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Isle of Man King Scallop 2022 Stock Survey Report

Isobel Bloor, Matthew Coleman & Stuart Jenkins

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Corresponding author: i.bloor@bangor.ac.uk

Bangor University Sustainable Fisheries and Aquaculture Group

School of Ocean Sciences, Bangor University

Fisheries Report

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Executive Summary

King scallops (*Pecten maximus*) in Isle of Man territorial waters

Stock development over time

There are currently two annual scallop surveys undertaken within the Isle of Man's territorial waters: a long-term, medium resolution, fixed site survey undertaken onboard the R.V. Prince Madog and a short-term, fine resolution, random stratified survey undertaken onboard two commercial fishing vessels. In 2022 both surveys were conducted in April.

The length-based abundance indices for recruits (< 95 mm) (Figure I: Left) and post-recruits (>95 mm) (Figure I: Right) from the long-term Prince Madog survey are presented below. Both indices have shown recent decreasing trends although there have been increases in the recruit index in the three most recent survey years and a significant increase in the post-recruit index in 2021 with a slight decrease in 2022 (no survey in 2020 due to CV regulations).

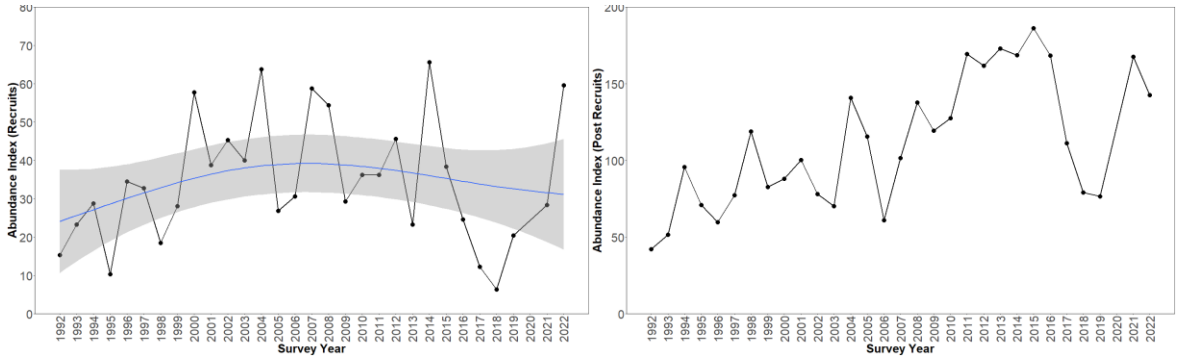

Figure I: *King scallops in Isle of Man Territorial waters. Left: Recruit abundance index from the long-term April survey and Right: Post-Recruit length abundance index from the long-term April survey.*

The fine-scale, short-term, industry survey data indicates a decrease in both the recruit and post-recruit indices for 2022 at the 3-12 nm TS level (which is combined data for EDG, TAR and CHI – three grounds surveyed consistently among survey years) (Table I).

Table I: *A summary of the changes in the abundance index (geometric mean) for over and under 95 mm by survey ground for the May Industry survey. Landings are also displayed in t from the 2021/2022 season for each ground based on data from the Daily Catch Return Forms and indications of fishing inside or outside of the 3nm limit (green indicates increase and red indicates decrease relative to previous season).*

Area	Ground	2021 <95 mm	2022 <95 mm	Change	2021 >95 mm	2022 >95 mm	Change	Landings 2021/22 (t)
TS	T.S.	0.203	0.172	-	0.830	0.717	-	1491
3-12 nm	EDG	0.280	0.151	-	0.943	0.650	-	553
	TAR	0.158	0.265	+	0.837	0.872	+	223
	CHI	0.150	0.127	-	0.634	0.671	+	326
	POA	NA	0.123	NA	NA	0.278	NA	17
0-3 nm	ECO	0.238	0.220	-	0.600	1.120	+	89
	BRA	0.189	0.177	-	0.603	0.940	+	181
	MGH	NA	0.133	NA	NA	0.452	NA	101

Stock advice (2022/2023)

A TAC for the 2022/2023 fishing season has been calculated in the main report using the ICES Category 3 data limited approach (based on post-recruit index only).

It is recommended that the management approach for 2022/2023 king scallop fishery continues to be precautionary and that it should incorporate all of the following three elements:

- **In-season reviews:** Monthly reviews of the fishery by the SMB or a subgroup for the entire TS fishery should be scheduled as standard.
- **Spatial monitoring and management:** Spatial monitoring for each individual ground should be undertaken as part of the in-season review to allow flexible spatial management (i.e. individual grounds to be opened or closed) based on the real-time data collected by the fishery. High density areas within a ground (i.e. Bradda) may require additional fine scale management to avoid high fishing intensities leading to excessive fishing mortality and habitat damage.
- **Closed area management:** The continued management of restricted areas and current/new closed areas is required to protect high density areas of post-recruits and recruits (king and queen scallops).

General recommendations for the 2022/2023 king scallop fishery based on the survey data analysis produced here therefore include:

- The ICES Category 3 approach indicates a potential to increase the TAC by 20%. Catch rates, various management measures, including the use of a DCL to ensure the TAC lasts throughout the season, and various logistical issues as a result of BREXIT and Coronavirus may have contributed to the under achievement of the TAC in recent seasons (2020, 2021 an 2022).
- A precautionary management approach should be considered in particular due to the decline in post-recruit abundance indices in both surveys despite only 73% of the TAC being achieved.
- An initial starting TAC based on a modification of the ICES Category 3 approach with a 20% increase of actual landings (TAC = 1790 t) is advised.
- Flexibility of decrease or increase of the TAC during the fishing season based on fisheries-dependent data (i.e. Daily Catch Return Forms), which is collected in near real-time during the season combined with industry feedback on market conditions.
- Consideration of restricted access and additional management measures within the high-density fishing area at Bradda.
- Consideration of temporary closed areas implemented to protect any high densities of recruits identified in the survey. For 2022 survey cells within TAR and BRA had the highest densities of recruits in the industry surveys and closures in these areas should be considered.
- Monitoring of LPUE and fishing intensity (swept area) should also be undertaken in managed areas to try and ensure overfishing of these spatially discrete areas does not occur. Metrics illustrating the relationship between different levels of LPUE and fishing intensity with consideration of possible impacts on the stock are under development and will continue to be examined in order to develop future threshold values for use in management.
- Monthly reviews of the TAC and fishery with consideration of LPUE and fishing intensity within each fishing ground (including combined fishing intensity of king and queen scallop activity).

Contents

1. Fishery Management:

A fishery for king scallops, *Pecten maximus*, has been prosecuted in and around the Isle of Man's territorial waters since 1937 and developed rapidly in the 1960s as more and larger boats joined the fishery (Duncan et al., 2016). The Isle of Man king scallop fishery is seasonal, occurring from 1st November to 31st May by vessels using toothed, Newhaven dredges. Management of the fishery differs between an inner 0 to 3 NM zone, and an outer 3 to 12 NM zone, with more stringent regulations in the inner zone. During the 2021/2022 season a total of 81 vessels from the Isle of Man, Wales, Scotland, England and Northern Ireland were eligible for a licence (including vessels with activated licences and licences currently on hold with DEFA) to fish for king scallops within Isle of Man territorial waters 3- 12 nm zone. For the 2021/2022 fishing season the management measures that applied to the fishery included (Table 1):

Table 1: Current management measures for the Isle of Man king scallop dredge fishery (as for 2021/2022 fishing season)

Management measure	Applicable zone
Total allowable catch of 2049 t	0 to 12 nm zone
Daily catch limit of 700 kg per vessel	0 to 12 nm zone
Closed areas (temporary and permanent)	0 to 12 nm zone
Minimum landing size (110 mm)	0 to 12 nm zone
Closed season (01/06 to 31/10)	0 to 12 nm zone
Curfew (18:00 to 06:00)	0 to 12 nm zone
Christmas break 24th Dec 2021 to 2nd Jan 2022 (incl.)	0 to 12 nm zone
VMS required for all vessels	0 to 12 nm zone
Submission of EU logbook	0 to 12 nm zone
Submission of IoM daily catch return	0 to 12 nm zone
Aggregate dredge width of 762 cm	0 to 3 nm zone
Aggregate dredge width of 1067 m	3 to 12 nm zone
Maximum of 9 teeth per dredge	0 to 12 nm zone
Minimum tooth spacing of 75 mm	0 to 12 nm zone
Maximum tow bar diameter of 185 mm	0 to 12 nm zone
Minimum belly ring internal diameter 75 mm	0 to 12 nm zone
Minimum dredge net mesh of 100 mm	0 to 12 nm zone
Under 221 kW (except Grandfather Rights)	0 to 12 nm zone
≤ 15.24 m vessel registered length	0 to 3 nm zone
French dredge prohibited	0 to 12 nm zone

These management measures were implemented under the Fisheries Act 2012, various secondary legislation and through restrictive licencing conditions.

Of the 81 vessels eligible for a licence to fish for king scallops during the 2021/22 fishing season 54 vessels reported landings of king scallops from within Isle of Man territorial waters. The TAC for 2021/2022 was 2049 t of which only 1491 t was landed (~ 73 %).

2. Annual (Calendar Year) Landings and Fishing Effort

2.1: Irish Sea

Annual landings (i.e. calendar year; January – December) of king scallops from the Irish Sea (Area VIIa) over the period 1950 – 2019 are shown in Figure 1 (ICES 2022a,b). Since 2006, landings have increased rapidly peaking in 2016 at > 11000 t. In the early part of the Irish Sea fishery (1950 – 1975), boats from the Isle of Man took the majority of the catch (80%), but between 2006 and 2019 the average annual Manx share of landings has declined to around 22%, with landings from United Kingdom vessels (Scotland, England, Wales and Northern Ireland) landing around 64% (the remainder was taken by

vessels from Belgium and the Republic of Ireland). Whilst there are some management measures in place within Area VIIa (i.e. a closed season for *P. maximus* which runs from 1st June to 31st October (inclusive) and a Minimum Landing Size of 110 mm shell length), the quantity of landings from the Irish Sea (VIIa) for the recent decade (2008 – 2018) are unprecedented in comparison to any other decade recorded (Figure 1), and of concern given the general lack of knowledge and management of the stock at these high fishing levels (Duncan et al., 2016). Landings in the most recent year of data following that decade continue to decrease (i.e. 2019).

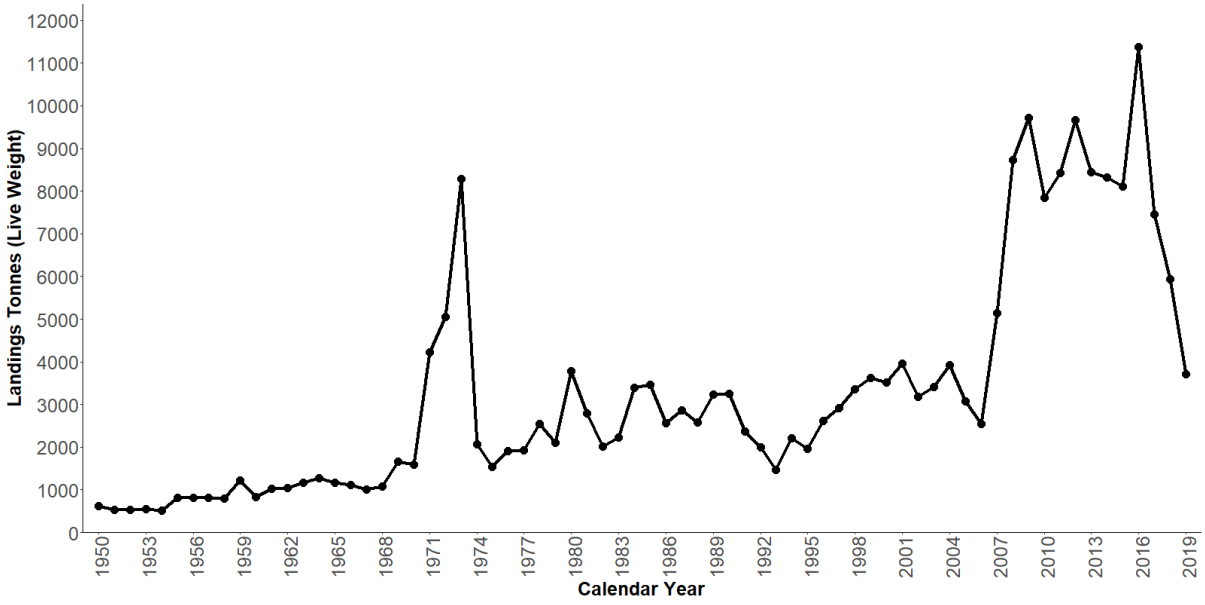

Figure 1: Annual King Scallop landings (t) from ICES Area VIIa for 1950 to 2019 using scallop landings from species Great Atlantic Scallop (SCE) and Scallop Nie (not included elsewhere) (ICES 2022a; ICES 2022b).

2.2: ICES Rectangles 36E5, 37E5 and 38E5

The annual landings (i.e. calendar year; January – December) of king scallops from the ICES Rectangles 36E5, 37E5 and 38E5, which cover the main extent of Isle of Man territorial waters, show a similar pattern of landings to those from the wider Irish Sea (Area VIIa) over the period 1992 – 2019 (Figure 2). Landings increased rapidly from 2006 to 2009 almost doubling during that period from 2111t to 3971t. Annual landings continued to increase since 2009 with an annual average of 4020t from 2010 – 2015 and a peak in 2016 of 5714t. Landings from ICES Rectangles 36E5, 37E5 and 38E5 decreased in 2017, 2018, 2019 and 2020 with a slight increase again in 2021. These reductions in landings followed the introduction of TACs within Isle of Man territorial waters. TACs are not the only factor that may have influenced the reduction in landings. Stock decline could also be a contributing factor and in more recent years Brexit and Coronavirus may have also had an impact (Figure 2).

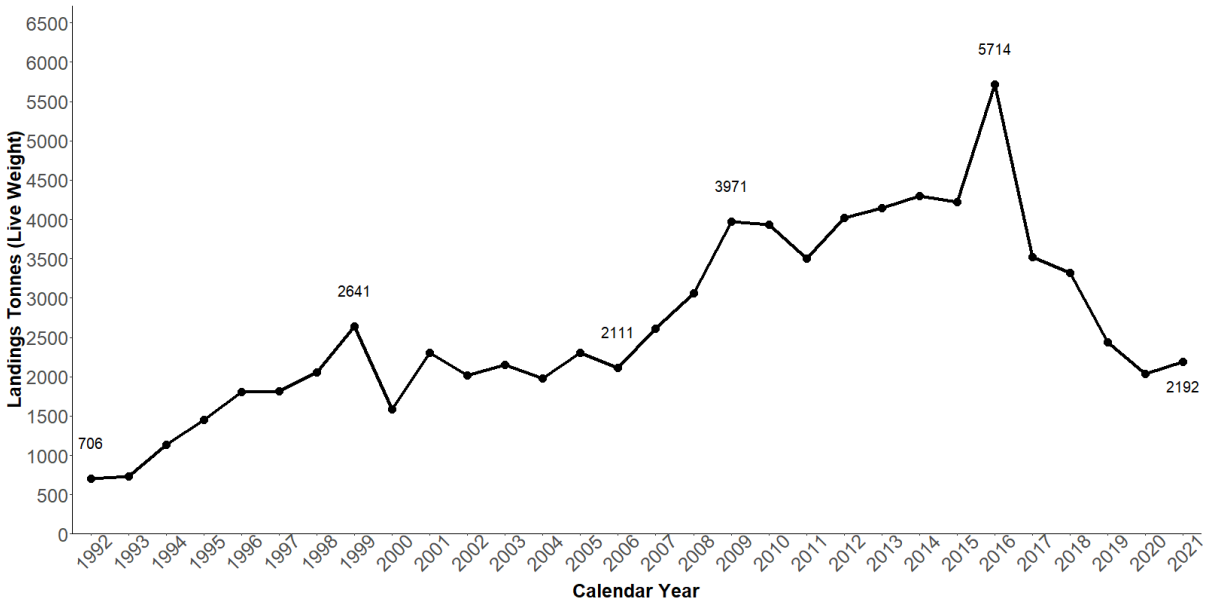

Figure 2: Annual (calendar year) King Scallop landings (t) from ICES Rectangles 36E5, 37E5 and 38E5 from 1992 to 2021 (Source: Logbook data DEFA, Marine Scotland, MMO and IFISH 2). For information the landings (t) values from key years are annotated on the graph.

3. Seasonal Landings and Fishing Effort

3.1: ICES Rectangles 36E5, 37E5 and 38E5

Seasonal landings of king scallops (i.e. covering the king scallop fishing season which runs from 1st November Year^{n} – 31st May Year^{n+1}) from ICES statistical rectangles 36E5, 37E5 and 38E5 show a similar pattern to annual data. Landings peaked in the 2016/2017 season at 5129 t. Following the introduction of TACs in Isle of Man territorial waters there were annual declines in landings from 2017/2018 to 2019/2020 (low of 1939 t in the 2019/2020 season) followed by a slight increase to 2411 t in 2020/2021 before another slight decrease to 2008 t in 2021/2022(Figure 3). *Note: these ICES Rectangles cover an area greater than the Isle of Man territorial waters.*

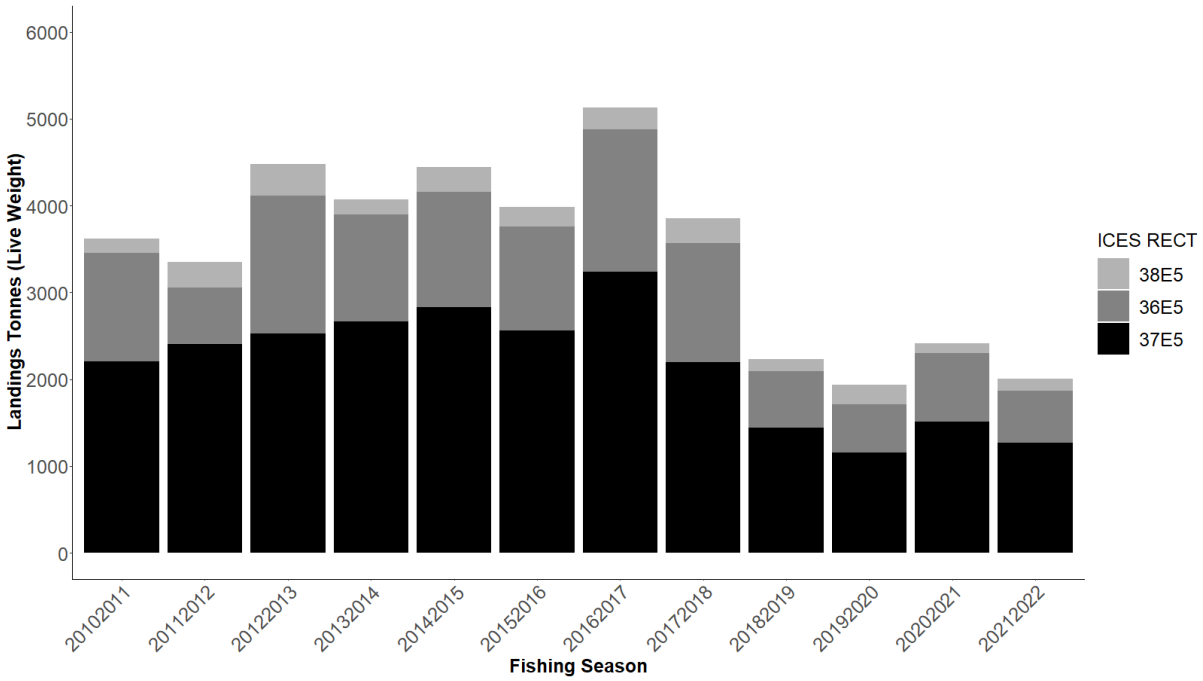

Figure 3: Seasonal landings (t) of king scallops from ICES Rectangles 36E5, 37E5 and 38E5 for the seasons 2010/2011 to 2021/2022. Data source: EU Logbooks downloaded through IFISH2. (NB. these data include ALL vessels fishing for king scallops (except vessels from Ireland for which we do not receive EU logbook data) and not only those vessels that are currently licenced to fish for king scallops within Isle of Man territorial waters).

3.2: Isle of Man Territorial Waters

A requirement of the king scallop fishing licence in the Isle of Man is that Daily Catch Return forms (DCRs) are submitted through an electronic App, by midnight on the day of fishing. This provides near real-time fisheries-dependent data from the fishery for the purpose of monitoring TACs and catch rates, etc. at the level of Irish Sea (IS) boxes (Figure 4). IS boxes are used rather than ICES Rectangles as they have a finer spatial resolution and largely align with the main fishing grounds. The spatial location of landings varies annually and often reflects densities. The data from the 2021/2022 fishing season are displayed in Figure 5. The largest proportion of landings for the 2021/2022 fishing season came from IS15: East of Douglas (EDG).

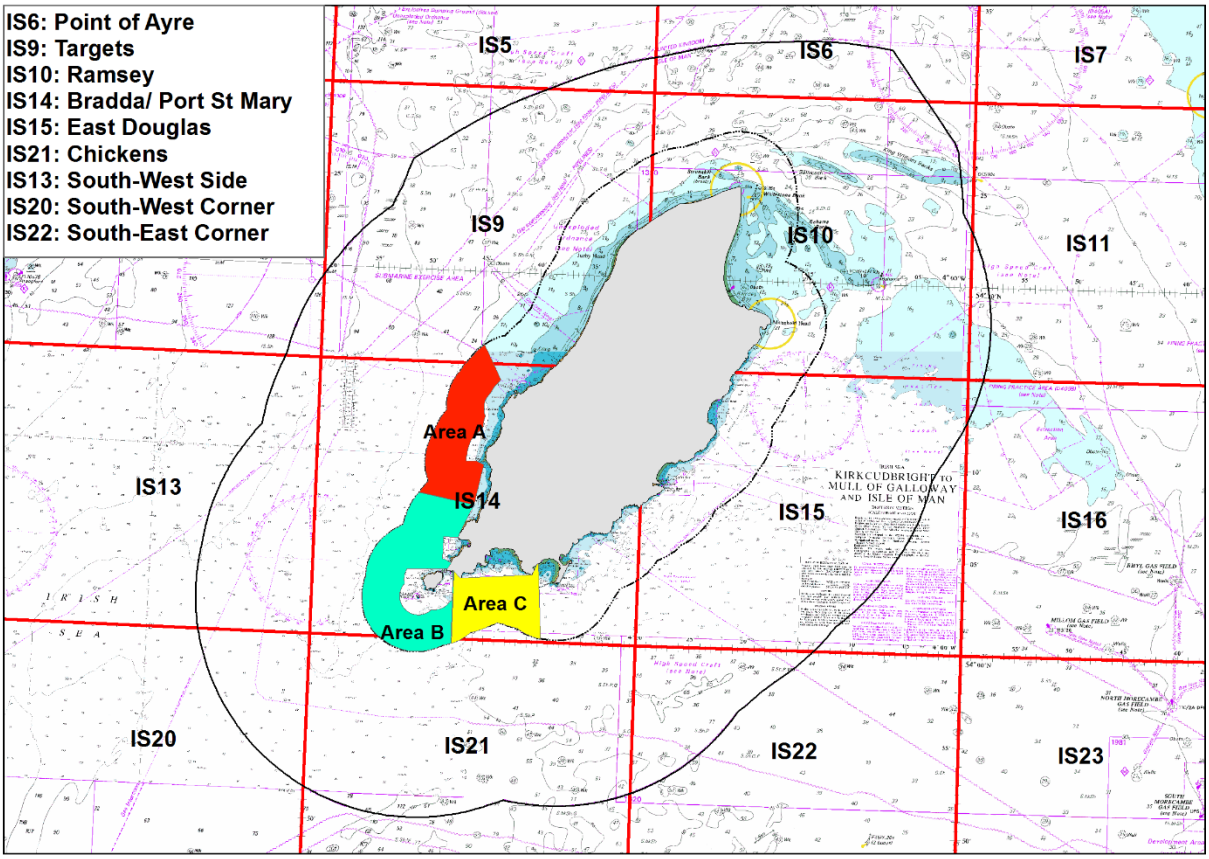

Figure 4: Map showing location of Irish Sea Boxes which are used to define fishing areas in the Nest Forms Landings Data. The fishing grounds delineated within each IS box are listed on the map. In addition, Subzones for reporting fishing within 3 subzones within the 0-3 nm limit are also shown (Area A = West Coast, Area B = Bradda/Calf and Area C = Port St Mary).

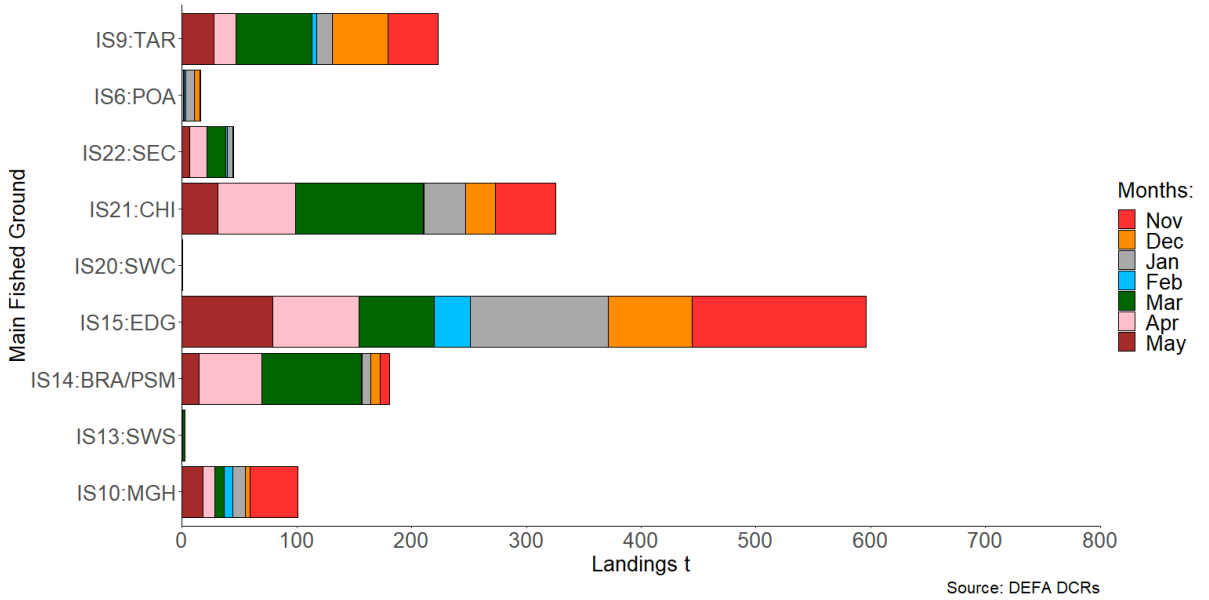

Figure 5: Scallop (SCE) Landings (t) reported by main fished ground (IS Box) and separated by colour for each month to show the spatial and temporal pattern of landings for the 2021/2022 king scallop fishing season. The main fishing grounds are covered by IS9 TAR = Targets, IS6 POA = Point of Ayre, IS21 CHI = Chickens, IS15 EDG = East of Douglas, IS14 BRA/PSM = Bradda and Port St Mary and the remaining smaller fishable areas are covered by IS20 SWC = South West Corner, IS22 SEC = South East Corner, IS13 SWS = South West Side, IS10 MGH = Maughold.

A comparison of average LPUE (kg per hour fished per dredge) at each of the main fished grounds is displayed below for the 2017/18, 2018/19, 2019/20, 2020/21 (grey) and 2021/22 (green) seasons by fished week. The LPUE in 2021/2022 at IS10 (MGH), IS14 (BRA/PSM) and IS21 (CHI) were all at the highest end of the range for historic LPUE trends for these grounds (2017/2018 – 2020/2021) (Figure 6).

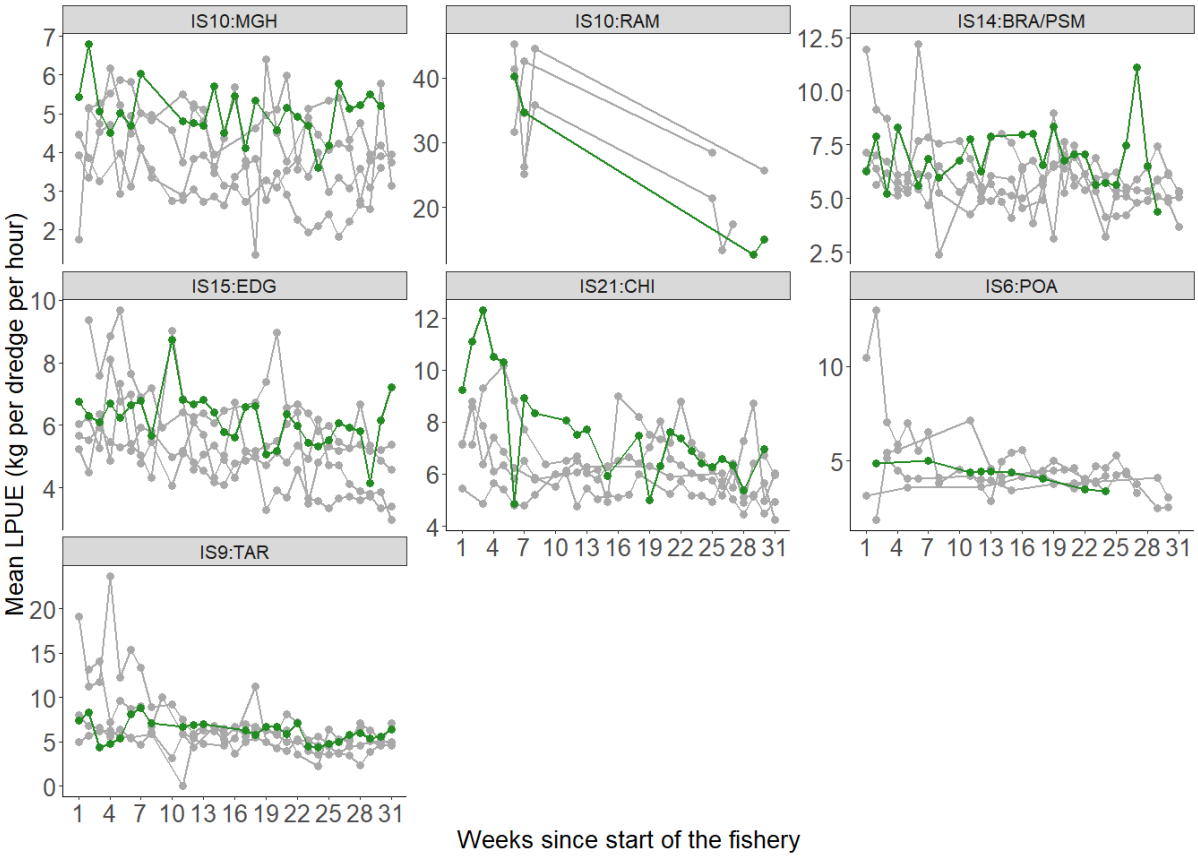

Figure 6: LPUE (kg per hour fished per dredge) displayed by main fished ground for current (2021/2022 (green) and historic (2017/2018 – 2020/2021 (grey)) seasons. Note the different scales on the Y-axis (LPUE), in addition the fishery closed for Christmas around Week 9 in all seasons

4. Scallop Surveys:

4.1: Background

There are currently two annual scallop surveys undertaken within the Isle of Man's territorial waters:

Long-term, medium resolution, fixed site survey: This survey has been undertaken since 1992 and is currently completed on the R.V. Prince Madog. It is a medium resolution survey (~ 3nm between survey sites), conducted at fixed survey stations. There is a long-term data set associated with this survey which enables stock assessment to be undertaken along with provision of a time series for calculation of the ICES Category 3 data limited approach to TAC calculation (i.e. survey-based methods approach). Unfortunately, due to the Coronavirus restrictions in place in both the IoM and the UK this survey could not be completed in April 2020. This survey is subsequently referred to in this report as the 'Prince Madog' survey.

Short-term, fine resolution, random stratified survey: This is a new survey that was undertaken for the first time in June 2019. It is currently completed on two industry fishing vessels and sampling is coordinated by the MFPO with scientific support from Bangor University. It is a fine resolution survey

(survey cells: 1 min (longitude) x 0.5 min (latitude)). This survey was able to be completed by local industry in 2020 in line with the Coronavirus restrictions and social distancing regulations. Due to funding constraints not all grounds have been surveyed in all years. This survey is subsequently referred to in this report as the 'Industry' survey.

In line with recommendations developed with the scallop management board (SMB), the long-term survey data from the Prince Madog survey has been used to support the calculation of the 'ICES Category 3 data limited' approach to estimating annual total allowable catch (TAC). This approach requires a minimum time series of data of five years with the survey indices of the two most recent survey years summed and then divided by the sum of the survey indices from the three years prior. This ratio is then used to adjust the previous year's TAC up or down by a maximum of 20%. The five-year time series of data is important in this calculation as stocks can be variable in any year and comparing one year against another doesn't incorporate trends in the data.

4.2: Prince Madog Annual Spring Survey:

4.2.1 Survey Methods:

Spring surveys of the Isle of Man's scallop populations have been undertaken annually since 1992 (Beukers-Stewart et al., 2003). The 2022 spring scallop survey was undertaken by the R.V. Prince Madog over 9 days from 2nd – 10th April 2022. A total of 47 survey stations were sampled (Figure 7). The standard survey gear comprises of a set of four Newhaven dredges: two with 80 mm ring diameter and 9 teeth of 110 mm [king dredges] and two with 55 mm ring diameter and 10 teeth of 60 mm [queen dredges]. At each station the dredges are towed at 2.6 knots for 20 minutes with the direction of the tow dependent on tidal state and current condition. For each tow the total biomass of king and queen scallops is recorded by dredge and a subsample of 90 queen scallops and 90 king scallops from each dredge are then weighed and measured (king scallops are also aged).

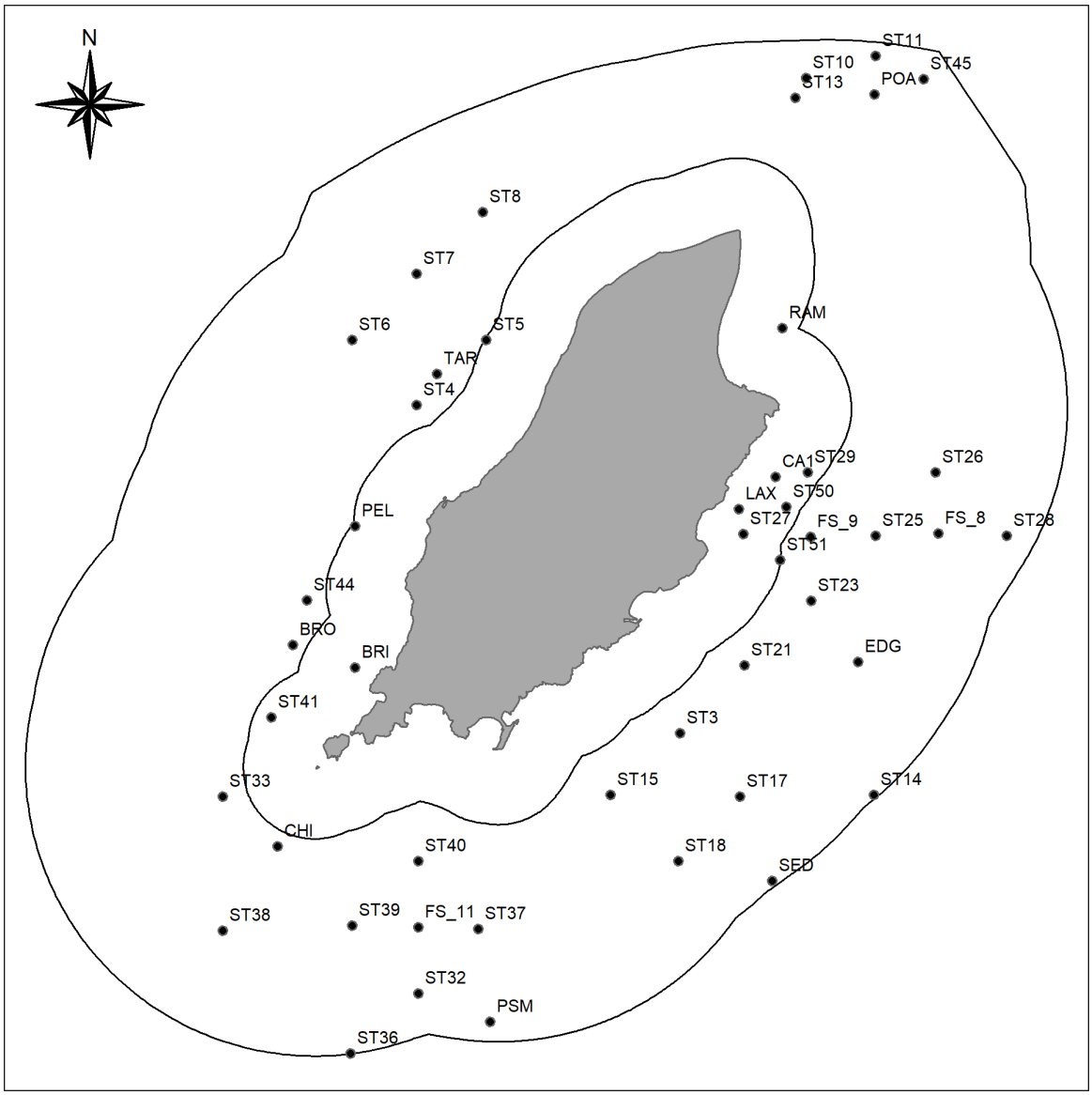

Figure 7: A map showing the location of all 2022 survey stations. Historical stations (i.e. those sampled from 1992) all have three letters (i.e. EDG, SED) while stations added from 2012 onwards are all labelled ST with a number (i.e. ST21, ST50). Fisher suggested stations (labelled F with a number (i.e. F6, F8)) were added in 2016 and finer resolution stations added in 2021 following discussions with the MFPO are labelled FS with a number (i.e. FS2, FS11).

4.2.2 Size Frequency:

Frequency-density plots of king scallop size data are presented for the 2021 and 2022 surveys in Figure 8 from samples measured at ten historical stock assessment stations (POA, LAX, EDG, SED, PSM, CHI, BRI, BRO, PEL and TAR; data from all dredges combined). In both 2021 and 2022, there is an absence of a significant peak for Cohort 1 at 40-60 mm (this size range reflects pre-recruits that would be recruiting into the fishery in two to three years), indicating limited pre-recruitment. The main peak in the data is within Cohort 2 which are post-recruits, i.e. king scallops that are typically already at minimum landing size (MLS). For both 2021 and 2022 the peak in Cohort 2 is around MLS (i.e. around 110 mm). This may indicate that the fishery is recruit driven and hence fishing intensity is high on scallops as they achieve MLS (Figure 8).

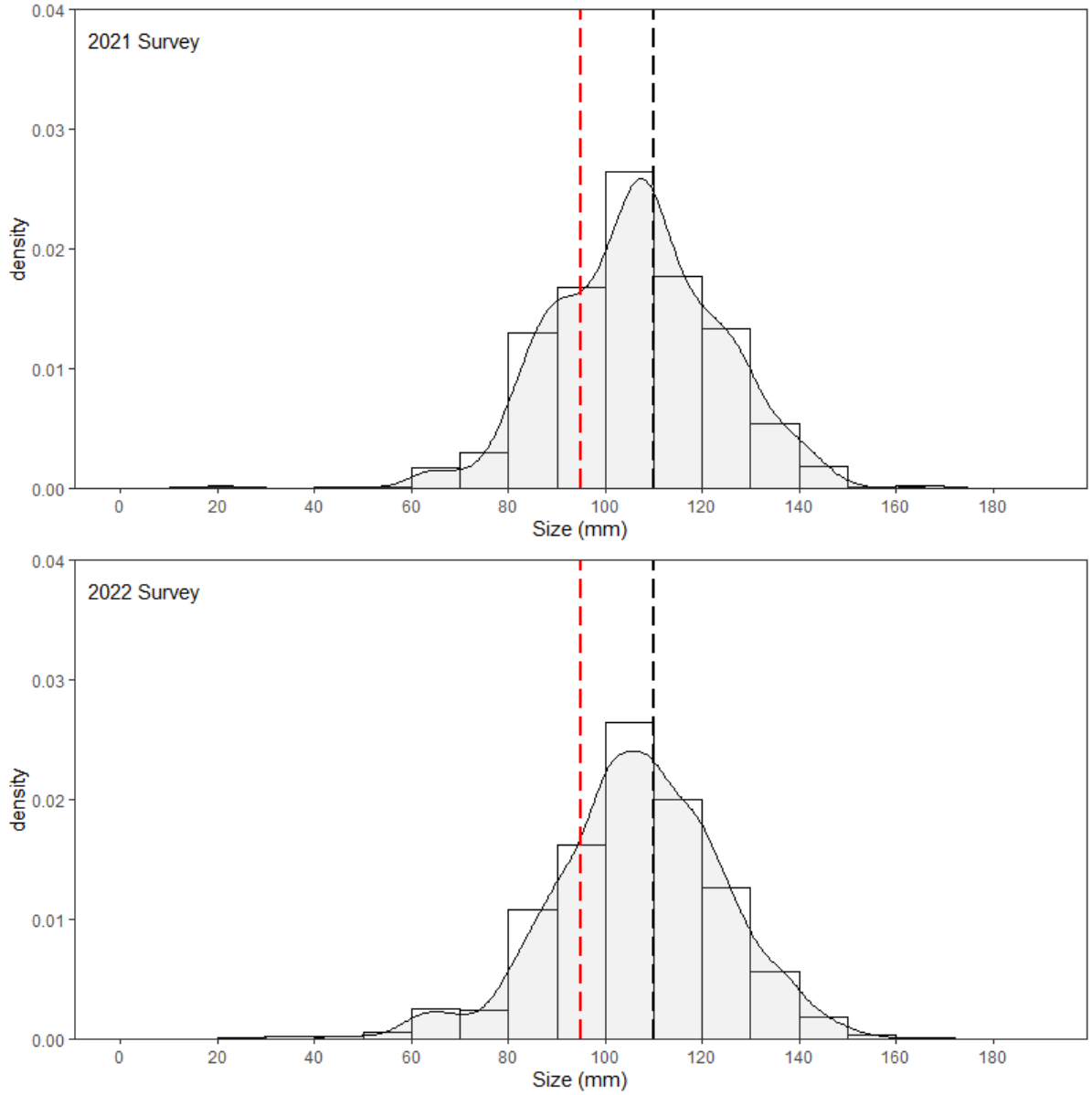

Figure 8: King scallop size frequency-density plot for 2021 (top) and 2022 (bottom). Black dashed line indicates MLS (110 mm) and the red dashed line indicates the estimated MLS cut-off width (95 mm) for the territorial sea (i.e. the size at which scallops sampled in April Year^{0} will typically have reached MLS by 31st May Year^{+1}). Data from historical stations (no RAM) and includes data from both king and queen scallop dredges.

4.2.3 Density Estimates:

The average survey density of king scallops (of all sizes caught) per 100 m^2 around the Isle of Man for the 2022 survey is displayed in Figure 9 for all survey stations. In 2022 the fishing grounds in the south-west of the Island (BRI and ST44) had the highest densities of king scallops per 100 m^2 (~6.8 and 5.5 king scallops per 100 m^2 respectively) (Figure 9).

The difference in mean survey density (scallops per 100 m^2) of king scallops from queen scallop dredges between 2021 and 2022 is displayed for all survey stations sampled in both years (Figure 10). This indicates positive increases between 2021 and 2022 in total scallop density at 21 stations and decreases at 23 stations.

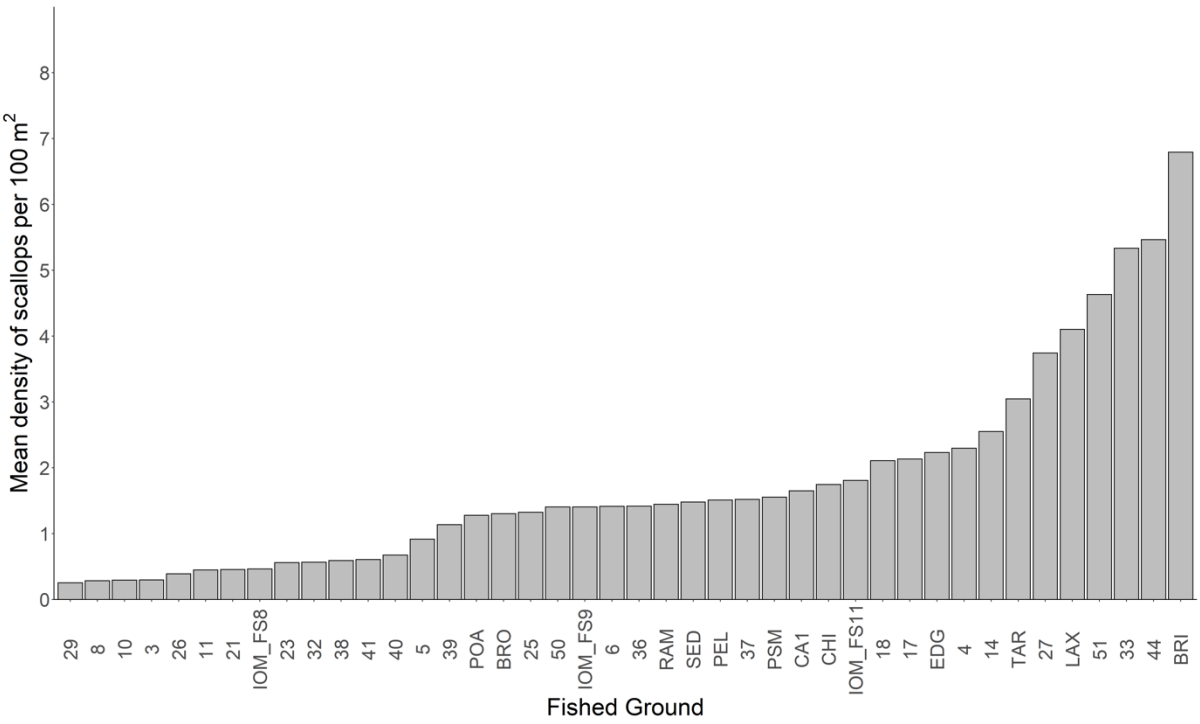

Figure 9: Survey densities (king scallops per 100 m²) displayed by survey station for spring 2022 survey (average of queen scallop dredge data). Only sites with densities ≥ 0.25 king scallops per 100 m² are displayed.

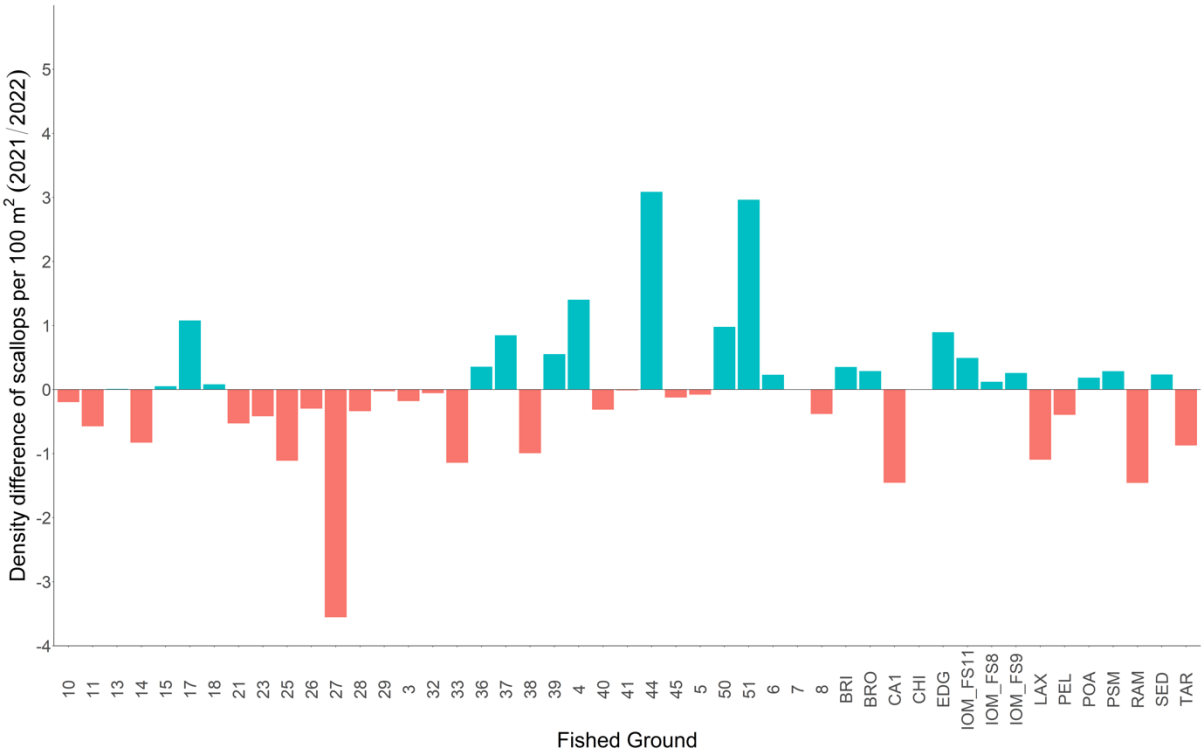

Figure 10: Difference in average survey density (scallops per 100 m²) of king scallops between 2021 and 2022 from queen scallop dredges for all survey stations sampled in both years (red bars indicate a reduction in scallop densities and green bars indicate an increase in scallop density from 2021 to 2022).

Despite positive increases in seven out of eleven of the historical stations between 2021 and 2022 the data need to be considered in the wider context of the time series. Figure 11 and Figure 12 indicate the density of king scallops per 100 m^2 for each of the eleven historical stations from 1992 to 2022.

The longer term data shows that for 2022 the densities at many historical stations are at the lower end of the range of values (e.g. TAR, BRO and CHI) or are sampled at stations that historically have consistently low densities (e.g. EDG, PSM, SED) (Figure 11 and Figure 12). However some high densities were recorded in 2022. BRI had the highest value recorded historically for this station with over 60 % of scallops sampled at the site over 95 mm following a substantial recruitment in 2021 (Figure 12). LAX also has one of the highest densities this site has seen (Figure 12) with a roughly equal split of post-recruits to recruits.

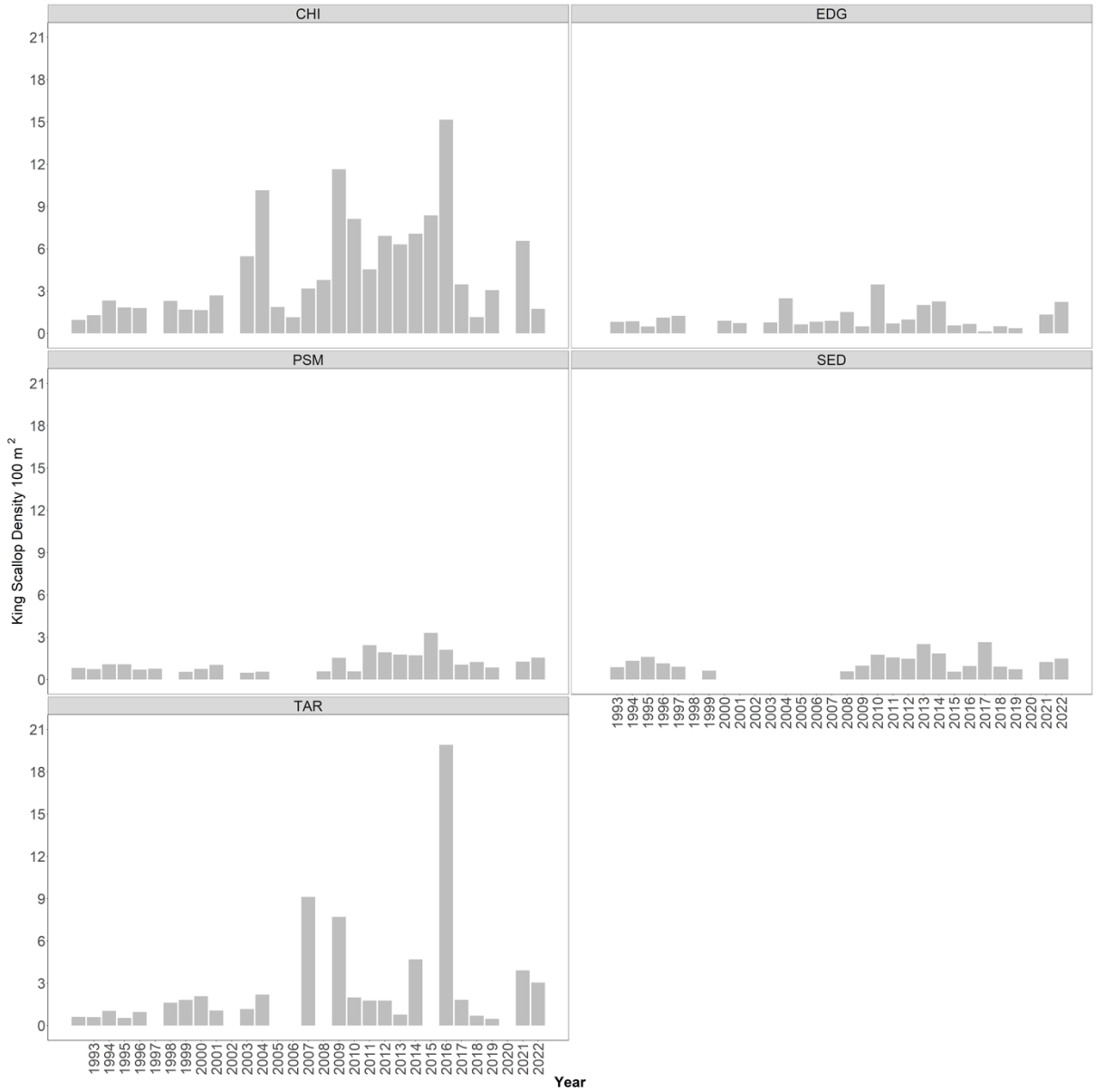

Figure 11: Density of king scallops (scallops per 100 m^2) at historical stations from 1992 to 2022 for the Prince Madog survey. Blank spaces indicate years with no survey data. Sites include CHI, EDG, PSM, RAM, SED and TAR

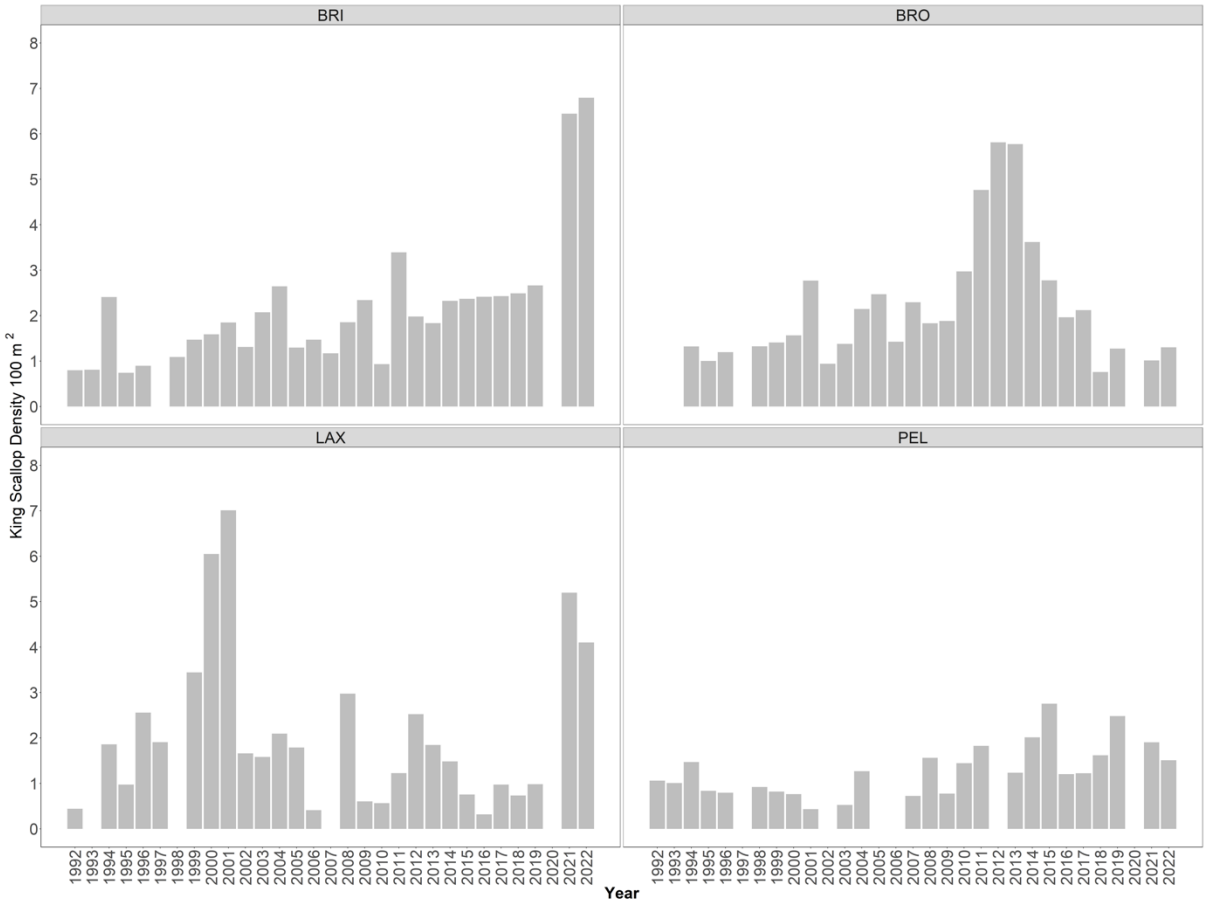

Figure 12: Density of king scallops (scallops per 100 m2) at historical stations from 1992 to 2022 for the Prince Madog survey. Blank spaces indicate years with no survey data. Sites include BRI, BRO, LAX and PEL.

4.2.4 Survey Abundance Indices:

Although the extent and number of survey stations has been increased since 2013 (Bloor & Kaiser, 2017) (recently introduced stations are represented by either just a number e.g. 46 or a number prefixed with an F e.g. F12; Figure 7) only 10 standard historical scallop survey stations (BRI, BRO, CHI, EDG, LAX, PEL, POA, PSM, SED and TAR), are included in the current survey abundance index assessments as these reflect the extent of the main, persistent king scallop beds within the Isle of Man's territorial sea. The eleventh historical station RAM was excluded from the abundance indices presented here as it is managed and assessed separately from the rest of the territorial sea scallop fishery.

The geometric mean of king scallop density was calculated across survey stations using data from **only** queen scallop dredges to derive the abundance indices. *Data from only queen scallop dredge types was used as the number of king scallops was generally higher in the queen scallop dredges across all length categories.* The use of the geometric mean to look at general stock trends across the territorial sea is precautionary and necessary to obtain meaningful stock assessment results. A failure to use the geometric mean, which down-weights isolated high-density patches of scallops, would increase the risk of over- estimating population size (Hutchings, 1996) and would provide a misleading over-optimistic estimate of scallop abundance. The arithmetic mean has also been calculated though and is presented along with the geometric mean as it allows the high levels of cyclical recruitment that

occurs at specific sites around the territorial sea (in particular Chickens and Targets) to be highlighted as stock management might differ in these 'bumper' years.

Length data is currently used for the king scallop abundance index as the measurement method is considered more robust than for Age data and a greater degree of variance within the population is included (i.e. age data could typically have a length variance of ~50 -115 mm for Age 2 scallops). The length based abundance index splits the data into recruits (scallops < 95 mm) and post-recruits (scallops ≥ 95 mm). A cut off point of 95 mm has been used for recruits as this is the average size at which scallops across the extent of the territorial sea would potentially grow into the fishery by the end of the following king scallop fishing season (i.e. 31st May). Growth rates do however differ quite significantly around the Island and this single cut off value is not representative of that.

4.2.4.1 Recruits:

Overall stock trends for recruits can be observed using the recruit abundance index calculated using the geometric mean (solid line; Figure 13). The recruit index (geometric mean) peaked in 2014 with subsequent year on year reductions until 2018. However, the three most recent years of data (2019, 2021 and 2022) all show increases in the abundance of recruits for the first time since 2014 (solid line; Figure 13).

Cyclical spatially specific recruitment events can be observed using the recruit abundance index calculated using the arithmetic mean (dashed line; Figure 13) which does not down-weight isolated high-density patches of scallops. Whilst the use of this index for stock assessment would cause an over-estimation of stock abundance it is useful for observing spatially specific recruitment events which may need to be managed independent of the remaining stock. This index shows peaks in 2007/2008 and in 2015 which tally with large recruitment events at both Chickens (south coast) and Targets (west coast). Both of these recruitment events supported high density fisheries of post-recruits on the west coast of the Island in the subsequent year (i.e. November 2009 and November 2016).

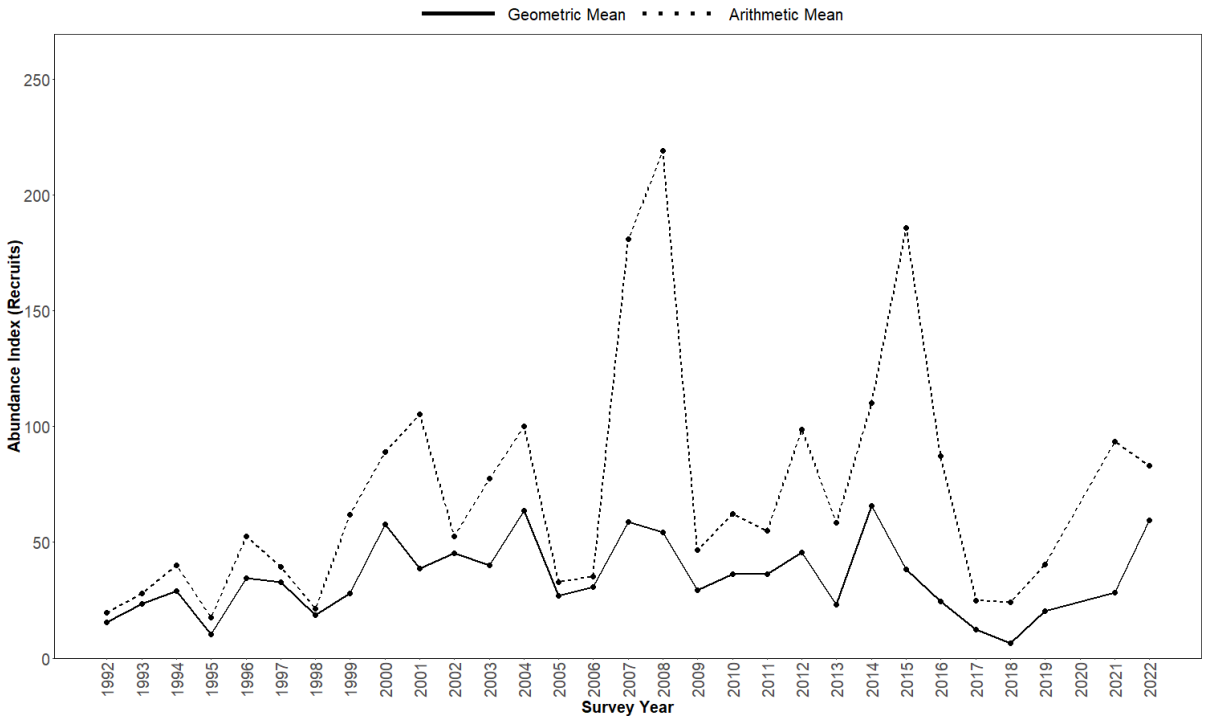

Figure 13: Recruit abundance index (scallops < 95 mm). Calculated based on length-based data where recruits were categorised as scallops under 95 mm at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. final day of the following season). The index is displayed using calculation of both the Geometric mean (solid line) for general stock trends and the Arithmetic mean (dashed line) for spatially specific cyclical recruitment events. The data is sourced from the April scallop survey using data from queen scallop dredges only.

4.2.4.2 Post-Recruits:

Overall stock trends for post recruits can be observed using the abundance index calculated using the geometric mean (solid line; Figure 14) which shows a general increasing trend in the mean abundance of post recruits (scallops ≥ 95 mm) from 1992 to 2015 (reaching the highest level on record in 2015). This was followed by three years of decreasing values before an increase in 2021 and a slight decrease in 2022.

The post recruit abundance index calculated using the arithmetic mean (dashed line; Figure 14) which does not down-weight isolated high-density patches of scallops shows peaks in 2009 and 2016 which tally with large recruitment events observed in the recruit index the year before.

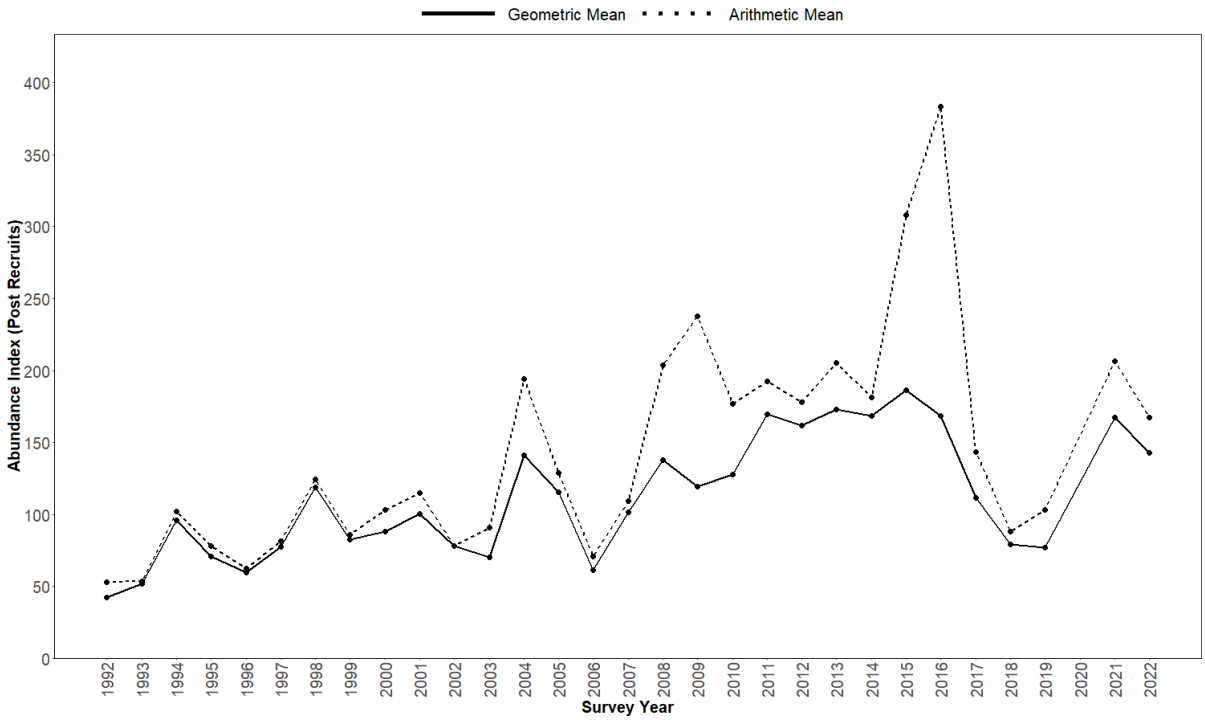

Figure 14: Post recruit abundance index (scallops ≥ 95 mm). Calculated based on length-based data where post recruits were categorised as scallops 95 mm or above at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. final day of the current season). The index is displayed using calculation of both the Geometric mean (solid line) for general stock trends and the Arithmetic mean (dashed line) for spatially specific cyclical recruitment events. The data is sourced from the April scallop survey using data from queen scallop dredges only.

4.3: Industry Spring Scallop Survey:

4.3.1 Survey Methods:

A survey for king and queen scallops was undertaken onboard two industry vessels (F.V. Benolas and F.V. Sarah Lena) from 10th – 19th April 2022. The survey was undertaken at all of the main king scallop fishing grounds (Table 2):

Table 2: Grounds surveyed during the 2022 industry scallop survey and number of survey days detailed

Ground	**Survey days**	**Area**
Targets (TAR)	3	3-12 nm
Chickens (CHI)	3	3-12 nm
East of Douglas (EDG)	3.5	3-12 nm
Bradda (BRA)	3.5	3-12 nm
Point of Ayre (POA)	1	3-12 nm
Maughold (MGH)	0.3	0-3 nm
East Coast (ECO)	0.5	0-3 nm
East of Douglas Experimental Research Area (EDG ERA)	0.3	0-3 nm

Survey areas were split into a fixed grid with a resolution of 1 min (longitude) x 0.5 min (latitude). Survey cells were sampled randomly within each ground strata (strata were defined predominately by depth) with approximately equal effort to ensure relatively even distribution of survey effort across the entire fished ground. Within each survey cell a 10-minute tow was undertaken at ~ 2.5 knots. Each vessel towed a 'standard survey dredge bar' with four dredges, two King and two Queen dredges

interspersed along the bar (Queen dredges had 10 teeth) and a 'juvenile survey dredge bar'. This is of the same design but uses Queen dredges with 17 teeth with a mesh (60 mm) attached internally that when stretched into a fixed position results in a maximum mesh size of 38 mm. The catch from each dredge was counted and a subsample of up to ~ 90 kings and 90 queens were measured.

Data cleaning: During 'data cleaning' any scallops in the subsample that were recorded as queen scallops over 100 mm were assumed to be king scallop recorded as the wrong species and the data adjusted accordingly. Discrepancies between the number reported on the tow sheet and the number sampled (where the whole dredge catch were measured) were altered to reflect the number measured.

Ground inclusion: POA and BRA were only surveyed for first time in 2020 (& POA was not surveyed in 2021). Therefore to keep the data constant only EDG, CHI and TAR are included in the main territorial sea analysis section for the 3-12 nm. Each ground will be analysed individually later in the report.

Targeted Cells: In addition to the random Survey Cells described above, additional selected cells (9 sites at BRA [Survey Cell: 4034, 4106, 4175, 4177, 4179, 4251, 4252, 4322, 4324] and 3 sites at CHI [Survey Cells: 5127, 5130, 5132] were surveyed on the basis of suitability for closed area or hotspot placement or exploratory fishing. These were excluded from the main analysis because these areas were chosen specifically as areas of known high scallop density (i.e. they were not a random selection of the particular fishing ground).

Data analysis: The geometric mean was used for data analysis due to the skewed (non-normal) distribution of the density data. Recruits (i.e. < 95 mm) were estimated using the data from standard queen and juvenile queen dredges whilst post-recruits (i.e. > 95 mm) were estimated using data from the standard king and standard queen dredges due to differences in the size selectivity of the dredges.

Survey timing: It should be noted that the 2019 industry surveys were undertaken in June for the 3-12 nm survey and April for the 0-3 nm survey. The 2020 and 2022 surveys were undertaken entirely in April (with 1 survey day in May for 2020) and the 2021 survey in May. It is acknowledged that the discrepancy in survey timing (up to 2 months difference in the 3-12 data) may have an effect on comparative inter-annual size-data, since scallops sampled in 2019 had an additional 2 months growth prior to measurement. In addition, the survey is conducted a variable number of months (between 5 and 7) prior to the start of the fishing season. Size-data has not however been adjusted to account for this growth due to the spatial-temporal complexity and uncertainty associated with scallop growth. However, a 95 mm cut off point for recruits has been used for the analysis to indicate the maximum size at which scallops on average caught in spring/summer could grow to 110 mm during the king scallop fishing season.

Data legend scales: Please note that the scales for each data subsection (i.e. TS, TAR, CHI, EDG, TAR, ECO, BRA etc.) differ among grounds and represent the range of density values within that dataset. The scales are consistent within each ground such that the same scale is used to represent recruit and post-recruit data.

4.3.2: Results:

The following sections show survey densities of under 95mm king scallops (based on data from juvenile and standard queen scallop dredges) and over 95mm king scallops (based on data from standard king and standard queen scallop dredges) for the years in which the industry survey has taken place. Initially data are presented for the whole Territorial Sea, and then ground by ground. In addition frequency histograms are presented to show the size distribution of sampled scallops.

4.3.2.1 Territorial Sea

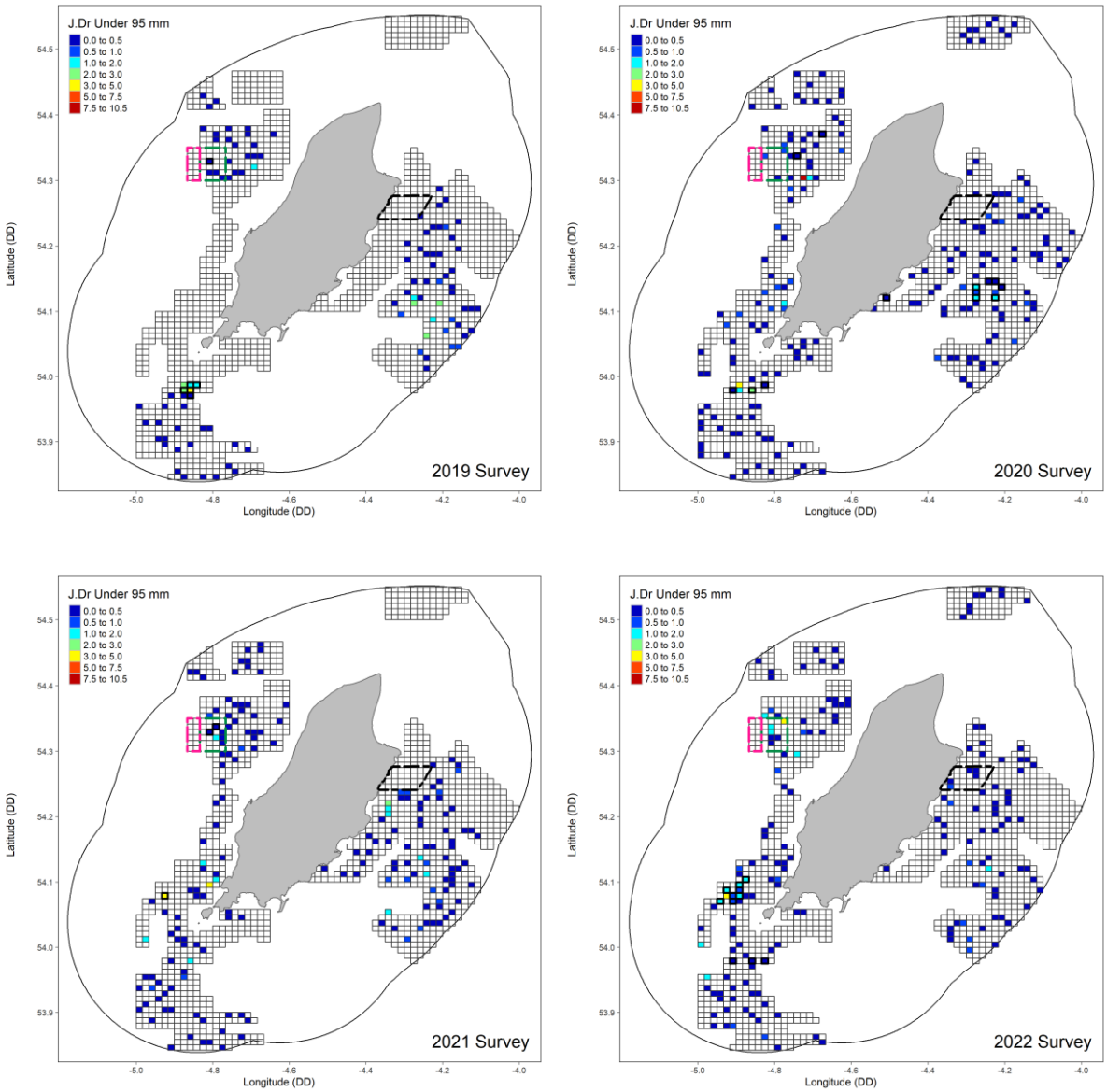

Figure 15: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile and standard queen scallop dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right). The green boxes indicate restricted access areas during the current queen scallop fishing season (i.e. 2022) and the pink boxes indicate areas currently closed for queen scallop fishing in 2022.The black box indicates the East of Douglas Experimental Research Area. Black cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although for some grounds analysis of targeted cells is presented).

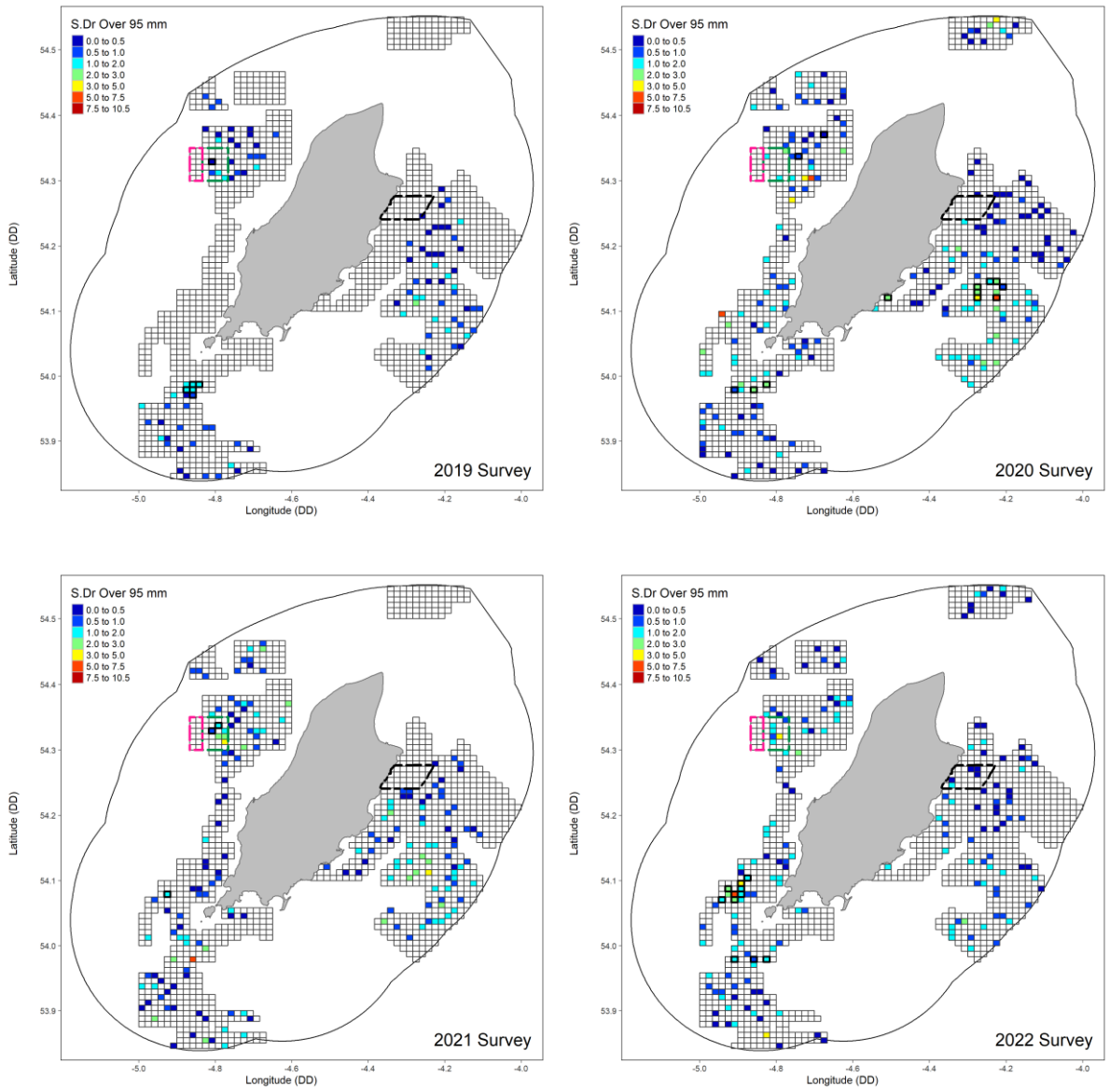

Figure 16: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard king and standard queen scallop dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right). In the 3-12 nm Point of Ayre in the north of the TS and in the 0-3 nm Bradda, East Coast and Maughold in the south-west, east and north-east of the TS were all surveyed for the first time in 2020. The green boxes indicate restricted access areas during the current queen scallop fishing season (i.e. 2022) and the pink boxes indicate areas currently closed for queen scallop fishing in 2022.The black box indicates the East of Douglas Experimental Research Area. Black cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although for some grounds analysis of targeted cells is presented).

Table 3: Abundance index (geometric mean) of king scallops per 100 m² split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for the territorial sea (EDG, CHI, TAR); note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2022 < 95 mm
Cells Surveyed	96	130	128	110
Min	0.00	0.00	0.00	0.00
Geometric Mean	**0.197**	**0.162**	**0.203**	**0.172**
Max	2.64	10.44	1.37	3.16

	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm	2022 > 95 mm
Cells Surveyed	96	130	128	110
Min	0.00	0.00	0.00	0.11
Geometric Mean	**0.571**	**0.689**	**0.830**	**0.717**
Max	2.11	5.67	5.59	3.54

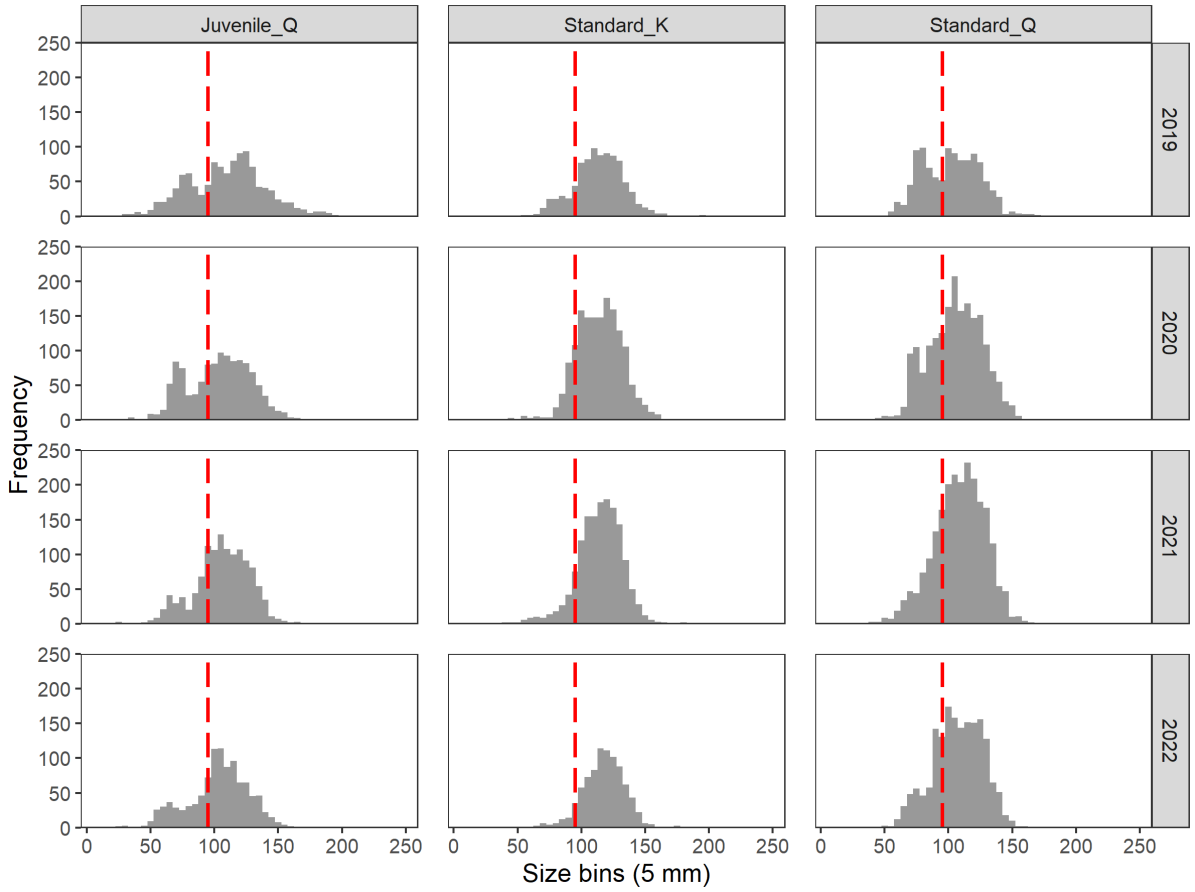

Figure 17: Size: density histogram of absolute counts of king scallops for the territorial sea displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

The size distribution of individuals from all three dredge types (Juvenile Queen, Standard King and Standard Queen) are shown in Figure 17. The juvenile dredges show two cohorts (one under and one over the 95 mm cut-off point) in all years. The cohort of scallops under 95 mm for 2022 has a smaller

peak than in 2019 and 2020 but is still evident. For post-recruits the peak in scallops over 95 mm is also smaller in 2022 than in 2021 and 2019 (Figure 17).

Calculation of the survey index for recruits and post-recruits uses data from different gear types. The Standard king scallop dredges do not sample scallops under 95 mm (i.e. recruits) as efficiently as either the juvenile or standard queen scallop dredges. As such the combined data from the juvenile and standard dredges is used to generate the survey index for recruits whilst for post-recruits data combined from the standard king and queen dredges are used. The overall data for the Isle of Man 3-12 nm territorial waters (i.e. CHI, TAR and EDG which are the only sites to have been surveyed in all years of the survey) indicates that for post-recruits (over 95 mm) the survey index increased annually for the first three years of the survey i.e. from **0.571 in 2019 to 0.689 in 2020 to 0.830 in 2021,** before recording a slight decrease in **2022 to 0.717** (Table 3) . For recruits (under 95 mm) the survey index is variable with decreases and increases in alternate years i.e. the index decreased from **2019 (0.197)** to **2020 (0.162)** and increased again in **2021 (0.203)** before decreasing again in **2022 (0.172)** (Table 3).

4.3.3 Fishing Grounds (3- 12 nm)

4.3.3.1 Targets

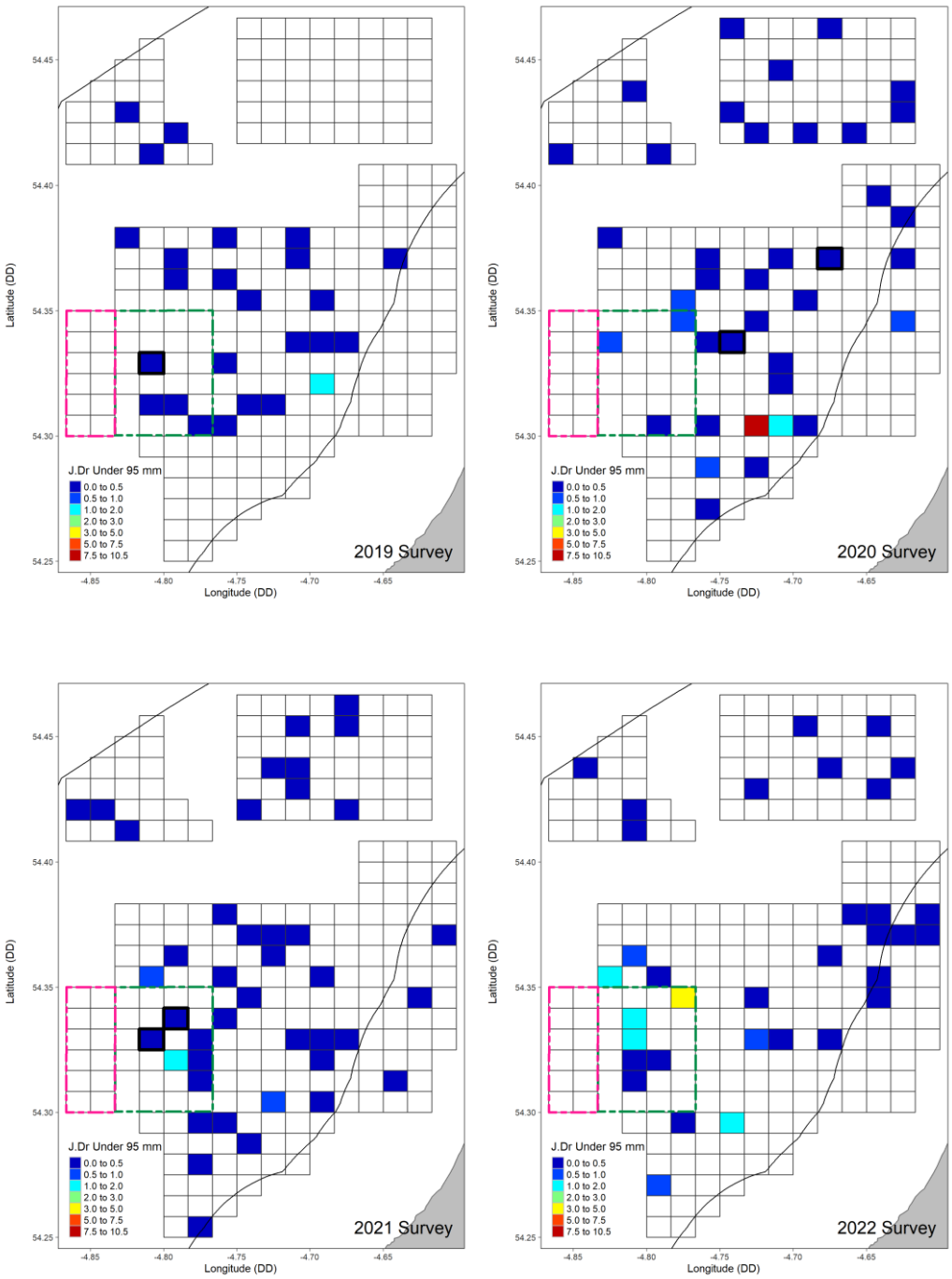

Figure 18: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at Targets (West coast). The green box indicates a restricted access area during the current queen scallop fishing season (i.e. 2022) and the pink box indicates an area currently closed for queen scallop fishing in 2022. Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing area analysis at Targets.

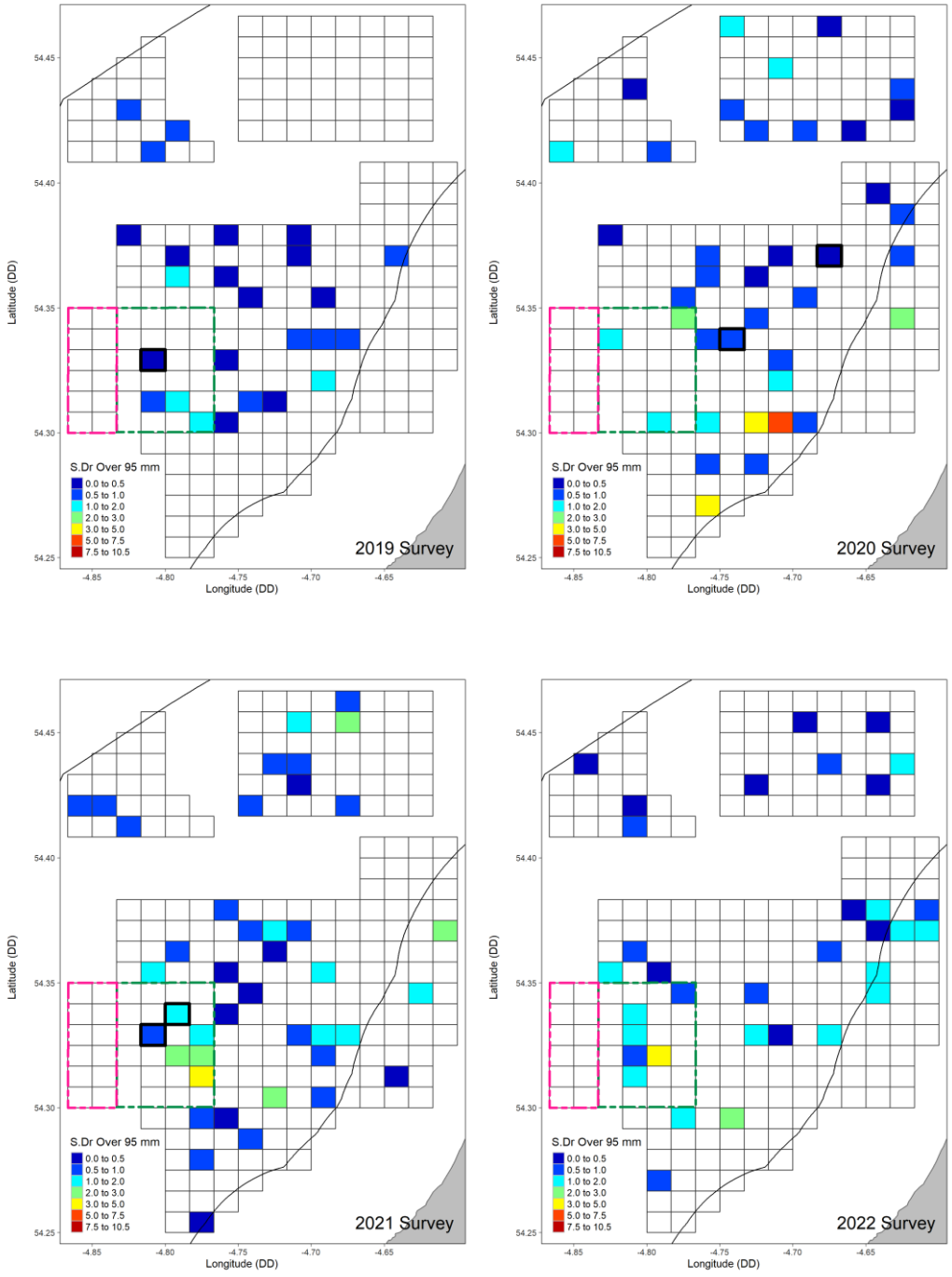

Figure 19: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard king and standard queen scallop dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at Targets (West coast). The green box indicates a restricted access area during the current queen scallop fishing season (i.e. 2022) and the pink box indicates an area currently closed for queen scallop fishing in 2022. Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing area analysis at Targets.

Table 4: Abundance index (geometric mean) of king scallops per 100 m² split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for Targets; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2022 < 95 mm
Cells Surveyed	24	37	40	34
Min	0.00	0.00	0.00	0.00
Geometric Mean	**0.102**	**0.186**	**0.158**	**0.265**
Max	1.81	10.44	1.11	3.16

	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm	2022 > 95 mm
Cells Surveyed	24	37	40	34
Min	0.19	0.05	0.00	0.17
Geometric Mean	**0.610**	**0.839**	**0.837**	**0.872**
Max	1.90	5.67	4.40	3.54

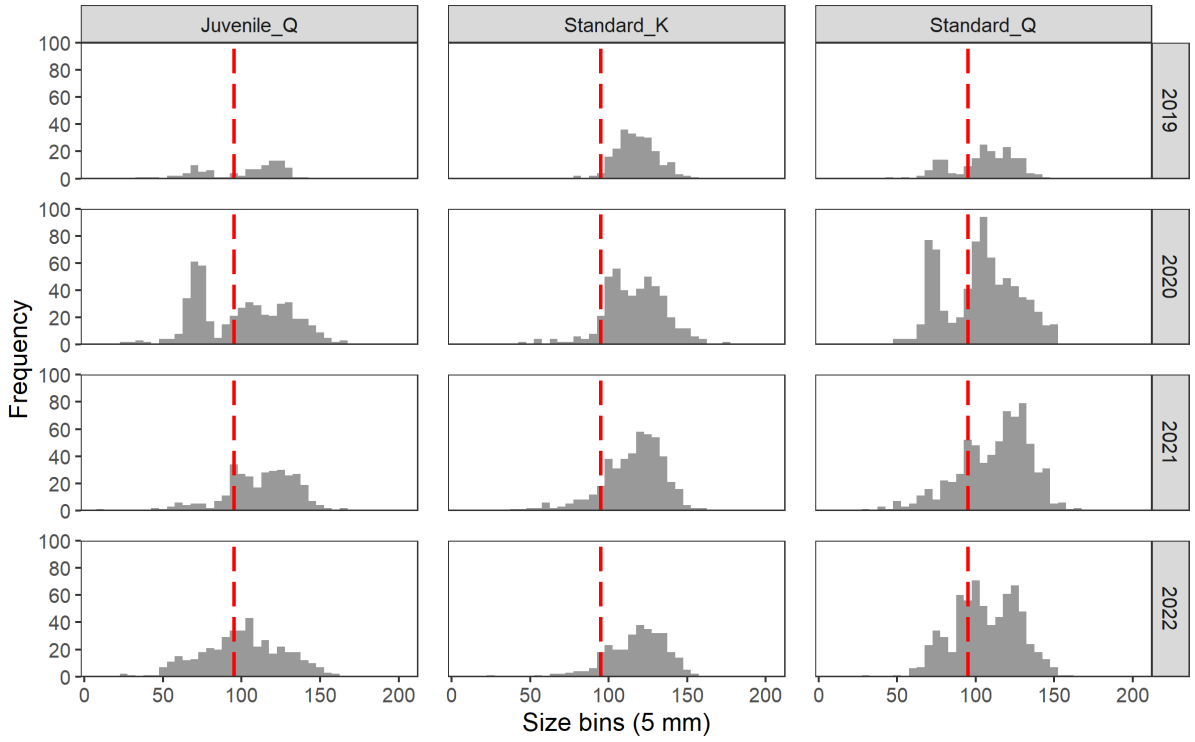

Figure 20: Size: density histogram of absolute counts of king scallops at Targets displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

The data from TAR indicates that for post-recruits (over 95 mm) the survey index increased from 2019 to 2020 and has then stayed relatively constant in 2020, 2021 and 2022 i.e. it increased from **0.610 in 2019 to 0.839 in 2020** and then remained relatively constant at **0.837 in 2021 and 0.872 in 2022** (Table 4). For recruits (under 95 mm) the survey index in 2022 is the highest recorded for this ground in the four-year time series (**2022 is 0.265**) (Table 4). These results are also reflected in the size density histograms presented above (Figure 20).

4.3.3.2 Chickens

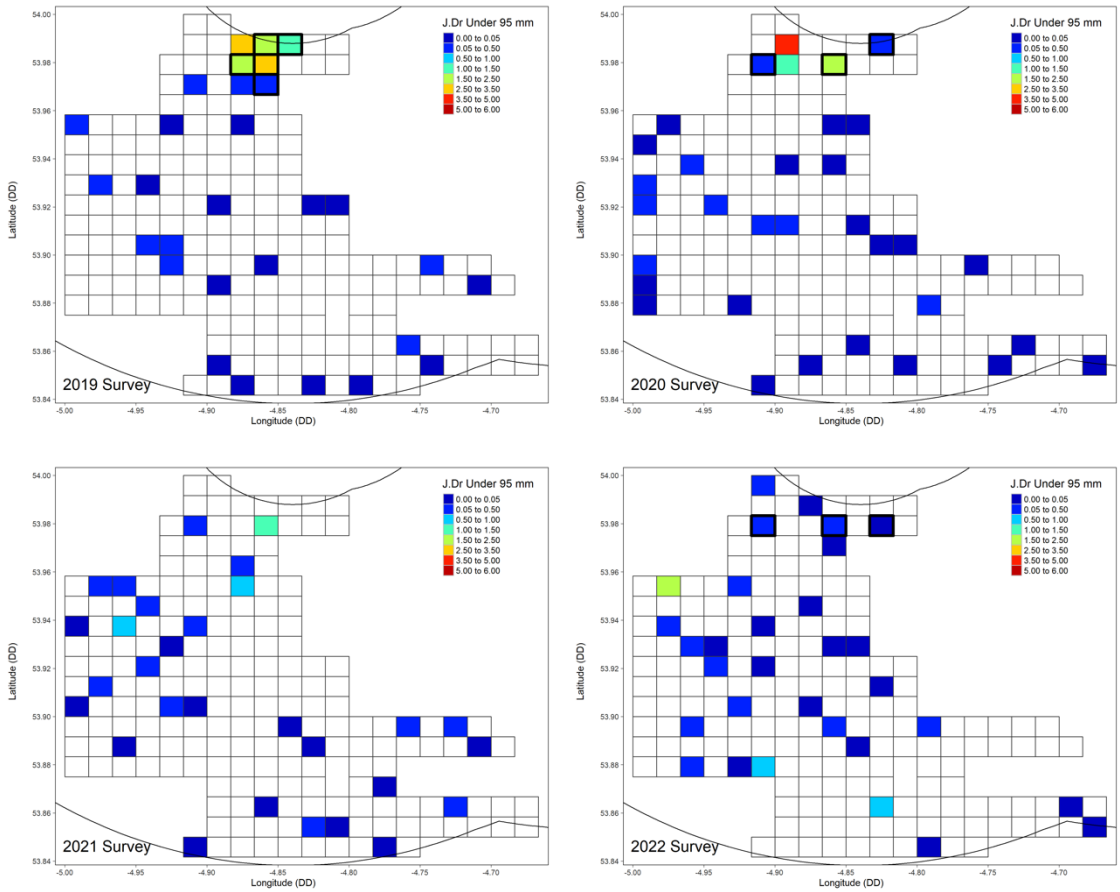

Figure 21: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at Chickens (West coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the Managed Area analysis).

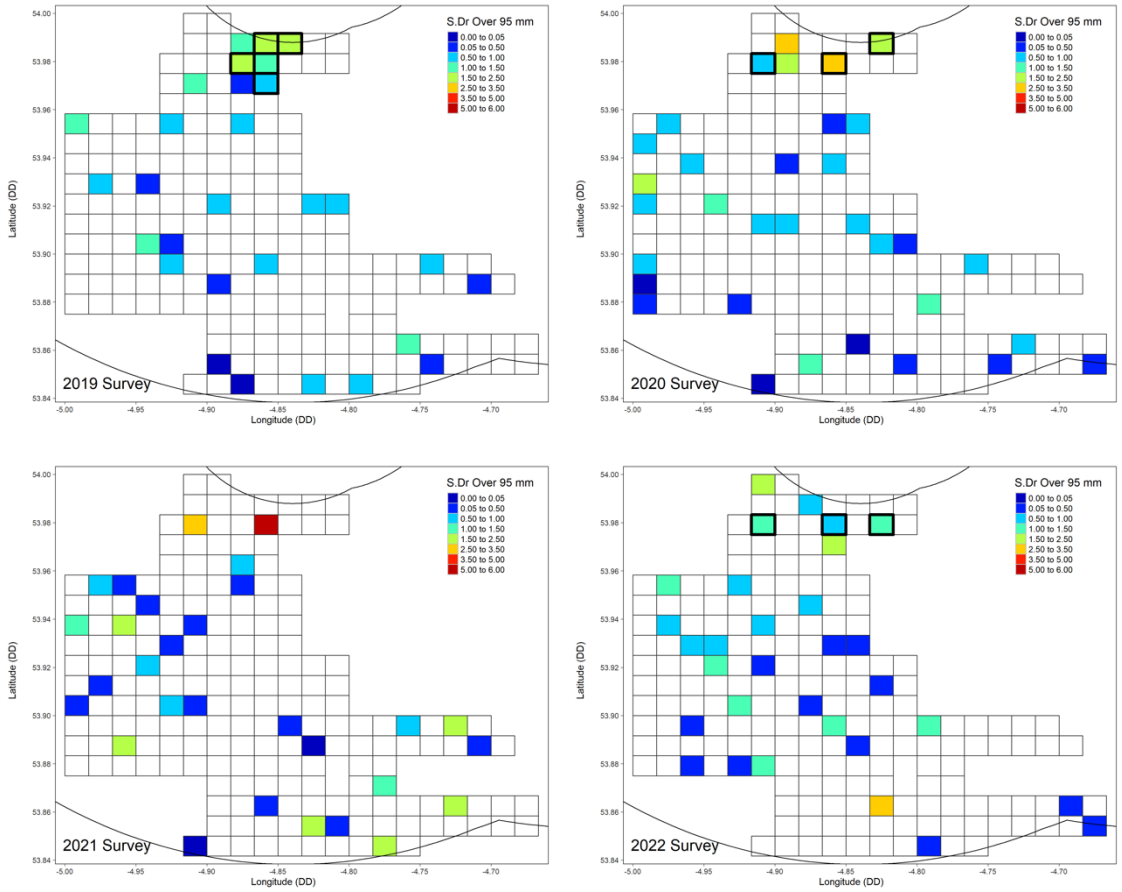

Figure 22: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2019 (top left), 2020 (top right), 2021 (top left) and 2022 (top right) at Chickens (South coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the Managed Area analysis

Table 5: Abundance index (geometric mean) of king scallops per 100 m^2 split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for Chickens; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2022 < 95 mm
Cells Surveyed	24	30	29	28
Min	0.00	0.00	0.00	0.00
Geometric Mean	**0.115**	**0.102**	**0.150**	**0.127**
Max	2.64	4.27	1.28	1.67

	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm	2022 > 95 mm
Cells Surveyed	24	30	29	28
Min	0.00	0.00	0.00	0.18
Geometric Mean	**0.581**	**0.567**	**0.634**	**0.671**
Max	1.41	2.83	5.59	3.01

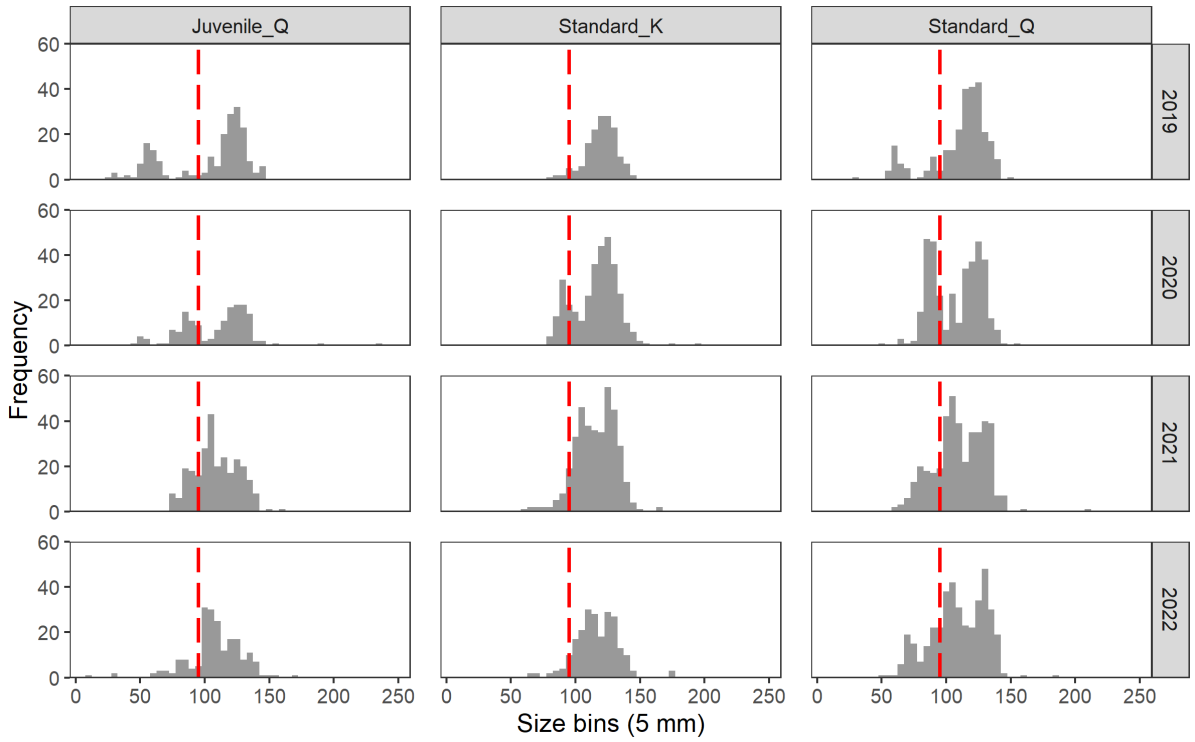

Figure 23: Size: density histogram of absolute counts of king scallops at Chickens displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

The data from CHI indicates that for post-recruits (over 95 mm) the survey in 2022 is the highest recorded for this ground in the four-year time series (**2022 is 0.671**) (Table 5). For recruits (under 95 mm) the survey index has fluctuated with decreases and increases in alternate years i.e. the index decreased from **2019 (0.115) to 2020 (0.102)** and then increased from 2020 to **2021 (0.150)** before decreasing again from 2021 to **2022 (0.127)** (Table 5).

4.3.3.3 East of Douglas

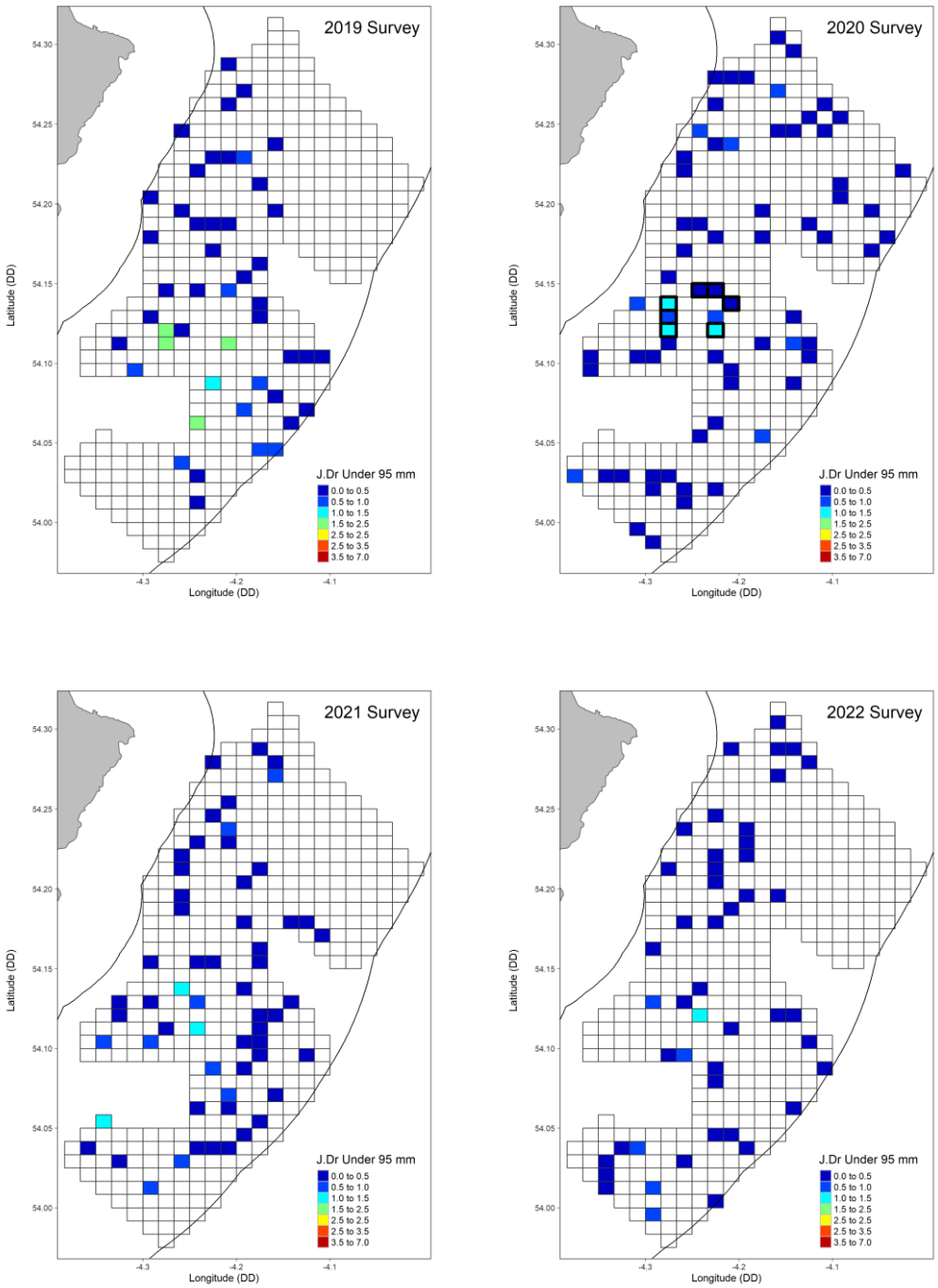

Figure 24: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at East Douglas (East coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing area analysis at East of Douglas.

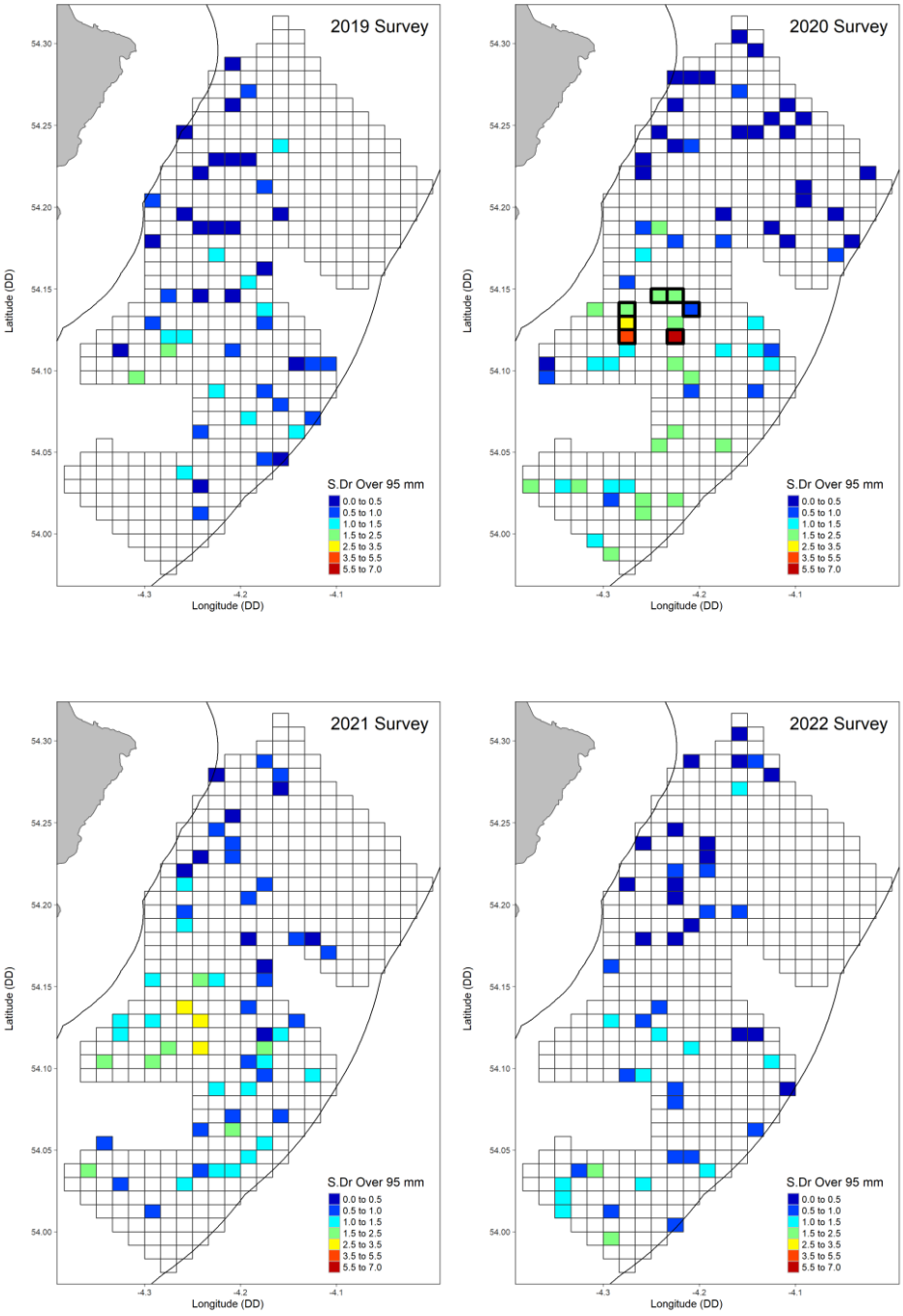

Figure 25: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at East Douglas (East coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing area analysis at East of Douglas.

Table 6: Abundance index (geometric mean) of king scallops per 100 m² split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for East of Douglas; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2022 < 95 mm
Cells Surveyed	48	63	59	48
Min	0.00	0.00	0.00	0.00
Geometric Mean	**0.358**	**0.185**	**0.280**	**0.151**
Max	2.48	0.98	1.37	1.19

	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm	2022 > 95 mm
Cells Surveyed	48	63	59	48
Min	0.00	0.00	0.00	0.11
Geometric Mean	**0.547**	**0.674**	**0.943**	**0.650**
Max	2.11	2.50	3.02	2.29

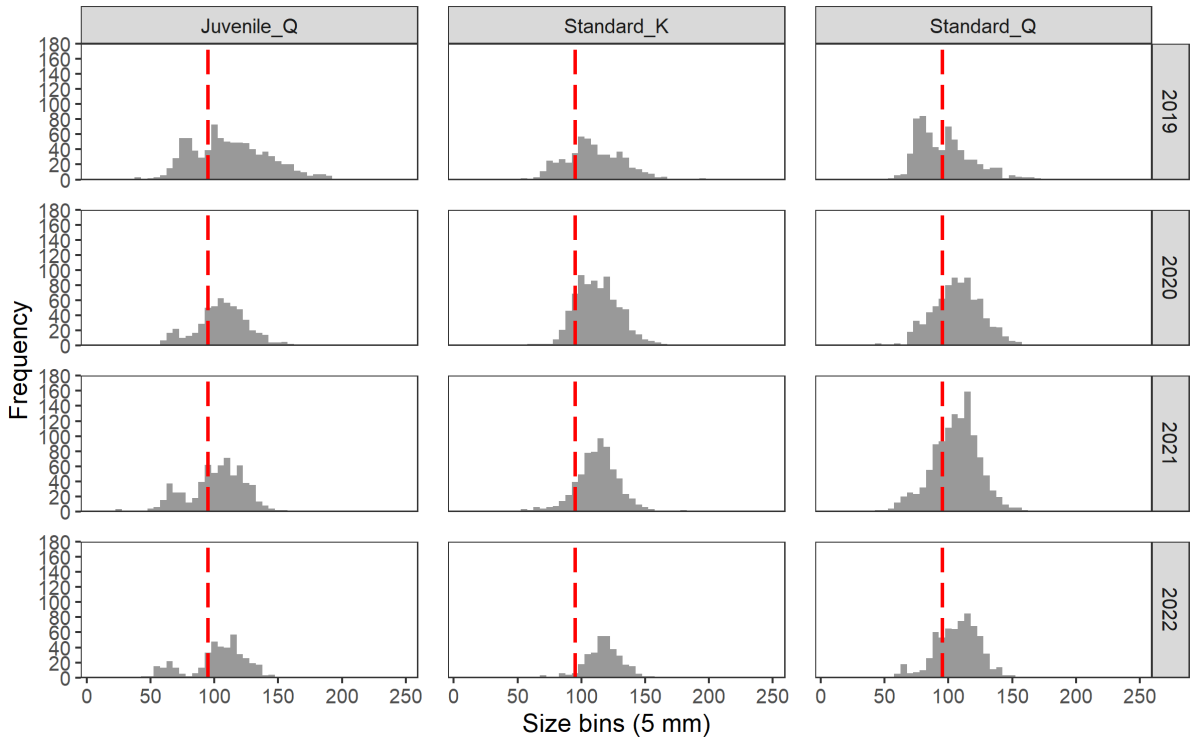

Figure 26: Size: density histogram of absolute counts of king scallops at East of Douglas displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

The data from EDG indicates that for post-recruits (over 95 mm) the survey index increased annually for the first three years from **0.547 in 2019 to 0.674 in 2020 to 0.943 in 2021** before decreasing to **0.650 in 2022** (Table 6). For recruits (under 95 mm) the survey index fluctuated with annual decreases and increases from **0.358 in 2019 to 0.185 in 2020 to 0.280 in 2021 to 0.151 in 2022** (Table 6).

4.3.3.4 Point of Ayre

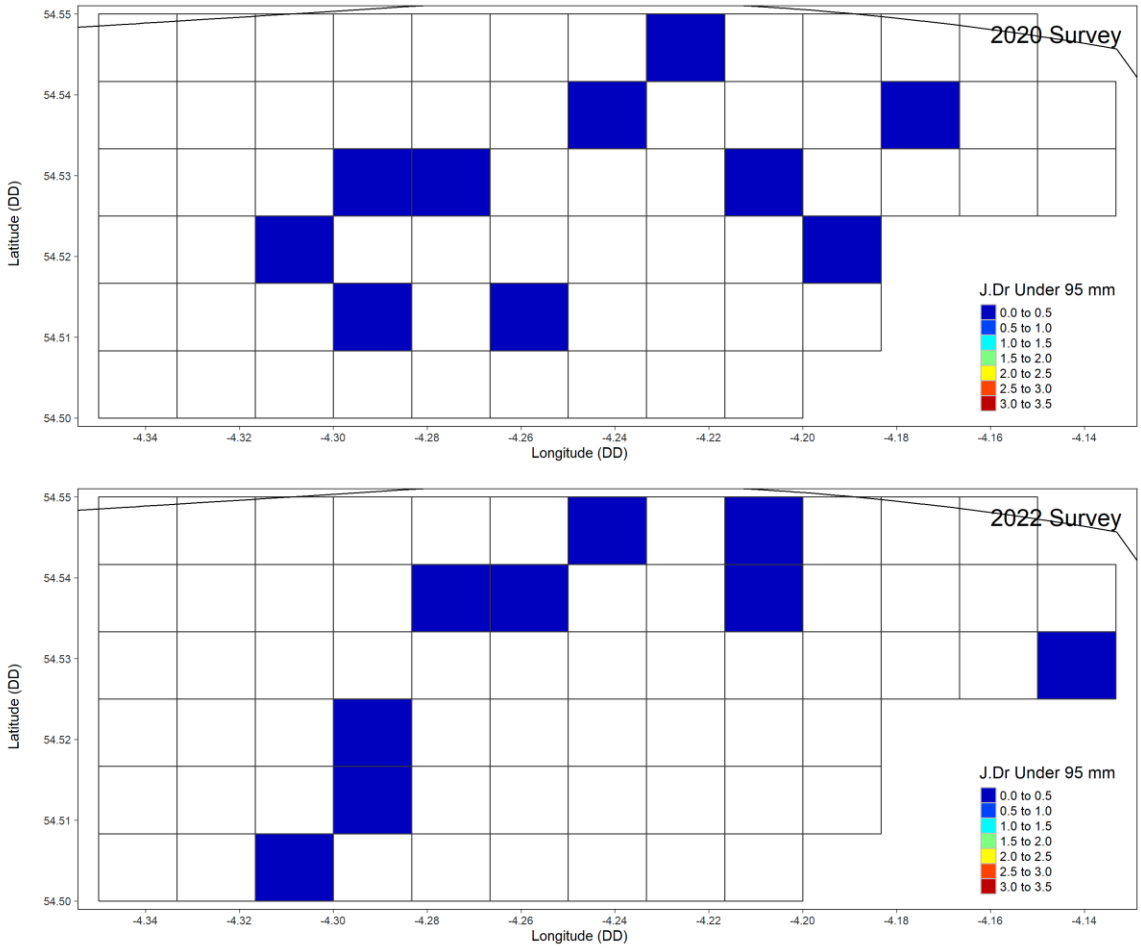

Figure 27: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2020 (top) and 2022 (bottom). This ground was not surveyed in 2019 or 2021.

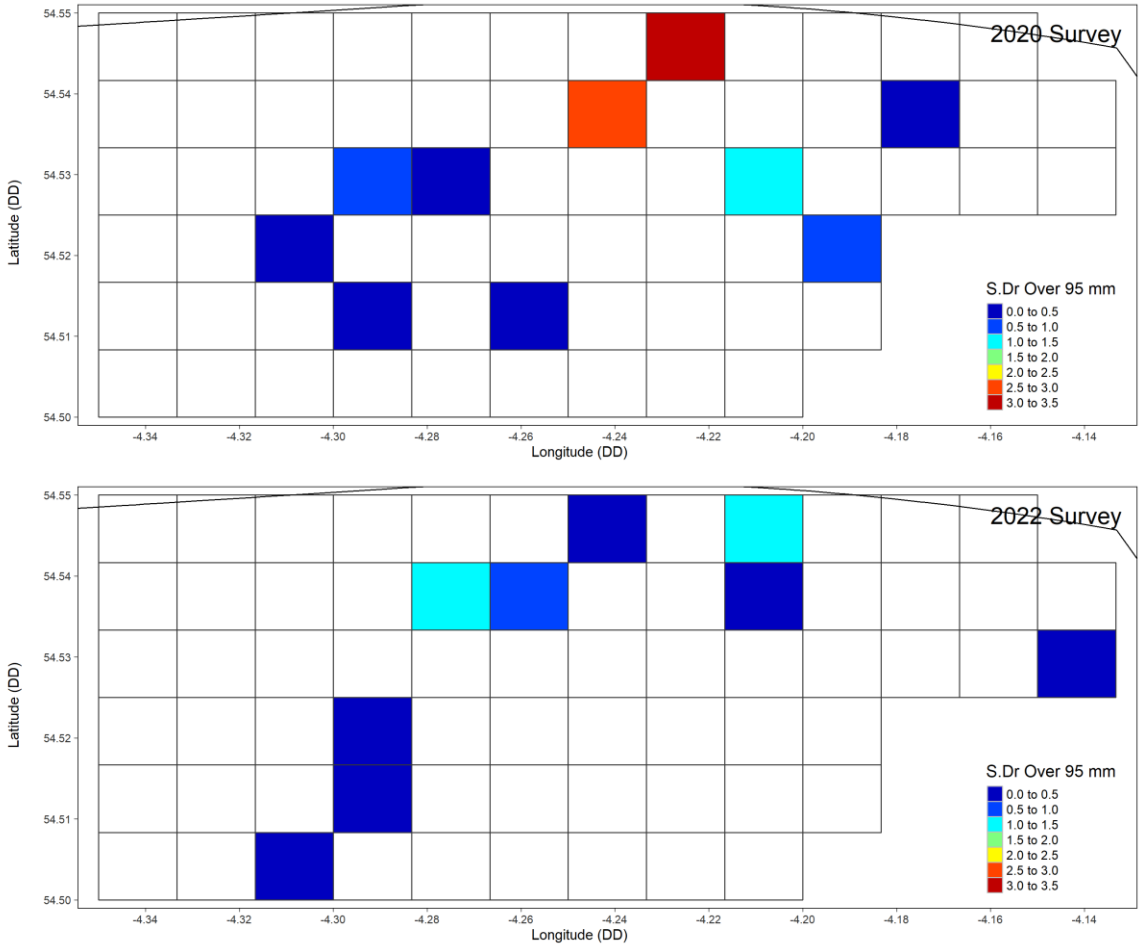

Figure 28: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2020 (top) and 2022 (bottom). This ground was not surveyed in 2019 or 2021.

Table 7: Abundance index (geometric mean) of king scallops per 100 m^2 split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for Point of Ayre; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2020 < 95 mm	2022 < 95 mm	2020 > 95 mm	2022 > 95 mm
Cells Surveyed	10	9	10	9
Min	0.00	0.00	0.13	0.00
Geometric Mean	**0.139**	**0.123**	**0.671**	**0.278**
Max	0.37	0.26	3.11	1.49

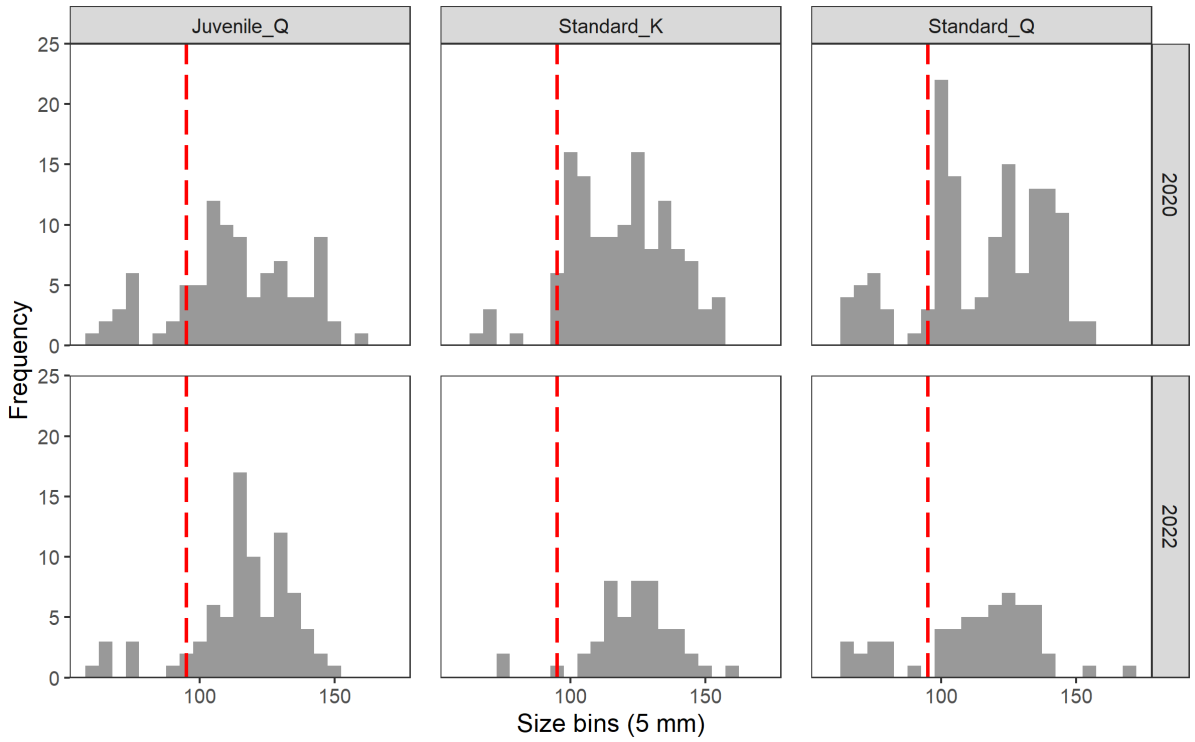

Figure 29: Size: density histogram of absolute counts of king scallops at Point of Ayre displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

Due to resource limitations and the distance to the fishing ground it has only been surveyed in two of the four survey years (2020 and 2022). The data from POA indicates that for post-recruits (over 95 mm) the survey index decreased between 2020 and 2022 from **0.671 in 2020 to 0.278 in 2022** (Table 7). For recruits (under 95 mm) the survey index also decreased between 2020 and 2022 from **0.139 in 2020 to 0.123 in 2022** (Table 7).

4.3.4 Fishing Grounds (0- 3 nm)

4.3.4.1 East Coast

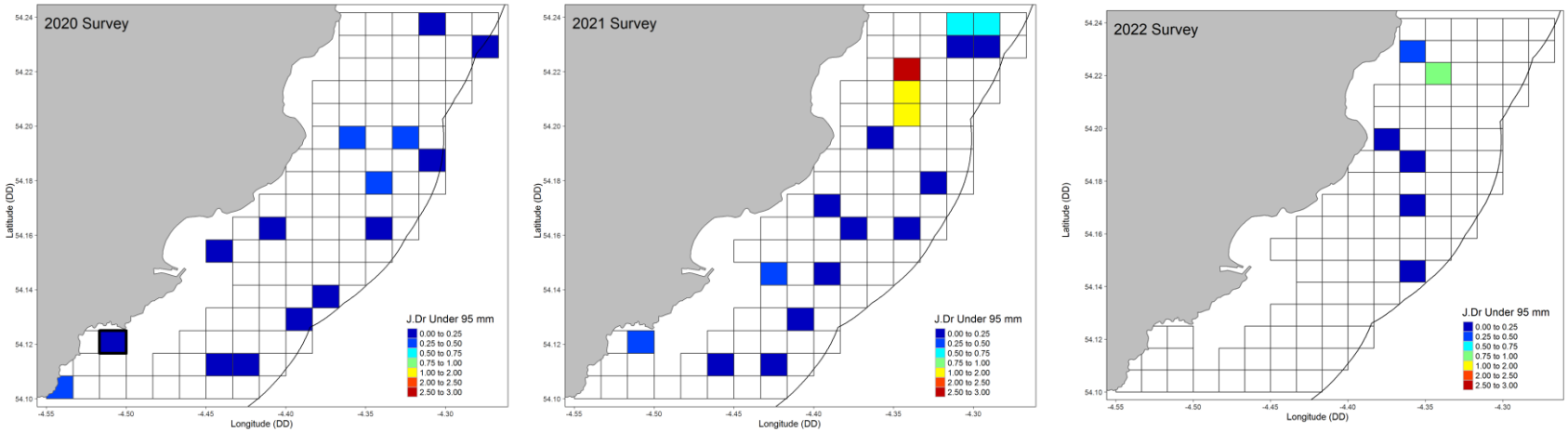

Figure 30: Map illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2020 and 2021 at East Coast 0 – 3 nm (East coast).

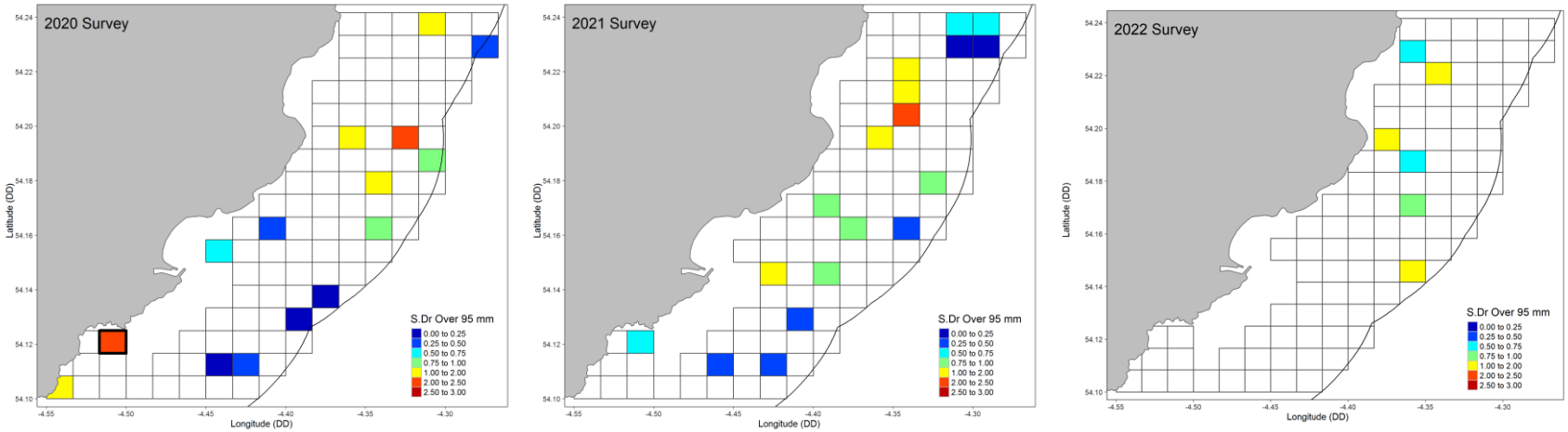

Figure 31: Map illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2020 and 2021 at East Coast 0 – 3 nm (East coast).

Table 8: Abundance index (geometric mean) of king scallops per 100 m² split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for East Coast 0 – 3 nm; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's).

	2020 < 95 mm	2021 < 95 mm	2022 < 95 mm	2020 > 95 mm	2021 > 95 mm	2022 > 95 mm
Cells Surveyed	15	18	6	15	18	6
Min	0.00	0.00	0.00	0.00	0.00	0.66
Geometric Mean	**0.153**	**0.238**	**0.220**	**0.548**	**0.606**	**1.12**
Max	0.47	2.73	0.94	2.22	2.39	1.62

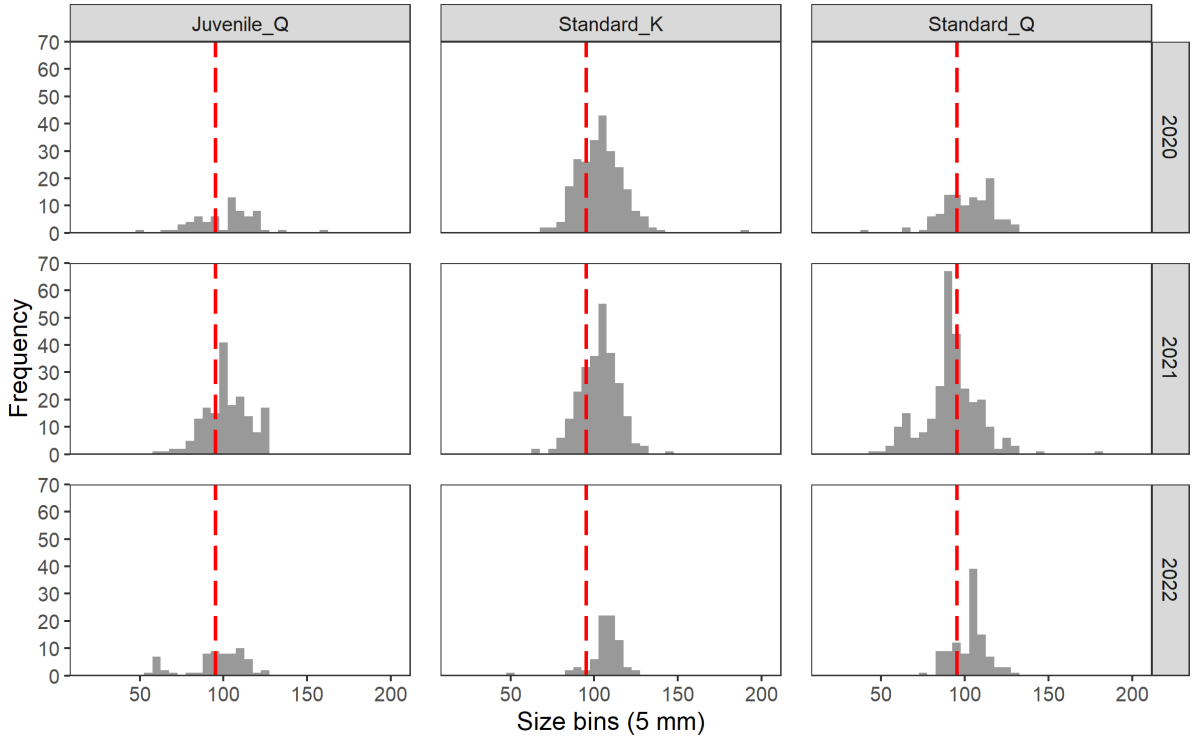

Figure 32: Size frequency of absolute counts of king scallops by dredge type for East Coast 0 – 3 nm 2020 and 2021. The red dashed line indicates the estimated recruit cut-off of 95 mm.

The data from ECO, which has no comparative survey data from 2019, indicates that for post-recruits (over 95 mm) the survey index was the highest recorded in the three-year time series in **2022 at 1.12** (Table 8). For recruits (under 95 mm) the survey index increased from **0.153 in 2020 to 0.238 in 2021** before decreasing to **0.220 in 2022** (Table 8), although the lower survey effort in 2022 (6 survey cells) compared to 2020 and 2021 (15 and 18 survey cells respectively) should be taken into consideration when considering these results.

4.3.4.2 Bradda (0-3nm and offshore)

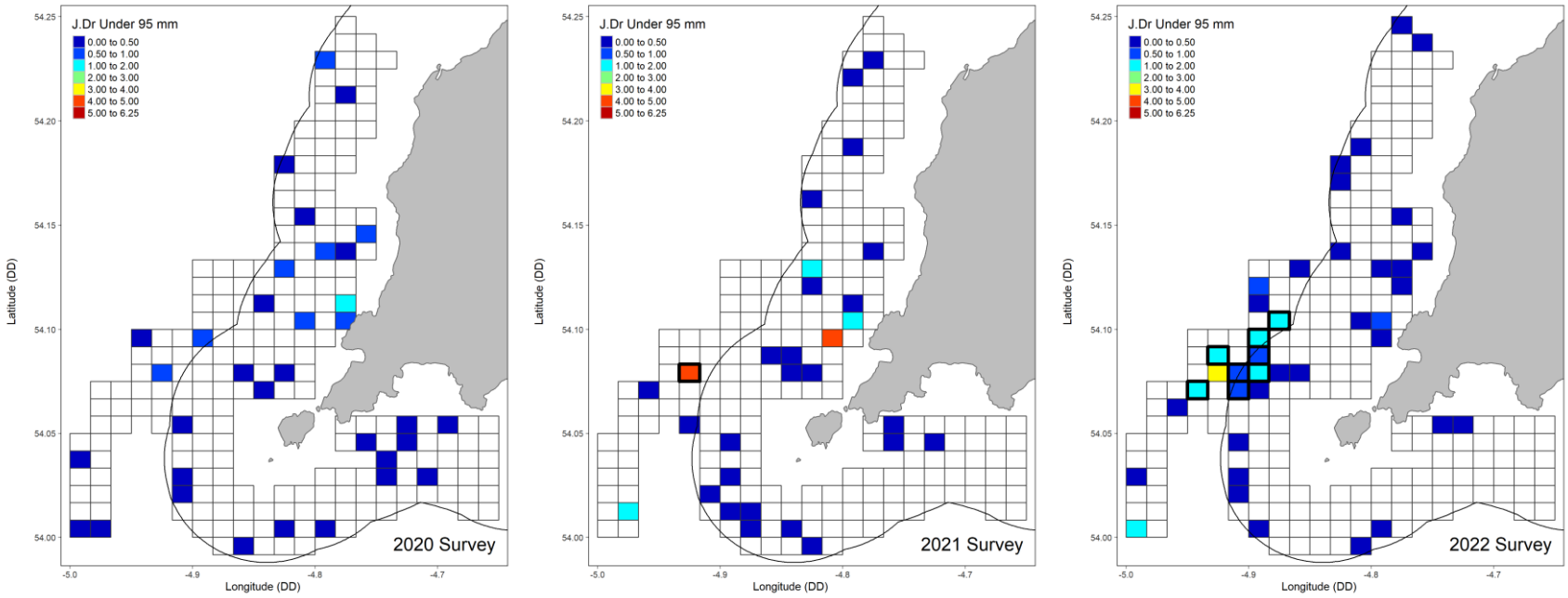

Figure 33: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2020, 2021 and 2022 at Bradda (0 – 3 nm and offshore) (South-west coast).

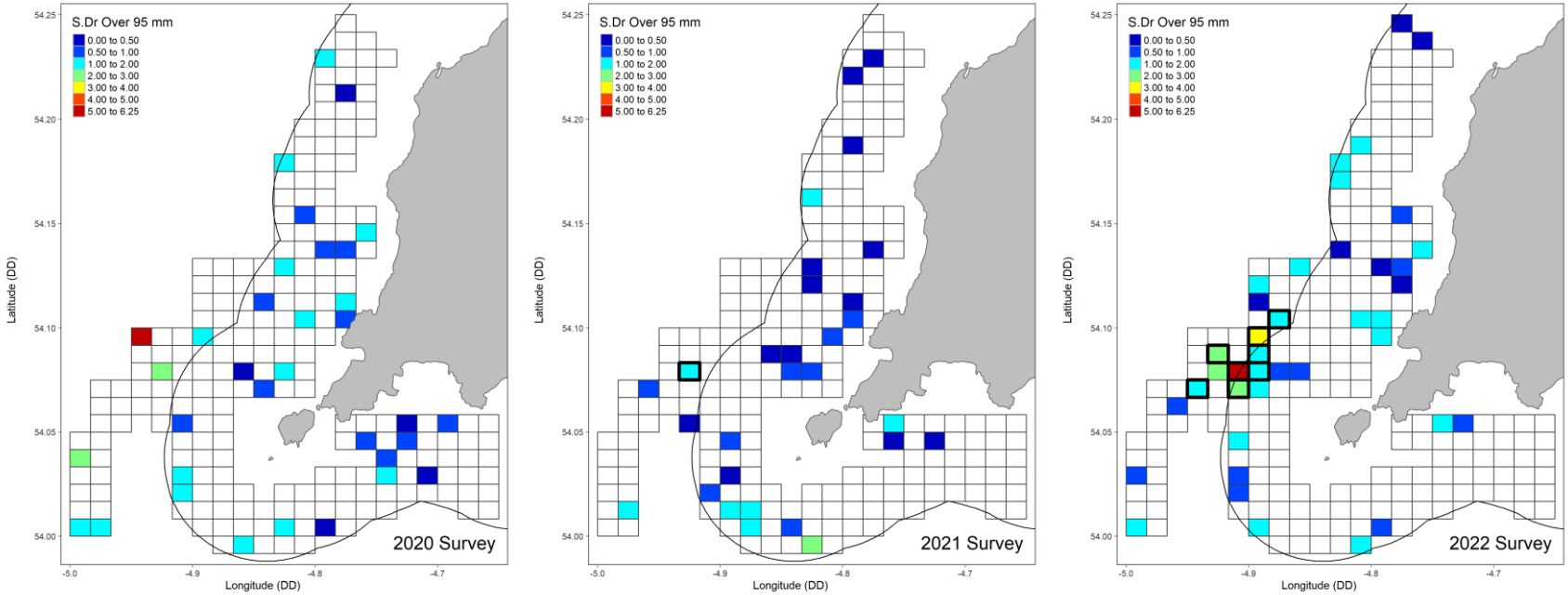

Figure 34: Map illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2020, 2021 and 2022 at Bradda (0 – 3 nm and offshore) (South-west coast).

Table 9: Abundance index (geometric mean) of king scallops per 100 m² split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for Bradda (0 – 3 nm and offshore); note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's).

	2020 < 95 mm	2021 < 95 mm	2022 < 95 mm	2020 > 95 mm	2021 > 95 mm	2022 > 95 mm
Cells Surveyed	34	28	32	34	28	32
Min	0.00	0.00	0.00	0.13	0.00	0.26
Geometric Mean	**0.259**	**0.198**	**0.177**	**1.01**	**0.623**	**0.940**
Max	1.62	4.35	3.07	5.41	2.18	2.37

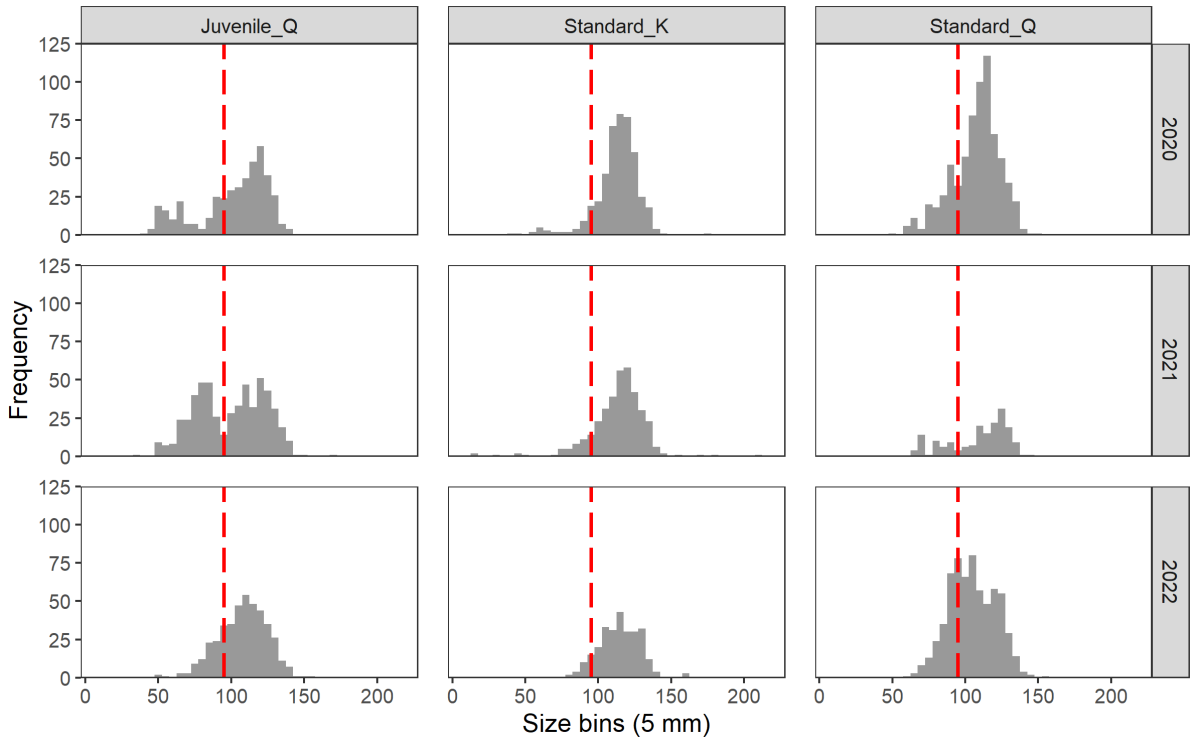

Figure 35: Size frequency of absolute counts of king scallops by dredge type for Bradda (0 – 3 nm and offshore) 2020, 2021 and 2022. The red dashed line indicates the estimated recruit cut-off of 95 mm.

The data from BRA, which has no comparative survey data from 2019, indicates that for post-recruits (over 95 mm) the survey index decreased from 2020 to 2021 from **1.01 in 2020 to 0.623 in 2021** and then increased to **0.940 in 2022** (Table 9). For recruits (under 95 mm) the survey index has decreased annually from **0.247 in 2020 to 0.189 in 2021 to 0.177 in 2022** (Table 9).

In 2022, a survey of eight targeted cells recorded a higher density patch of scallops in the south-west of the ground with a maximum of 6.25 scallops recorded per 100 m² (Figure 34).

4.3.4.3 Maughold 0-3nm

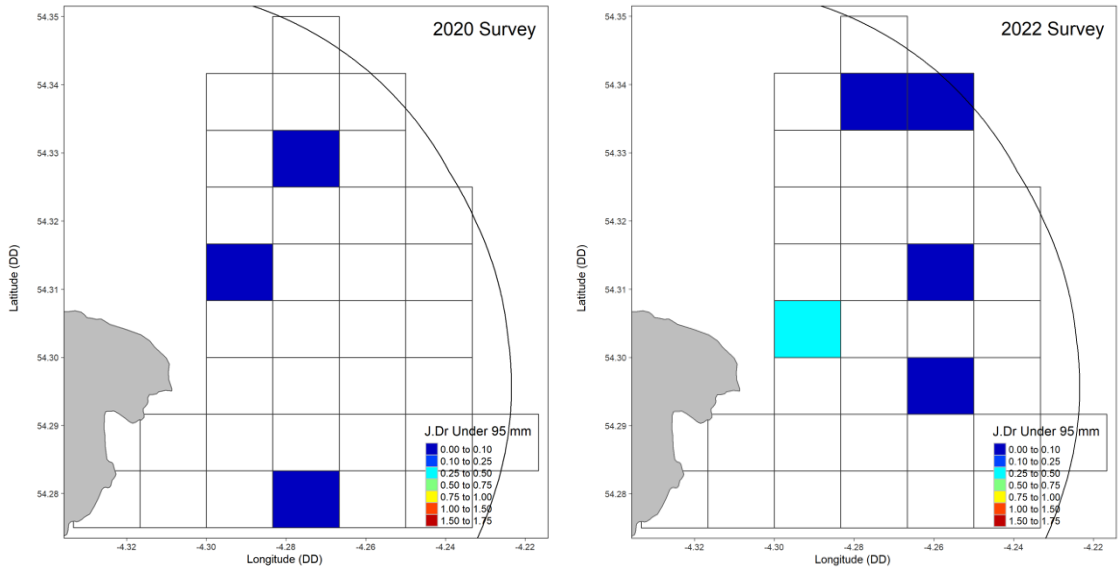

Figure 36: Maps illustrating the survey densities (scallops per 100 m²) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2020 and 2022 at Maughold (0 – 3 nm and offshore) (north-east coast).

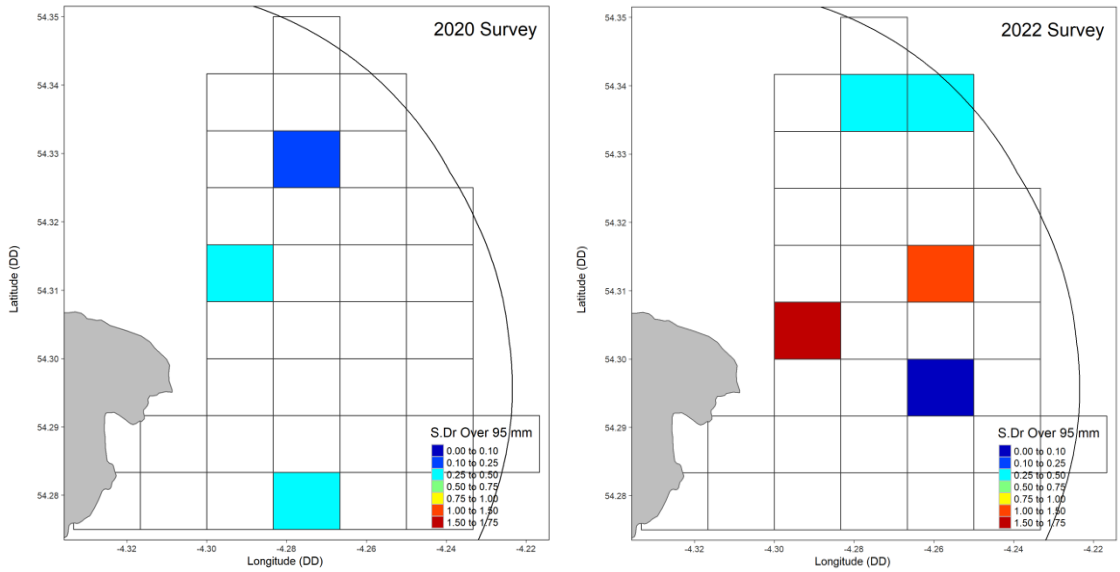

Figure 37: Maps illustrating the survey densities (scallops per 100 m²) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2020 and 2022 at Maughold (0 – 3 nm and offshore) (north-east coast).

Table 10: Abundance index (geometric mean) of king scallops per 100 m² split by over (from standard king and standard queen scallop dredges) and under (from juvenile queen and standard queen scallop dredges) 95 mm for Maughold (0 – 3 nm); note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's).

	2020 < 95 mm	2022 < 95 mm	2020 > 95 mm	2022 > 95 mm
Cells Surveyed	3	5	3	5
Min	0.01	0.00	0.22	0.00
Geometric Mean	**0.078**	**0.133**	**0.336**	**0.452**
Max	0.05	0.41	0.36	1.72

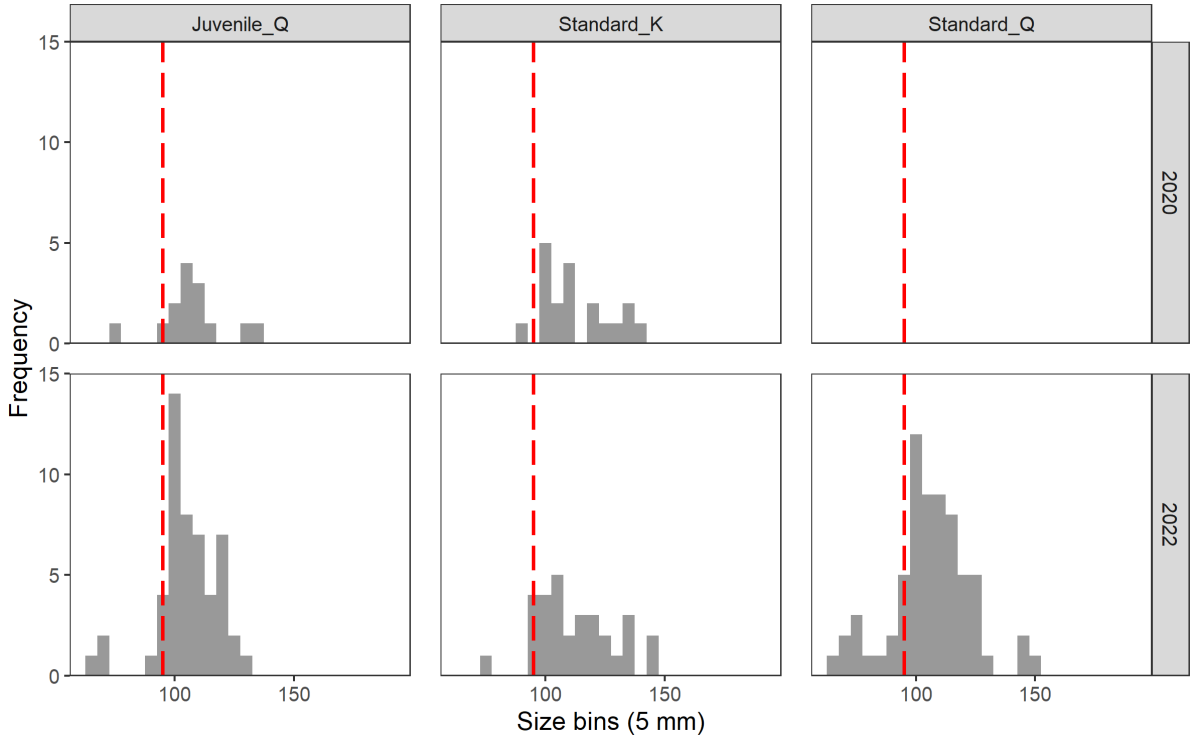

Figure 38: Size frequency of absolute counts of king scallops by dredge type for Maughold (0 – 3 nm) 2020 and 2022. The red dashed line indicates the estimated recruit cut-off of 95 mm.

The data from MGH, which has no comparative survey data for 2019 or 2021, indicates that for post-recruits (over 95 mm) the survey index increased from 2020 to 2022 from **0.336 to 0.452** (Table 9). For recruits (under 95 mm) the survey index has also increased from **0.078 in 2020 to 0.133 in 2022** (Table 9).

5. Overall Spatial and Temporal Comparisons

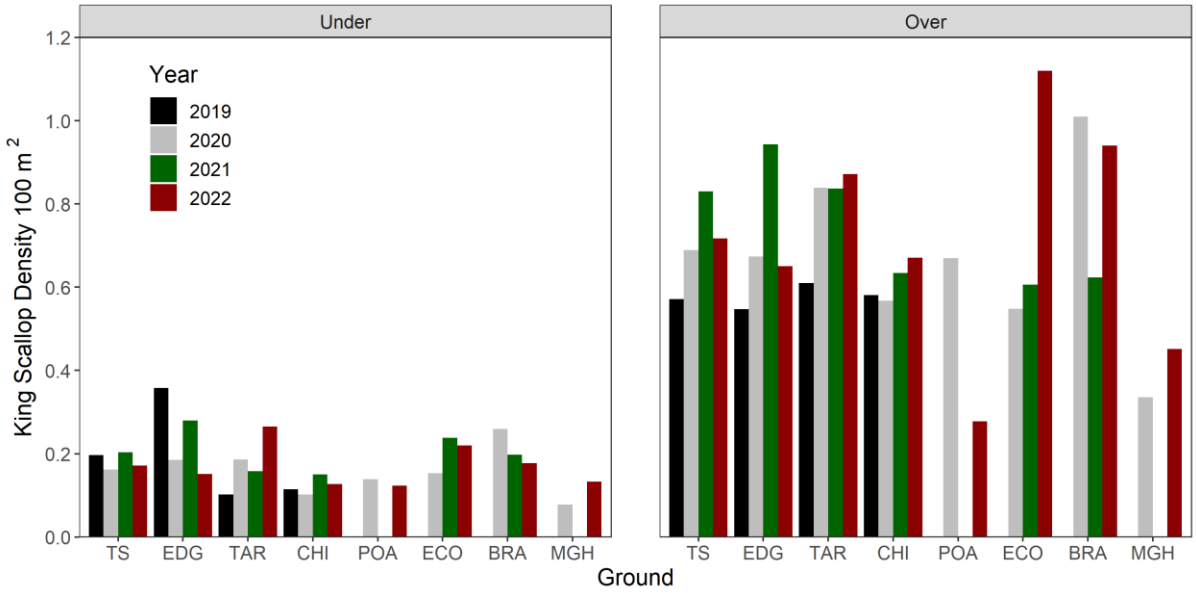

Figure 39: Comparison of king scallop abundance indices (geometric mean) (over and under 95 mm) by year and by ground for the industry survey

Within the 3-12 nm territorial sea there has been an overall decrease in the abundance index (geometric mean) from 2021 to 2022 from the industry survey for both post-recruits and recruits when combining the three grounds, EDG, TAR and CHI which have been surveyed in all years. This decrease is driven by EDG which recorded the highest landings in the 2021/2022 fishing season (TS; Figure 39). The Prince Madog survey shows the same decreasing pattern for the post-recruit abundance index from 2021 to 2022 although the recruit index shows a slight increase from 2021 to 2022 (Figure 13 and Figure 14). The declines in post-recruit abundance observed in both the industry and Prince Madog surveys follow 1491 t of landings from the whole territorial sea area during the 2021/2022 fishing season (from a total TAC of 2049 t) (Table 11).

While the abundance index for post recruits has shown a general decline across the Territorial Sea (EDG, CHI and TAR combined), the picture varies among individual grounds. Four grounds (TAR, CHI, ECO, BRA) showed an increase in the post recruit index. In both surveys BRA in the south-west of the Island recorded the highest densities for 2022. In the Prince Madog survey Stations at BRA, ST44 and ST33 all have high densities ranging from 6 - 7 scallops per 100 m^2 (all sizes). In the Industry survey the recorded densities in the surveyed area range up to 6.25 scallops per 100 m^2 (scallops over 95 mm only). The abundance index calculated for the BRA ground is lower as the targeted survey cells within this ground which recorded the high densities are not included in the standard analysis based on cells surveyed as part of the random stratified sampling methodology (Figure 9 and Figure 12).

Both surveys also recorded high densities at the inshore east coast sites. The Prince Madog survey recorded densities of 4-5 scallops per 100 m^2 at sites ST51, LAX and ST27 while the industry survey recorded lower densities (1-2 scallops per 100 m^2). However these densities were still relatively high for post recruits (over 95 mm) compared to other survey grounds (Table 11).

Table 11: A summary of the changes in the abundance index (geometric mean) for over and under 95 mm by survey ground. Landings are also displayed in t from the 2021/2022 season for each ground based on data from the Daily Catch Return Forms and indications of fishing inside or outside of the 3nm limit (green indicates increase and red indicates decrease relative to previous season).

Area	Ground	2021 <95 mm	2022 <95 mm	Change	2021 >95 mm	2022 >95 mm	Change	Landings 2021/22 (t)
TS	T.S.	0.203	0.172	-	0.830	0.717	-	1491
3-12 nm	EDG	0.280	0.151	-	0.943	0.650	-	553
	TAR	0.158	0.265	+	0.837	0.872	+	223
	CHI	0.150	0.127	-	0.634	0.671	+	326
	POA	NA	0.123	NA	NA	0.278	NA	17
0-3 nm	ECO	0.238	0.220	-	0.600	1.120	+	89
	BRA	0.189	0.177	-	0.603	0.940	+	181
	MGH	NA	0.133	NA	NA	0.452	NA	101

6. TAC Calculation for 2022/2023 SCE fishing season (Abundance Index)

6.1 ICES data-limited approach for Category 3 stocks

The king scallop stock within the Isle of Man's territorial sea is currently categorised as data-limited as there is no full peer-reviewed quantitative stock assessment in place. Within the framework outlined by ICES it is considered a category 3 stock (i.e. a stock for which survey-based assessments indicate

trends (ICES 2012)). The SMB proposed that the king scallop TAC should be based on the precautionary approach outlined by ICES for Category 3 (Data-limited) stocks. For category 3 stocks, without a quantitative assessment, an abundance index from research surveys, can be used as an indicator of stock size to estimate the level of TAC advised for the following year.

The annual advice is based on a two-over-three rule with a comparison of the average of the last two year's survey indices relative to the average of the three preceding years producing a % increase or decrease in TAC. Survey indices can contain a level of noise within the data and as such a +/- 20% uncertainty cap on inter annual changes in the TAC is advised (ICES, 2012). As such, if the ratio change is + 5% then the TAC is increased by 5% whilst if the ratio change is -10% then the TAC is decreased by 10%. However if the ratio change is ≥20% (+/-) then the uncertainty cap is applied and any inter annual increase or decrease of the TAC is capped at 20%. These methods are designed to be precautionary and where there is uncertainty due to a deficiency of information (i.e. stock status relative to reference points or exploitation is unknown) an additional 'Precautionary Buffer', which equates to a further 20% reduction in catch, is advised, unless expert knowledge or evidence indicates that the stock is not reproductively impaired or that stock size is increasing (ICES, 2012).

As per the Survey Based Methods (Category 3) Decision Tree, Method 3.2 will be used. The protocol for this method is (ICES, 2012):

1. Use the survey trend to adjust the catch
2. Limit the influence of the survey's noise with the uncertainty cap (+/- 20 %)
3. If recommended, apply an additional 20% precautionary buffer to the catch advice

When a biomass index becomes available this should be used in preference to an abundance index.

*Table 12: Abundance Index values for 2018 to 2022 from the annual spring scallop survey. **Estimated value for 2020 (mean of 2021 and 2019).*

Survey Year	Abundance Index All	Abundance Index Post-Recruit	Abundance Index Recruits
2018	85	79	6
2019	97	77	20
2020	NA	147**	NA
2021	196	168	28
2022	202	143	60

- Index A (average 2021 – 2022) = 199; Index B (average 2018 – 2020**) = 110; Index Ratio = +84 %
- Due to the ratio change of + 84% being greater than 20% then the uncertainty cap is applied and thus the inter-annual change in TAC is capped at an increase of 20%.

6.1.1 Previous catch advice

The TAC for 2021/2022 was 2049 t of which only 1491 was landed (~ 73 %)

6.1.2 TAC calculation and catch advice

Two scenarios are presented for consideration:

Scenario 1: Using the data and methods outlined in the previous sections, the provisional catch advice for 2022/2023 is calculated as 2459 t based on a 20% increase in the previous year's TAC (Scenario I; Table 13).

Scenario 2: Given that only 73% of the 2021/2022 TAC was achieved (i.e. 1491 t), the TAC calculated in Scenario I is **based on unachieved total landings from which a decline in the 3-12 nm TS abundance index was seen from 2021 relative to 2022 which could indicate fishing pressure is too high.** If, instead of basing the proposed TAC on an increase of last season's TAC, it is based on an increase of 20% of actual landings, then a TAC of ~1790 t is reached (Scenario II; Table 13). An additional precautionary buffer has not been applied for the TAC calculations for 2022/2023 as the recruitment index has increased from the year prior.

Table 13: Calculations and catch advice for the Isle of Man king scallop fishery using the ICES methodology outlined for a Category 3 stock (Method 3.2). Index A is the average of the last two year's survey abundance indices (2022 – 2021); Index B is the average of the three preceding year's survey abundance indices (2018 – 2020; 2020 is an estimated value); Index Ratio is a ratio of Index A divided by Index B. Survey indices can contain a level of noise within the data, as such a +/- 20% cap (Uncertainty Cap) on inter annual changes to the TAC from the Index Ratio is advised (ICES, 2012). These methods are designed to be precautionary and so where there is uncertainty due to a deficiency of information (i.e. stock status relative to references points or exploitation is unknown) a 'Precautionary Buffer' of a 20% reduction in catch is advised unless expert knowledge or evidence indicates that the stock is not reproductively impaired or that stock size is increasing (ICES, 2012).

	I	II
Index A (2021 - 2022)	199	199
Index B (2018 – 2020**)	110	110
Index Ratio (A/B)	1.85	1.85
Uncertainty cap	1.2	1.2
TAC from 2018/2019 season	2049	1491
Discard rate	-	-
Precautionary buffer	NA	NA
Catch advice for 2022/2023*	2460	1790

** For Scenario II: only 73% of the TAC for 2021/2022 was achieved. Therefore Scenario II: (actual landings for 2021/2022 x Uncertainty Cap)*

*** 2020 is an estimated value (mean of 2021 and 2019) as no survey was conducted due to Coronavirus regulations.*

7. Recommendations:

A TAC for the 2022/2023 fishing season has been calculated in the main report using the ICES Category 3 data limited approach (based on post-recruit index only).

It is recommended that the management approach for 2022/2023 king scallop fishery continues to be precautionary and that it should incorporate all of the following three elements:

- **In-season reviews:** Monthly reviews of the fishery by the SMB or a subgroup for the entire TS fishery should be scheduled as standard.
- **Spatial monitoring and management:** Spatial monitoring for each individual ground should be undertaken as part of the in-season review to allow flexible spatial management (i.e.

individual grounds to be opened or closed) based on the real-time data collected by the fishery. High density areas within a ground (i.e. Bradda) may require additional fine scale management to avoid high fishing intensities leading to excessive fishing mortality and habitat damage.

- **Closed area management:** The continued management of restricted areas and current/new closed areas is required to protect high density areas of post-recruits and recruits (king and queen scallops).

General recommendations for the 2022/2023 king scallop fishery based on the survey data analysis produced here therefore include:

- The ICES Category 3 approach indicates a potential to increase the TAC by 20%. Catch rates, various management measures, including the use of a DCL to ensure the TAC lasts throughout the season, and various logistical issues as a result of BREXIT and Coronavirus may have contributed to the under achievement of the TAC in recent seasons (2020, 2021 and 2022).
- A precautionary management approach should be considered in particular due to the decline in post-recruit abundance indices in both surveys despite only 73% of the TAC being achieved.
- An initial starting TAC based on a 20% increase of actual landings (TAC = 1790 t) is advised.
- Flexibility of decrease or increase of the TAC during the fishing season based on fisheries-dependent data (i.e. Daily Catch Return Forms), which is collected in near real-time during the season combined with industry feedback on market conditions.
- Consideration of restricted access and additional management measures within the high-density fishing area at Bradda.
- Consideration of temporary closed areas implemented to protect any high densities of recruits identified in the survey. For 2022 survey cells within TAR and BRA had the highest densities of recruits in the industry surveys and closures in these areas should be considered.
- Monitoring of LPUE and fishing intensity (swept area) should also be undertaken in managed areas to try and ensure overfishing of these spatially discrete areas does not occur. Metrics illustrating the relationship between different levels of LPUE and fishing intensity with consideration of possible impacts on the stock are under development and will continue to be examined in order to develop future threshold values for use in management.
- Monthly reviews of the TAC and fishery with consideration of LPUE and fishing intensity within each fishing ground (including combined fishing intensity of king and queen scallop activity).

Long-term fisheries management plan:

A long-term management plan (LTMP) for the king scallop fishery has been developed and agreed with collaborative input from industry, and will be essential for ongoing monitoring, management and recovery of this stock. The LTMP includes a set of aims and goals for the fishery and ongoing and future work relevant to this plan includes:

Relative benthic status and fishing intensity:

Bottom-trawling, using gears such as benthic otter trawls, beam trawls and scallop dredges, is thought to be one of the greatest causes of disturbance to marine benthic communities. As well as having direct effects on target species through a reduction in abundances, trawling has wider biogeochemical impacts on the environment. Scallops typically form aggregations and so fishing activity is often focused within spatially discrete areas with high queen scallop density. A quantification of the impact

of fishing activity in benthic habitats is therefore an important metric for monitoring the fishery to ensure sustainability of scallop recruitment as well as the overall condition of the habitats and benthic communities. Fishing intensity is defined as the fishing effort per unit area per unit time. Consideration needs to be given to the potential for cumulative impacts of queen scallop trawling and queen and king scallop dredging within each fishing ground which may have disproportionally damaging effects compared to one or the other in isolation. So as to provide a metric that is usable in real time through the season fishing intensity data could be incorporated from King season y^{-1} and queen season y^{1} (i.e. fishing intensity from the 2022 queen scallop fishery and the 2022/2023 king scallop fishery could be combined to monitor cumulative impacts during the 2022/2023 king scallop fishery).

Relative Benthic Status (RBS) is a metric that should also be further developed and assessed for monitoring scallop fisheries. The status of trawled habitats and hence their RBS value depends on impact rate (depletion per trawl), recovery rate and exposure to trawling. This enables a quantitative estimate of status relative to an unimpacted baseline and could provide a useful monitoring metric for scallop fisheries. Using pre-defined management criteria to assess each habitat type within the territorial waters or within a fishing ground would indicate areas aat risk from higher fishing intensities and whether levels of fishing intensity would have a negative impact on habitat status.

Recruitment:

The high-resolution industry survey has allowed greater insight into the patterns of recruitment across the three major fishing grounds of the territorial sea. The differences in general oceanography and frontal systems across the territorial sea might lead to long-term recruitment patterns varying considerably among individual fishing grounds. At present we only have three years of data for three of the main king scallop fishing grounds within the 3-12 nm. As the time series continues to extend then the survey data will provide a better insight into what is average, good and poor in terms of recruitment densities for individual grounds. Historical analysis of the scientific survey data would for example indicate that larger recruitment events typically occur at CHI and TAR compared to EDG or POA. A longer-term data set will therefore provide more information on what is normal in terms of recruitment at the fishing ground level. This in turn will assist with a longer-term management approach and forecasting when to expect above average fisheries within each ground.

Irish Sea Management:

The Irish Sea king scallop fishery should be managed at the appropriate spatial scale, which would ideally relate to the function unit (FU) of the stock. Unpublished genetic and oceanographic research indicates that northern Irish Sea populations of king scallops may be considered a singular, connected functional unit of many sub-populations. The most appropriate unit for managing the fishery in Isle of Man territorial waters may therefore be the Northern Irish Sea FU. It is vital that work continues towards achieving a collaborative management approach for king scallop stocks within the different regions of the Irish Sea.

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