Isle of Man King Scallop 2021 Stock Survey 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 in April onboard the R.V. Prince Madog and a short-term, fine resolution, random stratified survey undertaken in May onboard two commercial fishing vessels.

The length based abundance indices for recruits (< 95 mm) (Figure I: Left) and post-recruits (>95 mm) (Figure I: Right) from the long-term April survey are presented below. Both indices have shown recent decreasing trends although there has been positive increases in both the recruit and post-recruit indices in the two most recent survey years (2019 and 2021; no survey in 2020 due to CV regulations).

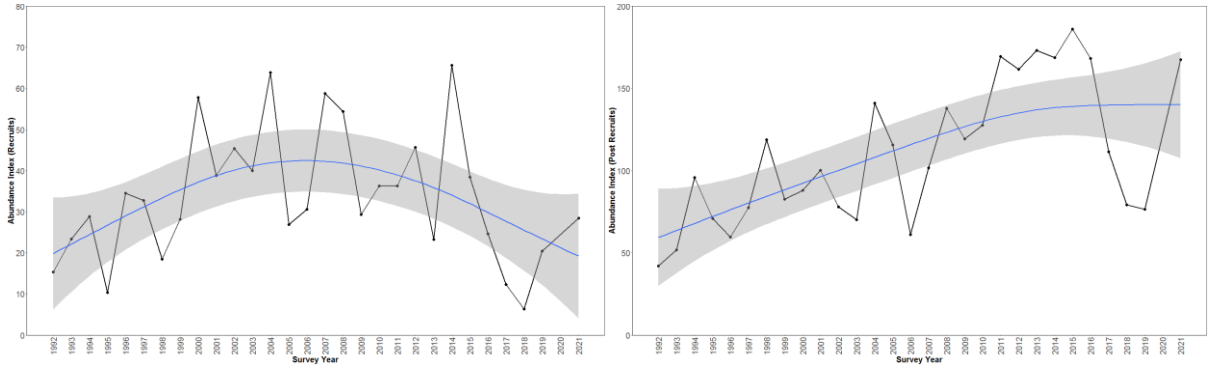

Figure I: *King scallops in Isle of Man Territorial waters. Left: Recruit length abundance index from the long-term April survey and Right: Post-Recruit length abundance index from the long-term April survey.*

The same general increasing trend is seen in the fine-scale, short-term, industry survey data for both recruits and post-recruits at the 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 2020/2021 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	2020 <95 mm	2021 <95 mm	Change	2020 >95 mm	2021 >95 mm	Change	Landings 2020/21 (t)
TS	T.S.	0.162	0.203	+	0.689	0.830	+	1727
3-12 nm	EDG	0.185	0.280	+	0.674	0.943	+	751.7
	TAR	0.186	0.158	-	0.839	0.837	=	312.3
	CHI	0.102	0.150	+	0.567	0.634	+	317.6
	POA	0.130	NA	NA	0.670	NA	NA	22.9
0-3 nm	ECO	0.153	0.238	+	0.548	0.600	+	47.9
	BRA	0.247	0.189	-	0.926	0.603	-	197.9
	MGH	0.120	NA	NA	0.720	NA	NA	76.4

Stock advice (2021/2022)

A TAC for the 2021/2022 fishing season has not been calculated in the main report using the ICES Category 3 data limited approach due to the year of missing data in the long-term survey abundance index for 2020. TAC calculations for 2020/2021 and 2021/2022 are provided for reference in Appendix 1 following the approach suggested by ICES for dealing with missing data due to CV-19. It is recommended that the management approach for 2021/2022 king scallop fishery should be precautionary and 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 opened or closed) based on the real-time data collected by the fishery. High density areas within a ground (i.e. TAR or CHI) may require additional 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 2021/2022 king scallop fishery based on the survey data analysis:

- A precautionary management approach should be considered in particular due to the uncertainty in a TAC calculation for 2021/2022 due to missing data in 2020.
- In addition to 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 restrictions, may have contributed to the under achievement of the TAC in recent seasons. However, it is highlighted that the quantity of removals which have impacted the current survey densities are lower than the TAC limits set for the past two fishing seasons and so a precautionary approach to the setting of the TAC is advised.
- Starting TAC to remain at 2020/2021 fishing levels (i.e. 2049 t) which, if achieved, would already be a 15% increase in landings from 2020/2021 and a 42% increase in landings compared to 2019/2020.
- 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.
- Restricted access and management of the two high density fishing areas at Chickens and Targets that are defined as restricted areas during the current queen scallop fishing season.
- 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. Both metrics are under development and the relationship between different levels and impacts on the stock will continue to be examined to develop threshold values for 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).
- Temporary closed areas implemented to protect any high densities of recruits identified in the survey (Bradda (i.e. BRI) and East Coast (i.e. ST27) had the highest densities of recruits in the 2021 industry and scientific surveys and may be suitable areas for consideration.
- Strict monitoring and enforcement of daily catch limits within high density restricted areas should be in place.

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 2020/2021 season a total of 83 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 2020/2021 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 2020/2021 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 22nd Dec 2020 to 4th Jan 2021	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 83 vessels eligible for a licence to fish for king scallops during the 2020/21 fishing season 64 vessels reported landings of king scallops from within Isle of Man territorial waters. The TAC for 2020/2021 was 2049 t of which only 1727 t was landed (~ 84 %).

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 – 2018 are shown in Figure 1 (ICES 2020a,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 2018 the average annual Manx share of landings has declined to around 21%, 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 most 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).

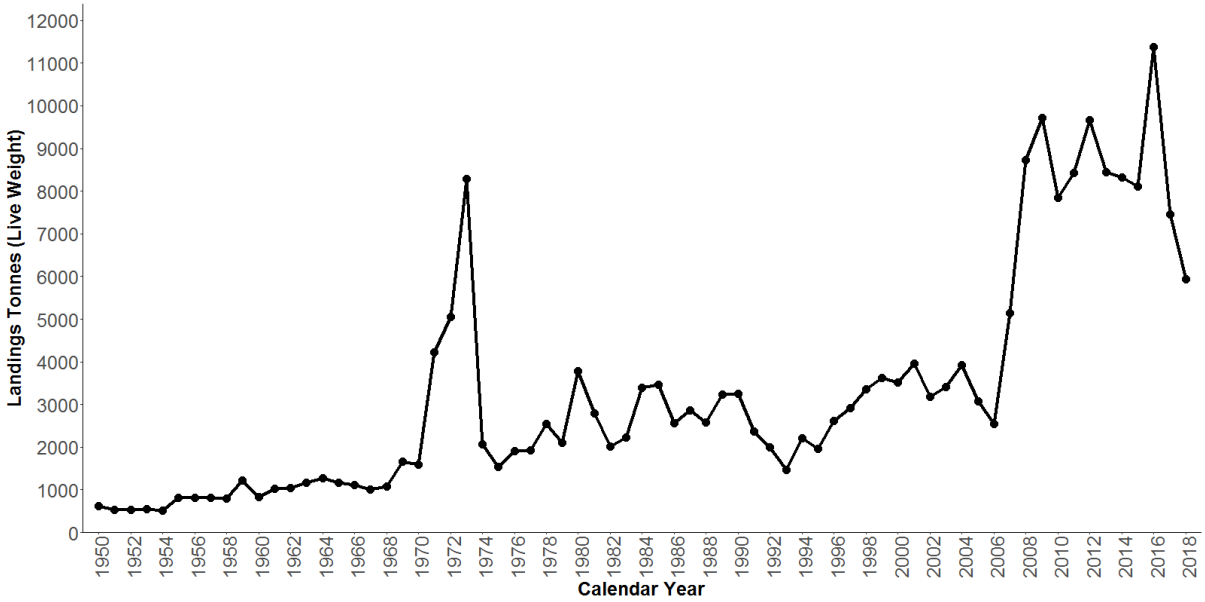

Figure 1: Annual King Scallop landings (t) from ICES Area VIIa for 1950 to 2018 using scallop landings from species Great Atlantic Scallop (SCE) and Scallop Nie (not included elsewhere) (ICES 2020a; ICES 2020b).

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 following 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 the impacts of Brexit and Coronavirus may have also affected landings (Figure 2).

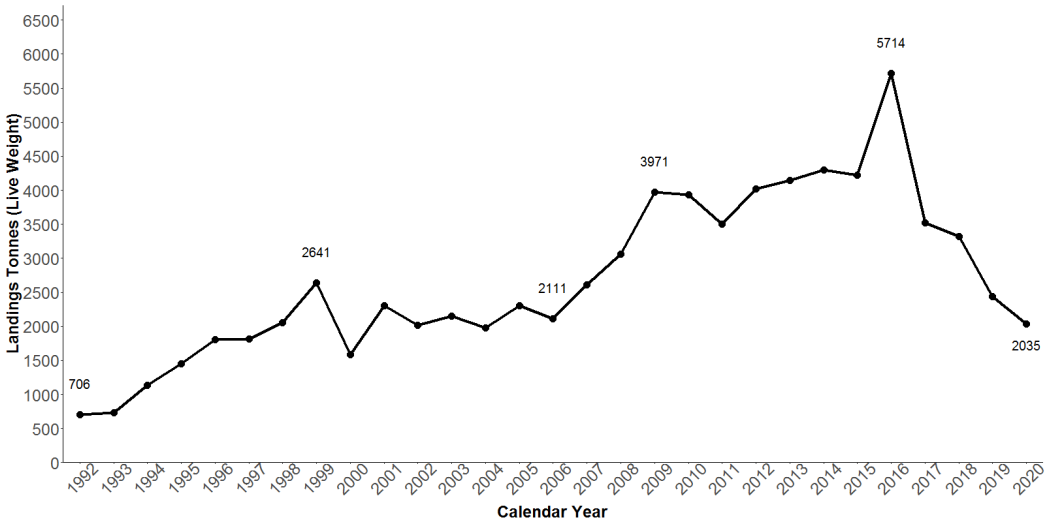

Figure 2: Annual (calendar year) King Scallop landings (t) from ICES Rectangles 36E5, 37E5 and 38E5 from 1992 to 2020 (Source: Logbook data DEFA, Marine Scotland, MMO and IFISH 2). For information the landings (t) values from key years are annotated on the graph.

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 5134 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 1715 t in the 2019/2020 season) followed by a slight increase to 2429 t in 2020/2021 (Figure 3). *Note: these ICES Rectangles cover an area greater than the Isle of Man territorial waters.*

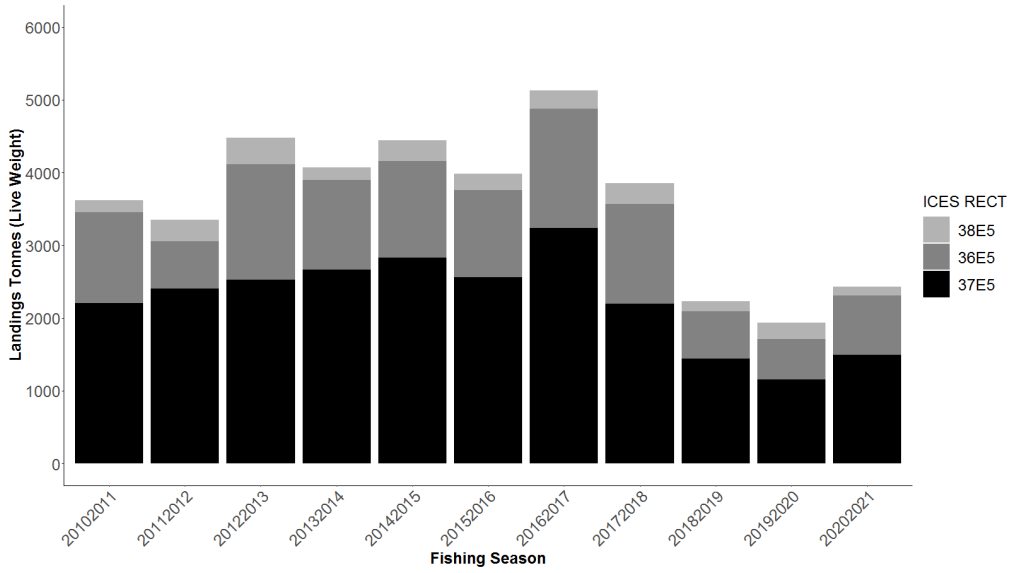

Figure 3: Seasonal landings (t) of king scallops from ICES Rectangles 36E5, 37E5 and 38E5 for the seasons 2010/2011 to 2020/2021. Data source: EU Logbooks downloaded through IFISH2. (NB. these data include ALL vessels fishing for king scallops (except vessels from Ireland for which we do not receive 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 2020/2021 fishing season are displayed in Figure 5. The largest proportion of landings for the 2020/2021 fishing season came from IS15: East of Douglas (EDG).

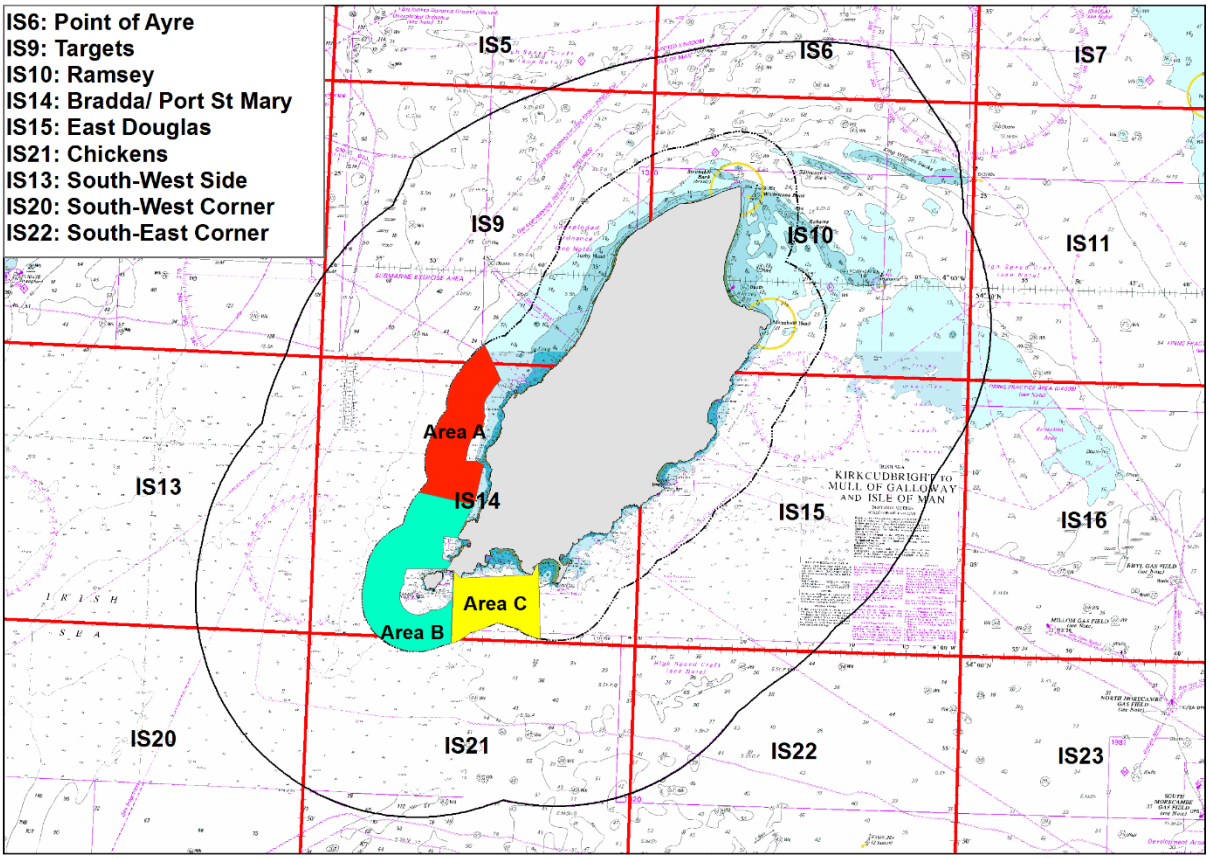

Figure 4: Map showing location of Irish Sea Boxes which are used to define fishing areas in the Nest Forms Landings Data. The fishing grounds delineated within each IS box are listed on the map. In addition, Subzones for reporting fishing within 3 subzones within the 0-3 nm limit are also shown (Area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

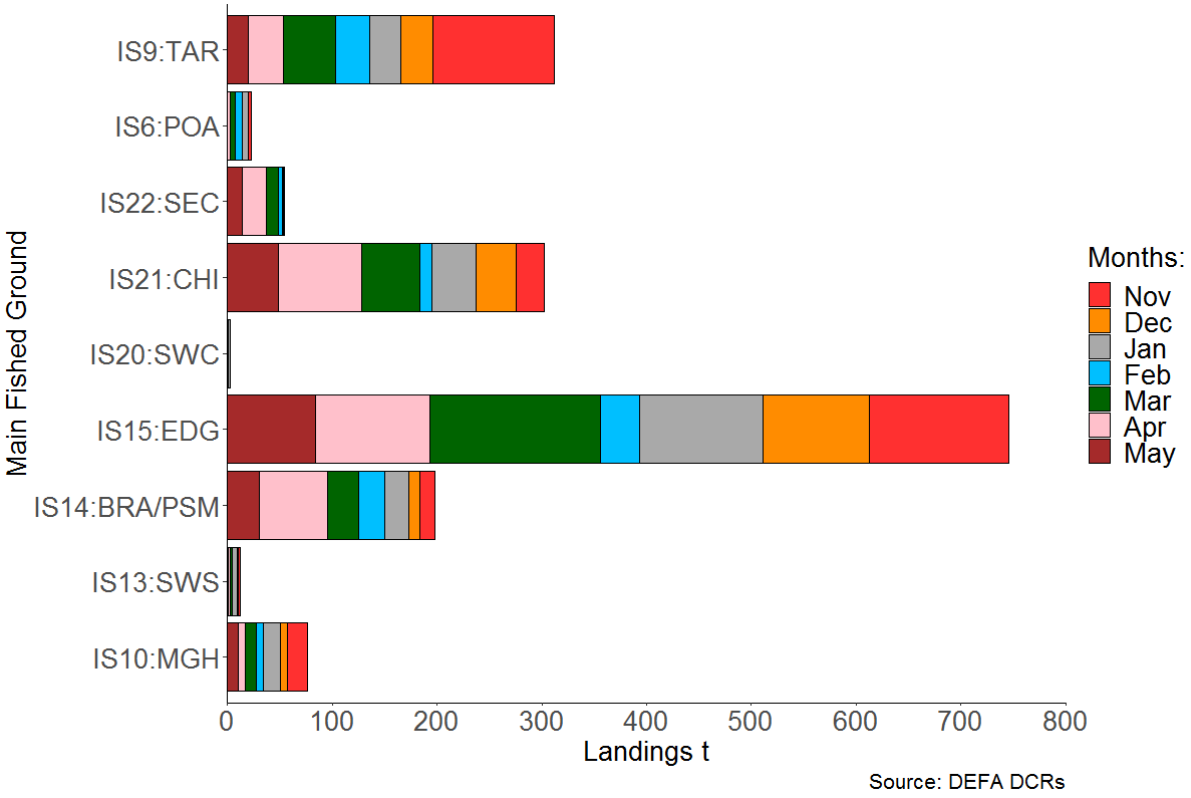

Figure 5: Scallop (SCE) Landings (t) reported by main fished ground (IS Box) and separated by colour for each month to show the spatial and temporal pattern of landings for the 2020/2021 king scallop fishing season. The main fishing grounds are covered by IS9 TAR = Targets, IS6 POA = Point of Ayre, IS21 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 and 2020/21 seasons by fished week. The LPUE in 2020/2021 at IS15 (EDG), IS10 (RAM) and IS21 (CHI) were all above the historical trends for these grounds (2017/2018 – 2019/2020) (Figure 6).

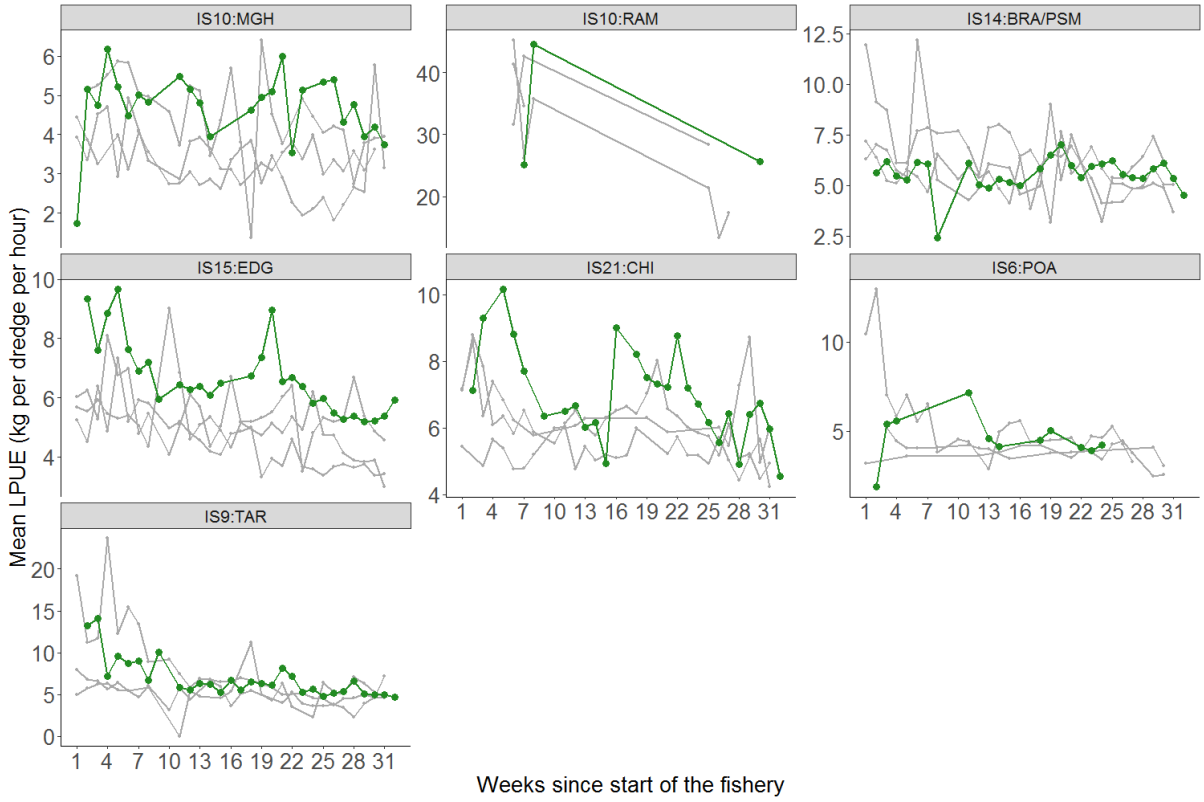

Figure 6: LPUE (kg per hour fished per dredge) displayed by main fished ground for current (2020/2021 (green) and historic (2017/2018 – 2019/2020 (grey)) seasons. Note the different scales on the Y-axis (LPUE), in addition the fishery closed for Christmas during Week 9 in all seasons

Reported landings are also delineated to fishing zone such that landings can be recorded from within the 3-12 nm limit only, 0-3 nm limit only or both. From Figure 7 we can see a declining trend from 2017/2018 to 2020/2021 in both days at sea and landings from the 0-3 nm limit only.

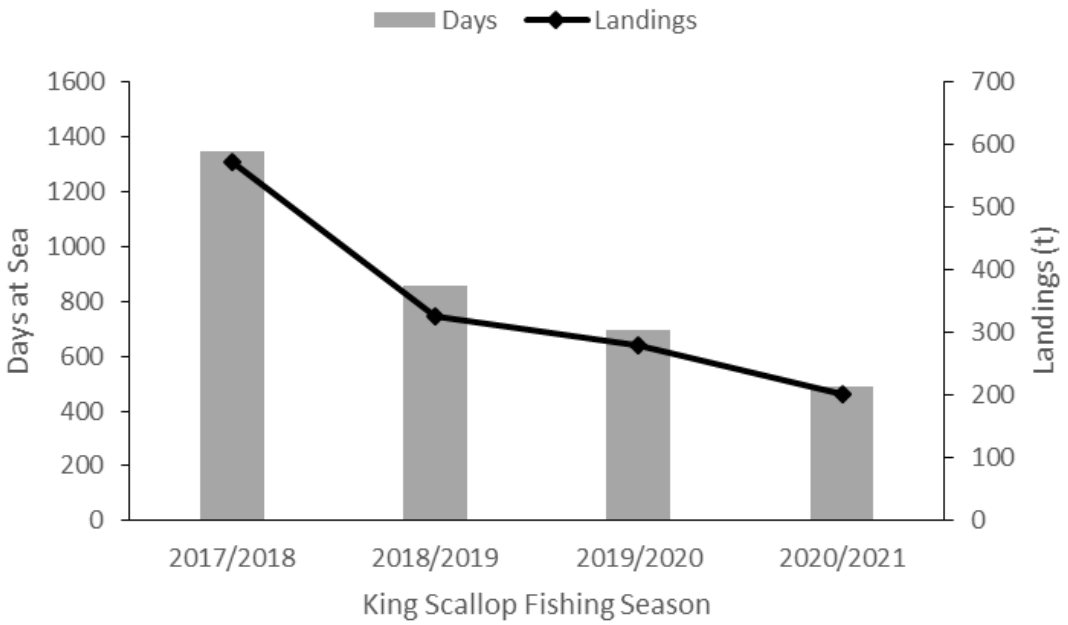

Figure 7: Days at sea (grey bars) and Landings (black line) for king scallops reported to have been fished from within the 0-3 nm limit only, displayed by fishing season from 2017/2018 to 2020/2021.

Area B has the most fishing activity (days at sea) reported of each of the three 0-3 nm subzones in each fishing season (Figure 8).

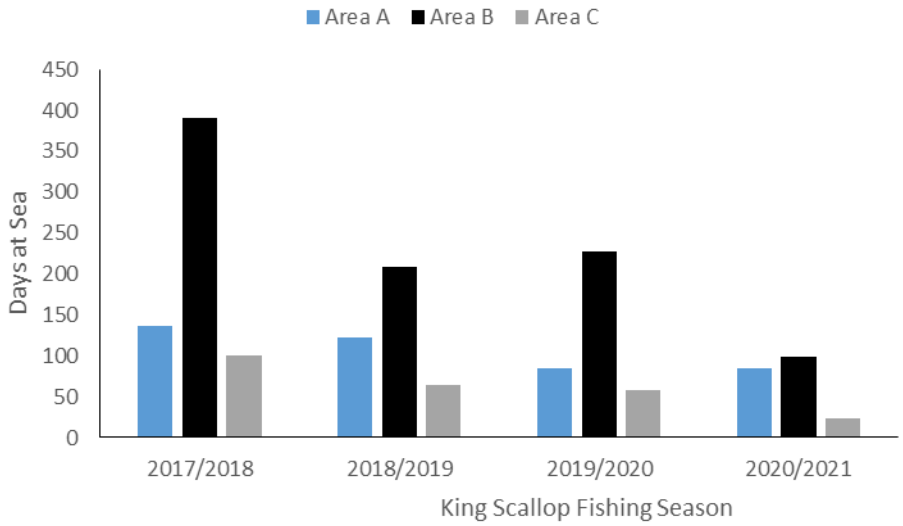

Figure 8: Days at sea split by 0-3 nm subzone and displayed by fishing season from 2017/2018 to 2020/2021. Please note not all 0-3 nm fishing activity within the 0-3 nm limit has been attributed to a subzone by fishers when submitting their Daily Catch Return

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, but data was collected in April 2021. A single year of missing data will not impact on the use of stock assessment models however it can impact the use of the data limited approach to TAC calculation (see below).

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 both April 2020 and May 2021 in line with the Coronavirus restrictions and social distancing regulations. The 2021 survey included three main fishing grounds (EDG, CHI and TAR), however due to funding constraints the fourth main ground at POA was not surveyed.

In line with recommendations developed with the scallop management board (SMB), the long-term survey data 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. The ICES Category 3 data limited approach was not calculated for the 2020/2021 season due to uncertainty with how to treat the missing year of data. Current advice from ICES states that the missing data year from Covid should be treated as a missing value. Whilst this approach is not presented within the main report, as using this method would have changed the advice for 2020/2021 (i.e. a 20 % reduction in TAC for 2020/2021 despite the potential that the index would have seen an increase in 2020, as per the industry survey which was completed in 2020 (Bloor et al., 2020), had the scientific survey been undertaken). The ICES Category 3 stock TAC calculations have been included in Appendix 1 for reference (calculations for both the 2020/2021 and 2021/2022 seasons).

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 2021 spring scallop survey was undertaken by the R.V. Prince Madog over 8 days from 8th – 15th April 2021. A total of 64 survey stations were sampled (Figure 9). 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).

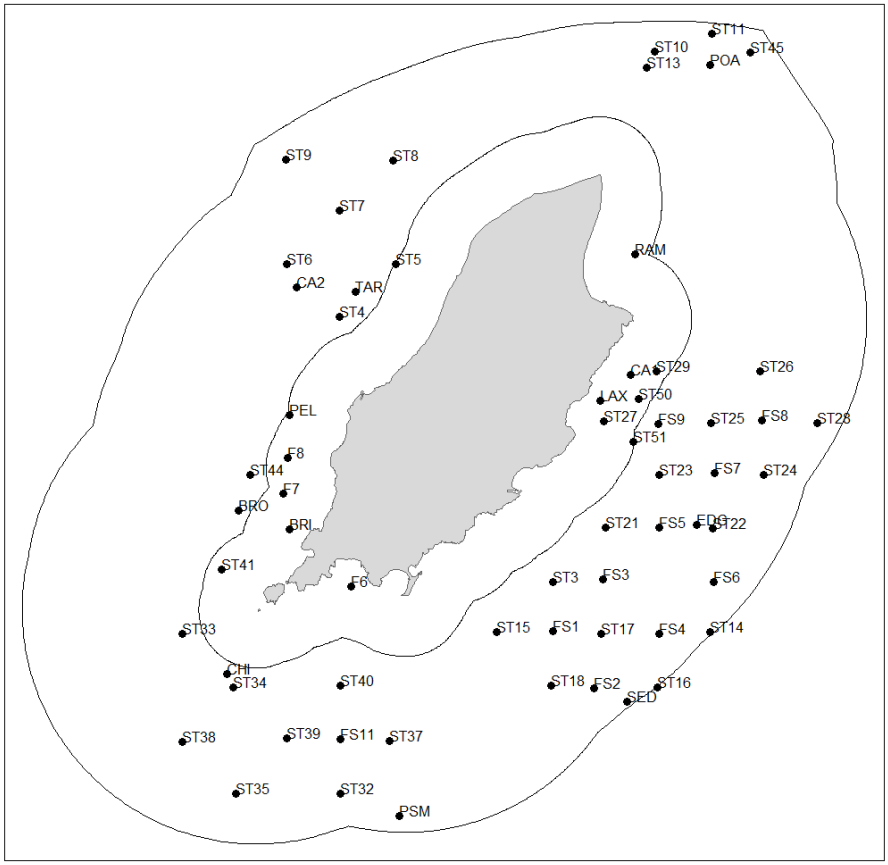

Figure 9: A map showing the location of all 2021 survey stations. Historical stations (i.e. those sampled from 1992) all have three letters (i.e. EDG, SED) while stations added from 2012 onwards are all labelled ST with a number (i.e. ST21, ST50). Fisher suggested stations (labelled F with a number (i.e. 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 is presented for 2019 and 2021 (no survey in 2020) in Figure 10 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 2019, two main cohorts can be seen in the size data: Cohort 1 with a peak at 40-60 mm and Cohort 2 with a peak at 110-130 mm. Cohort 1 indicates pre-recruits that will be recruiting into the fishery two to three years, whilst Cohort 2 represents post-recruits, i.e. king scallops that are typically already at minimum landing size (MLS). There are also additional cohorts mixed into the population but for which a peak can't be seen, scallops in these cohorts (i.e. 70 -100 mm) will either grow into the fishery during the following fishing season or the season after (for king scallops in the Isle of Man waters it is estimated that on average scallops of 95 mm or above at the time of the survey in April year^{0} will typically have reached 110 mm by 31st May Year^{+1} i.e. the end of the following fishing season). In 2021 the main peak of scallops is at 100 – 110 mm, which may grow into the fishery during the upcoming fishing season. Whilst there is an absence of a peak for Cohort 1 at 40-60 mm, indicating limited pre-recruitment, there is another peak around 80-100 mm which may represent growth progression of the peak in Cohort 1 from 2019 (Figure 10).

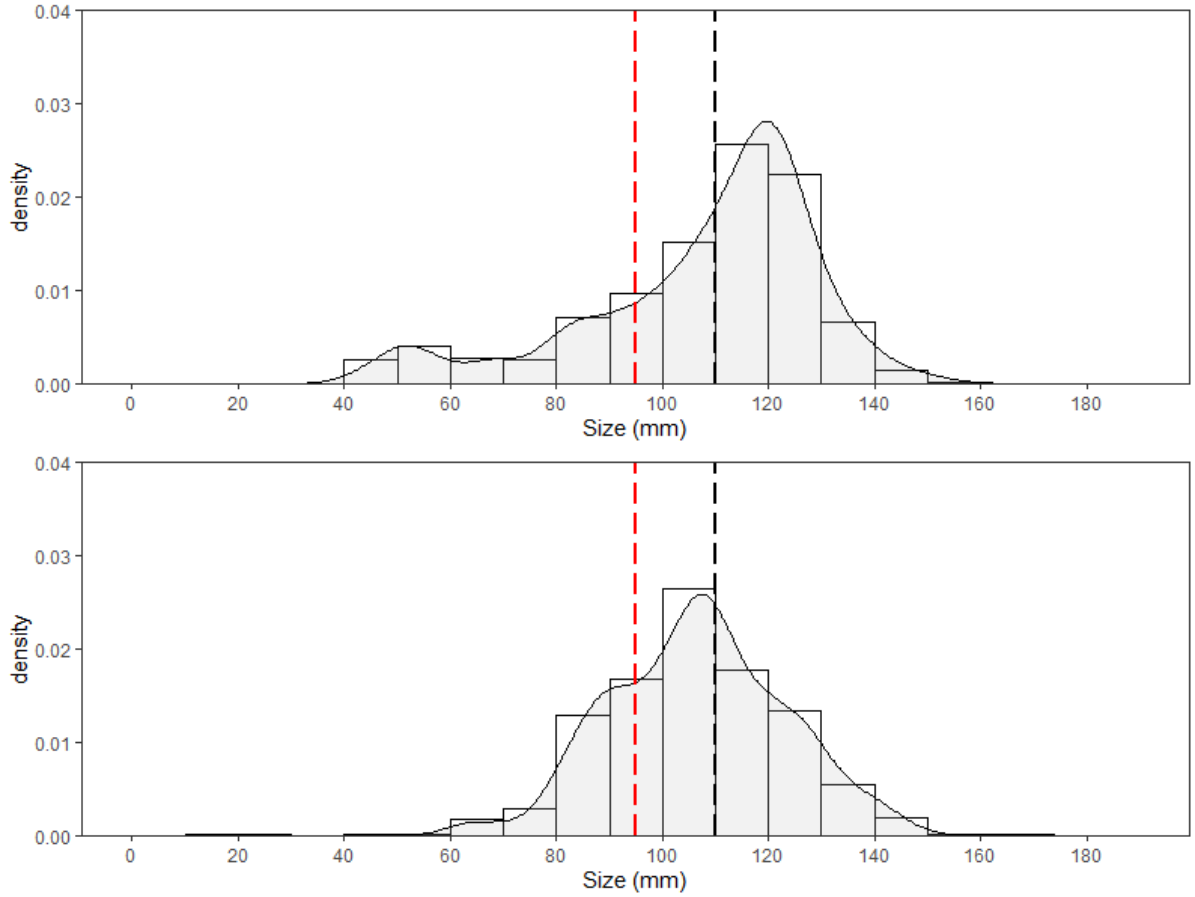

Figure 10: King scallop size frequency-density plot for 2019 (top) and 2021 (bottom). Black dashed line indicates MLS (110 mm) and the red dashed line indicates the estimated MLS cut-off width (95 mm) for the territorial sea (i.e. the size at which scallops sampled in April Year^{0} will typically have reached MLS by 31$_{st}$ 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 2021 survey is displayed in Figure 11 for all survey stations. In 2021 the fishing grounds in the inshore east coast and to the south of the Island (ST27 and CHI) had the highest densities of king scallops per 100 m^2 (~7.3 and 6.6 king scallops per 100 m^2 respectively) (Figure 11).

The difference in mean survey density (scallops per 100 m^2) of king scallops from queen scallop dredges between 2019 and 2021 (no survey data for 2020) is displayed for all survey stations sampled in both years (Figure 12). This indicates positive increases between 2019 and 2021 in total scallop density at 28 of the 51 historical stations, but decreases in 21.

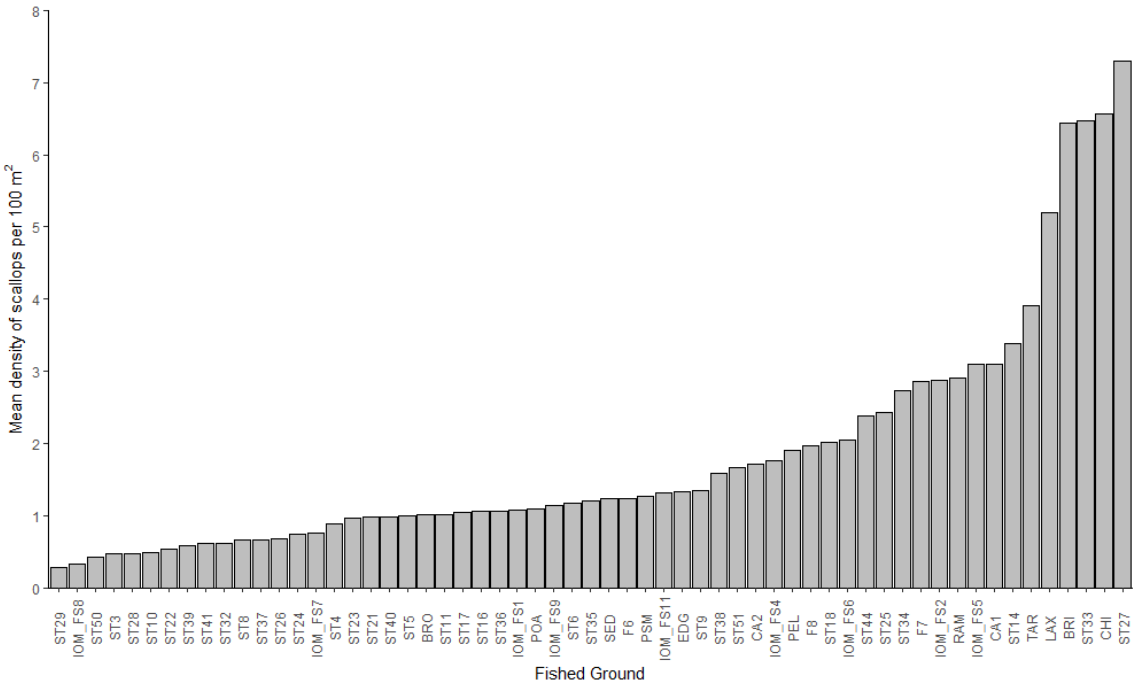

Figure 11: Survey densities (king scallops per 100 m²) displayed by survey station for spring 2021 survey (average of queen scallop dredge data).

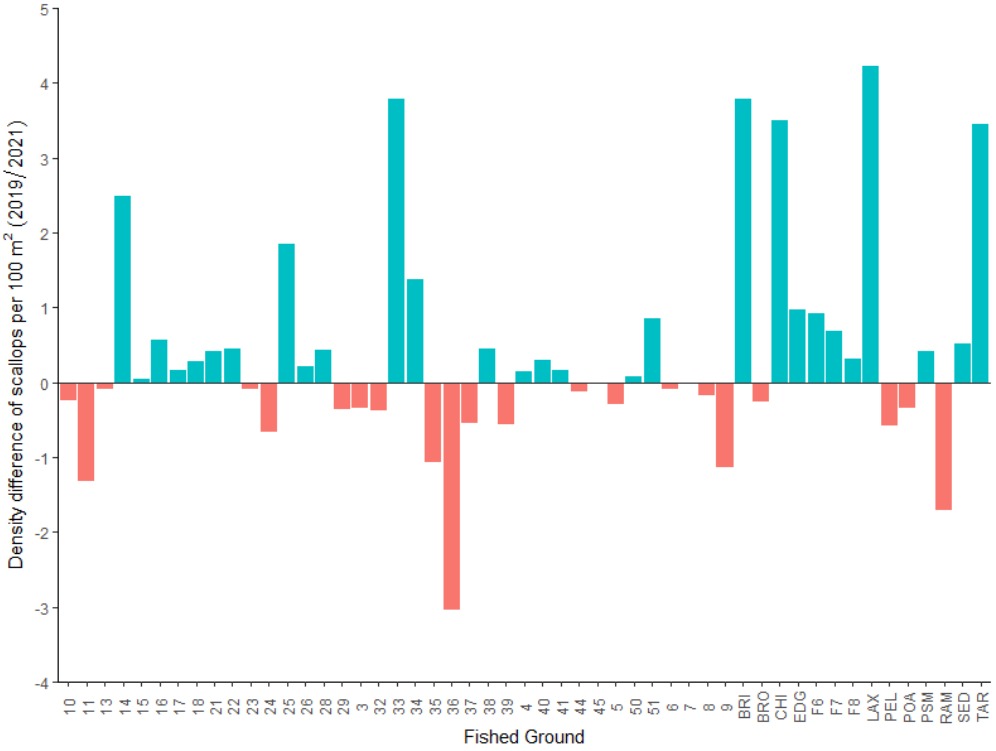

Figure 12: Difference in average survey density (scallops per 100 m²) of king scallops between 2019 and 2021 (no survey data for 2020) from queen scallop dredges for all survey stations sampled in both years (red bars indicate a reduction in scallop densities and green bars indicate an increase in scallop density from 2019 to 2021).

Despite positive increases in seven out of eleven of the historical stations between 2021 and 2019 the data need to be considered in the wider context of the time series. Figure 13 and Figure 14 indicate the density of king scallops per 100 m2 for each of the eleven historical stations from 1992 to 2021. The longer term data shows that for 2021 the densities are typically at the lower end of the range of

values for these stations (Figure 13 and Figure 14). BRI had the highest value recorded historically for this station in 2021 following a substantial recruitment with over 60 % of scallops sampled at the site under 95 mm (Figure 14). LAX also has one of the highest densities this site has seen with a roughly equal split of post-recruits to recruits (Figure 14). At other historical sites (e.g. TAR and BRO) the densities are still low relative to historical values (Figure 13 and Figure 14).

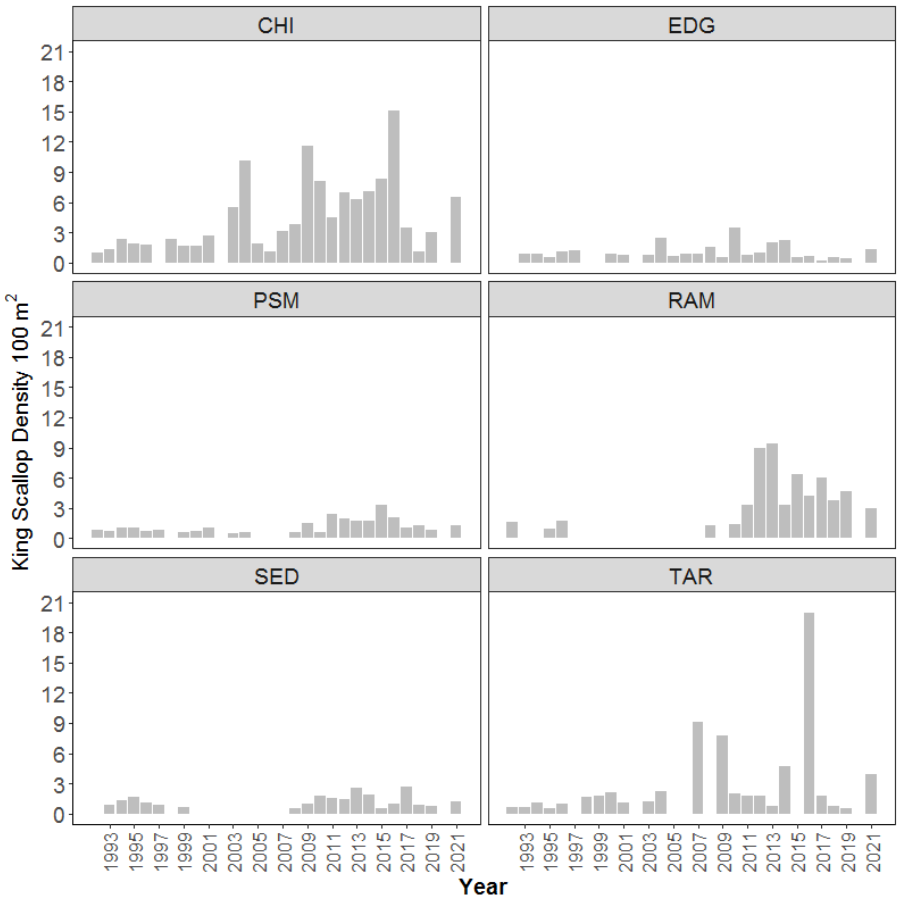

Figure 13: Density of king scallops (scallops per 100 m²) at historical stations from 1992 to 2021 for the scientific survey. Blank spaces indicate years with no survey data. Sites include CHI, EDG, PSM, RAM, SED and TAR

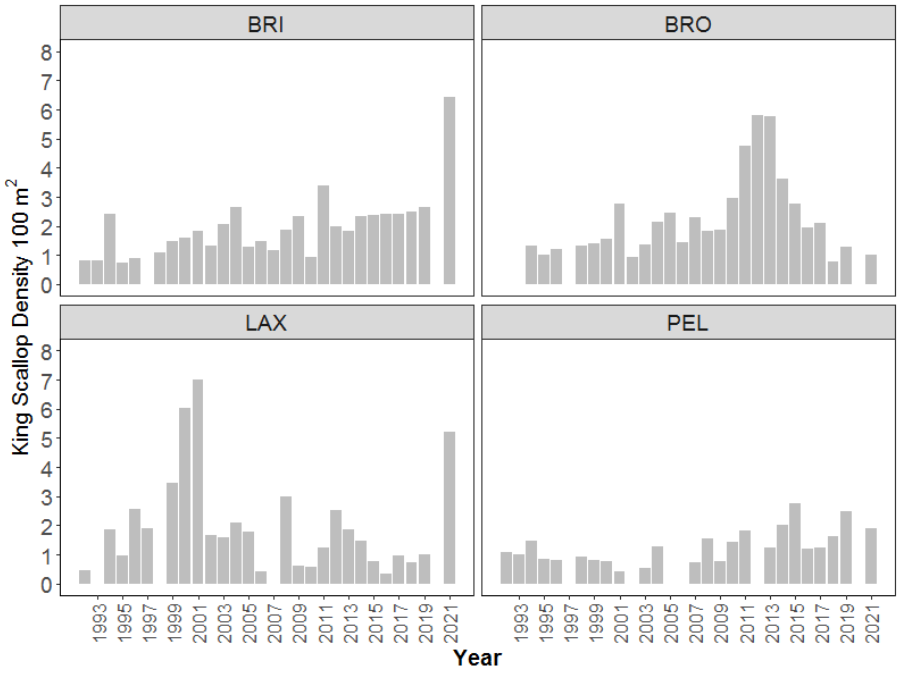

Figure 14: Density of king scallops (scallops per 100 m2) at historical stations from 1992 to 2021 for the scientific survey. Blank spaces indicate years with no survey data. Sites include BRI, BRO, LAX and PEL.

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 9) only 10 standard historical scallop survey stations (BRI, BRO, CHI, EDG, LAX, PEL, POA, PSM, SED and TAR), were 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 15 and Figure 16) which shows a general increasing trend in the mean abundance of recruits (scallops < 95 mm) from 1992 to 2007 and a general decreasing trend from 2007 to 2021. The recruit index (geometric mean) peaked in 2014 with subsequent year on year reductions until 2018. However, the most recent years (2019 and 2021) both show increases in the abundance of recruits for the first time since 2014 (solid line; Figure 15 and Figure 16).

Cyclical spatially specific recruitment events can be observed using the recruit abundance index calculated using the arithmetic mean (dashed line; Figure 15) 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).

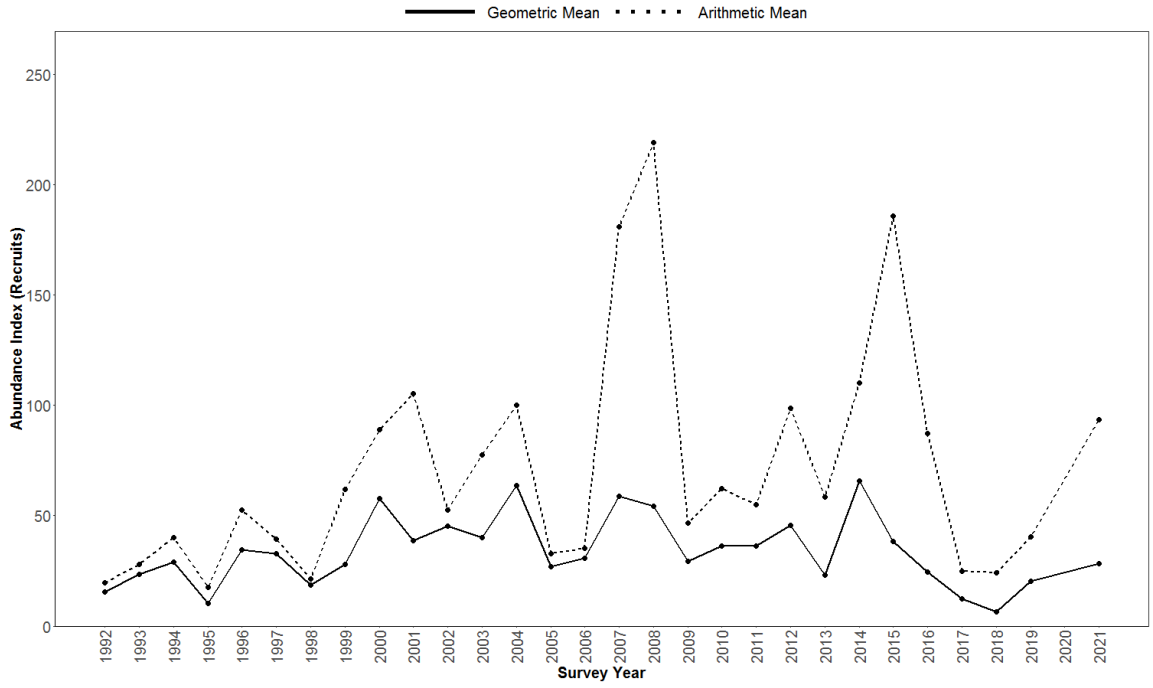

Figure 15: Recruit abundance index (scallops < 95 mm). Calculated based on length-based data where recruits were categorised as scallops under 95 mm at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. final day of 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.

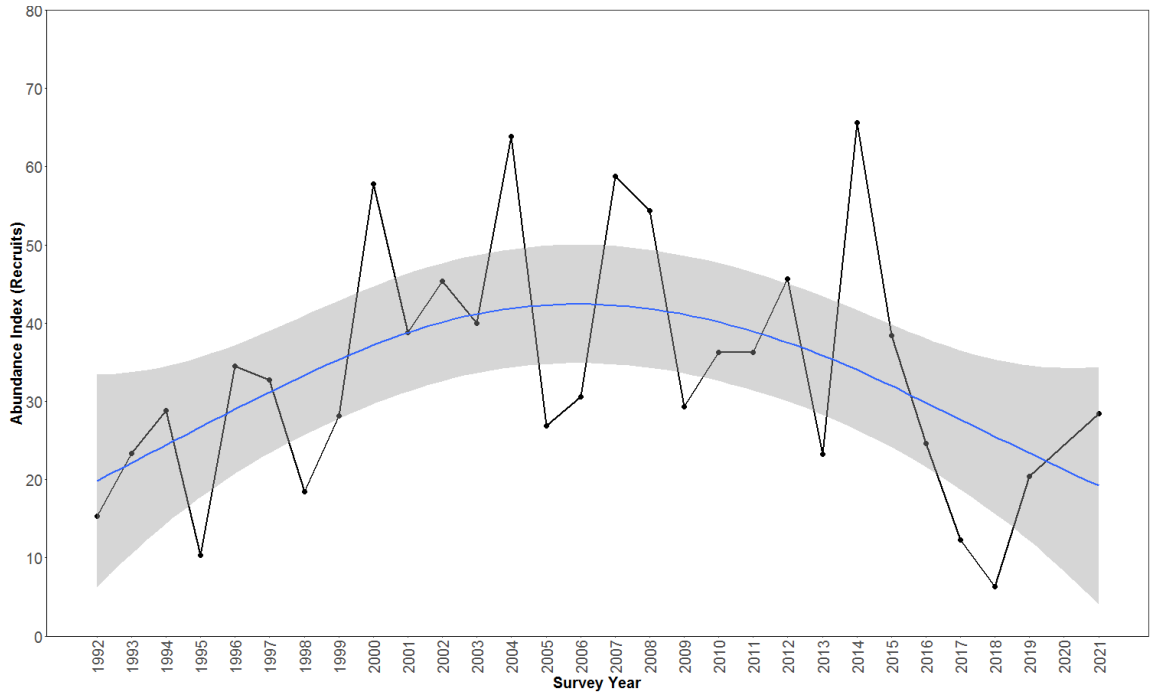

Figure 16: Recruit abundance index (scallops < 95 mm) with geometric smooth (methods = "loess") displayed to indicate the general trends of the index (grey area represents confidence bands (0.95)). Calculated based on length-based data where recruits were categorised as scallops under 95 mm at the time 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 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 17 and Figure 18) 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), followed by three years of decreasing values before an increase in the most recent year (2021).

Cyclical spatially specific recruitment events can be observed using the recruit abundance index calculated using the arithmetic mean (dashed line; Figure 17) 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 post-recruits 2009 and 2016 which tally with large recruitment events observed in the recruit index the year before.

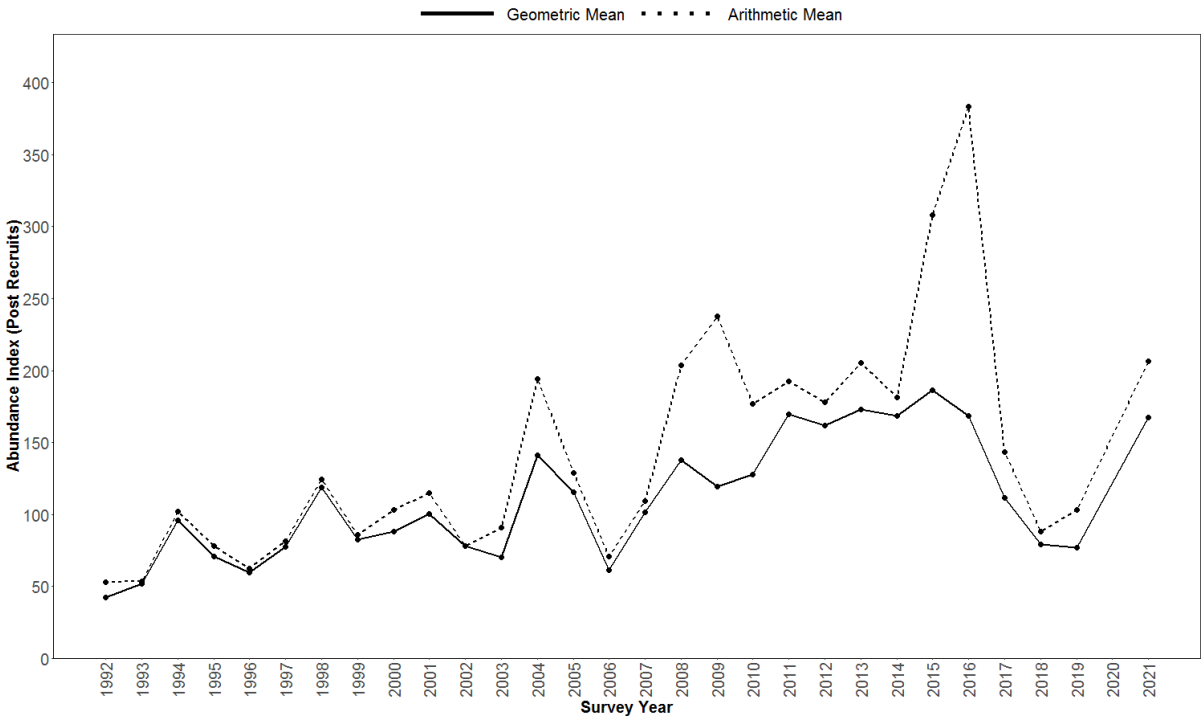

Figure 17: Post recruit abundance index (scallops ≥ 95 mm). Calculated based on length-based data where post recruits were categorised as scallops 95 mm or above at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. 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.

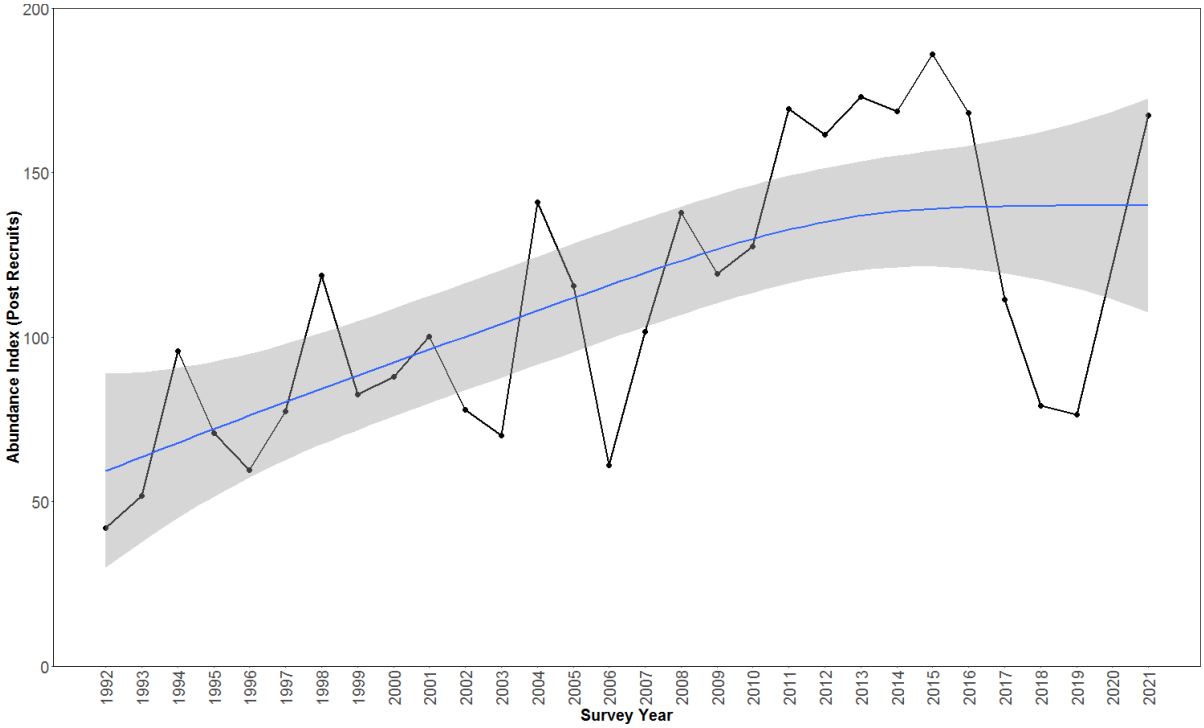

Figure 18: Post recruit abundance index (scallops ≥ 95 mm) with geometric smooth (methods = "loess") displayed to indicate the general trends of the index (grey area represents confidence bands (0.95)). Calculated based on length-based data where post recruits were categorised as scallops 95 mm or above at the time of the spring survey (generally April) which would typically be considered of size to grow into the fishery by 31st May (i.e. final day of the current season). The index is displayed here using calculation of the Geometric mean (solid line) for general stock trends only. 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 11th – 17th May 2021. The survey was undertaken at four of the main king scallop fishing grounds (Table 2):

Table 2: Grounds surveyed during the 2021 industry scallop survey with ground type and number of survey days detailed

Ground	Survey days	Type
Targets (TAR)	3	Permanent
Chickens (CHI)	2	Permanent
East of Douglas (EDG)	4	Permanent
Bradda (BRA)	2	Permanent

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' of the same design but using Queen dredges with 17 teeth with a mesh (60 mm) attached internally that when stretched into a fixed position resulted 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) so to keep the data constant only EDG, CHI and TAR are included in the main territorial sea analysis section. Each ground will be analysed individually later in the report.

Targeted Cells: In addition to the random Survey Cells described above, additional selected cells (1 site at BRA [Survey Cell: 4250] and 2 sites at TAR [Survey Cells: 1995 and 2067] 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 because they were typically areas of known high queen 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 whilst the 2020 survey was undertaken entirely in April (with 1 survey day in May) 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:

4.3.2.1 Territorial Sea

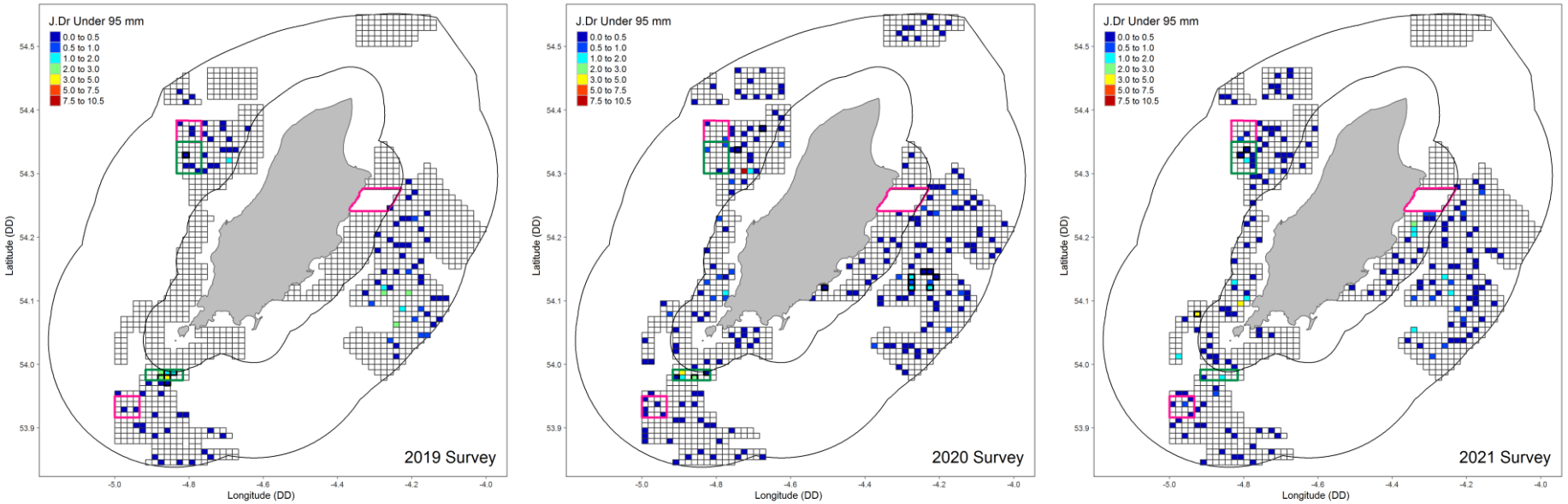

Figure 19: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile and standard queen scallop dredges for 2019 (left), 2020 (middle) and 2021 (right). In the 3-12 nm Point of Ayre in the north of the TS and in the 0-3 nm Bradda, East Coast and Maughold 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. 2021) and the pink boxes indicate areas currently closed for queen scallop fishing in 2021. 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 for some grounds analysis of targeted cells is presented).

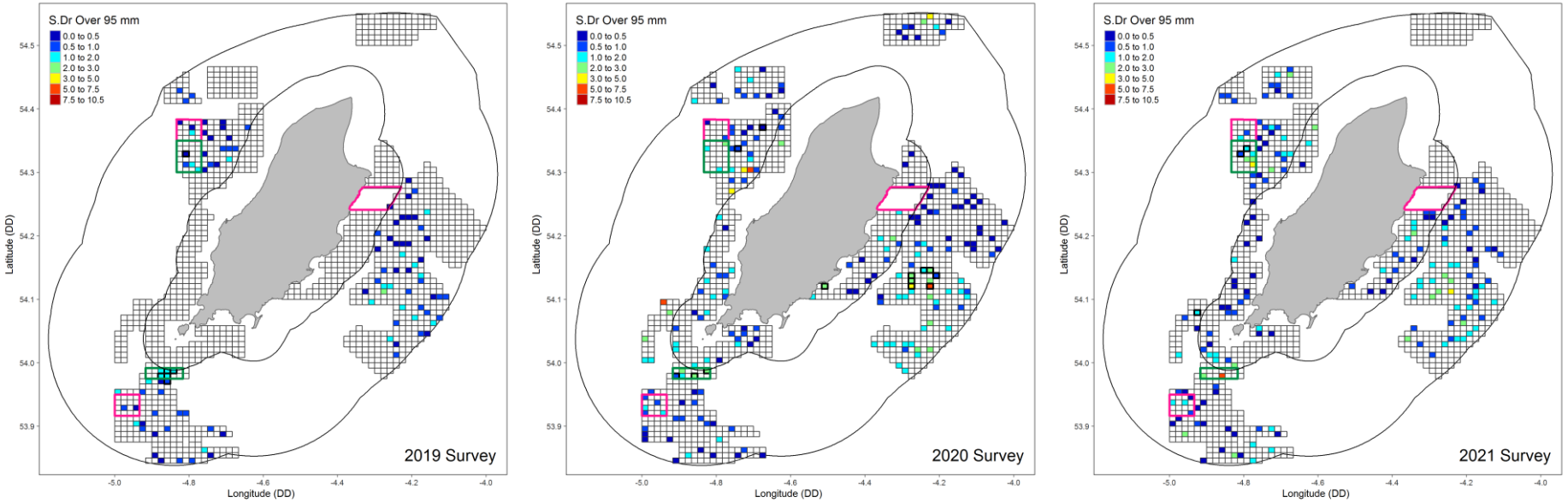

Figure 20: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard king and standard queen scallop dredges for 2019 (left), 2020 (middle) and 2021 (right). In the 3-12 nm Point of Ayre in the north of the TS and in the 0-3 nm Bradda, East Coast and Maughold 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. 2021) and the pink boxes indicate areas currently closed for queen scallop fishing in 2021. 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 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	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
Cells Surveyed	96	130	128	96	130	128
Min	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	**0.197**	**0.162**	**0.203**	**0.571**	**0.689**	**0.830**
Max	2.64	10.44	1.37	2.11	5.67	5.59

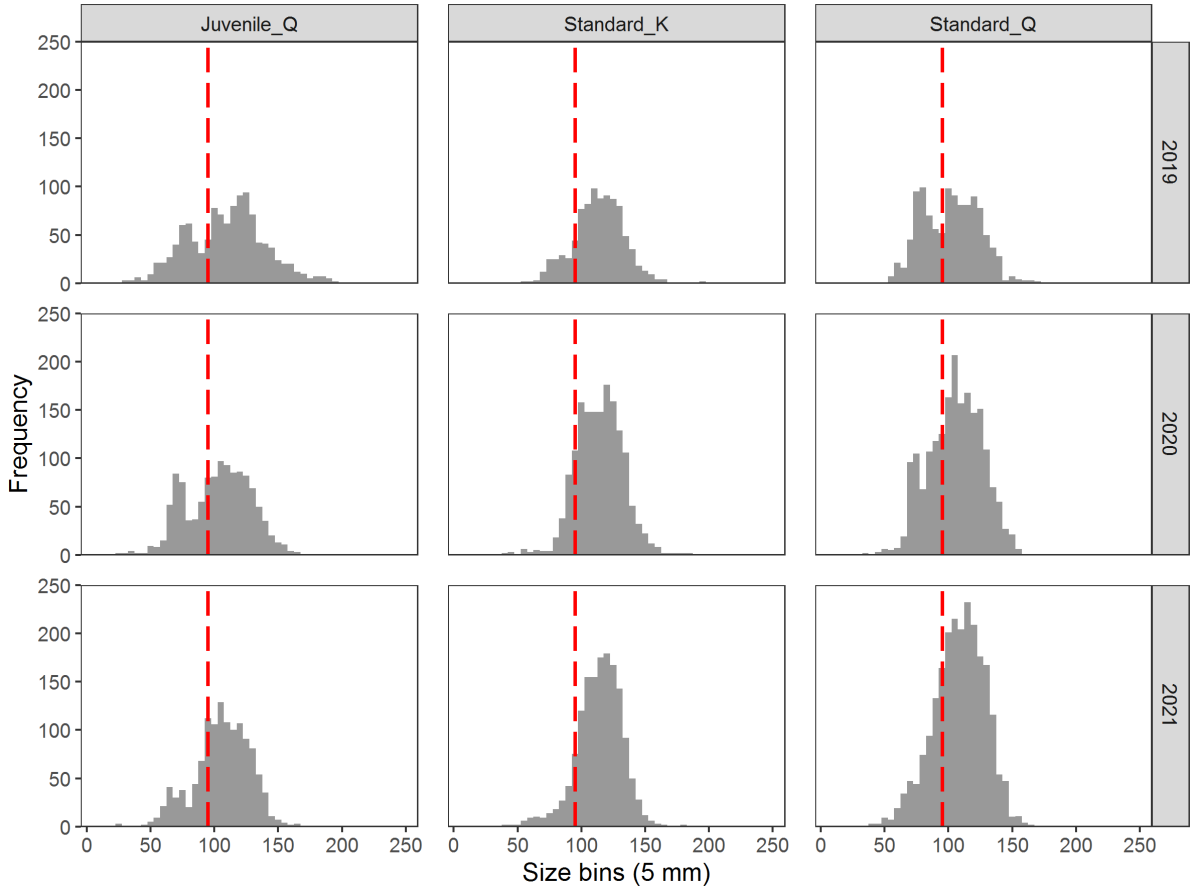

Figure 21: Size: density histogram of absolute counts of king scallops for the territorial sea displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

The overall data for the Isle of Man territorial waters indicates that for post-recruits (over 95 mm) the survey index increased annually from **0.571 in 2019 to 0.689 in 2020 to 0.830 in 2021** (Table 3) . For recruits (under 95 mm) the survey index decreased from 2019 to 2020 and increased again from 2020 to 2021 from **0.197 in 2019 to 0.162 in 2020 to 0.203 in 2021 (**Table 3**)**.

4.3.3 Fishing Grounds (3- 12 nm)

4.3.3.1 Targets

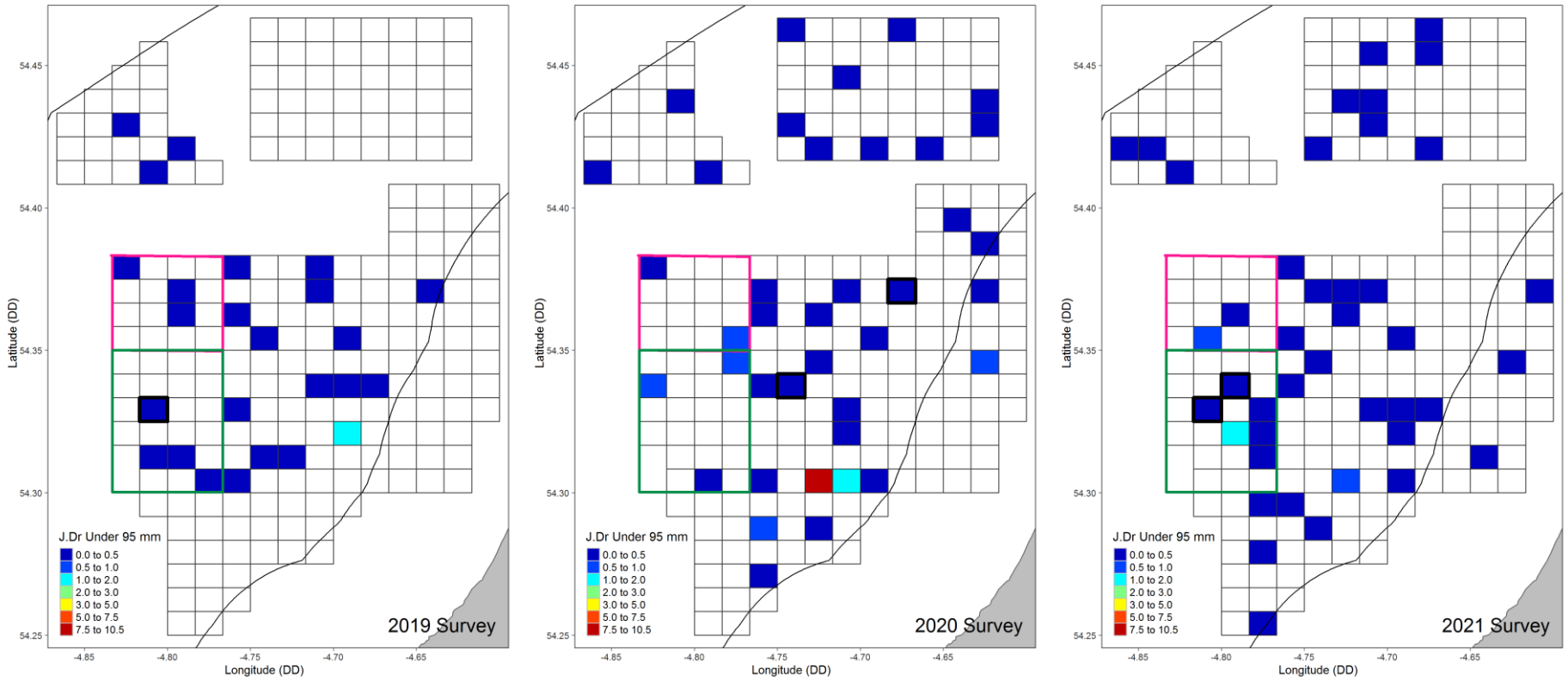

Figure 22: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2019 (left), 2020 (middle) and 2021 (right) at Targets (West coast). The green boxes indicate restricted access areas during the current queen scallop fishing season (i.e. 2021) and the pink boxes indicate areas currently closed for queen scallop fishing in 2021. 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.

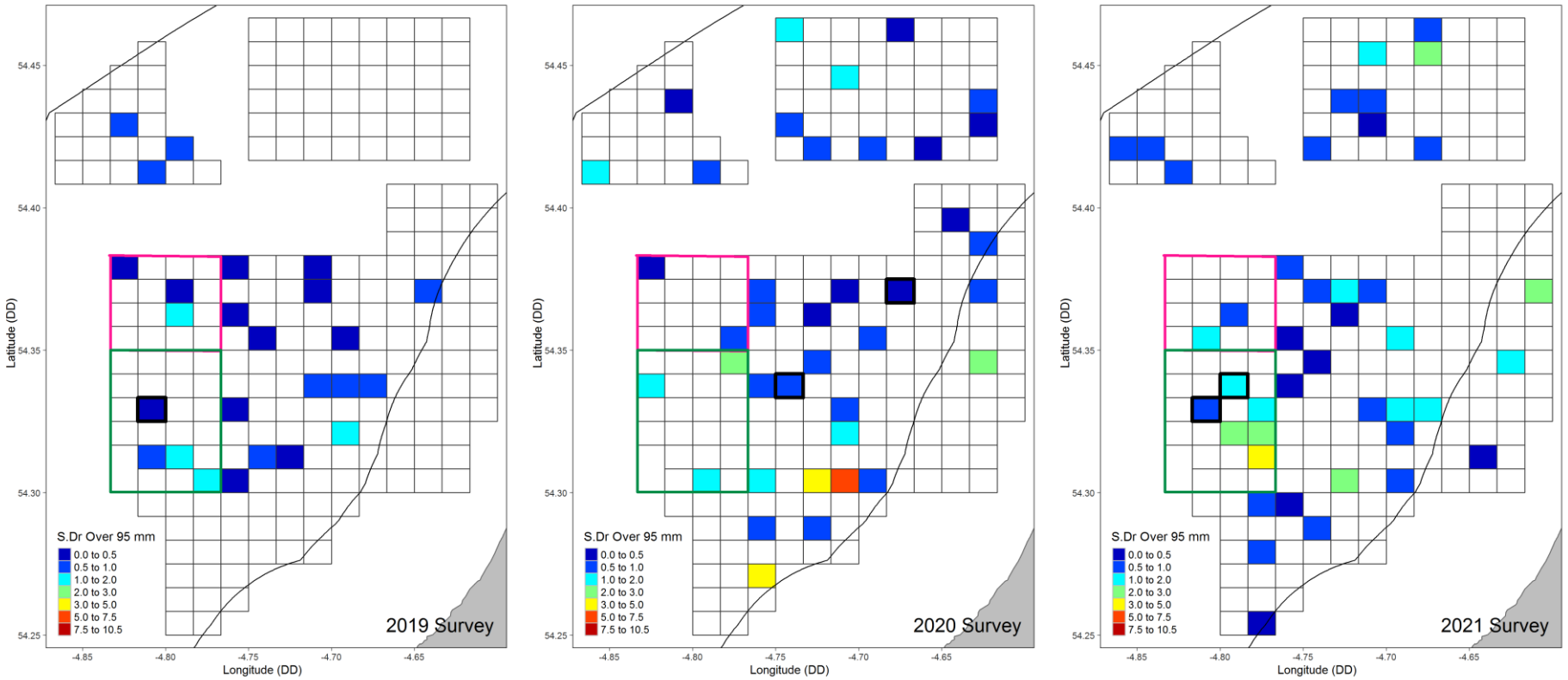

Figure 23: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard king and standard queen scallop dredges for 2019 (left), 2020 (middle) and 2021 (right) at Targets (West coast). The green boxes indicate restricted access areas during the current queen scallop fishing season (i.e. 2021) and the pink boxes indicate areas currently closed for queen scallop fishing in 2021. 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	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
Cells Surveyed	24	37	40	24	37	40
Min	0.00	0.00	0.00	0.19	0.05	0.00
Geometric Mean	**0.102**	**0.186**	**0.158**	**0.610**	**0.839**	**0.837**
Max	1.81	10.44	1.11	1.90	5.67	4.40

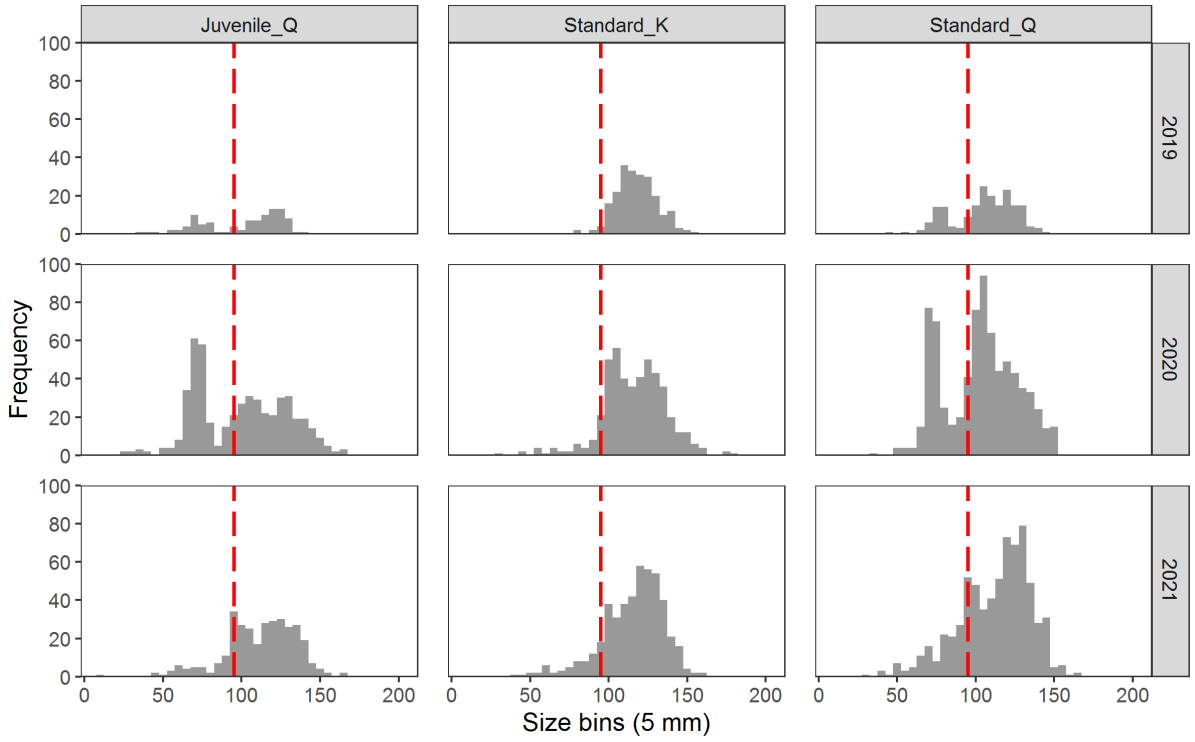

Figure 24: Size: density histogram of absolute counts of king scallops at Targets displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total 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 stayed relatively constant in 2021 from **0.610 in 2019 to 0.839 in 2020 to 0.837 in 2021** (Table 4). For recruits (under 95 mm) the survey index increased from 2019 to 2020 and then decreased from 2020 to 2021 from **0.102 in 2019 to 0.186 in 2020 to 0.158 in 2021** (Table 4).

The highest recorded densities for king scallops recruits for 2020 were recorded in the southern area of the Targets fishing ground, east of the 2019 Closed Area: ~ 10 king scallops per 100 m² (recruits). This area also recorded high densities of post-recruits (3- 7.5 king scallops per 100 m²). Despite scientific advice the area was not included in a closure during the 2020 king scallop fishing season. The 2021 industry survey detected post-recruit densities of only 2-3 king scallops per 100 m² in the survey cell with the high density of recruits from 2020 (Figure 23).

TAR Closed and Restricted Area (2020)

The 2020 Restricted Area at TAR comprised the bottom 3 rows of the 2021 queen scallop restricted area and the 2020 Closed Area comprised the top 3 rows of the 2021 queen scallop restricted area (Figure 23).

*Table 5: 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 **2020 Closed Area**; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.*

CLOSED	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
n	3	1	3	3	1	3
Min	0.00	0.22	0.00	0.73	1.15	2.43
GeoMean	**0.050**	**0.265**	**0.199**	**1.290**	**1.200**	**3.110**
Max	0.00	0.22	1.11	1.81	1.15	4.40

*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 Targets **2020 Restricted Area**; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.*

RESTRICTED	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
n	1	2	3	1	2	3
Min	0.13	0.81	0.18	0.49	1.37	0.70
GeoMean	**0.180**	**0.901**	**0.299**	**0.540**	**2.010**	**0.950**
Max	0.13	0.90	0.34	0.49	2.82	1.04

The data from the TAR 2020 Closed Area (where there was no fishing activity during the 2020 king scallop fishing season) indicates that for post-recruits (over 95 mm) the survey index increased in 2021 compared to 2019 and 2020 from **1.290 in 2019 to 1.200 in 2020** to **3.110 in 2021** (Table 5). For recruits (under 95 mm) the survey index increased from 2019 to 2020 and then decreased from 2020 to 2021 from **0.050 in 2019 to 0.265 in 2020 to 0.199 in 2021** (Table 5).

The data from the TAR 2020 Restricted Area (where there was restricted fishing activity during the 2020 king scallop fishing season) indicates that for post-recruits (over 95 mm) the survey index increased from 2019 to 2020 and then decreased from 2020 to 2021 from **0.540 in 2019 to 2.010 in 2020** to **0.950 in 2021** (Table 6). For recruits (under 95 mm) the survey index increased from 2019 to 2020 and then decreased from 2020 to 2021 from **0.180 in 2019 to 0.901 in 2020** to **0.299 in 2021** (Table 6).

4.3.3.2 Chickens

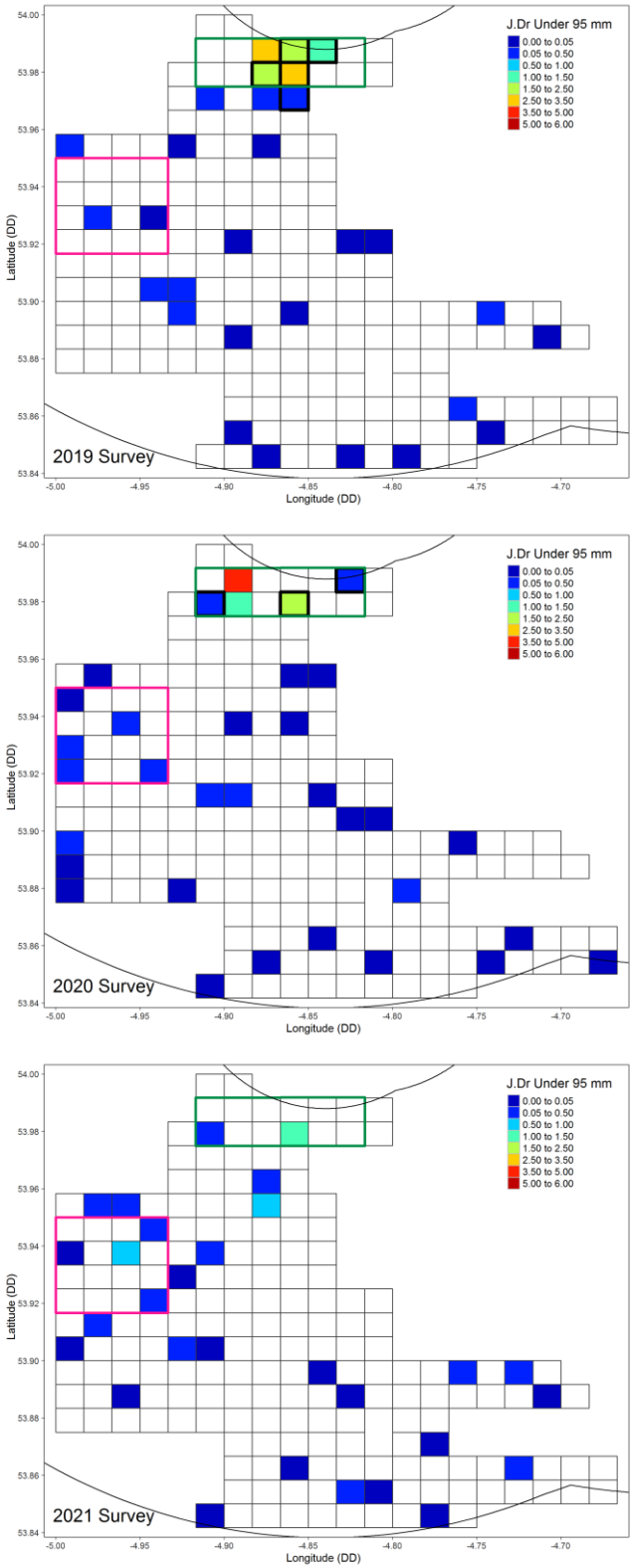

Figure 25: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2019 (left), 2020 (middle) and 2021 (right) at Chickens (West coast). The green boxes indicate restricted access areas during the current queen scallop fishing season (i.e. 2021) and the pink boxes indicate areas currently closed for queen scallop fishing in 2021. 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).

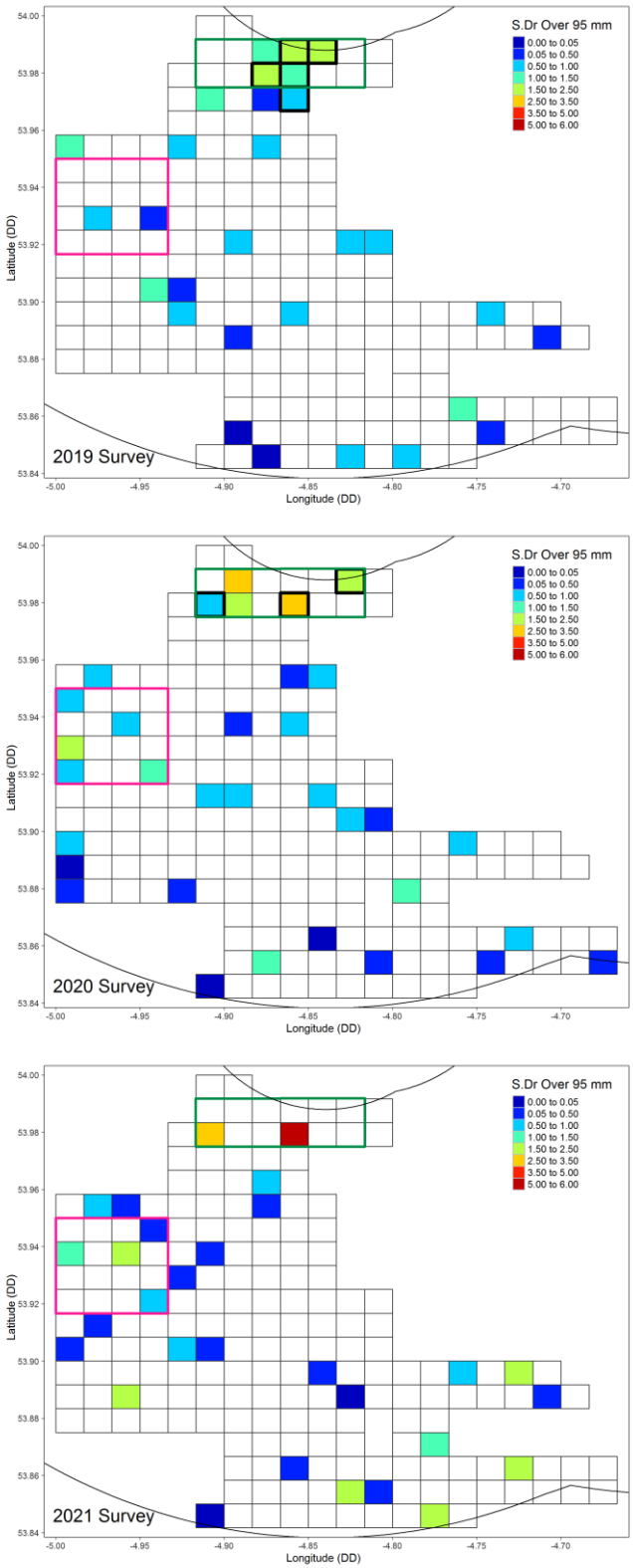

Figure 26: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2019 (left), 2020 (middle) and 2021 (right) at Chickens (South coast). The green boxes indicate restricted access areas during the current queen scallop fishing season (i.e. 2021) and the pink boxes indicate areas currently closed for queen scallop fishing in 2021. 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 7: 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 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	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
Cells Surveyed	24	30	29	24	30	29
Min	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	**0.115**	**0.102**	**0.150**	**0.581**	**0.567**	**0.634**
Max	2.64	4.27	1.28	1.41	2.83	5.59

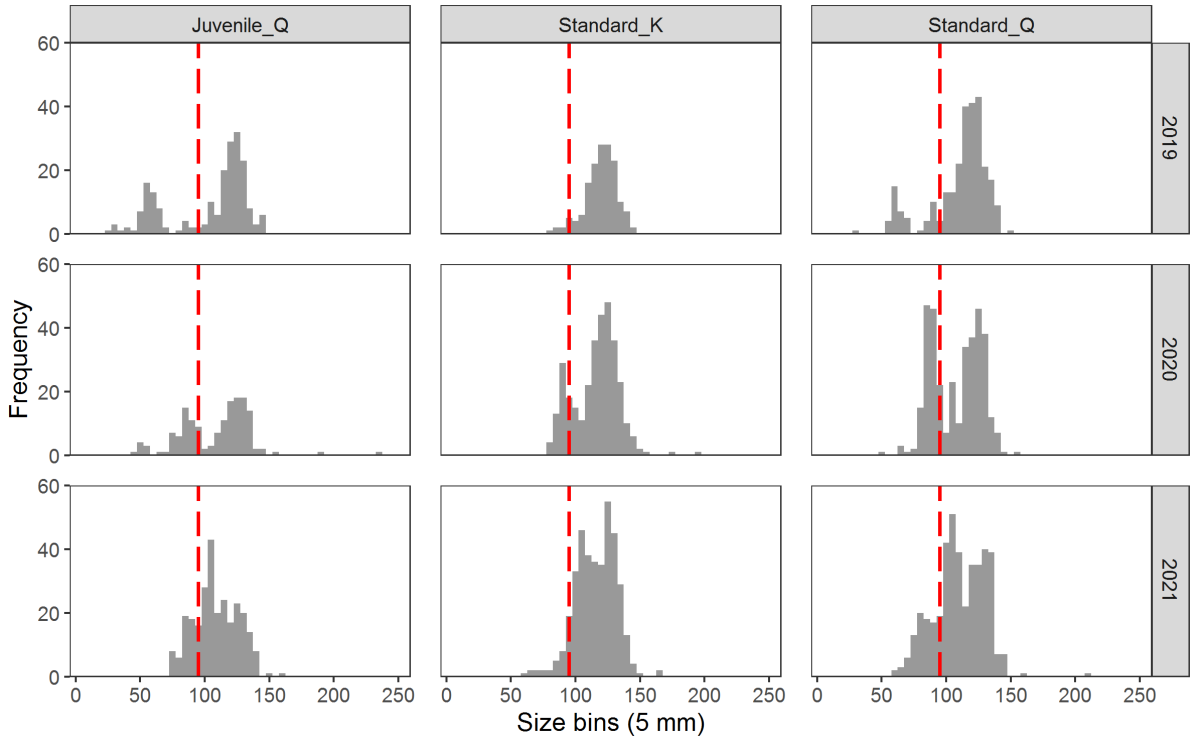

Figure 27: Size: density histogram of absolute counts of king scallops at Chickens displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of 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 index stayed relatively constant between 2019 and 2020 and then increased from 2020 to 2021 from **0.581 in 2019 to 0.567 in 2020 to 0.634in 2021** (Table 7). For recruits (under 95 mm) the survey index decreased from 2019 to 2020 and then increased from 2020 to 2021 from **0.115 in 2019 to 0.102 in 2020 to 0.150 in 2021** (Table 7).

A recruitment peak (i.e. new recruits ~ 45-60 mm) can be seen in the 2019 survey data, this peak was protected by closures and by 2020/2021 and 2021/2022 this peak had grown into the fishery (Figure 27). However, **no new recruitment peak is present in 2021** (Figure 27), this is an important consideration when looking at sustainable management over a > 1 year period.

CHI Closed and Restricted Areas

*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 Chickens **2020 Closed Area**; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.*

CLOSED	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
n	2	5	4	2	5	4
Min	0.00	0.00	0.05	0.24	0.64	0.47
GeoMean	**0.095**	**0.137**	**0.238**	**0.482**	**0.979**	**1.060**
Max	0.13	0.17	0.56	0.77	1.75	1.83

*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 Chickens **2020 Restricted Area**; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.*

RESTRICTED	2019 < 95 mm	2020 < 95 mm	2021 < 95 mm	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
n	5	5	2	5	5	2
Min	1.24	0.30	0.30	1.30	0.84	2.73
GeoMean	**2.120**	**1.170**	**0.682**	**1.480**	**1.840**	**3.960**
Max	3.16	4.27	1.28	1.71	2.83	5.59

The data from the CHI 2020 Closed Area (where there was no fishing activity during the 2020 king scallop fishing season) indicates that for post-recruits (over 95 mm) the survey index increased annually from **0.482 in 2019 to 0.979 in 2020** to **1.060 in 2021** (Table 8). For recruits (under 95 mm) the survey index increased annually from **0.095 in 2019 to 0.137 in 2020 to 0.238 in 2021**. Despite no fishing activity a cable was laid through the middle of the closed area during 2020. The 2020 Closed Area has remained in the same location for the 2021 queen scallop fishery (Figure 26).

The data from the CHI 2020 Restricted Area (where there was restricted fishing activity during the 2020 king scallop fishing season) indicates that for post-recruits (over 95 mm) the survey index increased annually from **1.480in 2019 to 1.840 in 2020** to **3.960 in 2021** (Table 9). For recruits (under 95 mm) the survey index decreased annually from **2.120 in 2019 to 1.170 in 2020** to **0.682 in 2021**. The 2020 Restricted Area has remained in the same location for the 2021 queen scallop fishery (Figure 26).

4.3.3.3 East of Douglas

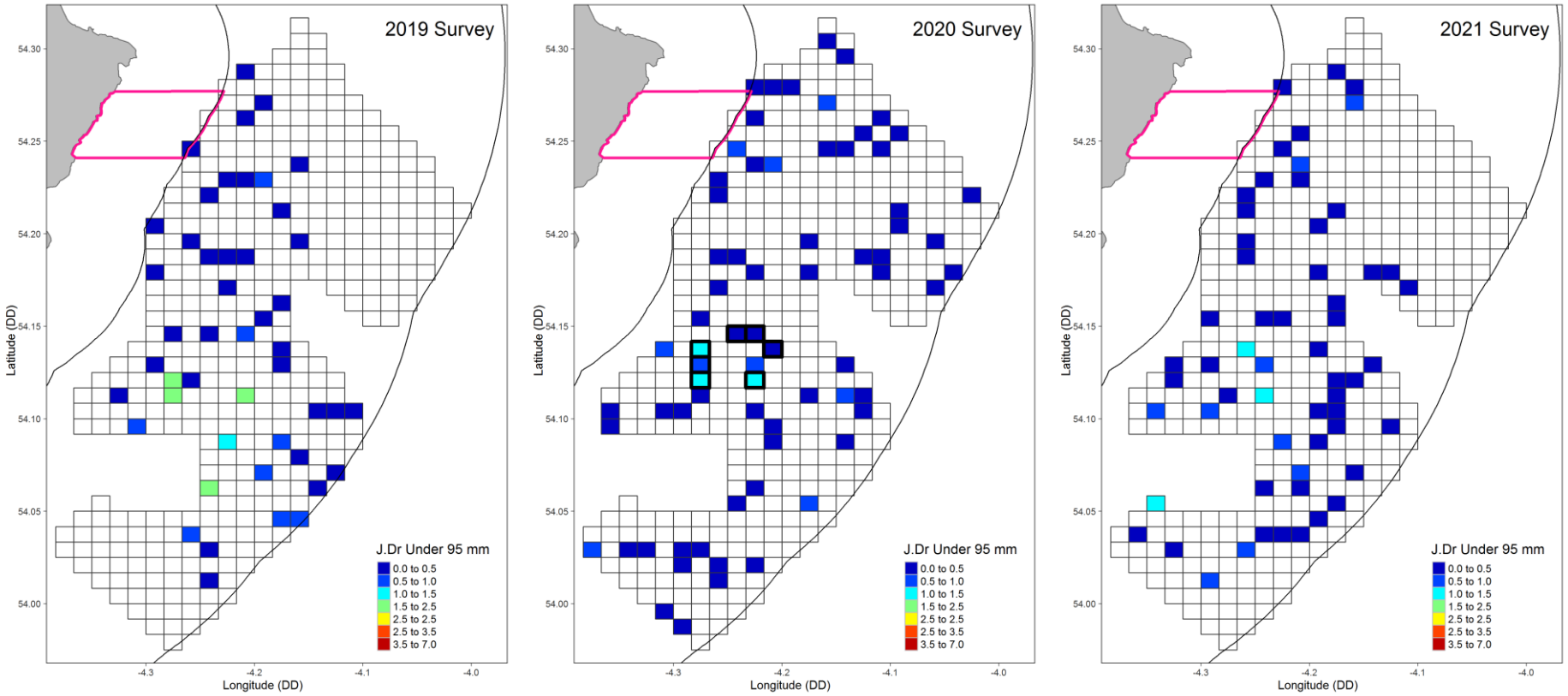

Figure 28: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2019 (left), 2020 (middle) and 2021 (right) at East Douglas (East coast). The pink box indicate areas currently closed to scallop fishing in. 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.

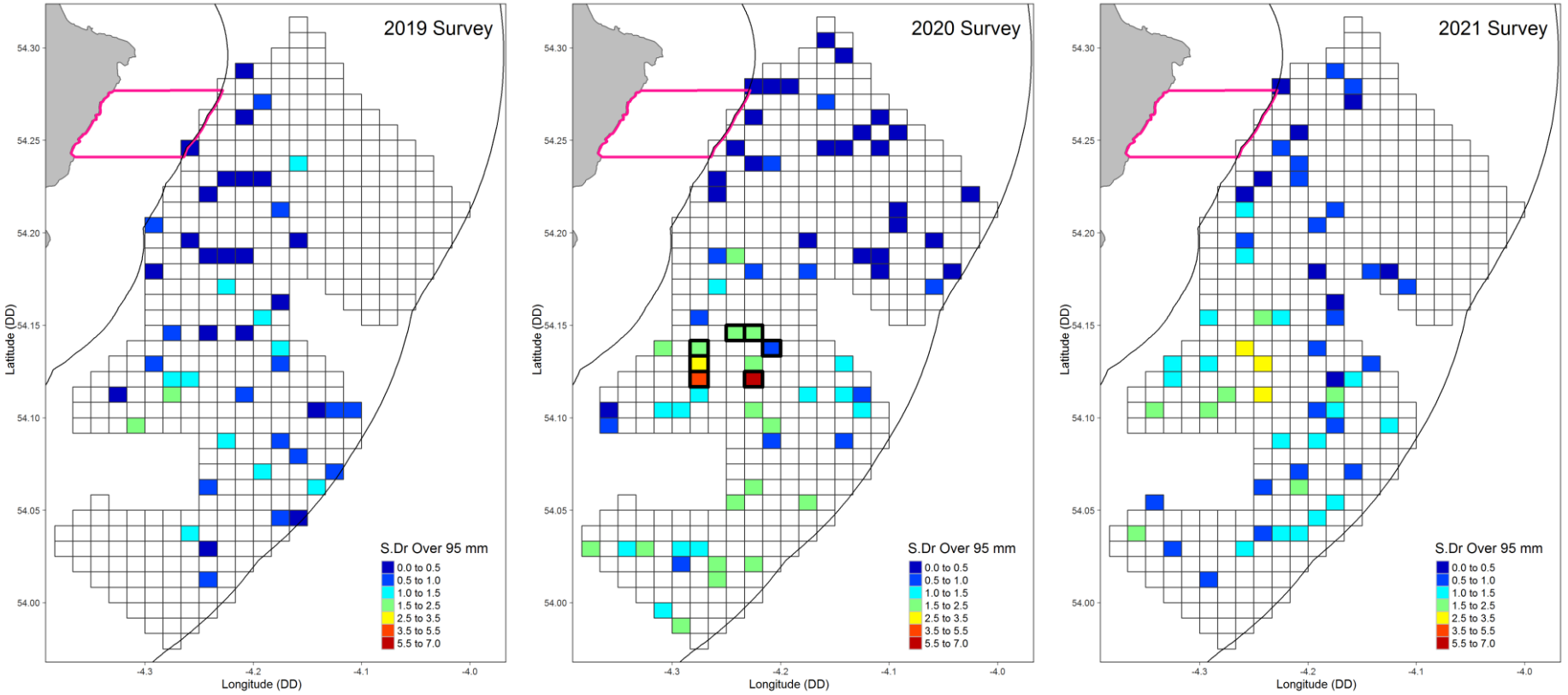

Figure 29: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2019 (left), 2020 (middle) and 2021 (right) at East Douglas (East coast). The pink box indicate areas currently closed to scallop fishing in. 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 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 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	2019 > 95 mm	2020 > 95 mm	2021 > 95 mm
Cells Surveyed	48	63	59	48	63	59
Min	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	**0.358**	**0.185**	**0.280**	**0.547**	**0.674**	**0.943**
Max	2.25	0.64	1.24	2.11	2.50	3.02

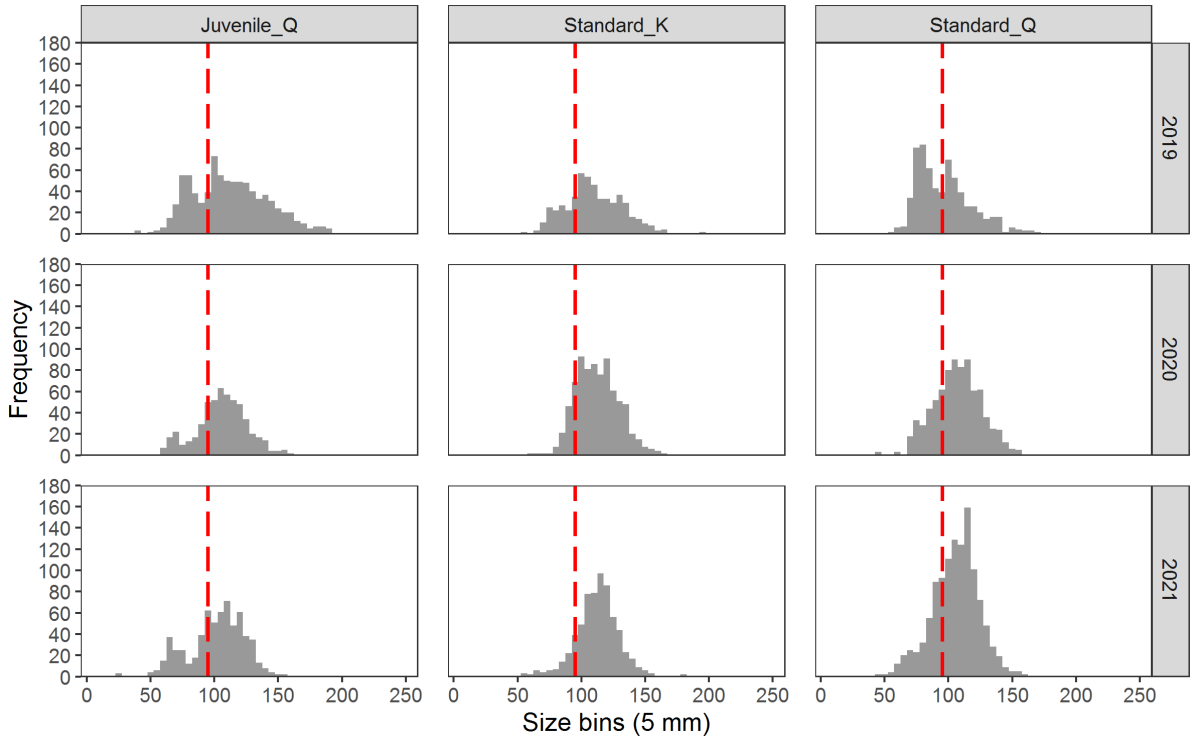

Figure 30: Size: density histogram of absolute counts of king scallops at East of Douglas displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 95 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio 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 from **0.547 in 2019 to 0.674 in 2020 to 0.943 in 2021** (Table 10). For recruits (under 95 mm) the survey index decreased from 2019 to 2020 and then increased from 2020 to 2021 from **0.358 in 2019 to 0.185 in 2020 to 0.280 in 2021** (Table 10).

4.3.3.4 Point of Ayre

Point of Ayre fishing ground was not surveyed in 2021 due to resource limitations.

4.3.4 Fishing Grounds (0- 3 nm)

4.3.4.1 East Coast

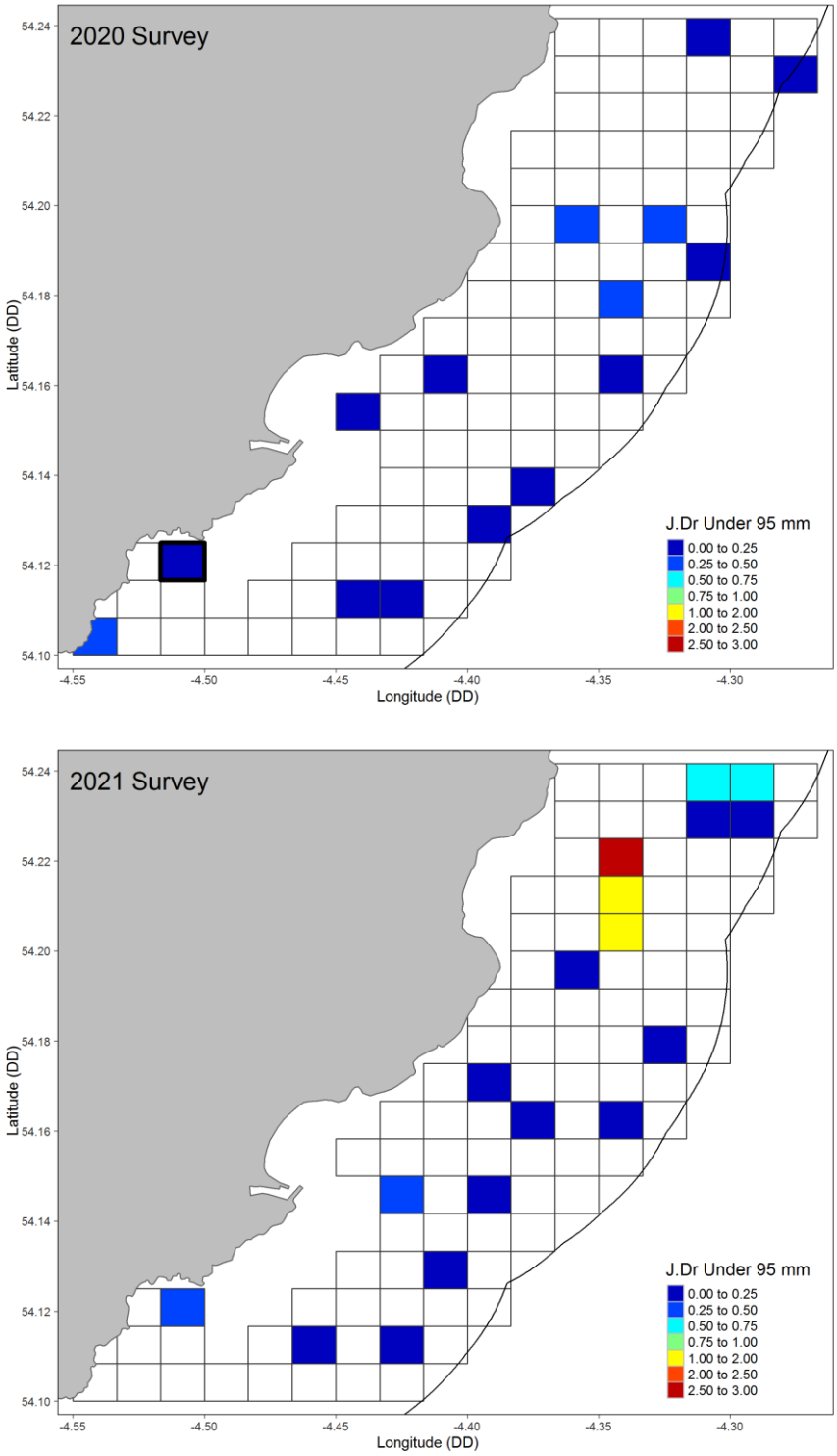

Figure 31: Map illustrating the survey densities (scallops per 100 m²) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2020 and 2021 at East Coast 0 – 3 nm (East coast).

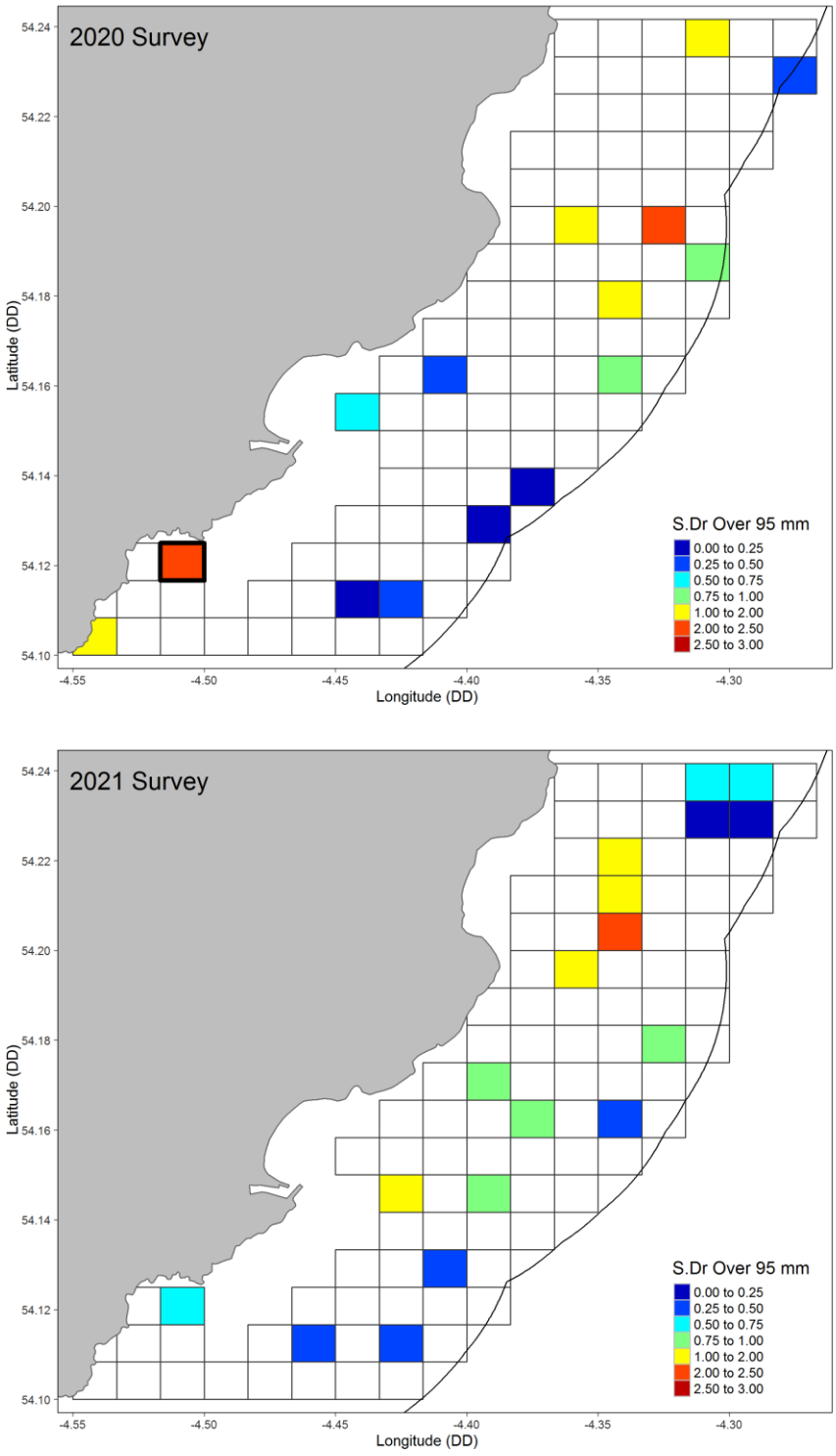

Figure 32: Map illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2020 and 2021 at East Coast 0 – 3 nm (East coast).

Table 11: 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	2020 > 95 mm	2021 > 95 mm
Cells Surveyed	15	18	15	18
Min	0.00	0.00	0.00	0.00
Geometric Mean	**0.153**	**0.238**	**0.548**	**0.606**
Max	0.47	2.73	2.22	2.39

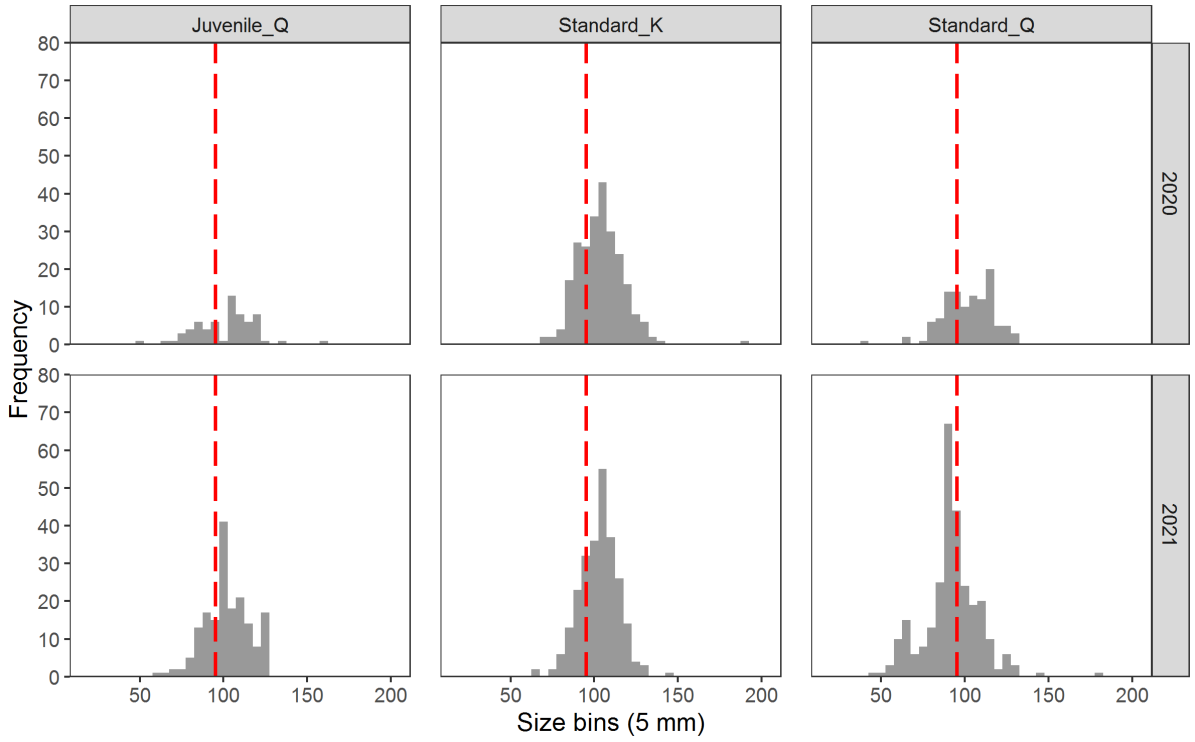

Figure 33: Size frequency of absolute counts of king scallops by dredge type for East Coast 0 – 3 nm 2020 and 2021. The red dashed line indicates the estimated recruit cut-off of 95 mm.

The data from ECO, which has no comparative survey data from 2019, indicates that for post-recruits (over 95 mm) the survey index increased from 2020 to 2021 from **0.548 in 2020 to 0.606 in 2021** (Table 11). For recruits (under 95 mm) the survey index also increased from 2020 to 2021 from **0.153 in 2020 to 0.238 in 2021** (Table 11).

4.3.4.2 Bradda (0-3nm and offshore)

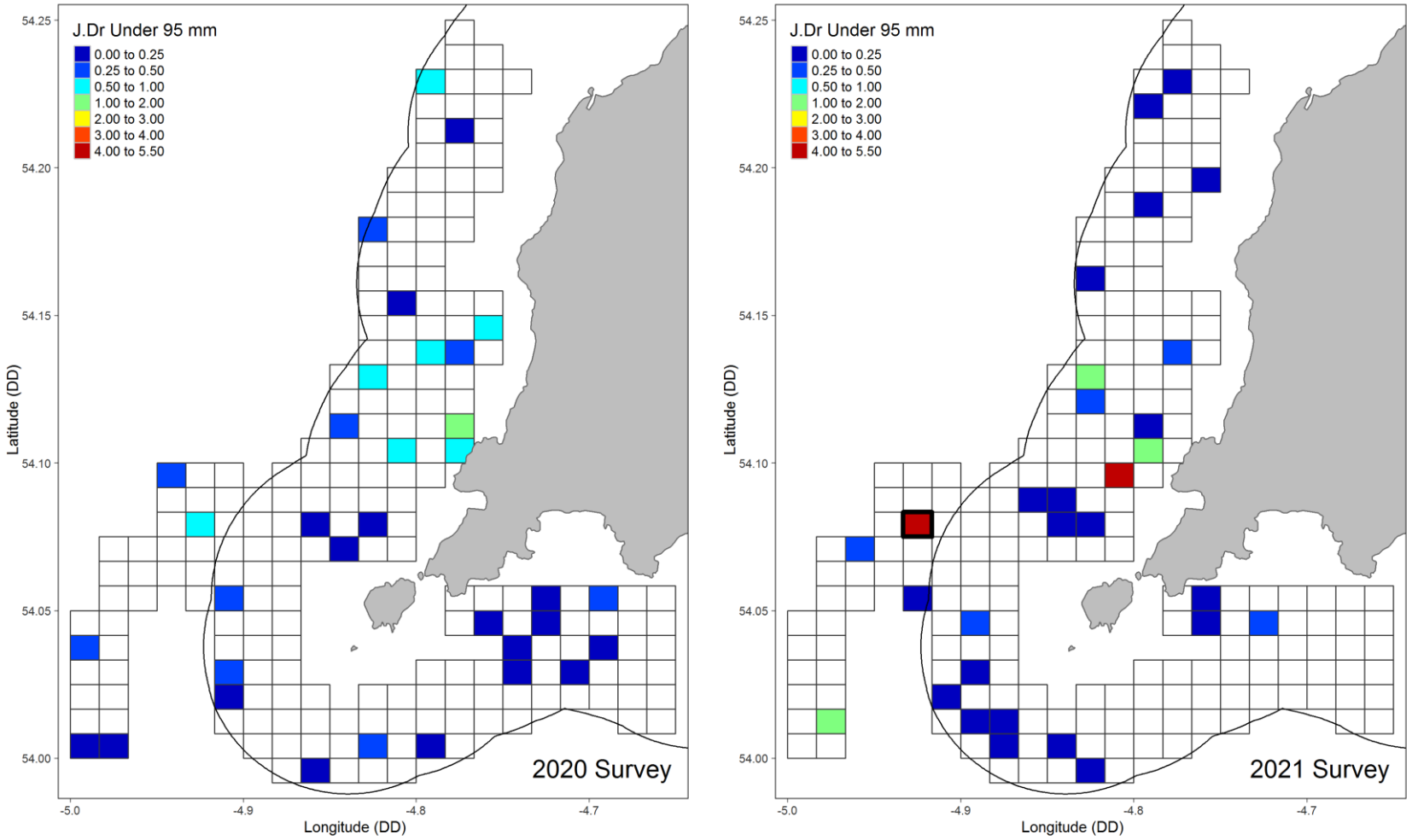

Figure 34: Maps illustrating the survey densities (scallops per 100 m²) for king scallops under 95 mm from juvenile queen and standard queen scallop dredges for 2020 and 2021 at Bradda (0 – 3 nm and offshore) (South-west coast).

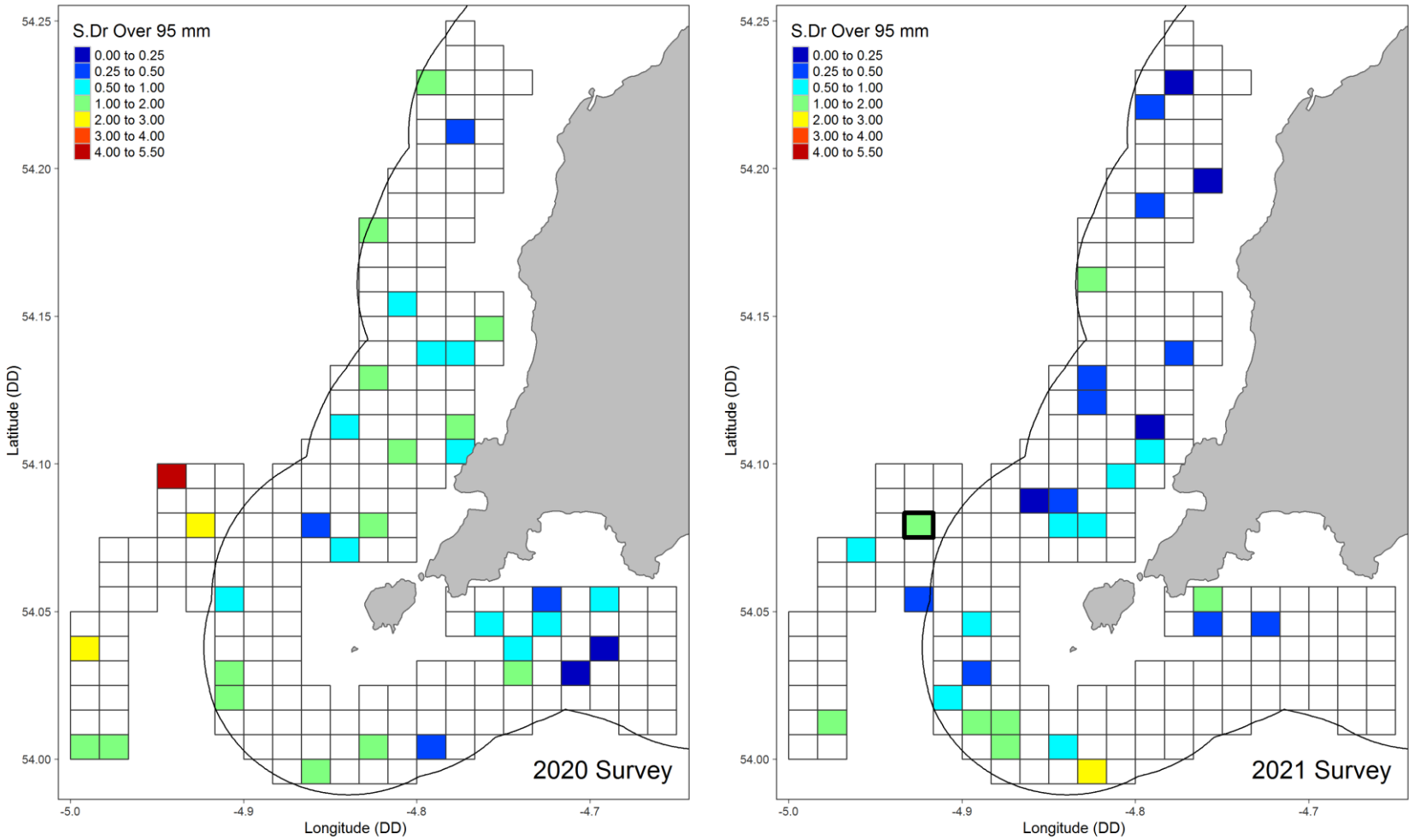

Figure 35: Map illustrating the survey densities (scallops per 100 m^2) for king scallops over 95 mm from standard queen and standard king scallop dredges for 2020 and 2021 at Bradda (0 – 3 nm and offshore) (South-west coast).

Table 12: 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	2020 > 95 mm	2021 > 95 mm
Cells Surveyed	35	29	35	29
Min	0.00	0.00	0.13	0.00
Geometric Mean	**0.247**	**0.189**	**0.926**	**0.603**
Max	1.62	4.35	5.41	2.18

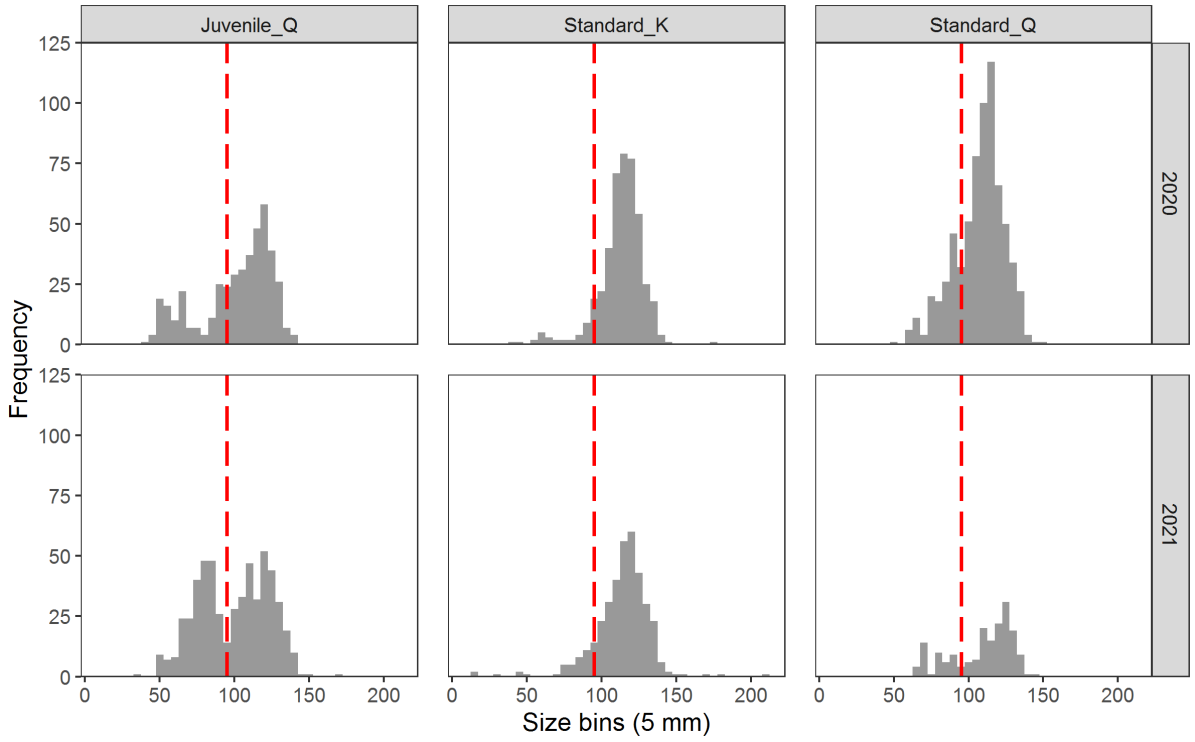

Figure 36: Size frequency of absolute counts of king scallops by dredge type for Bradda (0 – 3 nm and offshore) 2020 and 2021. The red dashed line indicates the estimated recruit cut-off of 95 mm.

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 **0.926 in 2020 to 0.603 in 2021** (Table 12). For recruits (under 95 mm) the survey index also decreased from 2020 to 2021 from **0.247 in 2020 to 0.189 in 2021** (Table 12).

4.3.4.3 Maughold 0-3nm

Maughold 0-3 nm fishing ground was not surveyed in 2021

5. Overall Spatial and Temporal Comparisons

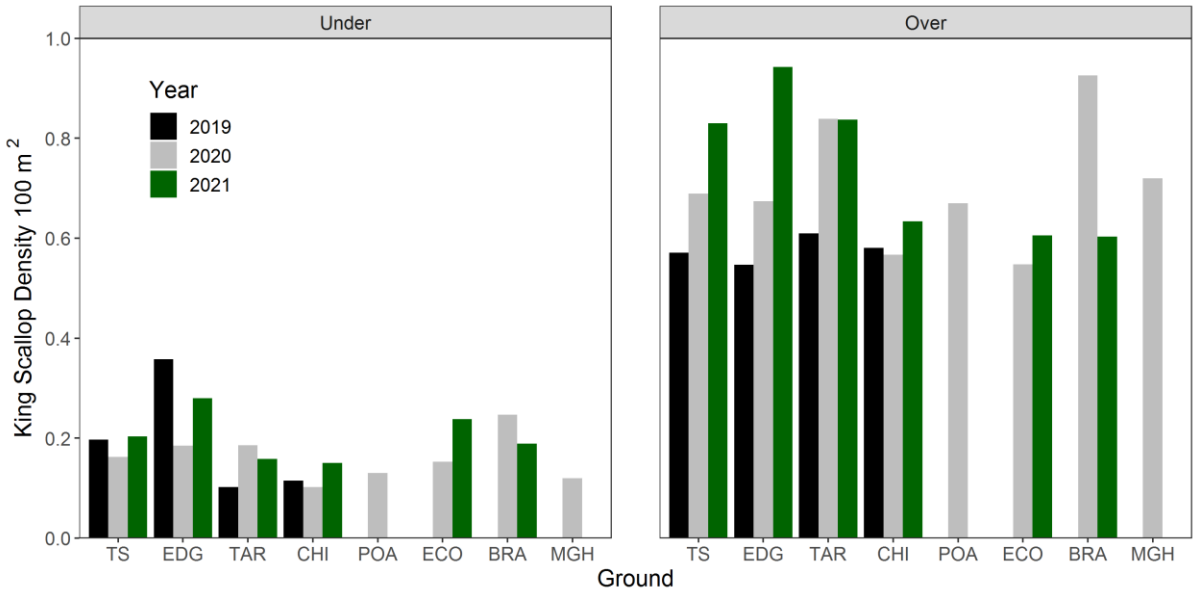

Figure 37: Comparison of king scallop abundance indices (geometric mean) (over and under 95 mm) by year and by ground for the industry survey

Within the territorial sea there has been an overall increase in the abundance index (geometric mean) from 2020 to 2021 from the industry survey for both post-recruits and recruits when combining the three grounds, EDG, TAR and CHI (TS; Figure 37). The same increasing pattern is evident in the scientific survey for both recruit and post-recruit abundance indices from 2019 to 2021 (missing year of data in 2020) (Figure 16 and Figure 18). This follows 1727 t of landings reported for the whole territorial sea area during the 2020/2021 fishing season (Table 13).

Of the three grounds surveyed in 2021 by the industry survey within the 3-12 nm limit (EDG, CHI and TAR), two (CHI and EDG) have seen increases in the post-recruit abundance for 2021, while the third, TAR shows no change. In terms of recruits both CHI and EDG recorded increases in abundance from 2020, while TAR showed a decline. EDG has the highest post-recruit and recruit index value for 2021 (Table 13) (although the current restricted area at CHI and closed area at TAR both have higher localised densities of post-recruits: Table 5 and Table 9). From the scientific survey the highest density sites in the 3-12 nm area were CHI and ST33 (south) (Figure 11).

Of the two grounds surveyed in 2021 by the industry survey within the 0 – 3nm limit (ECO and BRA), one (ECO) saw an increase in both post-recruit and recruit abundance for 2021 while the second, BRA saw a decrease in both post-recruit and recruit abundance for 2021. From the scientific survey the highest density sites in the 0-3 nm area were BRI (south-west), LAX and ST27 (east) (Figure 11 and Figure 14) which all had good densities with large proportions of recruits.

Table 13: 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 2020/2021 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	2020 <95 mm	2021 <95 mm	Change	2020 >95 mm	2021 >95 mm	Change	Landings 2020/21 (t)
TS	T.S.	0.162	0.203	+	0.689	0.830	+	1727
3-12 nm	EDG	0.185	0.280	+	0.674	0.943	+	751.7
	TAR	0.186	0.158	-	0.839	0.837	=	312.3
	CHI	0.102	0.150	+	0.567	0.634	+	317.6
	POA	0.130	NA	NA	0.670	NA	NA	22.9
0-3 nm	ECO	0.153	0.238	+	0.548	0.600	+	47.9
	BRA	0.247	0.189	-	0.926	0.603	-	197.9
	MGH	0.120	NA	NA	0.720	NA	NA	76.4

6. Recommendations:

A TAC for the 2021/2022 fishing season has not been calculated in the main report using the ICES Category 3 data limited approach due to the year of missing data in the long-term survey abundance index for 2020 (see Section 4.1 for more detail). TAC calculations for 2020/2021 and 2021/2022 are provided for reference in Appendix 1 following the approach suggested by ICES for dealing with missing data due to CV-19.

It is recommended that the management approach for 2021/2022 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. TAR or CHI) 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 2021/2022 king scallop fishery based on the survey data analysis produced here therefore include:

- A precautionary management approach should be considered in particular due to the uncertainty in a TAC calculation for 2021/2022 due to missing data in 2020 (Appendix 1).
- In addition to 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 restrictions, may have contributed to the under achievement of the TAC in recent seasons. However, it is highlighted that the quantity of removals which have impacted the current survey densities are lower than the TAC limits set for the past two fishing seasons and so a precautionary approach to the setting of the TAC is advised.

- Starting TAC to remain at 2020/2021 fishing levels (i.e. 2049 t) which, if achieved, would already be a 15% increase in landings from 2020/2021 and a 42% increase in landings compared to 2019/2020.
- 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.
- Restricted access and management of the two high density fishing areas at Chickens and Targets that are defined as restricted areas during the current queen scallop fishing season.
- 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. Both metrics are under development and the relationship between different levels and possible impacts on the stock 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).
- Temporary closed areas implemented to protect any high densities of recruits identified in the survey (Bradda (i.e. BRI) and East Coast (i.e. ST27) had the highest densities of recruits in the 2021 industry and scientific surveys and may be suitable areas for consideration.
- Strict monitoring and enforcement of daily catch limits within high density restricted areas should be in place.

Long-term fisheries management plan:

A long-term management plan (LTMP) for the king scallop fishery is currently under development, with collaborative input from industry, and will be essential for ongoing monitoring, management and recovery of this stock. The LTMP should include a set of aims and goals for the fishery, to provide DEFA, Bangor and the SMB with clear direction in formulating management advice. 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 2021 queen scallop fishery and the 2021/2022 king scallop fishery could be combined to monitor cumulative impacts during the 2021/2022 king scallop fishery).

Relative Benthic Status 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 metric for monitoring of scallop

fisheries. This approach would allow an assessment of each habitat type within the territorial waters or within a fishing ground to indicate which areas are more at risk from higher fishing intensities and whether levels of fishing intensity would have a negative impact on habitat status (using pre-defined management criteria).

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 knowing when to expect above average fisheries within each ground in the coming year(s).

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.

7. References:

Beukers-Stewart, B.D., Mosley, M.W.J. and Brand, A.R. (2003). Population dynamics and predictions in the Isle of Man fishery for the great scallop, *Pecten maximus* (L.). ICES Journal of Marine Science, 60:223-241.

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8. Appendix 1

Advice for missing data due to Covid for ICES Category 3 and 4 Stock TAC Calculations

The advice is most often based on a trend analysis of a survey index (last 2 years average over previous 3 years average or other range of years). If one of the last two years is missing, the ratio can be calculated by treating that value as missing. This would mean that the last 2-year average would be based on the one available estimate. For an example, please see the 2020 advice for Anglerfish (*Lophius budegassa, Lophius piscatorius*) in subareas 4 and 6, and in Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat;

If the survey estimates are missing for the last 2 years (e.g. 2020 and 2021 as would be used for some autumn advice stocks) then there is no data available for the last 2 years to calculate the advice. In these cases, if the advice was due to consider the PA buffer (done every 3 years) then advice could be given by applying the PA buffer to the previous advice. If the PA buffer was not to be considered then advice would remain unchanged. In both cases, the advice sheet should indicate that the survey information was not available.

For the Isle of Man King Scallop fishery the TAC advice would follow as below, if 2020 was treated as a missing year of data (i.e. only a single year of data is used in Index A). Effectively assuming the 2020 data point is either equivalent to 2019 (for 2020/21 calculation) or to 2021 (for 2021/22 calculation).

Table 14: King scallops in Isle of Man territorial waters, TAC calculation based on ICES Category 3 stock approach for 2020/2021 advice treating 2020 as a missing data value.

Index A (2019 – 2020; 2020 not available)		97
Index B (2016-2018)		134
Index ratio (A/B)		0.72
Uncertainty cap	Applied|	0.8
Advised catch for 2019/2020		2049 tonnes
Precautionary buffer	Not applied|	
Catch advice for 2020/2021		1639 tonnes
% advice change relative to prior season		- 20 %

Table 15: King scallops in Isle of Man territorial waters, TAC calculation based on ICES Category 3 stock approach for 2021/2022 advice treating 2020 as a missing data value.

Index A (2020 – 2021; 2020 not available)		196
Index B (2017-2019)		102
Index ratio (A/B)		1.92
Uncertainty cap	Applied|	1.2
Advised catch for 2020/2021		1639 tonnes
Precautionary buffer	Not applied|	
Catch advice for 2021/2022		1967 tonnes
% advice change relative to prior season		+ 20 %

Angler fish advice downloaded at:
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/anf.27.3a46.pdf

ICES missing data advice downloaded at:
https://www.ices.dk/about-ICES/Documents/Approaches_Missing_Data_2021_and_templates.pdf