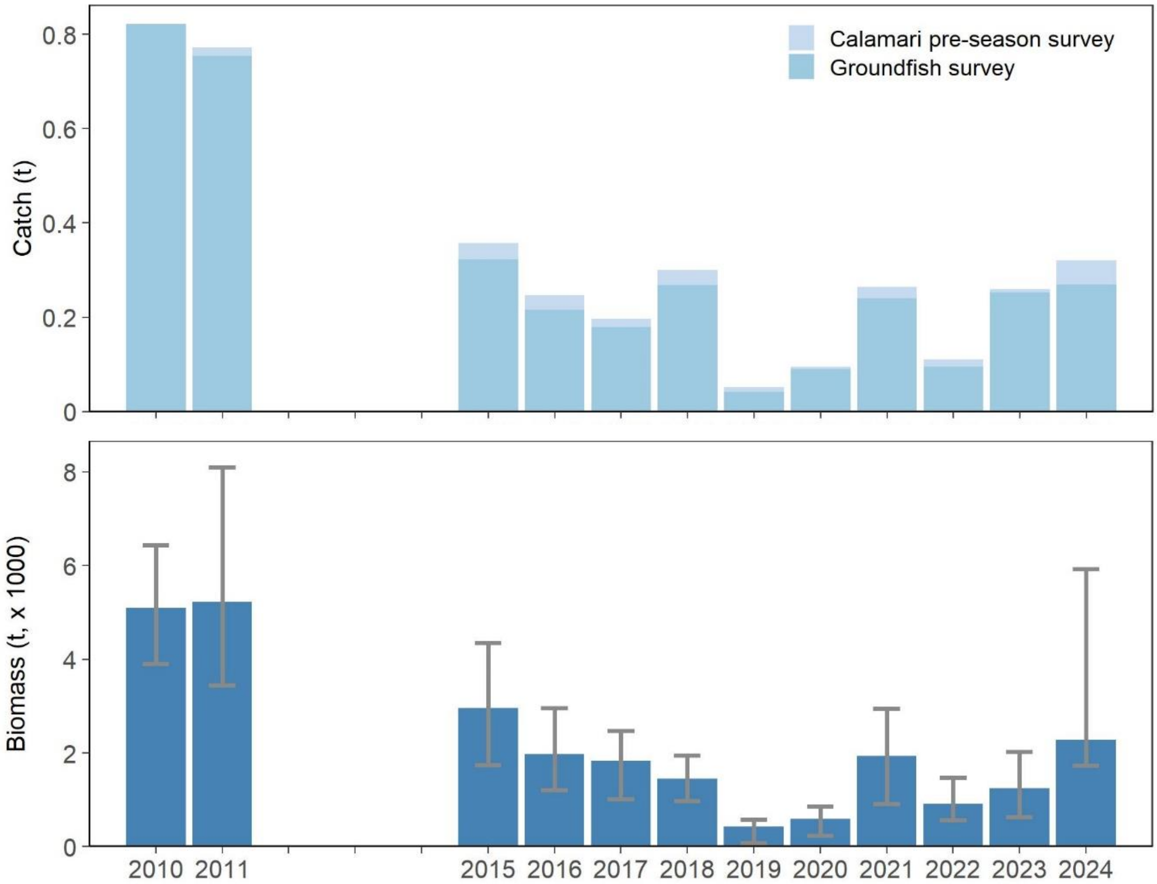

Fig. 29. Catch (t), and mean biomass (t) ± 95% confidence intervals of southern hake (*Merluccius australis*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

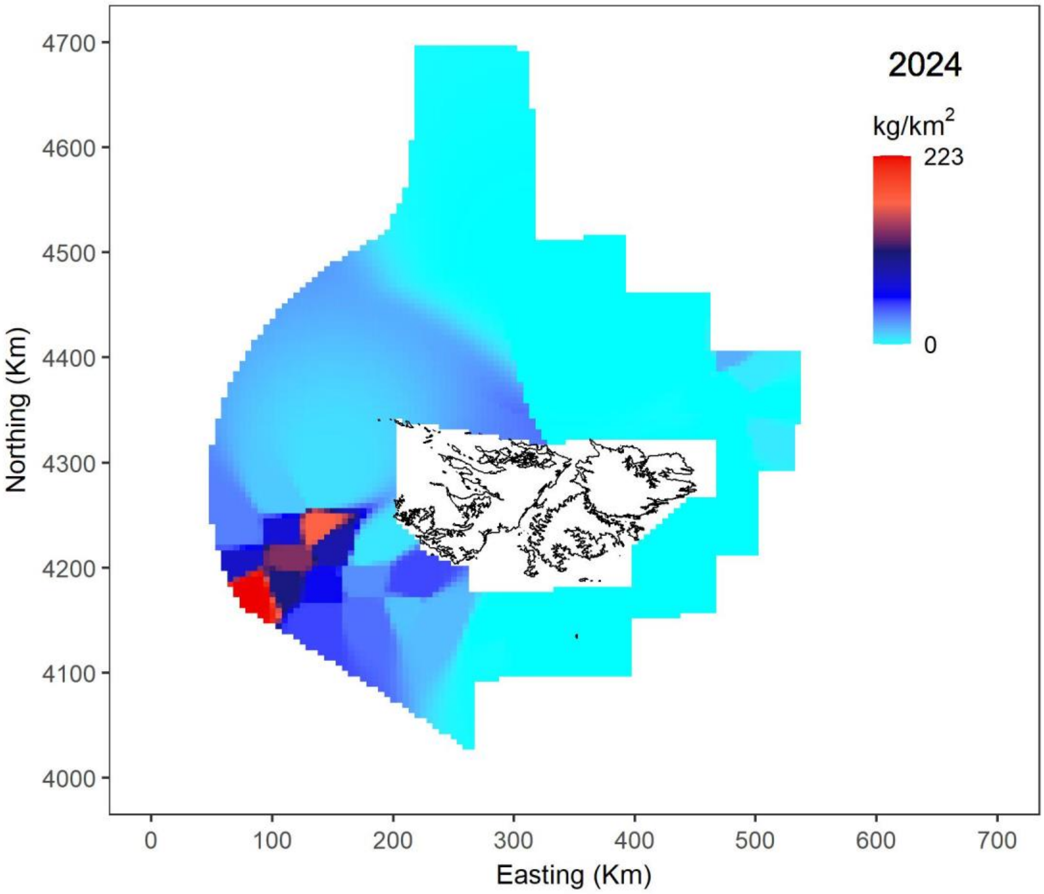

Fig. 30. Distribution and abundance of southern hake (*Merluccius australis*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

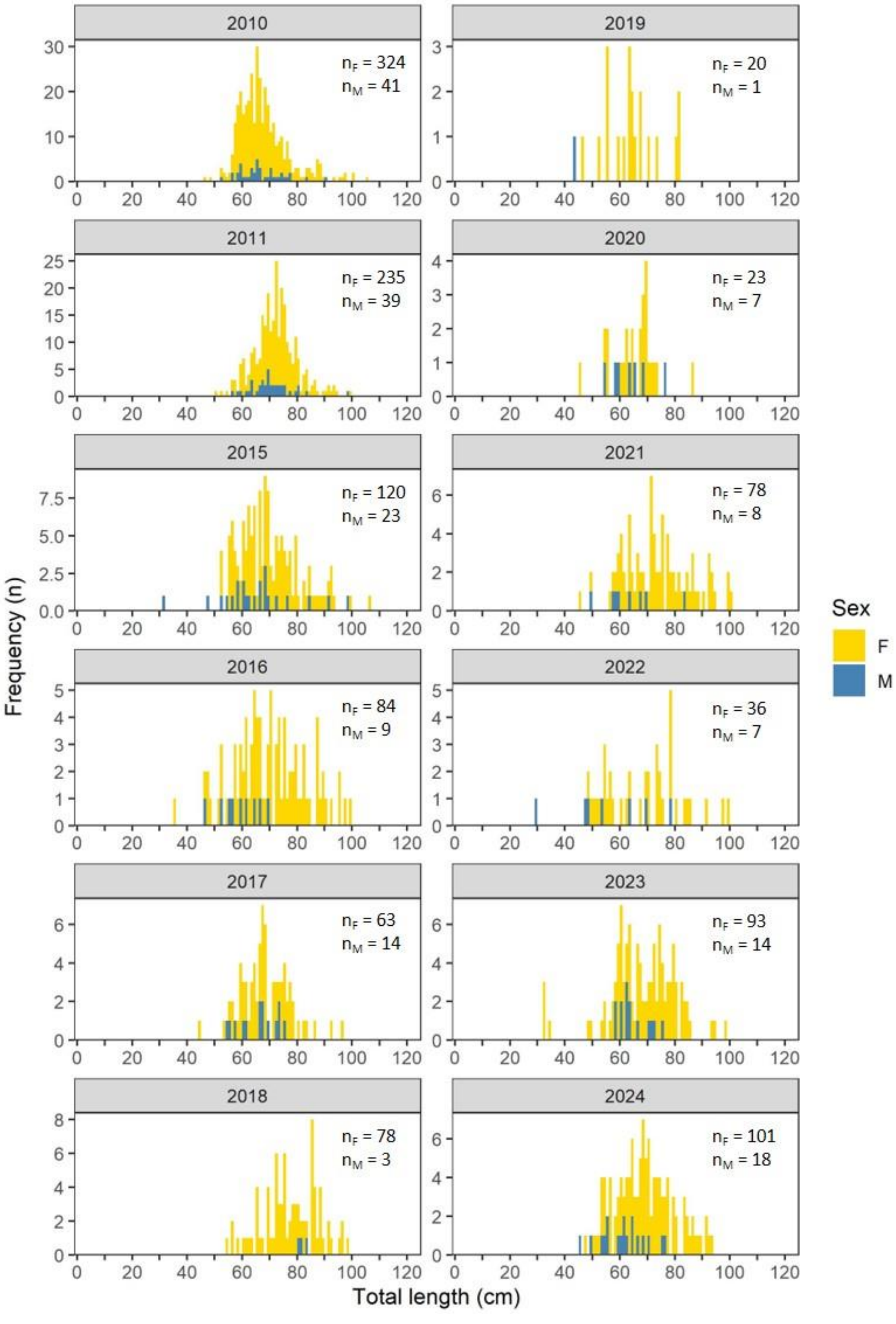

Fig. 31. Length frequency of southern hake (*Merluccius australis*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

4.2.11. Toothfish (*Dissostichus eleginoides*)

Adult toothfish are caught mainly using longline; therefore, the information provided in this report is not representative of the adult portion of the toothfish population.

The proportion of toothfish catches between groundfish and calamari pre-season surveys was variable across years but on average was 53% for calamari pre-season surveys and 47% for groundfish surveys. The maximum total catch was reported in 2017 (2.5 t) followed by 2011 (2.4 t), and the lowest catch was reported in 2022 (331 kg). The catch in 2024 was 1.6 t, which is just above the average (1.3 t) of the time series (Fig. 32; Appendix II). The highest biomass of toothfish was calculated for 2011 (10,588 t), and the lowest biomass was calculated for 2020 (2,499 t). In 2024, the biomass of toothfish was calculated at 4,285 t, below the average (6,151 t) of the time series, and it was 45% of its biomass in 2010 (9,492 t) (Fig. 32; Table II). However, there was no statistically significant trend in biomass from 2010 to 2024 (Appendix IV).

In 2024, the highest densities of toothfish were detected at scattered locations across the FICZ, with the largest aggregation to the south-west of West Falkland (152 kg/km^2; Fig. 33). Toothfish had a patchy distribution around the Falkland Islands through the time series, with the highest density reported in 2018 to the west and south-west of West Falkland (902 kg/km^2; Appendix XVI).

Length frequency histograms show that toothfish had a range of sizes from 5 cm to 115 cm throughout the time series, with several length-groups present. A small group had modal length at 30–36 cm total length in several years. However, the small numbers of small individuals suggest that recruitment has been low in recent years. Two length-groups were detected in 2024, the small length-group had modal length at 33 cm total length, and the larger length-group had a modal length at 45 cm total length (Fig. 34).

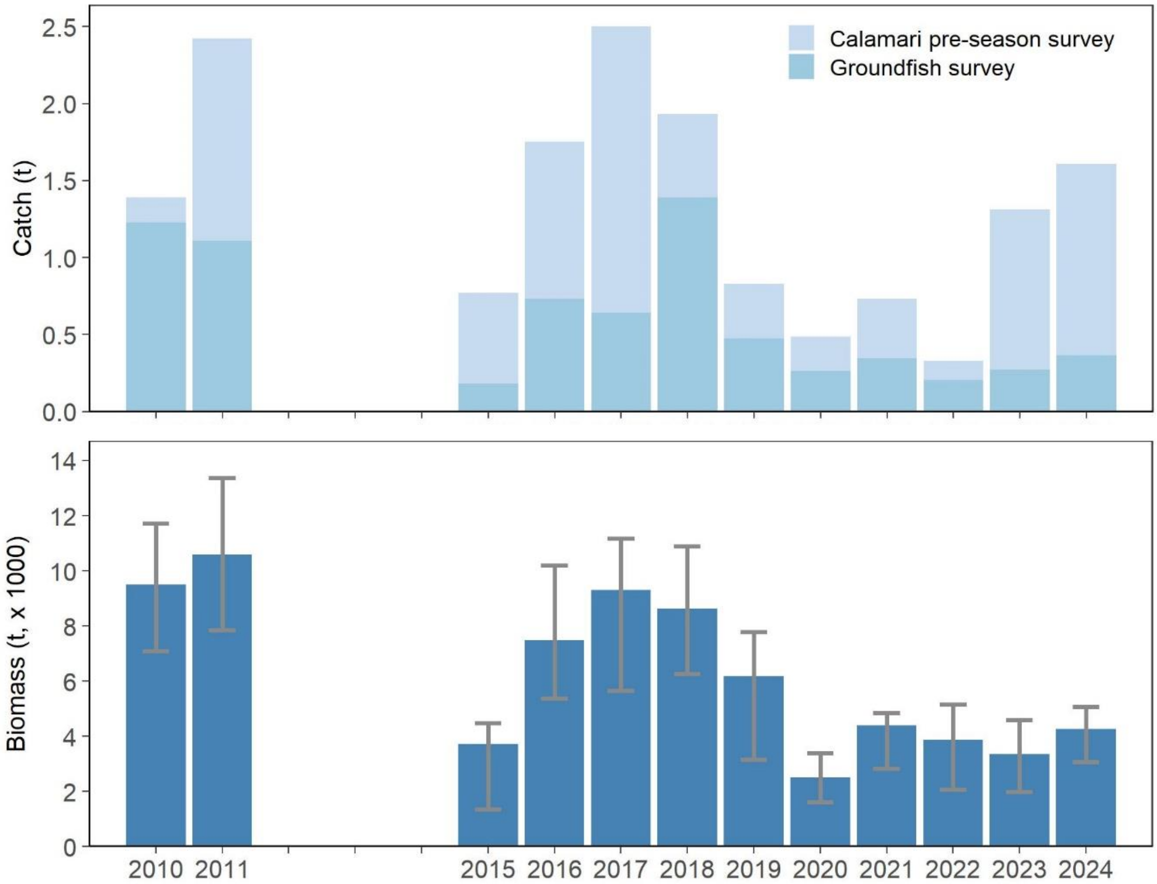

Fig. 32. Catch (t), and mean biomass (t) ± 95% confidence intervals of toothfish (*Dissostichus eleginoides*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

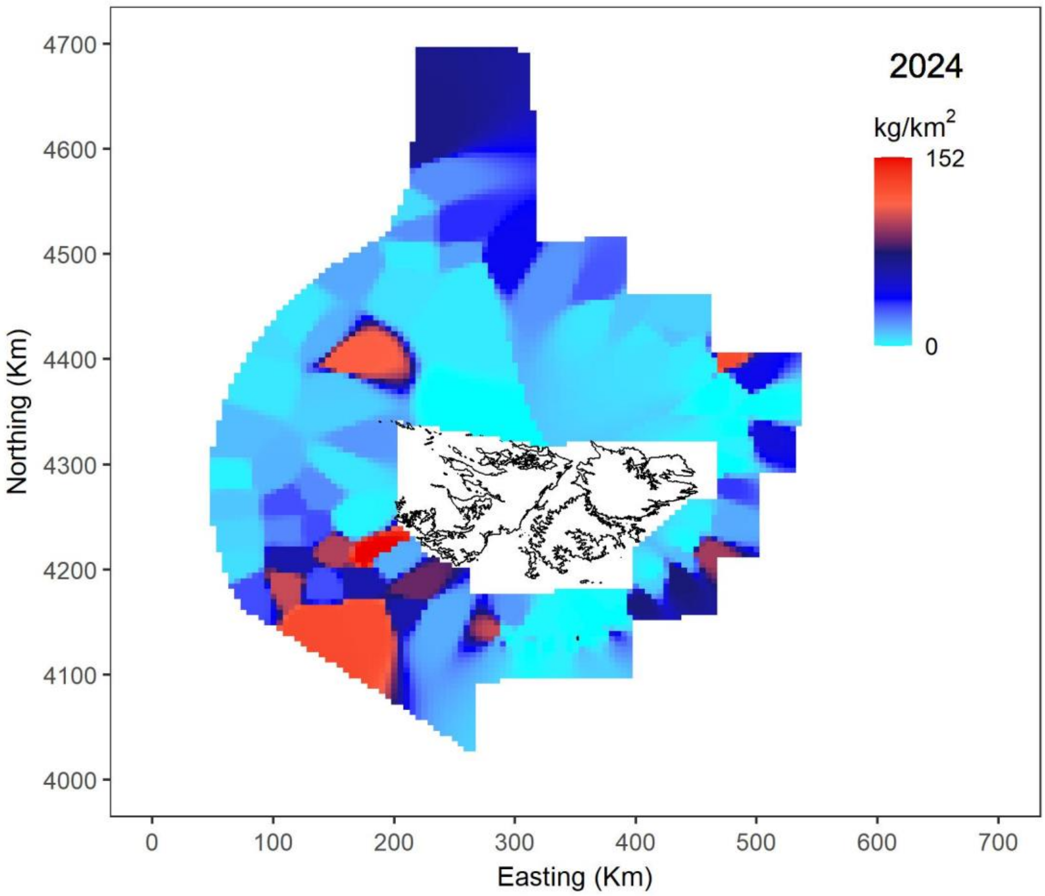

Fig. 33. Distribution and abundance of toothfish (*Dissostichus eleginoides*) calculated from the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

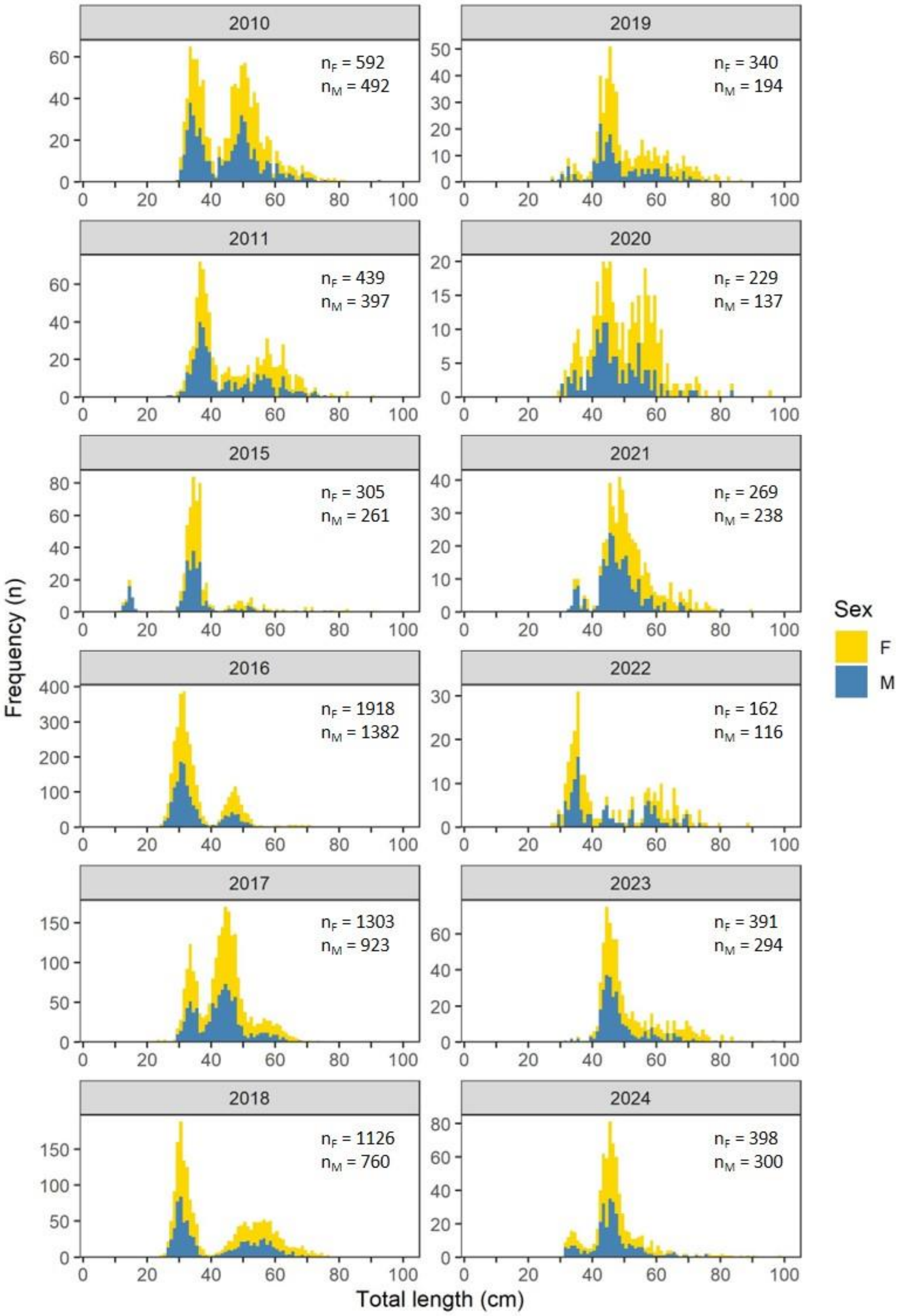

Fig. 34. Length frequency of toothfish (*Dissostichus eleginoides*) during the February groundfish and calamari pre-season surveys in Falkland Islands waters. Blue and yellow bars are superimposed.

5. Discussion

The biomasses of two commercial stocks calculated from the February parallel demersal surveys were statistically significantly lower in 2024 than in 2010: rock cod and southern hake. The lowest biomass levels of these two species were reached in 2019–2020. Rock cod had the greatest decrease in biomass from 2010 to 2024; its biomass in 2024 (122,995 t) was only 15% of its biomass in 2010 (817,086 t). Southern hake biomass in 2024 (2,282 t) was 45% of its biomass in 2010 (5,097 t).

Falkland Islands fisheries contribute a major proportion of the reported total catch of rock cod shared with Argentina in the Southwest Atlantic, i.e., 84% of the 10-year average catch of rock cod (Ramos & Winter 2023a), and pertinent management decisions made at FIFD are relevant for the sustainability of this stock. Commercial rock cod catches in Falkland Islands waters have decreased significantly since 2010 (Ramos & Winter 2023a), and the proportion of rock cod discarded has increased from an annual average of 14% over the period 2010–2015 to 70% from 2016 to 2023, with up to 94% discards reported in 2021 (Falkland Islands Government *unpublished data*). Rock cod are discarded in the commercial fishery because of their small size and most of these small individuals have not reproduced during their lifetime. Survival rates of discards are low, and the future growth and biomass of these individuals is therefore wasted. Discarding may also result in less certain stock assessments because discarded catch is often not reported accurately (Guillen et al. 2018).

Currently, rock cod is a permitted catch in finfish vessels and apart from a TAC there are no other conservation measures in any Falkland Islands fisheries (Falkland Islands Government 2023), including the Patagonian squid fishery that contributes most rock cod catches in Falkland Islands waters since 2016 (Ramos & Winter 2023a). Lack of conservation measures against the incidental catch and discard of juvenile individuals can affect the state of a fishery stock, and recruitment to the fishery (Gilman et al. 2020). The declining biomass trend of rock cod in February parallel demersal surveys is consistent with the declining biomass trend from 2005 to 2019 based on commercial data (Winter 2020), and with the declining trend of CPUE since 2011, which has stabilized at low levels since 2020 (Ramos & Winter 2023a). An apparent change in its geographic distribution inferred from increasing out-of-zone catches may also have contributed to the decrease in abundance of this stock in Falkland Islands waters from 2016 to 2018 (Winter 2021, Table A1).

Falkland Islands fisheries contribute a minor proportion of the southern hake shared catch with Argentina (Ramos & Winter 2022b), likely resulting in a smaller impact on the southern hake stock. Argentine shortfin squid, banded whiptail grenadier, common hake, hoki, kingclip, Patagonian squid, southern blue whiting, and toothfish did not have statistically significant trends from 2010 to 2024.

Consistent with the biomass pattern observed from February parallel demersal surveys across years, hoki stock assessment using data-poor methods such as LBB and OCOM found a declining biomass trend from 1987 to 2018, with the biomass calculated for 2018 being only 13% of the biomass calculated for 1987, and with no trend at low biomass levels in recent years (Ramos & Winter 2019). The recent levelling of hoki and southern blue whiting abundances may be a consequence of the establishment of a no-fishing area to the south and south-west of the Falkland Islands from 1 July to 15 October since 2007, mandated for S-licensed vessels targeting both southern blue whiting and hoki stocks (Falkland Islands Government 2024). Both stocks may have further benefited from reduced fishing pressure because of the S-licence not being used since 2017. Nevertheless, both stocks are targeted across several nations' Exclusive Economic Zones and the Falkland Islands contribute only a small proportion of the total shared catch in the Southwest Atlantic and Southeast Pacific. For instance, Falkland Islands fisheries contributed nearly 8% and 10% of the 10-year average catch of southern blue whiting and hoki respectively, shared with Argentina and Chile (Ramos & Winter 2022c, 2023b). Biomass declines of these stocks may in part be due to high fishing pressure outside Falkland Islands waters. Conservation measures still must be implemented, in particular for southern blue whiting, given that one of its spawning grounds is located to the south of the Falkland Islands (Shubnikov et al. 1969; Pájaro & Macchi 2001; Macchi et al. 2005).

A shift in fishing behaviour by finfish vessels (A–, G–, and W– licences), i.e., vessels fishing deeper and further south in the FICZ to capture ridge scaled rattail *Macrourus carinatus*, led the finfish fishery to catch more toothfish in 2016–2017, and catches declined again since 2018 (Falkland Islands Government 2024). The FIFD has made efforts to search for juvenile toothfish during austral spring or summer, by juvenile toothfish surveys (e.g., Pompert et al. 2015; Arkhipkin et al. 2017; Lee et al. 2018) or by including four inshore stations in February groundfish surveys (e.g., see Arkhipkin et al. 2019; Randhawa et al. 2020; Trevizan et al. 2021). In the February groundfish surveys, toothfish smaller than 20 cm total length (ages ≤ 1) have been scarce through the time series (n_{2010} = 0; n_{2011} = 60; n_{2015} = 237; n_{2016} =

57; n_{2017} = 109; n_{2018} = 0; n_{2019} = 1; n_{2020} = 2; n_{2021} = 26; $n_{2022\text{-onwards}}$ = 0); however, it must be noted that juvenile toothfish were not systematically searched for at least during the February 2010, 2011, and 2022–2024 surveys. Nevertheless, higher numbers of juveniles found in the February 2015 and 2017 surveys are consistent with higher recruitment in 2015 and 2017, with persistent recruitment hotspots for newly-settled toothfish found to the north-west in the FICZ, along with opportunistic areas to the north-east (2015), north (2016), and south (2017), coinciding with the main areas of upwelling and high productivity. The state of toothfish recruitment has remained low apart from 2015 and 2017; during years of low recruitment, juvenile toothfish are largely constrained to sheltered inshore regions to the north-west of the Falkland Islands (Lee et al. 2021). Juveniles of other species are recorded and measured opportunistically, but are not currently the objective of a systematic study.

The algorithm for calculating biomass estimates was adjusted in 2022 (see Methods, and Appendices II and III in Ramos & Winter 2022a) to give more effective weighting to survey trawls that are shortened but nevertheless valid, and therefore not excluded from analyses. Shortened but valid trawls occurred in several years, and can affect biomass estimation especially of species that have strongly aggregated distributions. For example, the hoki biomass estimate was particularly high in February 2021 due to the exceptionally large catch of this species on station 3362 of the groundfish survey, which had to be ended after just 20 minutes to avoid overloading the net (Ramos & Winter 2021; Trevizan et al. 2021). This trawl was valid as the gear was not defective, and the schooling behaviour of hoki makes such a high localized density realistic, but the influence of this one trawl on the overall biomass estimate needed to be down-weighted. An additional adjustment was applied to the February 2022 groundfish survey, which had only 42 trawl stations instead of the usual average 87 stations due to quarantine requirements. This adjustment for 2022 (only) provided a more realistic output of the biomass estimation uncertainties in shortened surveys.

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Appendix I. February surveys summary

February groundfish (gf) and calamari pre-season (pr) surveys information. Catches per survey and combined total include Argentine shortfin squid, banded whiptail grenadier, common hake, hoki, kingclip, Patagonian squid, red cod, rock cod, southern blue whiting, and toothfish.

Year	Vessel		No. of trawls			Stations excluded		Catch (t)		
	gf	pr	gf	pr	total	gf	pr	gf	pr	total
2010	Castelo (ZDLT1)	Beagle F.I. (ZDLZ)	87	55	142	478, 501	NA	194.24	457.99	652.2
2011	Castelo (ZDLT1)	Venturer (ZDLP1)	88	58	146	NA	NA	196.05	257.28	453.3
2015	Castelo (ZDLT1)	Baffin Bay (MSPL9)	89	57	146	NA	NA	121.35	392.82	514.2
2016	Castelo (ZDLT1)	Sil (ZDLR1)	90	56	146	NA	638	87.32	206.62	293.9
2017	Castelo (ZDLT1)	Argos Vigo (ZDLU1)	90	58	148	2328	1002	47.35	254.29	301.6
2018	Monteferro (ZDLM3)	Castelo (ZDLT1)	97	59	156	143,144,156,164,183	NA	80.91	169.47	250.4
2019	Monteferro (ZDLM3)	Argos Cíes (ZDLS3)	79	52	135	240,242,244,246	25,29,37	45.09	418.44	463.5
2020	Castelo (ZDLT1)	Argos Cíes (ZDLS3)	80	59	139	NA	NA	47.89	283.83	331.7
2021	Castelo (ZDLT1)	Capricorn (ZDLY)	80	55	135	3388,3391,3392,3393	NA	74.67	347.85	422.5
2022	Castelo (ZDLT1)	Argos Cíes (ZDLS3)	42	60	102	NA	NA	45.61	445.51	491.1
2023	Castelo (ZDLT1)	Igueldo (ZDLE1)	84	61	105	NA	1174	67.63	610.63	678.3
2024	Castelo (ZDLT1)	New Polar (ZDLF2)	84	64	148	NA	NA	66.26	966.15	1032.4

Appendix II. February surveys catches

Catches (t) of main commercial species during the February 2010–2011, and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.

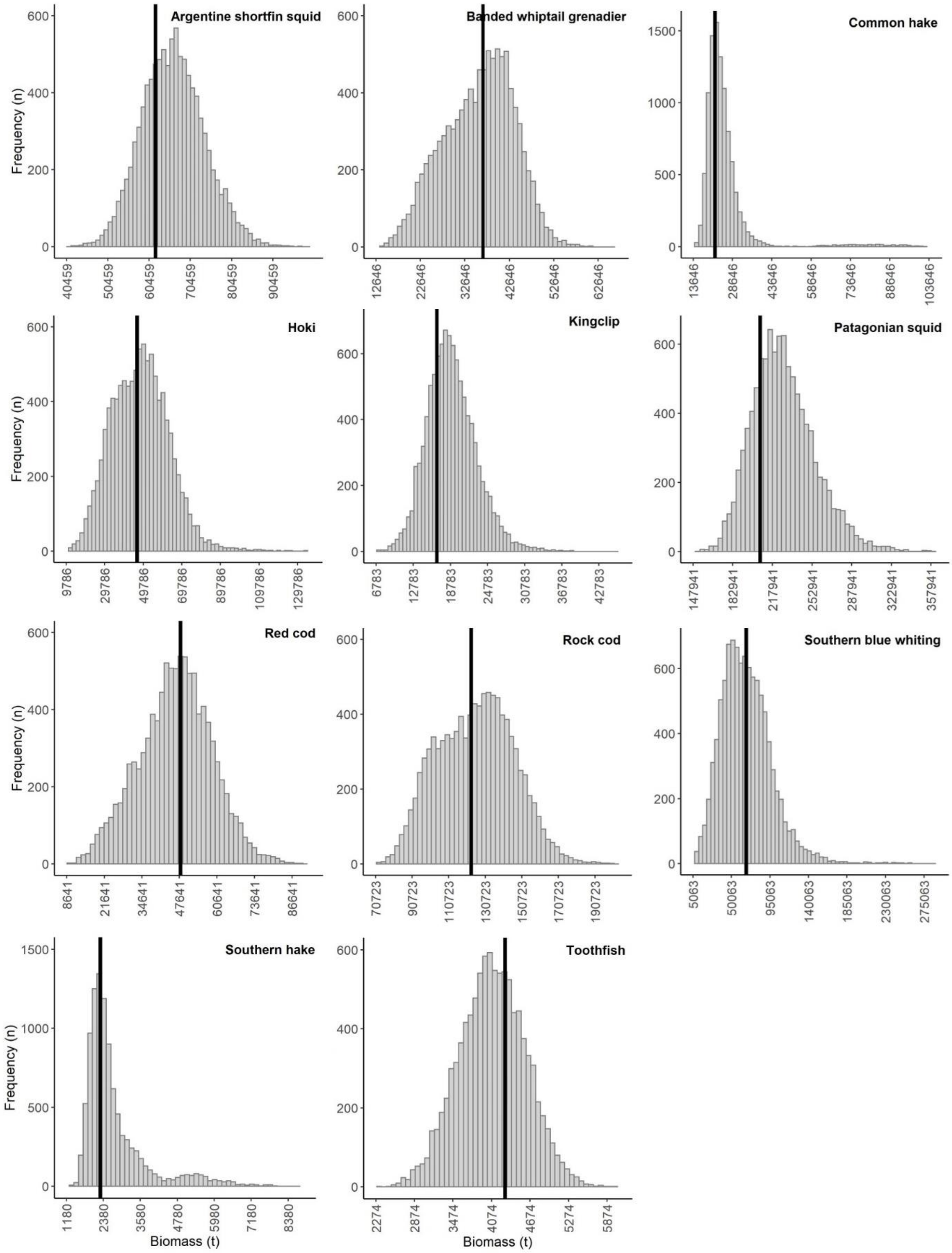
Year	Argentine shortfin squid	Banded whiptail grenadier	Common hake	Hoki	Kingclip	Patagonian squid	Red cod
2010	0.88	8.05	1.31	79.78	3.24	356.76	13.54
2011	1.95	6.20	1.67	56.00	8.59	50.51	23.54
2015	31.87	6.58	3.17	26.36	14.73	186.14	21.81
2016	0.10	3.28	0.69	38.92	5.45	66.90	19.95
2017	2.49	3.97	2.94	3.70	4.26	185.23	13.82
2018	10.70	7.54	1.73	30.02	3.59	115.84	13.30
2019	9.41	2.51	2.75	7.55	4.42	386.02	13.68
2020	17.92	2.62	0.73	14.38	3.63	272.08	3.71
2021	10.31	6.53	8.15	30.83	4.79	285.54	6.04
2022	0.78	4.50	5.65	9.71	2.79	422.74	10.41
2023	3.22	5.11	8.59	14.41	10.76	554.94	11.07
2024	16.51	3.93	6.11	20.84	5.03	682.71	6.41
Total	106.12	60.81	43.49	332.5	71.26	3,565.41	157.28
Mean	8.84	5.07	3.62	27.71	5.94	297.12	13.11

Appendix II. *continued*

Year	Rock cod	Southern blue whiting	Southern hake	Toothfish	Total	Mean
2010	164.59	21.87	0.82	1.39	652.23	59.29
2011	249.38	52.29	0.77	2.42	453.33	41.21
2015	198.27	24.12	0.36	0.77	514.17	46.74
2016	77.31	79.36	0.25	1.75	293.94	26.72
2017	76.13	6.41	0.20	2.50	301.63	27.42
2018	35.92	29.51	0.30	1.93	250.38	22.76
2019	27.93	8.38	0.05	0.83	463.53	42.14
2020	10.98	5.10	0.10	0.49	331.72	30.16
2021	57.16	12.17	0.26	0.73	422.51	38.41
2022	30.82	3.27	0.11	0.33	491.11	44.65
2023	36.21	32.39	0.26	1.31	678.26	61.66
2024	169.71	119.80	0.32	1.61	1,032.41	93.86
Total	1,133.87	394.66	3.80	16.06		
Mean	94.49	32.89	0.32	1.34		

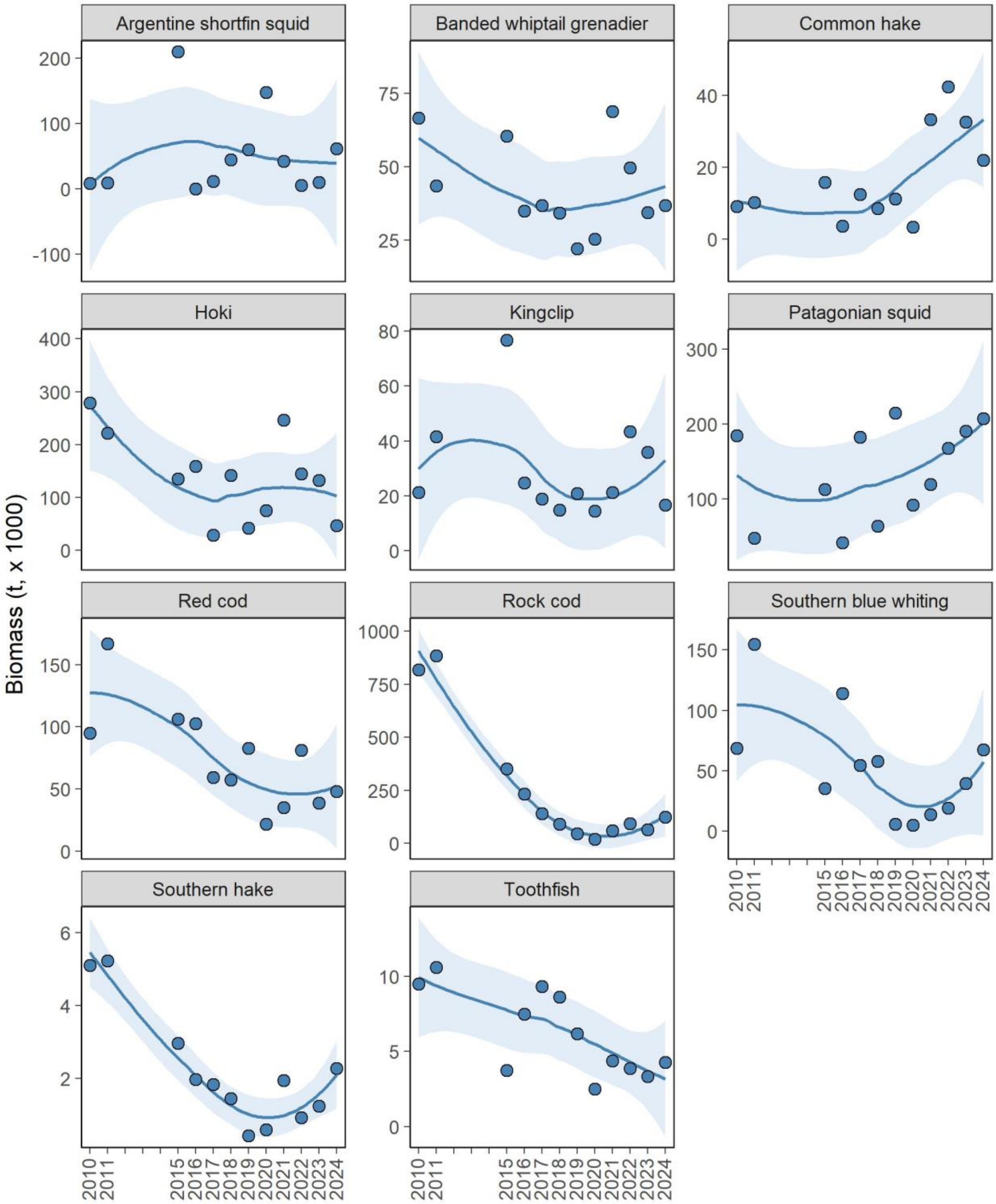
Appendix III. February 2024 biomass bootstrap histograms

Deterministic biomass (indicated by the vertical black line) and 10,000 bootstrap iterations.



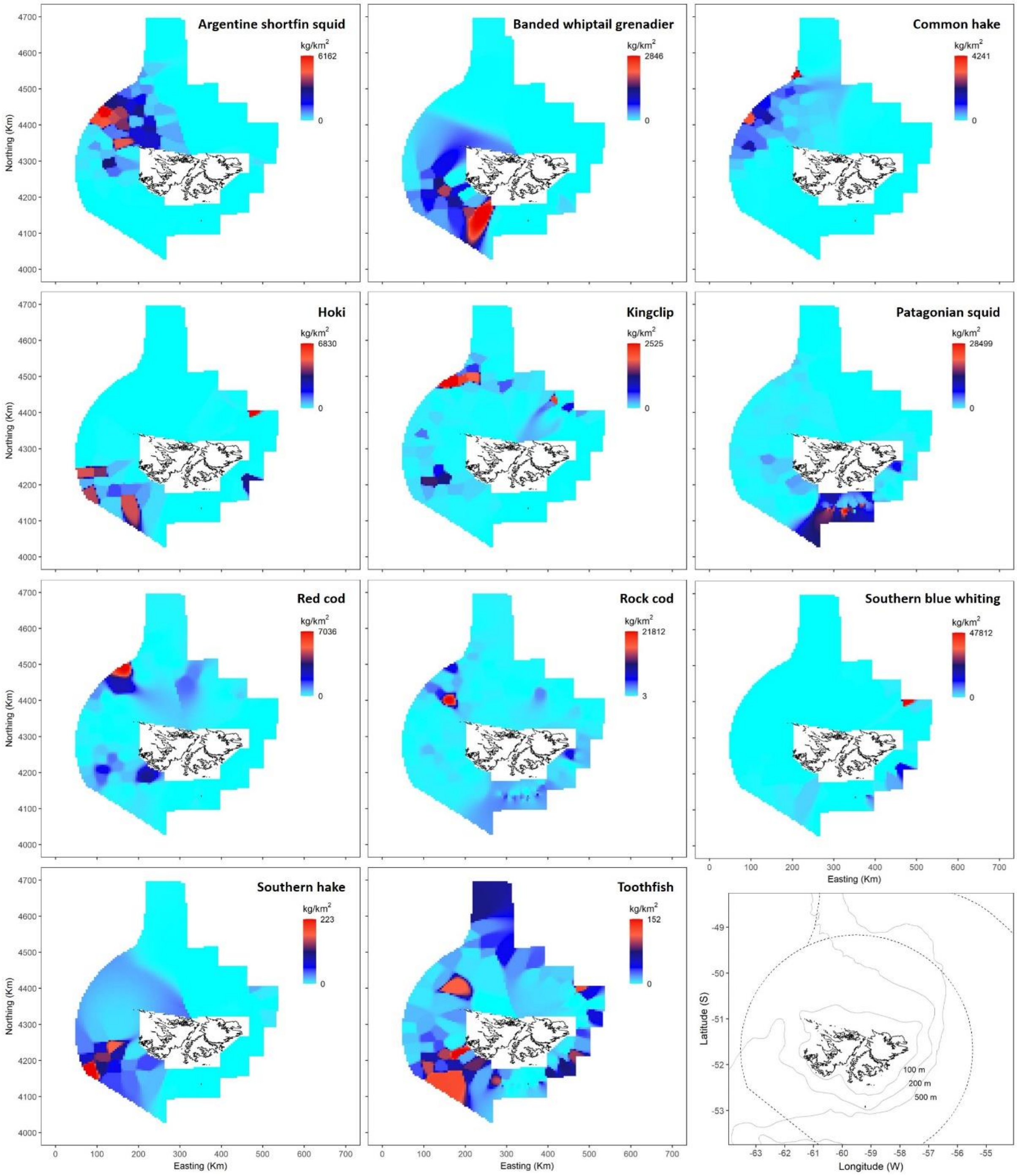
Appendix IV. February survey biomass trends

Biomass (t) of commercial species in February groundfish and calamari pre-season surveys during 2010-2011 and 2015-2024. LOESS smooth ± 95% confidence intervals.



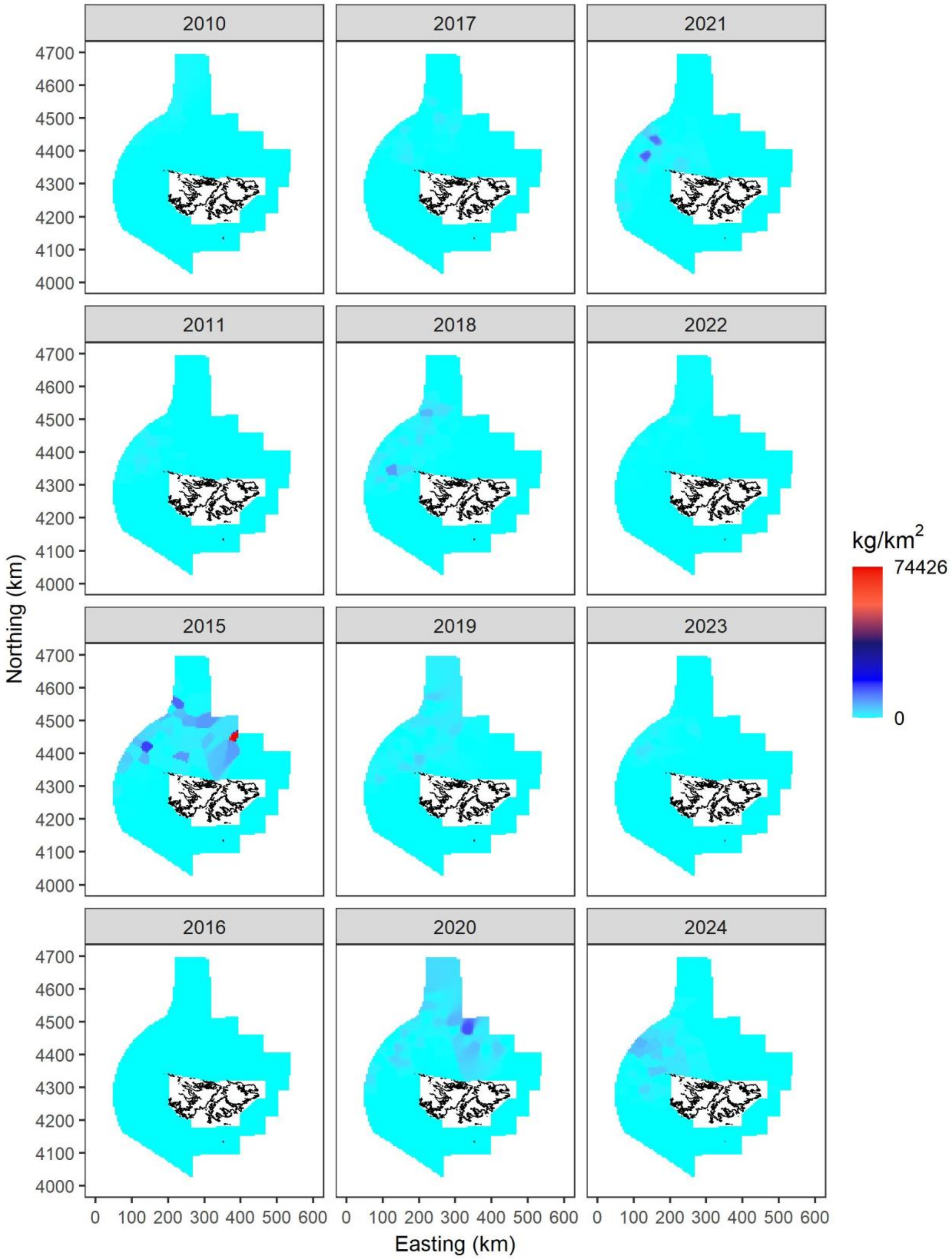
Appendix V. Species distribution during February 2024

Comparative density distribution of commercial species during the February 2024 groundfish and calamari pre-season surveys in Falkland Islands waters. Note the 100 m, 200 m, and 500 m isobaths in the bottom-right panel.



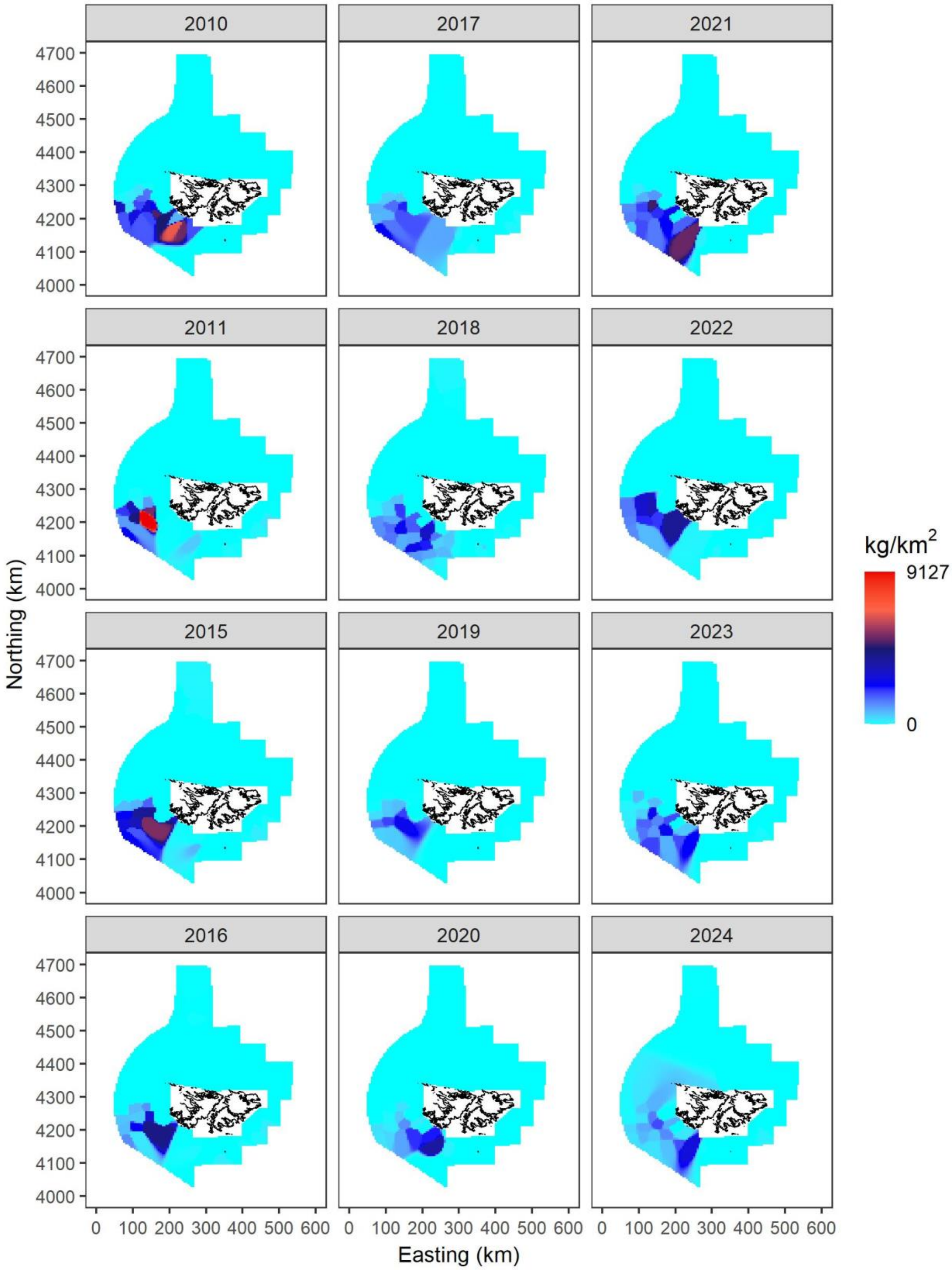
Appendix VI. Argentine shortfin squid inter-annual distribution

Comparative density distribution of the Argentine shortfin squid (*Illex argentinus*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



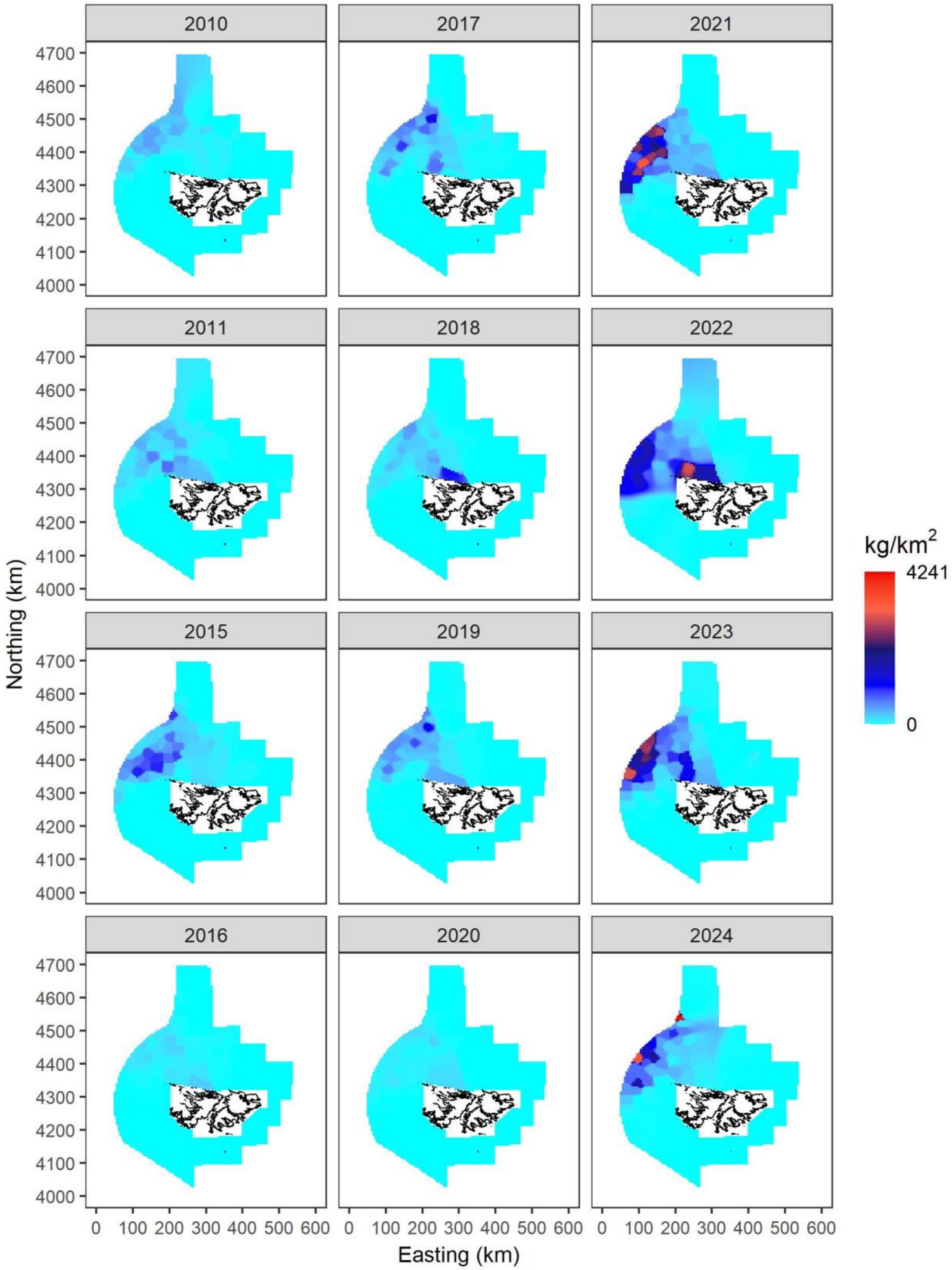
Appendix VII. Banded whiptail grenadier inter-annual distribution

Comparative density distribution of banded whiptail grenadier (*Coelorinchus fasciatus*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



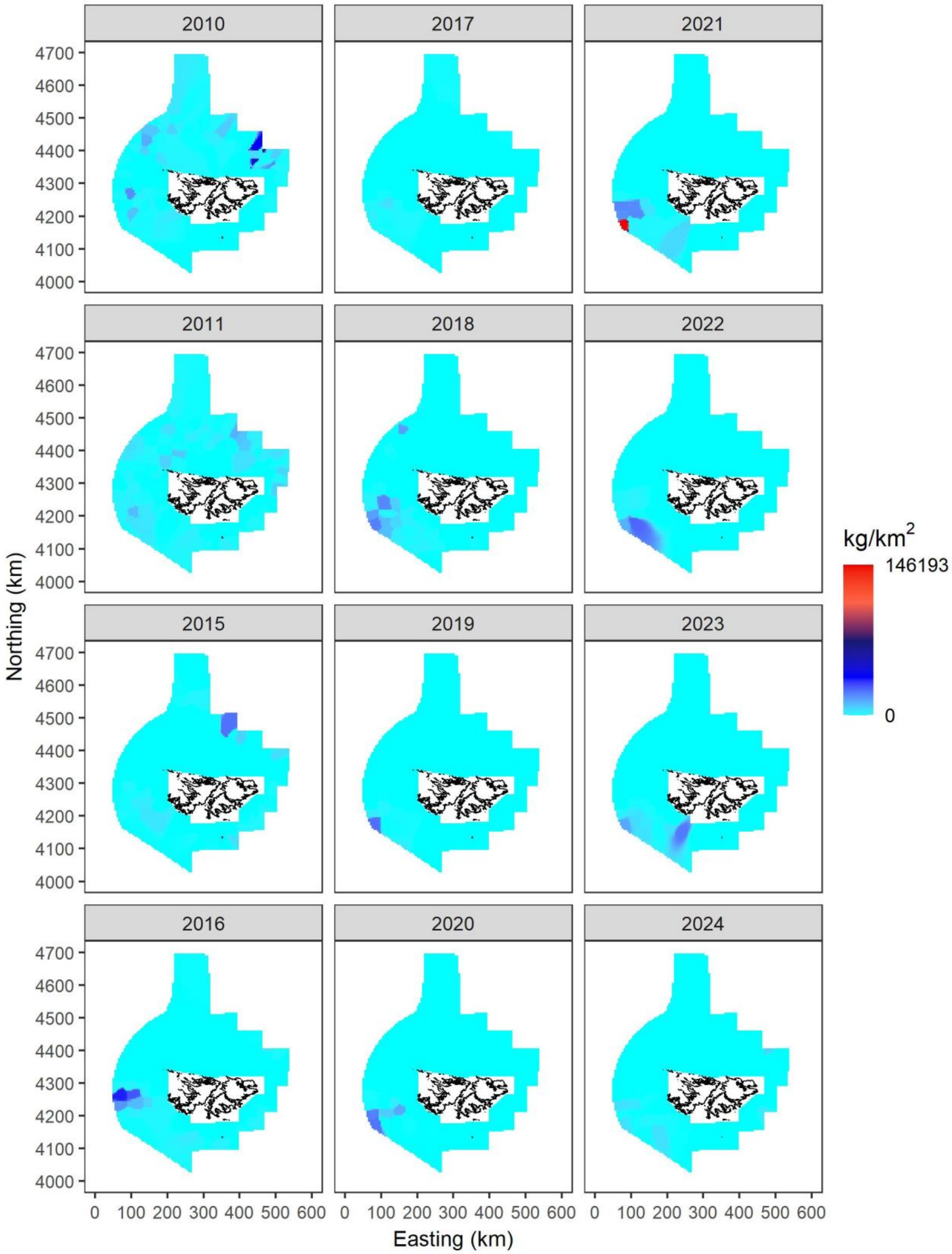
Appendix VIII. Common hake inter-annual distribution

Comparative density distribution of common hake (*Merluccius hubbsi*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



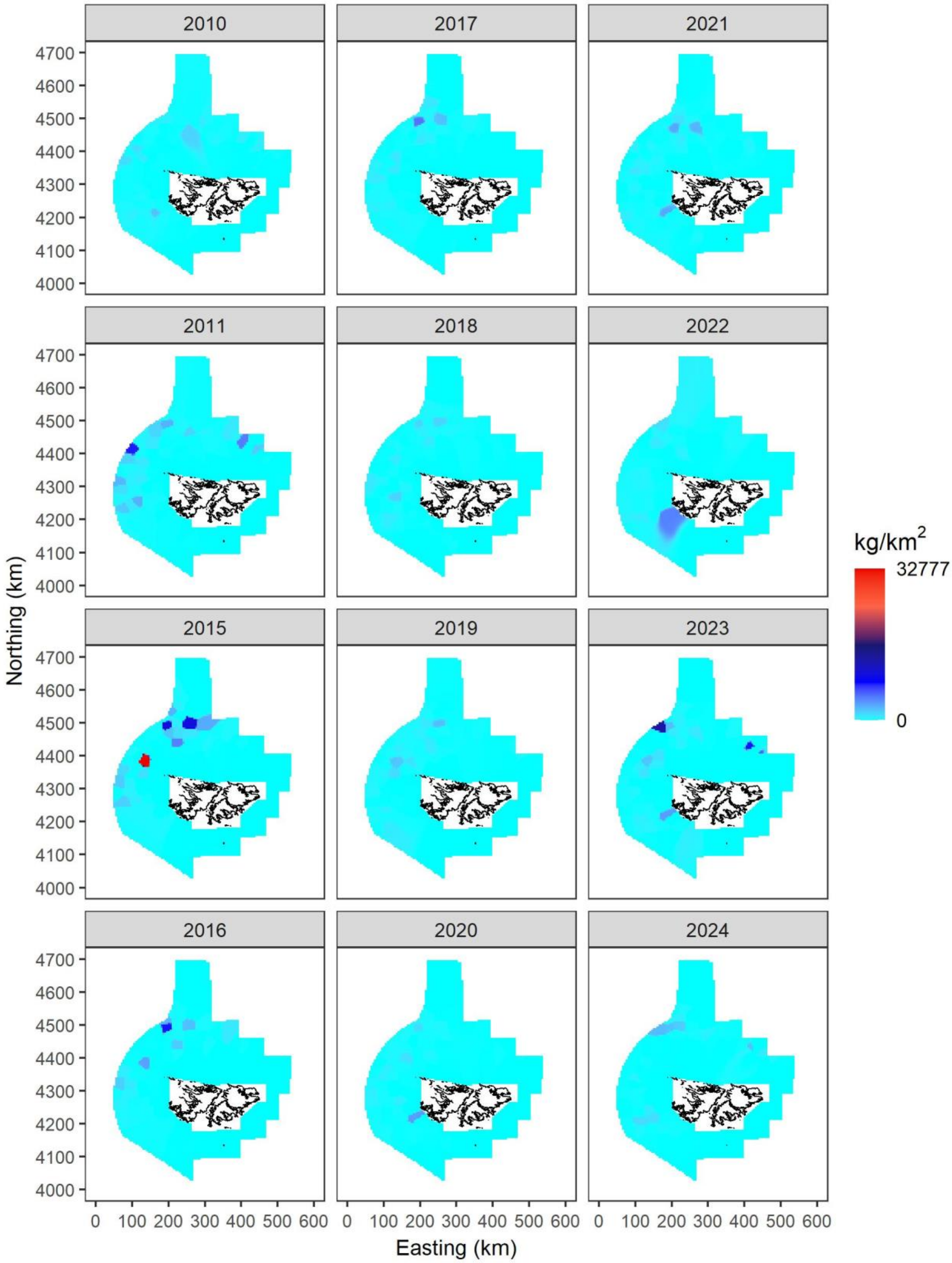
Appendix IX. Hoki inter-annual distribution

Comparative density distribution of hoki (*Macruronus magellanicus*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



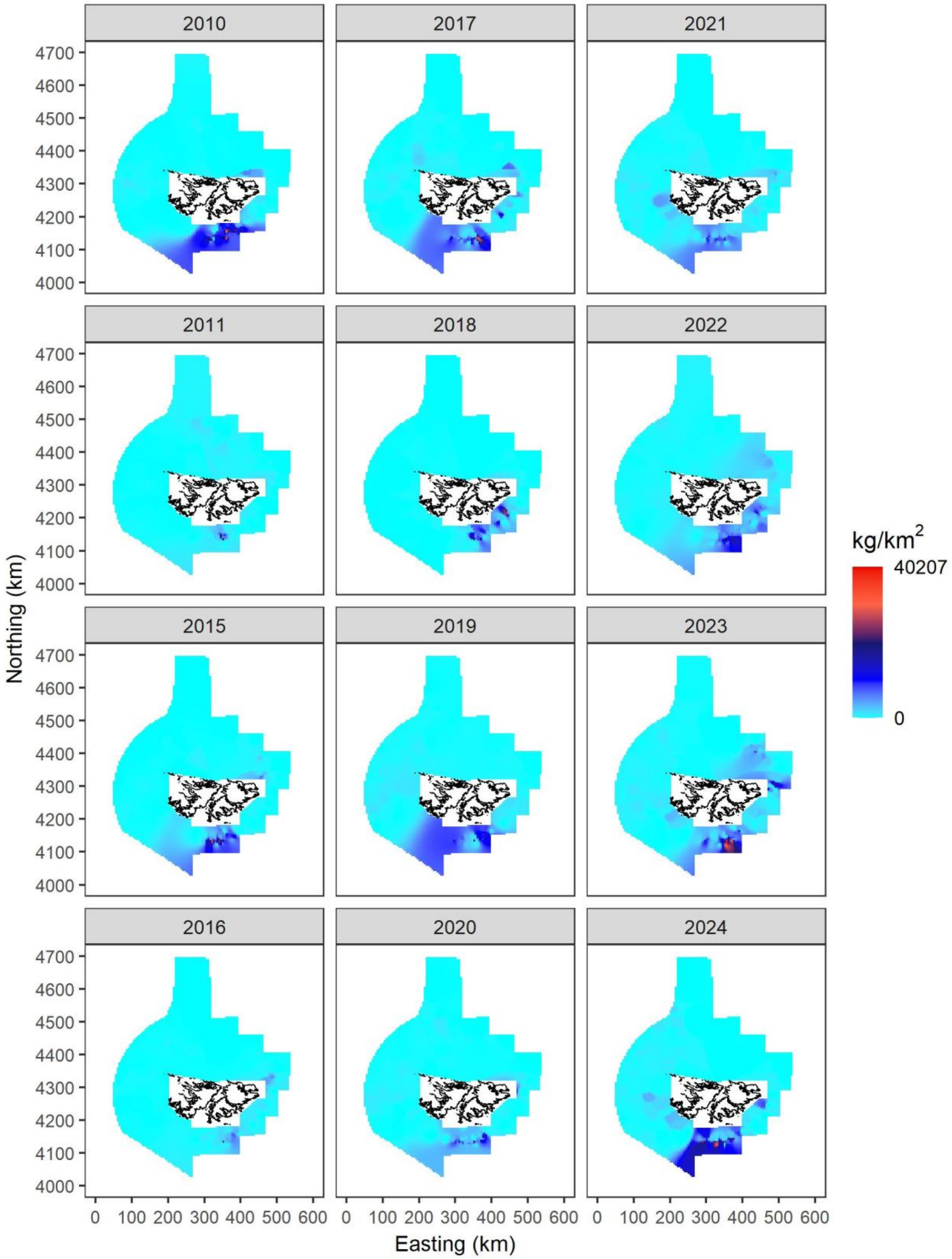
Appendix X. Kingclip inter-annual distribution

Comparative density distribution of kingclip (*Genypterus blacodes*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



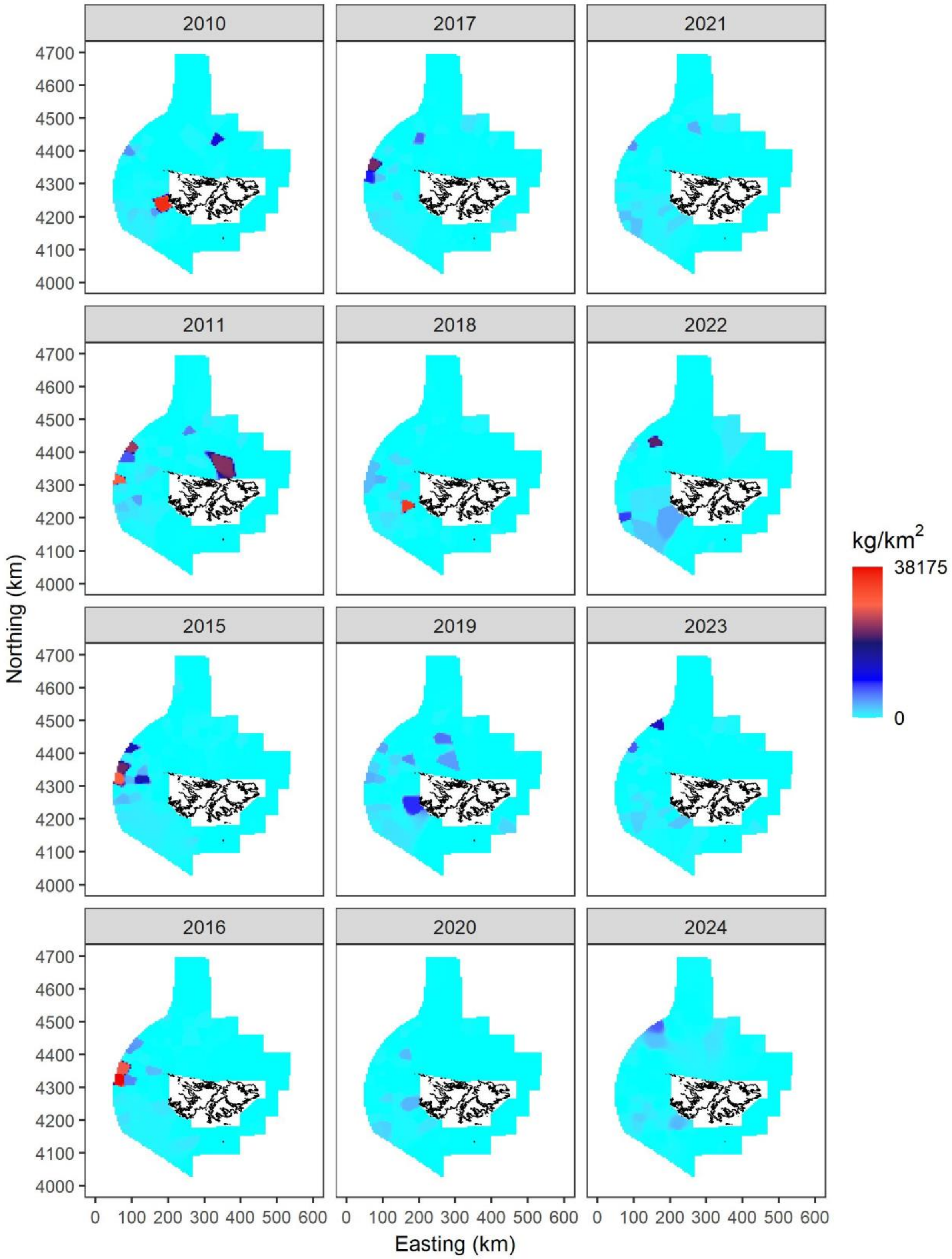
Appendix XI. Patagonian squid inter-annual distribution

Comparative density distribution of the Patagonian squid (*Doryteuthis gahi*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



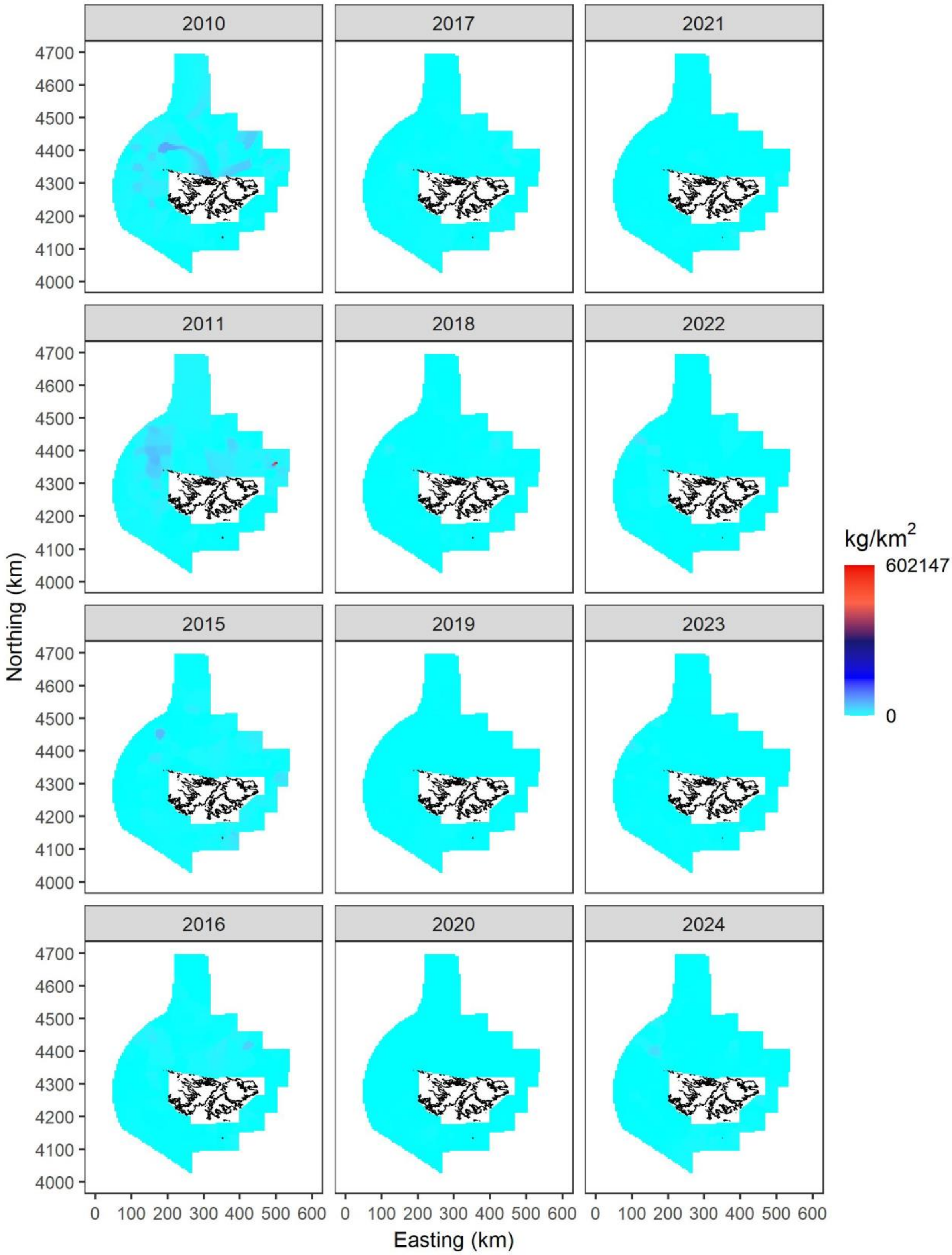
Appendix XII. Red cod inter-annual distribution

Comparative density distribution of red cod (*Salilota australis*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



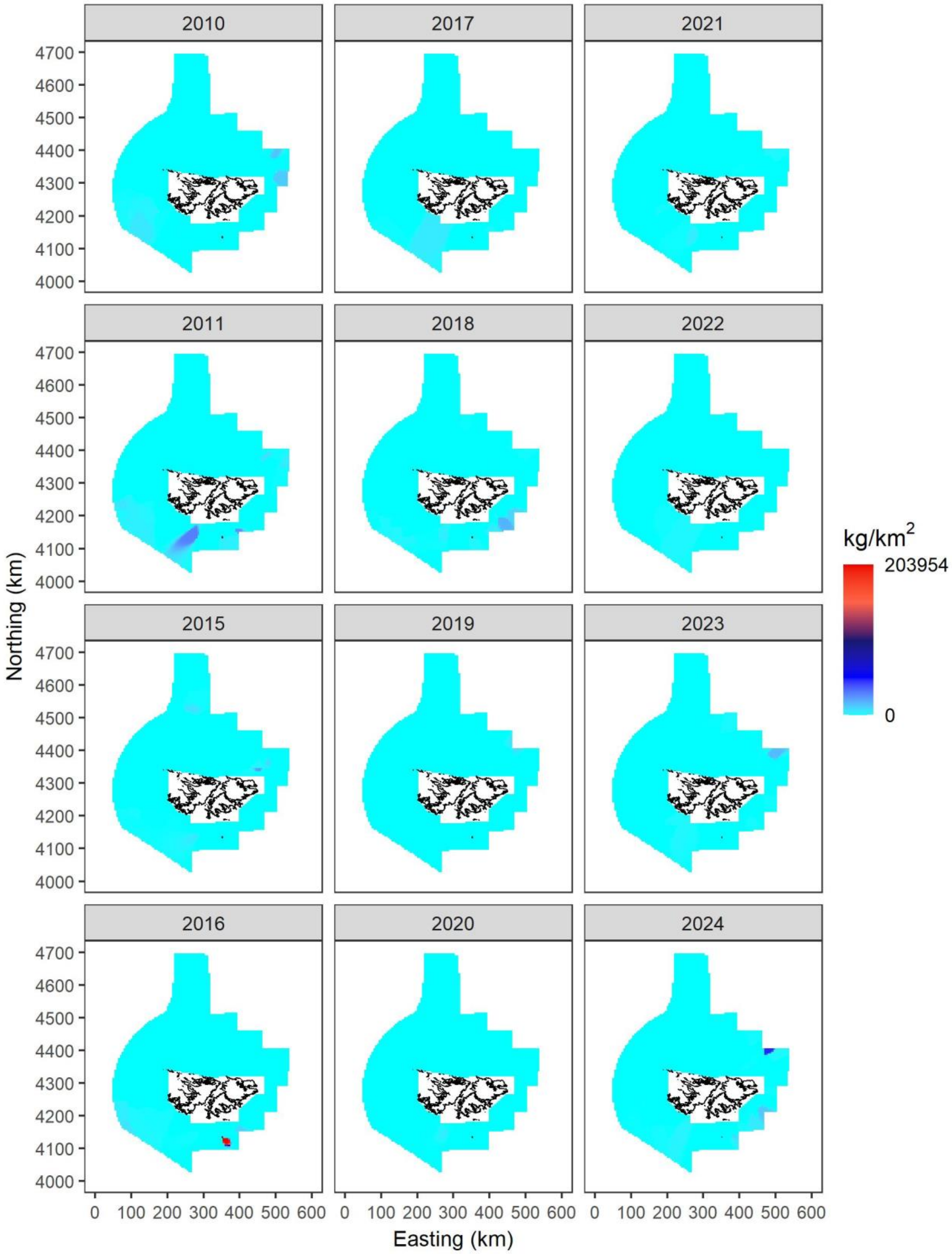
Appendix XIII. Rock cod inter-annual distribution

Comparative density distribution of rock cod (*Patagonotothen ramsayi*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



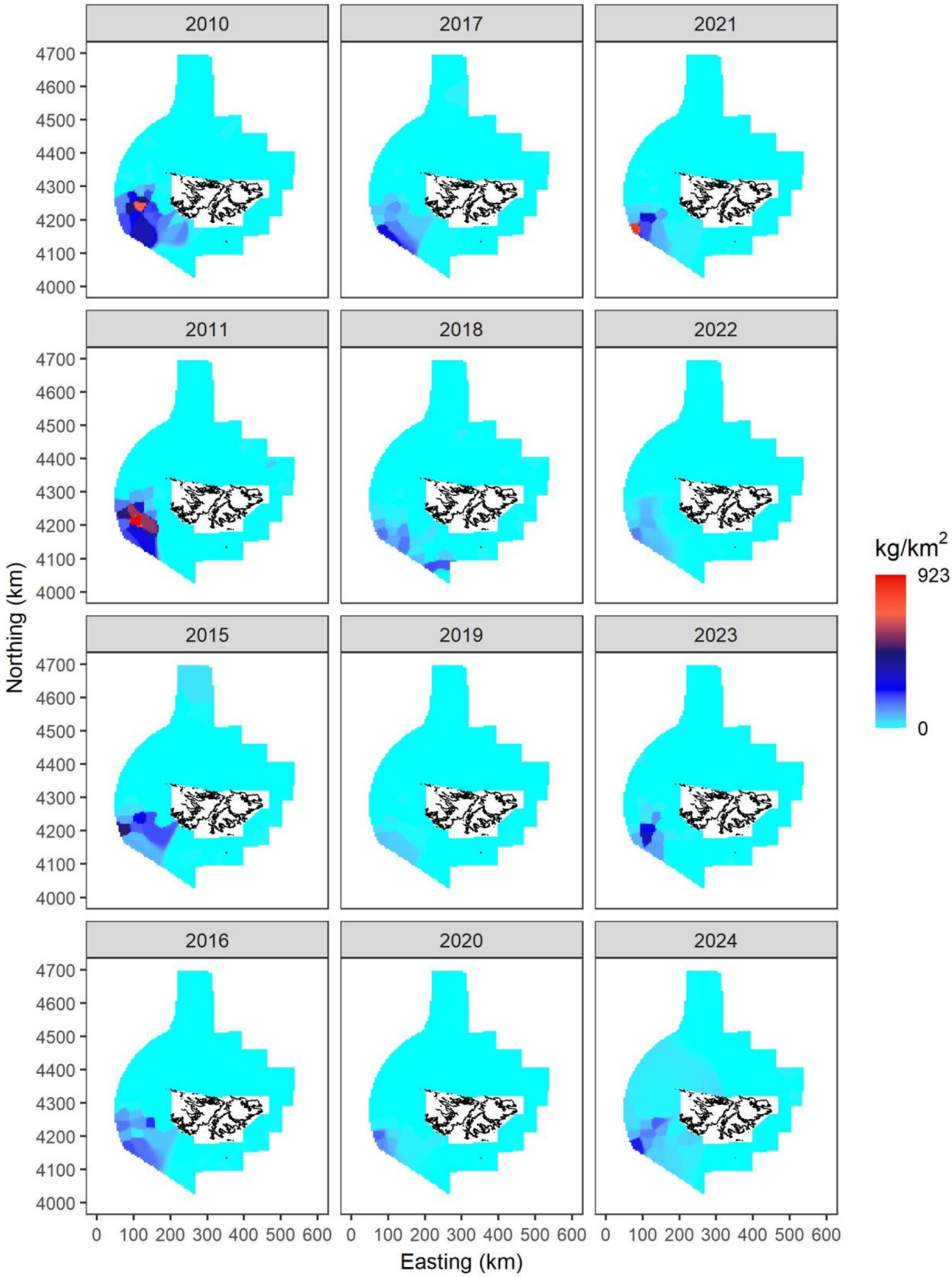
Appendix XIV. Southern blue whiting inter-annual distribution

Comparative density distribution of southern blue whiting (*Micromesistius australis*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



Appendix XV. Southern hake inter-annual distribution

Comparative density distribution of southern hake (*Merluccius australis*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.



Appendix XVI. Toothfish inter-annual distribution

Comparative density distribution of toothfish (*Dissostichus eleginoides*) during the February 2010–2011 and 2015–2024 groundfish and calamari pre-season surveys in Falkland Islands waters.