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King Scallop: 2020 Industry Survey Analysis

Bangor University and Manx Fish Producer Organisations Combined Report for the Scallop Management Board

September 2020

Sustainable Fisheries and Aquaculture Group, School of Ocean Sciences

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1. Introduction:

1.1: Background:
There are currently two annual scallop surveys undertaken within the Isle of Man territorial sea (TS):

1. **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 (survey cancelled for 2020).
2. **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)). The 2020 survey included the three main fishing grounds surveyed in 2019; East of Douglas (EDG), Chickens (CHI) and Targets (TAR) and also extended to include a fourth main king scallop fishing ground, Point of Ayre (POA) within the 3-12 nm and fishing grounds within the 0-3 nm (which includes three main grounds: East Coast (ECO), Maughold (MGH) and Bradda (BRA)). This survey was able to be completed by local industry in April 2020 in line with the Coronavirus restrictions and social distancing regulations.

The long-term survey data is used annually to undertake a quantitative stock assessment to estimate biomass and 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 (e.g. taking data from the two most recent years of 2020 and 2019 and comparing it with data from 2018, 2017 and 2016 gives a more accurate representation of stock trends than simply comparing a single years data from 2020 with a single years data from 2019).

With no long-term time series available for April 2020 the management advice for the 2020 king scallop (SCE) fishery will need to be based largely on the data analysis and results from the short-term high-resolution survey. It is however important to acknowledge the context of longer-term survey outputs from previous quantitative stock assessments and fishery dependent data from the fishery. As stated above the short-term survey has directly comparative data from 2019 and 2020 for EDG, CHI and TAR but there is only data from 2020 for POA in the 3-12 nm and BRA, ECO and MGH in the 0-3 nm. *However, the MFPO did collect data in 2019 from the 0-3 nm survey areas (BRA, ECO, MGH) using a different sampling methodology. Efforts have been made to standardise the 2019 data so that inter-annual comparisons are available for the purposes of this analysis; however, there are obvious caveats with 0-3 NM analysis and management advice resulting from a disparity in sampling methodology. This data will be presented separately to this report for reference.).*

2. Fishery:

2.1: Fishery 2019/2020

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 2019/2020 season a total of 82 vessels from the Isle of Man, Wales, Scotland, England and Northern Ireland had active licences to fish for king scallops in the Isle of Man's territorial waters 3- 12 NM zone and of those 36 vessels also had permits to fish for king scallops within the 0- 3 NM zone. For the 2019/2020 fishing season the management measures that applied to the fishery included:

- Total allowable catch (TAC) of 2049 tonnes
- A daily catch limit of 560 kg (increased to 630 kg for Weeks 6, 7 and 8 at Christmas)
- Daily curfew (18:00 – 06:00) [0 – 12 nm zone]
- Closed season: 01/06 to 31/10 [0 – 12 nm zone]
- ≤ 15.24 m vessel registered length [0 – 3 nm]
- Under 221 kw [0 -12 nm; excluding Grandfather rights vessels]
- Closed areas
- VMS required [0 – 12 nm zone] for all vessels
- Minimum landing size (110 mm)
- Maximum of 9 teeth per dredge
- Minimum tooth spacing of 75 mm [0 – 12 nm zone]
- Aggregate dredge width of no more than 762 cm [0 – 3 nm zone]
- Aggregate dredge width of no more than 1067 cm [3 – 12 nm zone]
- Maximum tow bar diameter of 185 mm [0 – 12 nm]
- Minimum belly ring diameter of 75 mm & Minimum dredge net mesh of 100 mm

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

Of the 82 vessels licenced to fish for king scallops during the 2019/20 fishing season 64 vessels reported landings of king scallops from within Isle of Man territorial waters. The TAC for 2019/2020 was 2049 t of which only 1186 t was landed (~ 58 %).

2.2: Annual Landings and Fishing Effort

2.2.1: Irish Sea

Annual landings 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).

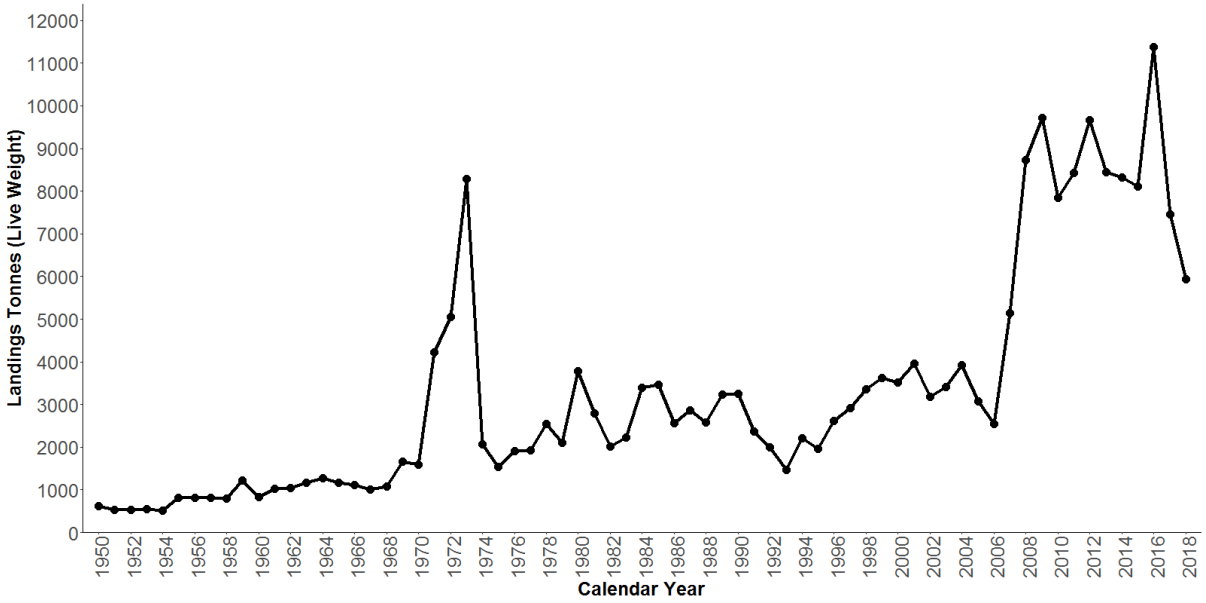

Figure 1: Annual King Scallop landings (t) from ICES Area VIIa for 1950 to 2018 using scallop landings from species Great Atlantic Scallop (SCE) and Scallop Nei (ICES 2020a; ICES 2020b).

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

The annual landings 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 and 2019 following the introduction of TACs within Isle of Man territorial waters; however landings continue to exceed pre-2006 values (with the exception of 1999).

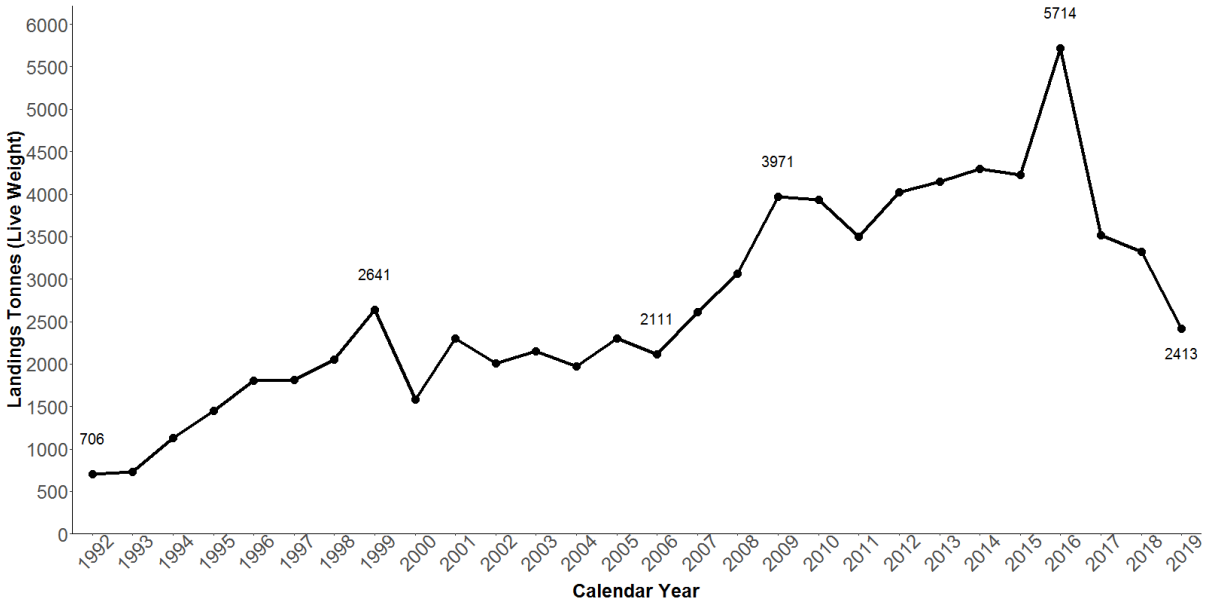

Figure 2: Annual (calendar year) King Scallop landings (t) from ICES Rectangles 36E5, 37E5 and 38E5 from 1992 to 2019 (Source: Logbook data DEFA, Marine Scotland, MMO and IFISH 2). For information the landings (t) values from key years are annotated on the graph.

2.3: Seasonal Landings and Fishing Effort

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

Seasonal landings of king scallops (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 followed by decline to a low of 1715 t in the 2019/2020 season following the introduction of TACs in Isle of Man territorial waters (Figure 3). *Note: these ICES Rectangles cover an area greater than the Isle of Man territorial waters.*

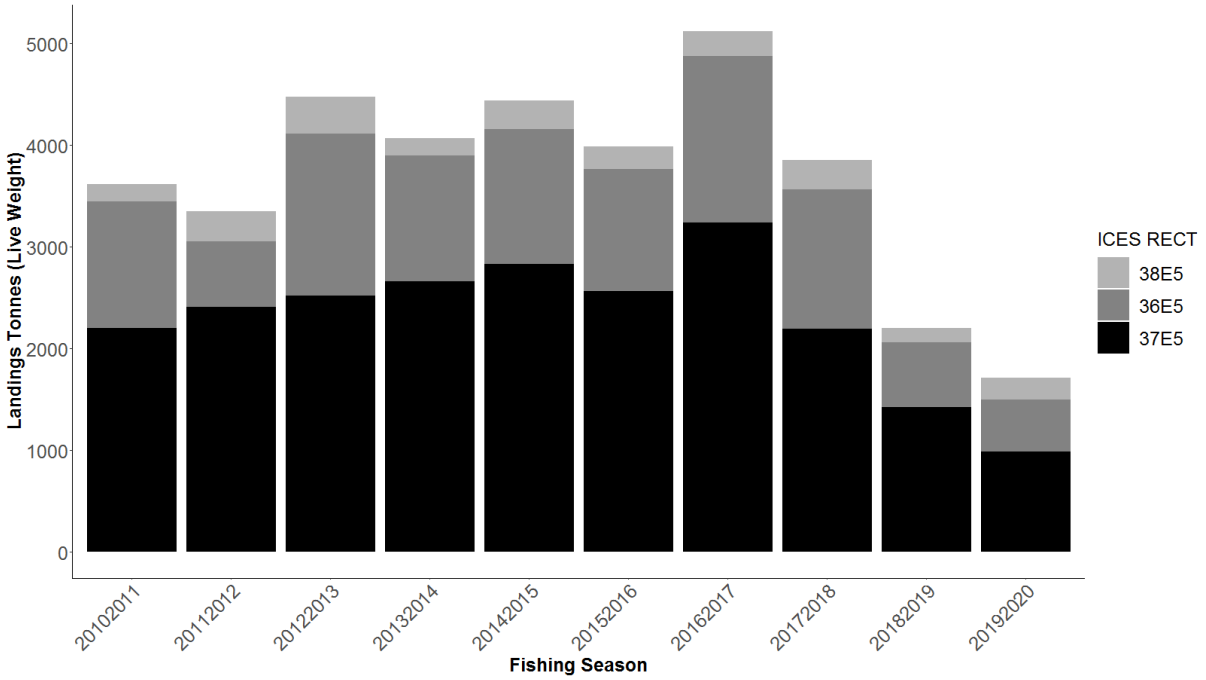

Figure 3: Seasonal landings (t) of king scallops from ICES Rectangles 36E5, 37E5 and 38E5 for the seasons 2010/2011 to 2019/2020. Data source: EU Logbooks downloaded through IFISH2. NB. This data includes ALL vessels fishing for king scallops

(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.

The temporal pattern of landings varied among seasons. In the 2016/2017 season, when landings reached their peak, there was a large spike in landings (> 2000t) during the first month of the fishery while previous fishing seasons were more stable at ~1000t or less (Figure 4). In contrast landings were uniformly low across all months in both the 2018/2019 and 2019/2020 seasons compared to other seasons (Figure 4).

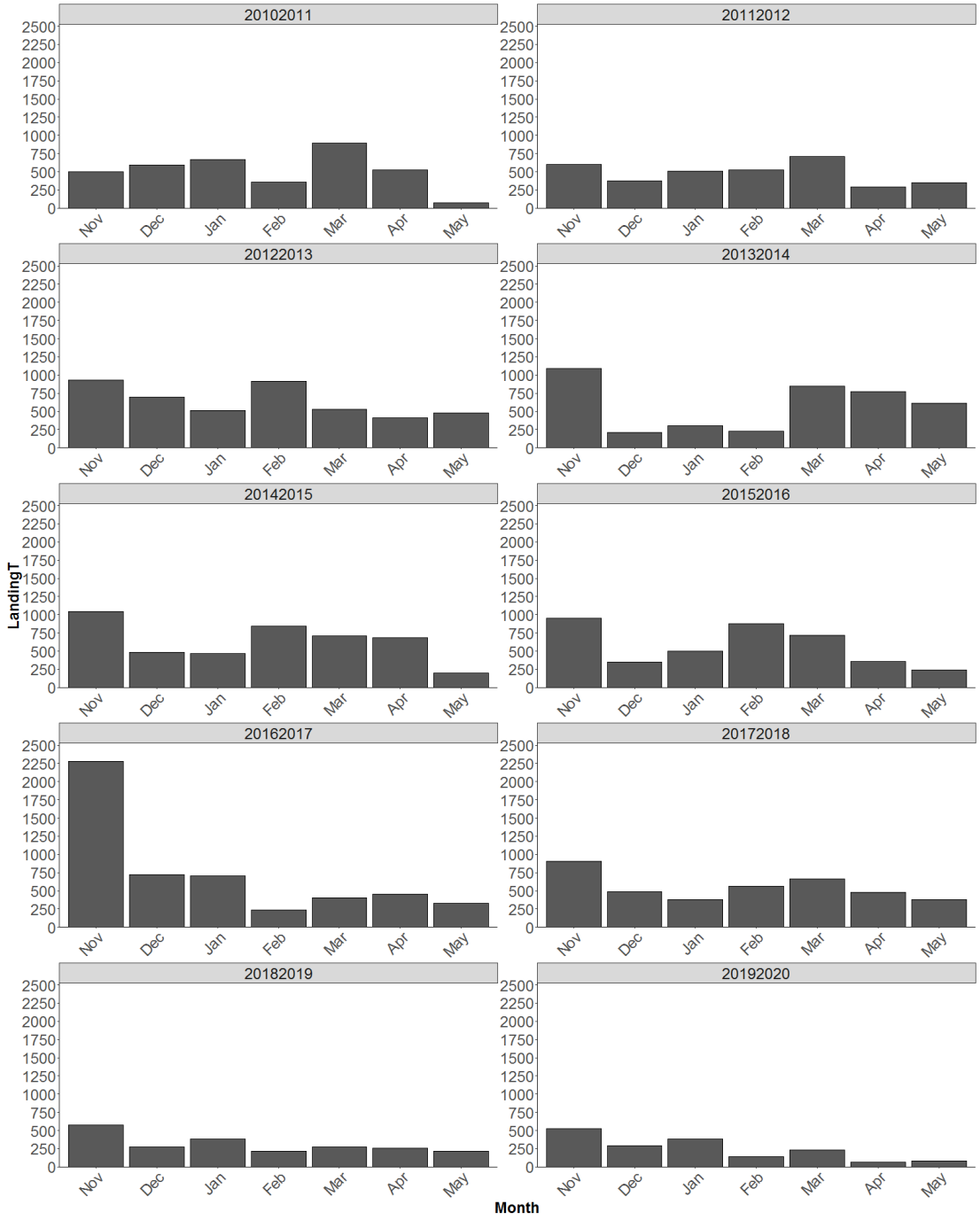

Figure 4: Landings of king scallops from 36E5, 37E5 and 38E5. Data are presented for each fishing season from 2012/2013 to 2019/2020 (1st Nov Year^{n} to 31st May Year^{n+1}). Data source: EU Logbooks downloaded through IFISH2. NB. This data includes ALL vessels fishing for king scallops (except vessels 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 the Isle of Man's territorial sea.

2.3.2: 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. The spatial location of landings varies annually and often reflects densities. The data from the 2019/2020 fishing season are displayed in Figure 5. Landings in the 2019/2020 fishing season were fairly equally distributed among five main fishing grounds (IS9: Targets; IS21: Chickens; IS15: East Douglas, IS14: Bradda/Port St Mary and IS10: Maughold).

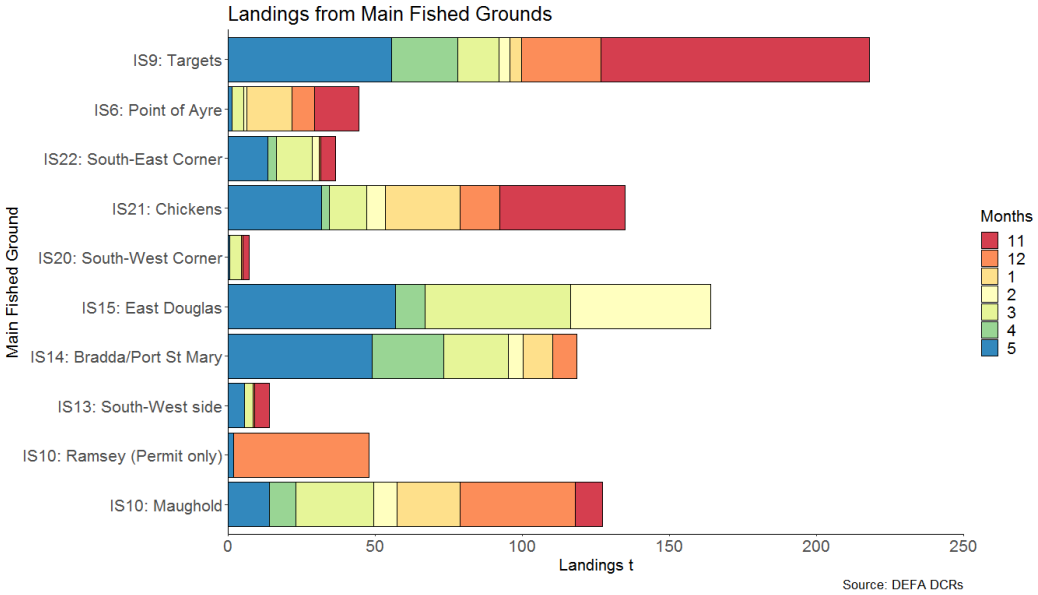

Figure 5: Landings (t) reported by main fished ground (IS Box) and separated by colour for each month to show the spatial and temporal pattern of landings for the 2019/2020 king scallop fishing season.

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 and 2019/20 seasons by fished week. IS10: Maughold was the only fishing ground where LPUE was consistently higher for 2019/20 than for the previous two fishing seasons.

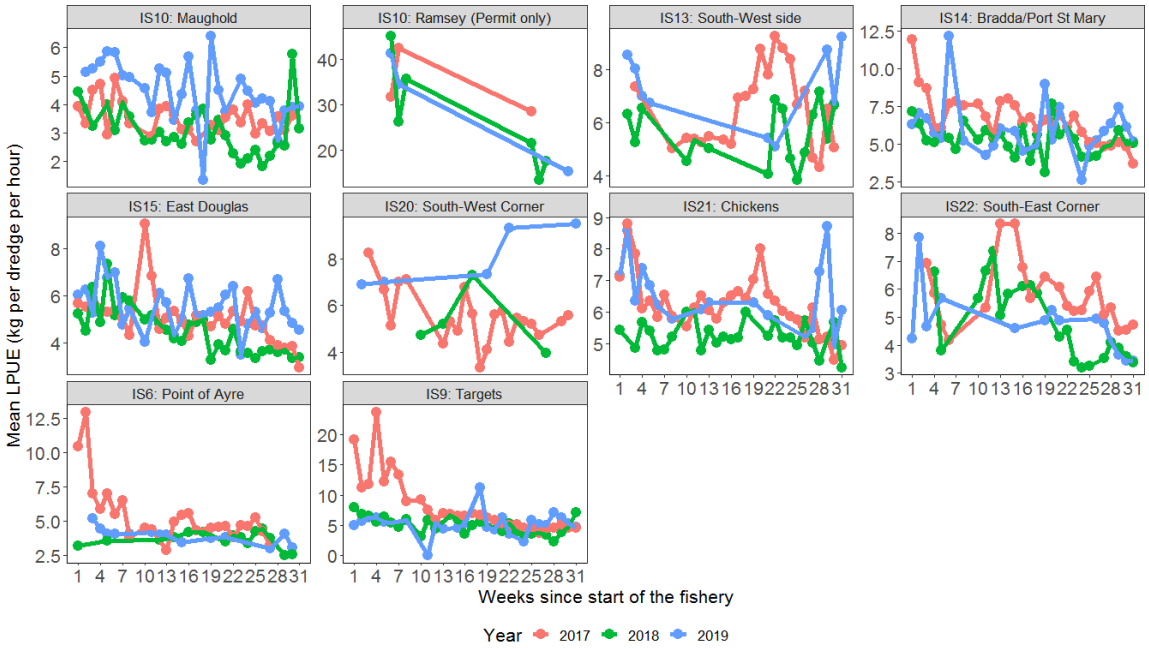

Figure 6: LPUE (kg per hour fished per dredge) displayed by main fished ground for each week of the 2017/2018 (red), 2018/2019 (green) and 2019/2020 (blue) seasons. Note the different scales on the Y-axis, in addition the fishery closed for Christmas during Week 9 in all seasons

3. Surveys:

3.1 Data collection and processing

Methods: A survey for king scallops was undertaken onboard two industry vessels (F.V. Benolas and F.V. Sarah Lena) from 18th – 28th April and 21st May 2020. The survey was undertaken at the four main fishing grounds in the 3-12nm (Targets (TAR) – 3 vessel days; Chickens (CHI) – 3 vessel days; Douglas (EDG) – 6 vessel days and, for the first time, at Point of Ayre (POA) – 1 vessel day). In addition, three main fishing grounds in the 0-3 nm were surveyed for the first time as part of this survey (East Coast 0-3 nm (ECO) – 2 vessel days, Bradda 0-3nm (BRA) – 3 vessel days and Maughold (MGH) – 0.5 vessel day). These 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 dredge bar either side of the vessel with four dredges on each; 'standard survey dredge bar' consisting of two King and two Queen dredges (Queen dredges had 10 teeth), and a 'juvenile survey dredge bar' of the same design but using modified Queen dredges. These modified dredges had 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 design of the 'standard' bar replicates previous survey protocols, whilst the 'juvenile' bar is designed to increase the catchability of very small individuals. The catch from each dredge was counted and a subsample of up to ~ 90 kings 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 refinement: The outer survey extent for each ground was refined for king scallops using vessel monitoring system data (VMS) amalgamated from 2011 – 2019. In order to identify king scallop fishing activity VMS data from the king fishing season were filtered to only include vessels moving at fishing speed (i.e. 1.0-4.0 knots). The entire survey extent was considered valid for king scallops which covers a wider area than the queen scallop fishery.

Ground inclusion: POA, MGH, BRA and ECO were surveyed for the first time in 2020. Therefore, in order to provide an inter-annual analysis for the Isle of Man territorial waters, only EDG, CHI and TAR are included in the main territorial waters analysis section.

Targeted Cells: In addition to the random Survey Cells described above, additionally selected cells (3 sites at CHI [Survey Cells: 5059, 5127 and 5130], 2 sites at TAR [Survey Cells: 1710 and 1998] and 7 sites at EDG [Survey Cells: 3707, 3708, 3778, 3782, 3851, 3924 and 3927]) were surveyed in those areas on the basis of suitability for closed area, hotspot identification, or exploratory fishing. These were excluded from the main analysis because these areas were chosen specifically because they were typically areas of known high king or 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. In addition, the juvenile queen (JQ) and standard queen (SQ) scallop dredges appear to be more efficient for catching recruits (i.e. < 90 mm) whilst the standard king (SK) and standard queen (SQ) scallop dredges appear to be more efficient for catching post recruits (i.e. ≥ 90 mm). The analysis within this report focuses on the data from only the relevant dredge types (i.e. JQ and SQ for recruits and SK and SQ for post-recruits) for recruits and post-recruits respectively.

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). It is acknowledged that the discrepancy in survey timing (2 month 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 5-7 months 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 90 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.

Additional survey data: An additional survey was undertaken by the MFPO in 2019, which covered the 0-3 nm area (i.e. survey grounds at MGH, BRA and ECO). Although the survey used a different methodology (typically 30 minute tows) and only used standard king and queen scallop dredges (no juvenile queen scallop dredges were used) it is possible to standardise the data from the dredges used to density (scallops per 100 m^2) as per the current survey to provide a basic comparison. For reference, this analysis will be presented separately to this report.

3.2 Results:

3.2.1 Territorial Sea

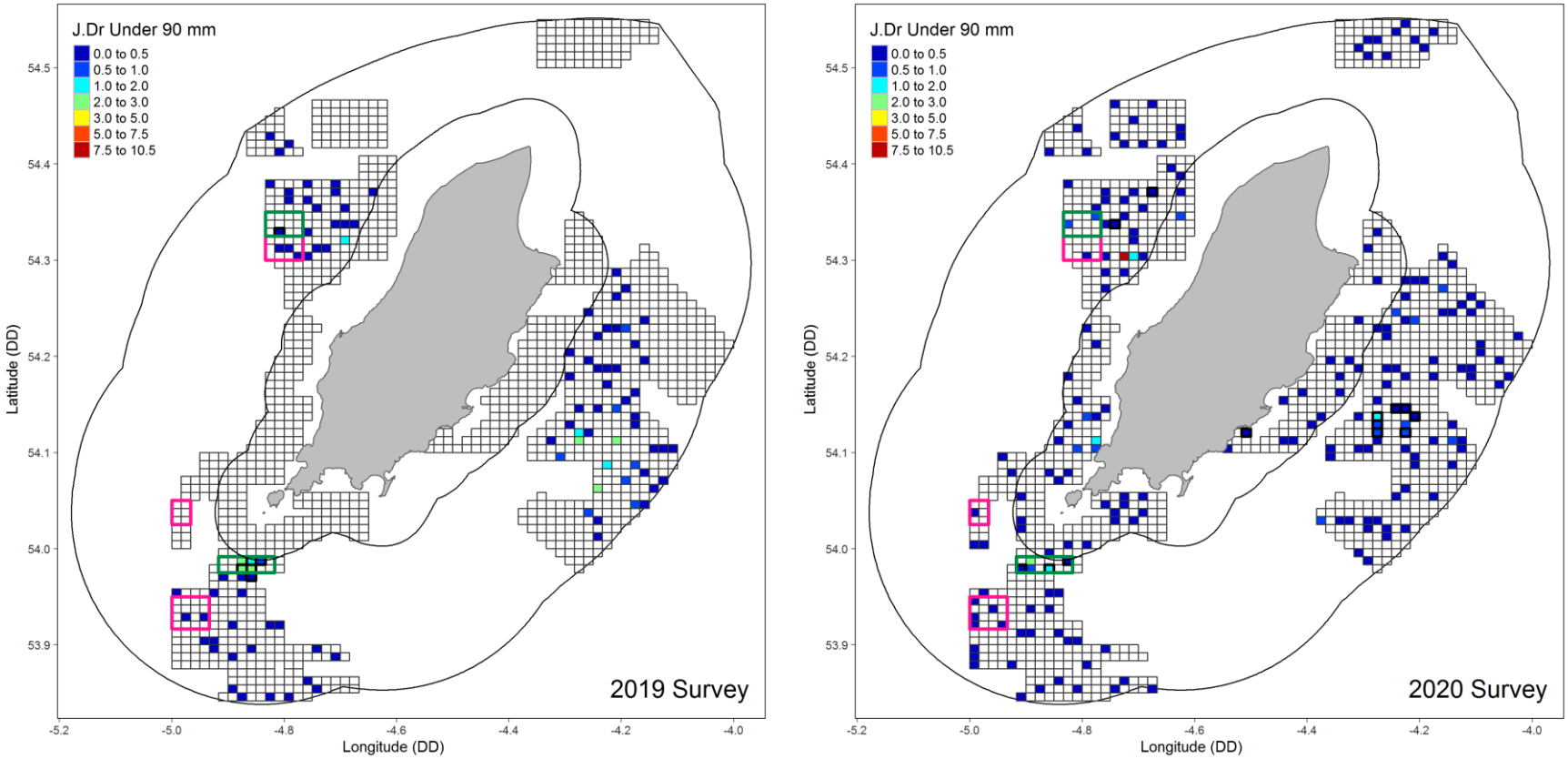

Figure 7: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile and standard queen scallop dredges for 2019 (left) and 2020 (right). In the 3-12 nm Point of Ayre in the north of the TS and in the 0-3 nm Bradda, East Coast and Maughold in the south-west, east and north-east of the TS were all surveyed for the first time in 2020. The green boxes indicate areas newly opened during the queen scallop fishing season (i.e. 2019 closed areas that are now open) and the pink boxes indicate areas currently closed for queen scallop fishing in 2020. 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).

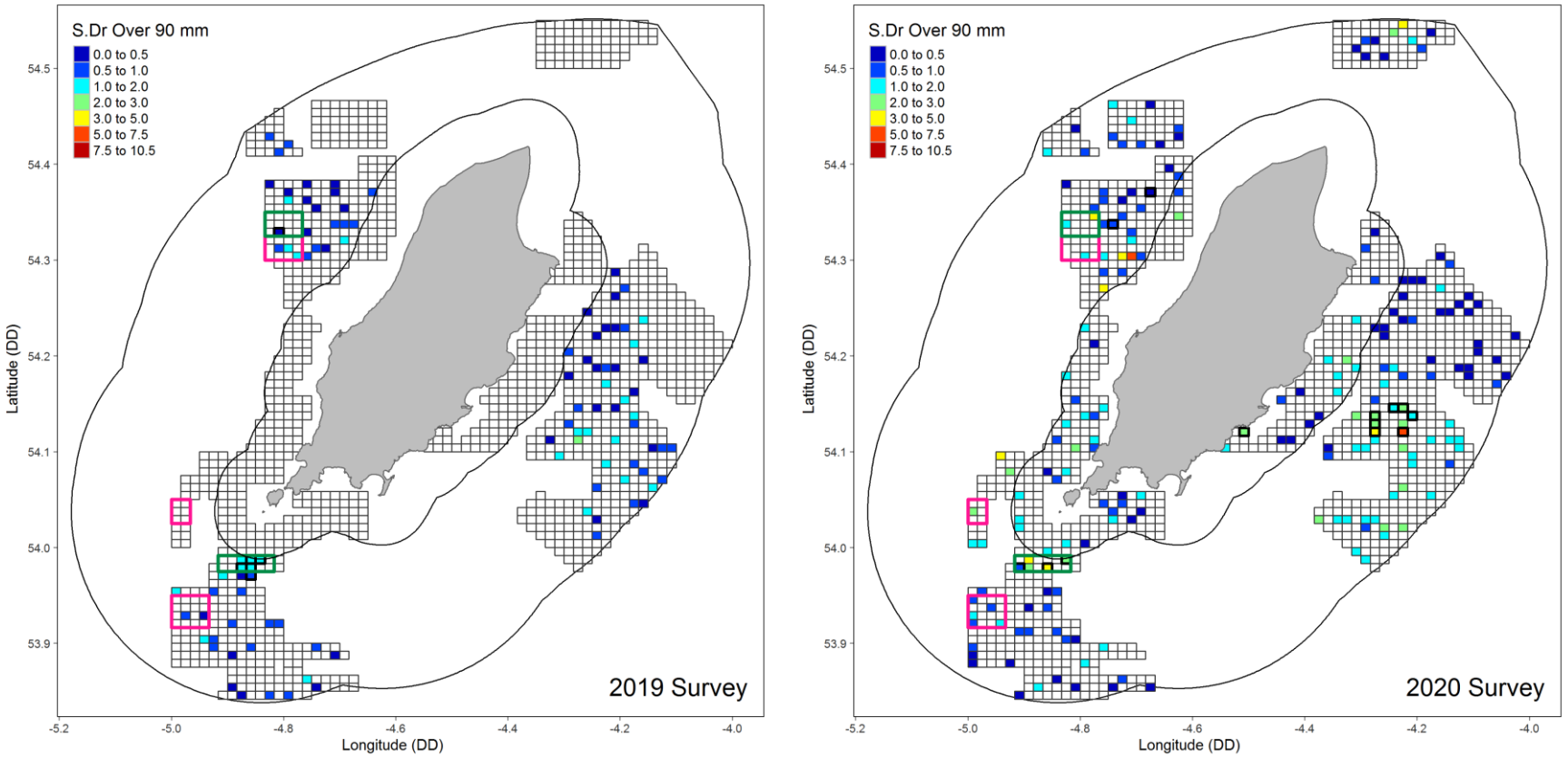

Figure 8: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 90 mm from standard king and standard queen scallop dredges for 2019 (left) and 2020 (right). In the 3-12 nm Point of Ayre in the north of the TS and in the 0-3 nm Bradda, East Coast and Maughold in the south-west, east and north-east of the TS were all surveyed for the first time in 2020. The green boxes indicate areas newly opened during the queen scallop fishing season (i.e. 2019 closed areas that are now open) and the pink boxes indicate areas currently closed for queen scallop fishing in 2020. 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 1: Density 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) 90 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 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	96	130	96	130
Min	0.00	0.00	0.00	0.00
Median	0.12	0.05	0.62	0.79
Mean	0.29	0.25	0.70	0.99
Geometric Mean	**0.17**	**0.14**	**0.60**	**0.72**
Max	2.60	10.28	2.26	5.73

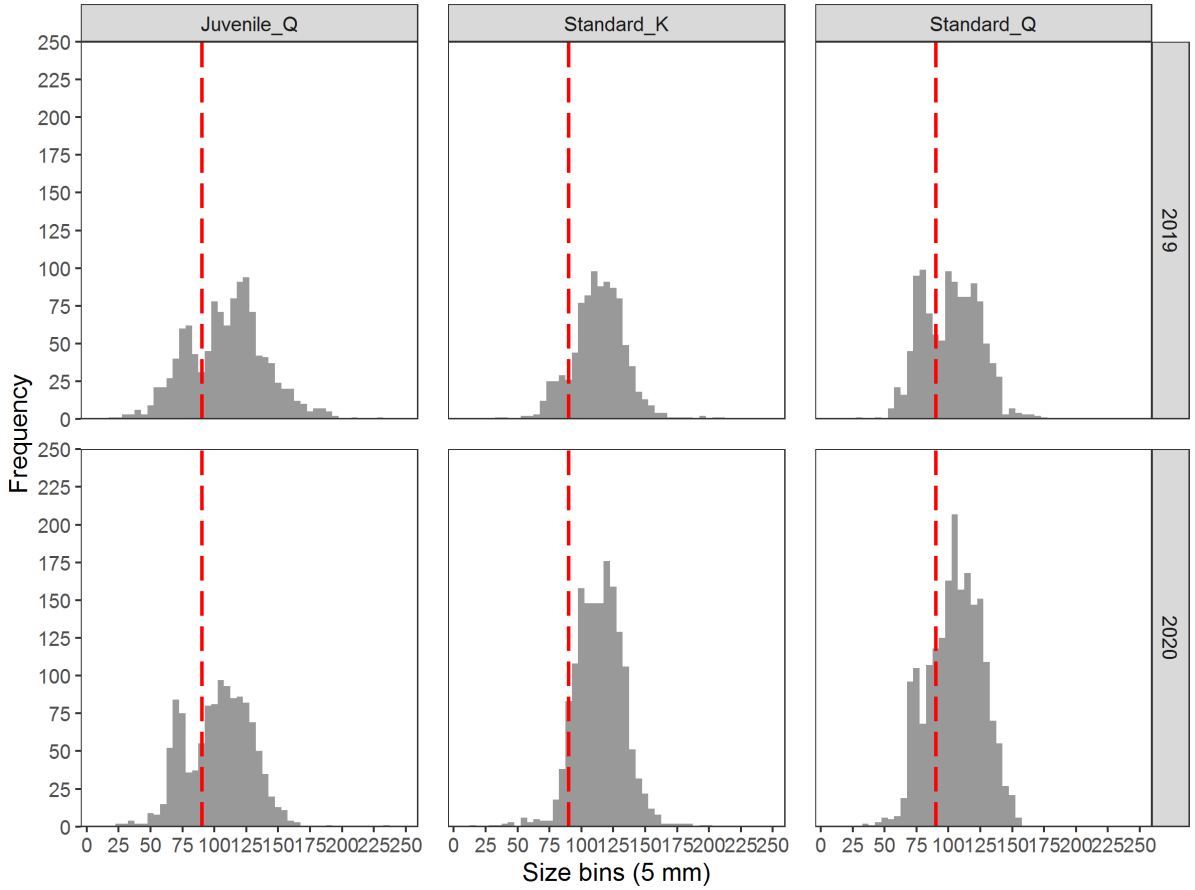

Figure 9: Size: density histogram of absolute counts of king scallops for the territorial sea displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 90 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the 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 the survey index has increased for post-recruits (over 90 mm) from **0.60 in 2019 to 0.72 in 2020** and decreased for recruits (under 90 mm) **from 0.17 in 2019 to 0.14 in 2020**.

3.2.2 Fishing Grounds (3- 12 nm)

3.2.2.1 Targets

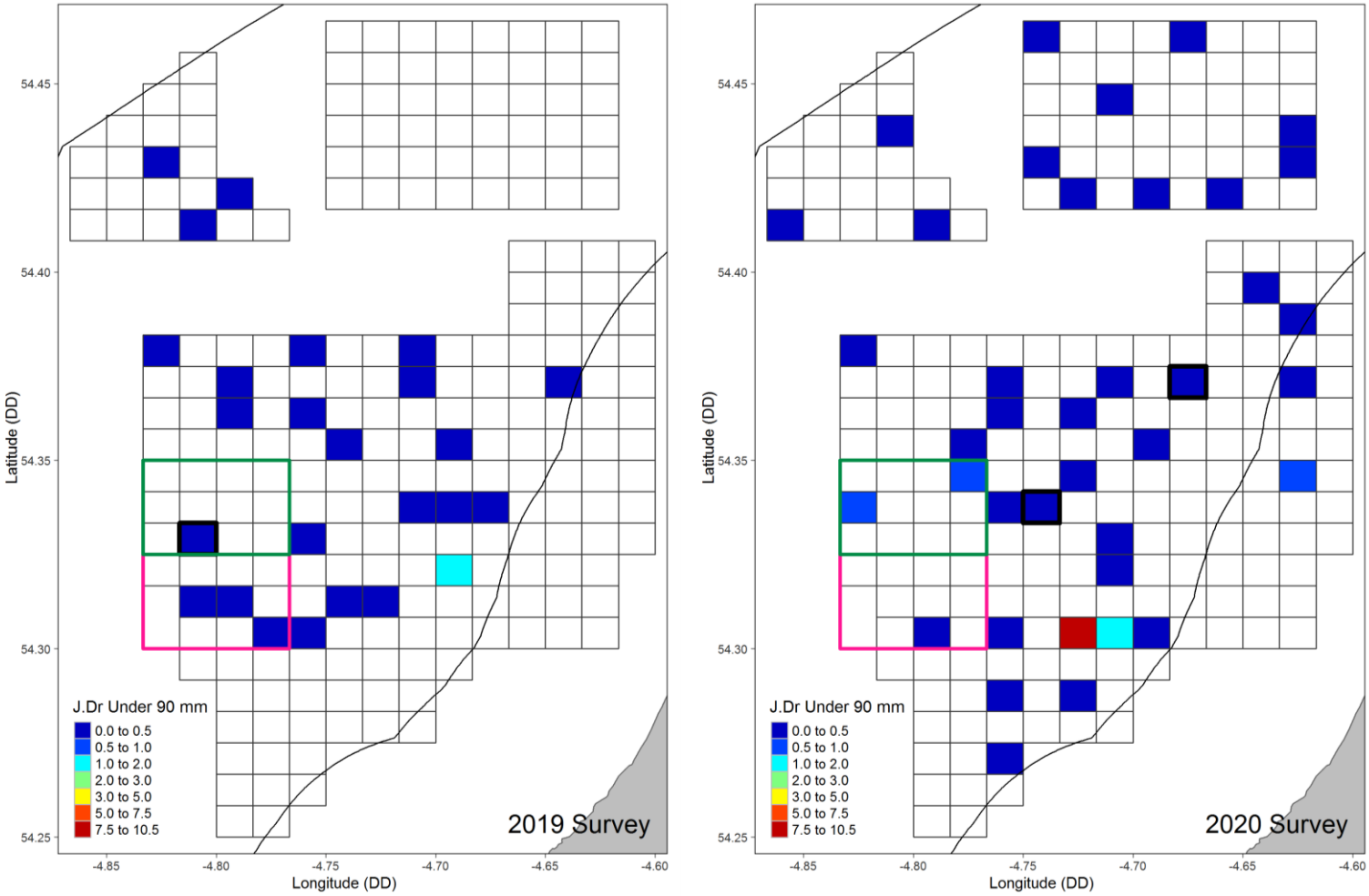

Figure 10: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile queen and standard queen scallop dredges for 2019 (left) and 2020 (right) at Targets (West coast). The green box indicates an area newly opened during the queen scallop fishing season (i.e. 2019 closed areas that are now open) and the pink box indicates an area currently closed for queen scallop fishing in 2020. 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.

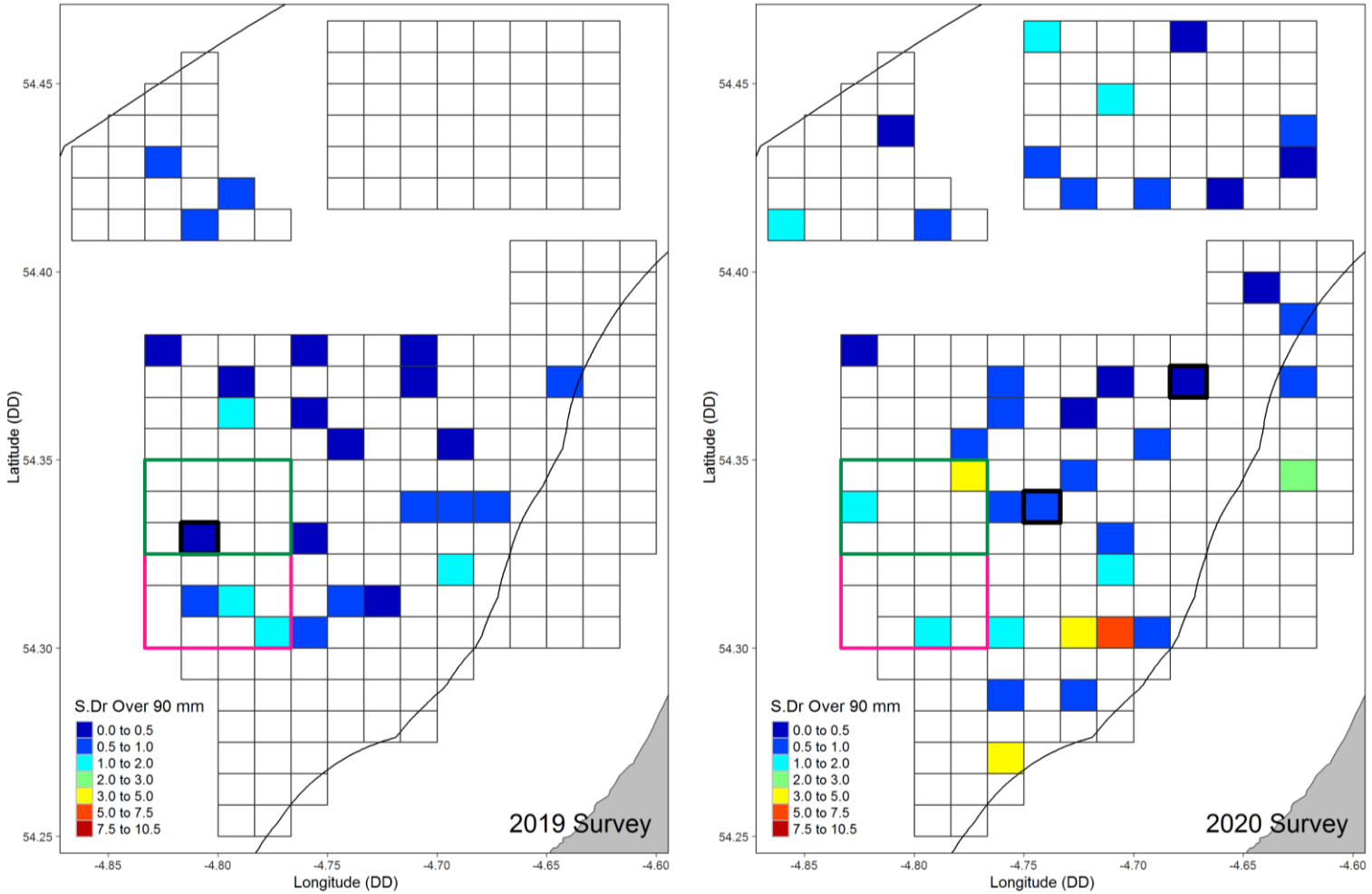

Figure 11: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 90 mm from standard king and standard queen scallop dredges for 2019 (left) and 2020 (right) at Targets (West coast). The green box indicates an area newly opened during the queen scallop fishing season (i.e. 2019 closed areas that are now open) and the pink box indicates an area currently closed for queen scallop fishing in 2020. 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 2: Density 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) 90 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 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	24	37	24	37
Min	0.00	0.00	0.19	0.05
Median	0.01	0.09	0.56	0.77
Mean	0.13	0.48	0.66	1.14
Geometric Mean	**0.10**	**0.17**	**0.62**	**0.86**
Max	1.79	10.28	1.81	5.73

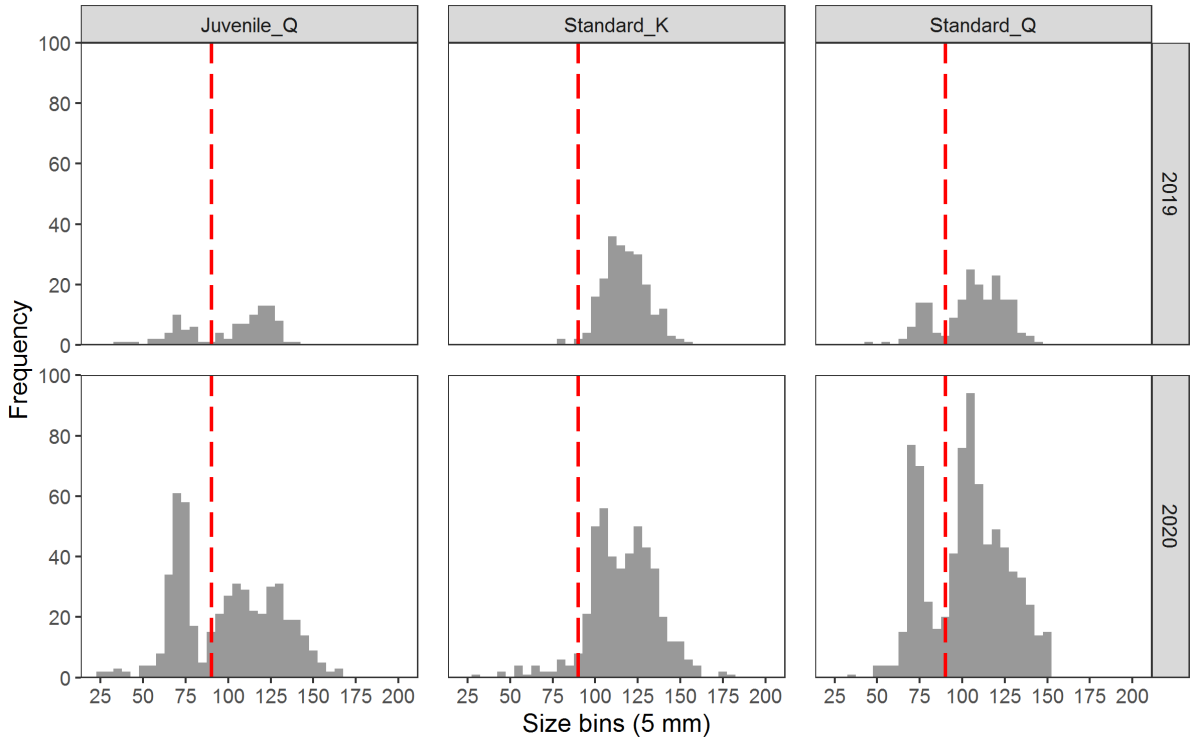

Figure 12: Size: density histogram of absolute counts of king scallops at Targets displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 90 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

The data from TAR indicates that the survey index has increased for post-recruits (over 90 mm) from **0.62 in 2019 to 0.86 in 2020** as well as for recruits (under 90 mm) **from 0.10 in 2019 to 0.17 in 2020**.

Note: the highest recorded densities for king scallops for 2020 were recorded in the southern area of the Targets fishing ground, east of the current 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) but providing protection to the area during this season is anticipated to provide benefits in subsequent seasons in terms of growth of post-recruits and protection of undersized scallops and thus this area should be considered for inclusion in the closed area box for the 2020/2021 fishing season.

3.2.2.2 Chickens

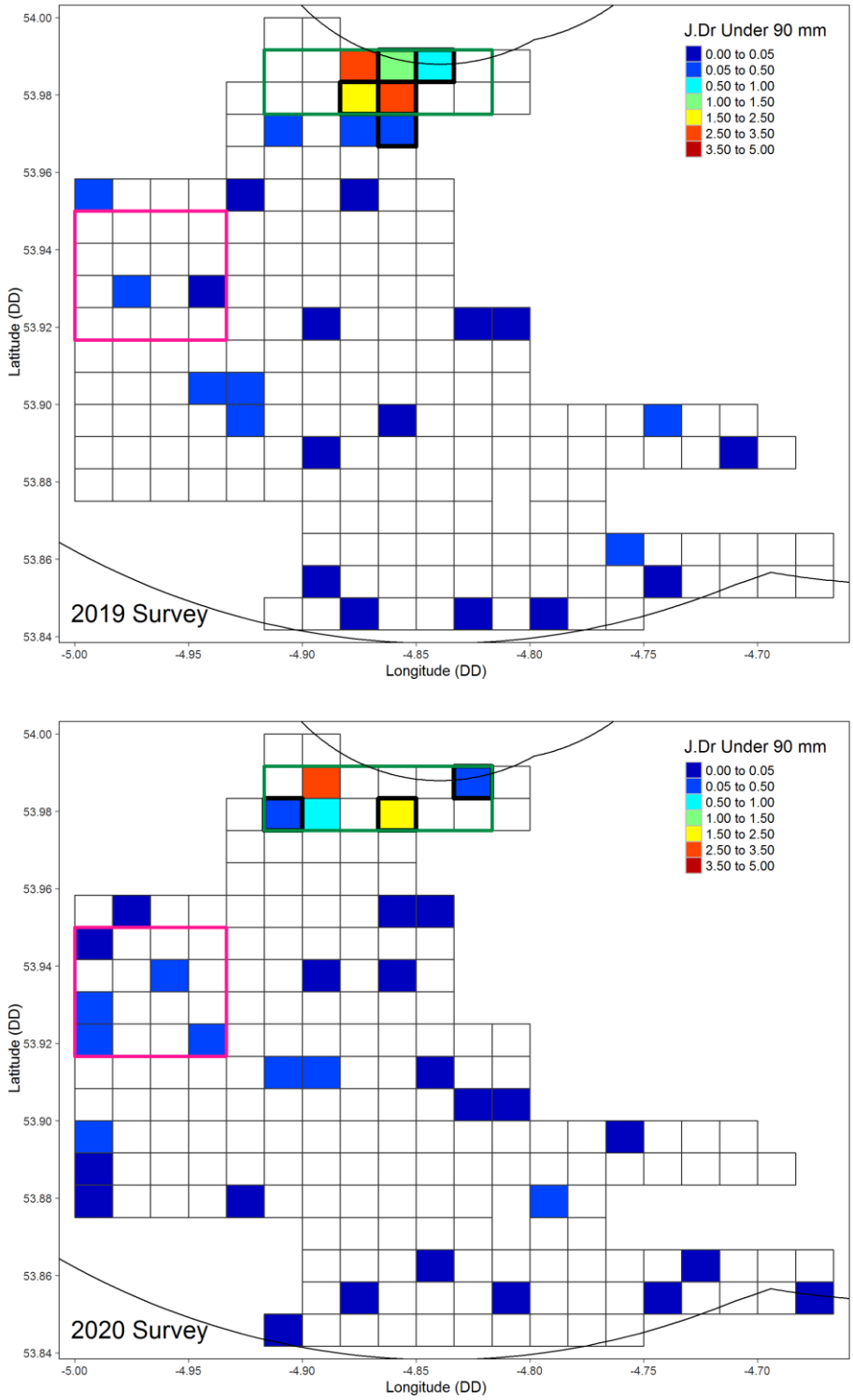

Figure 13: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile queen and standard queen scallop dredges for 2019 (left) and 2020 (right) at Chickens (South coast). The green box indicates an area newly opened during the queen scallop fishing season (i.e. 2019 closed areas that are now open) and the pink box indicates an area currently closed for queen scallop fishing in 2020. 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 NOA analysis).

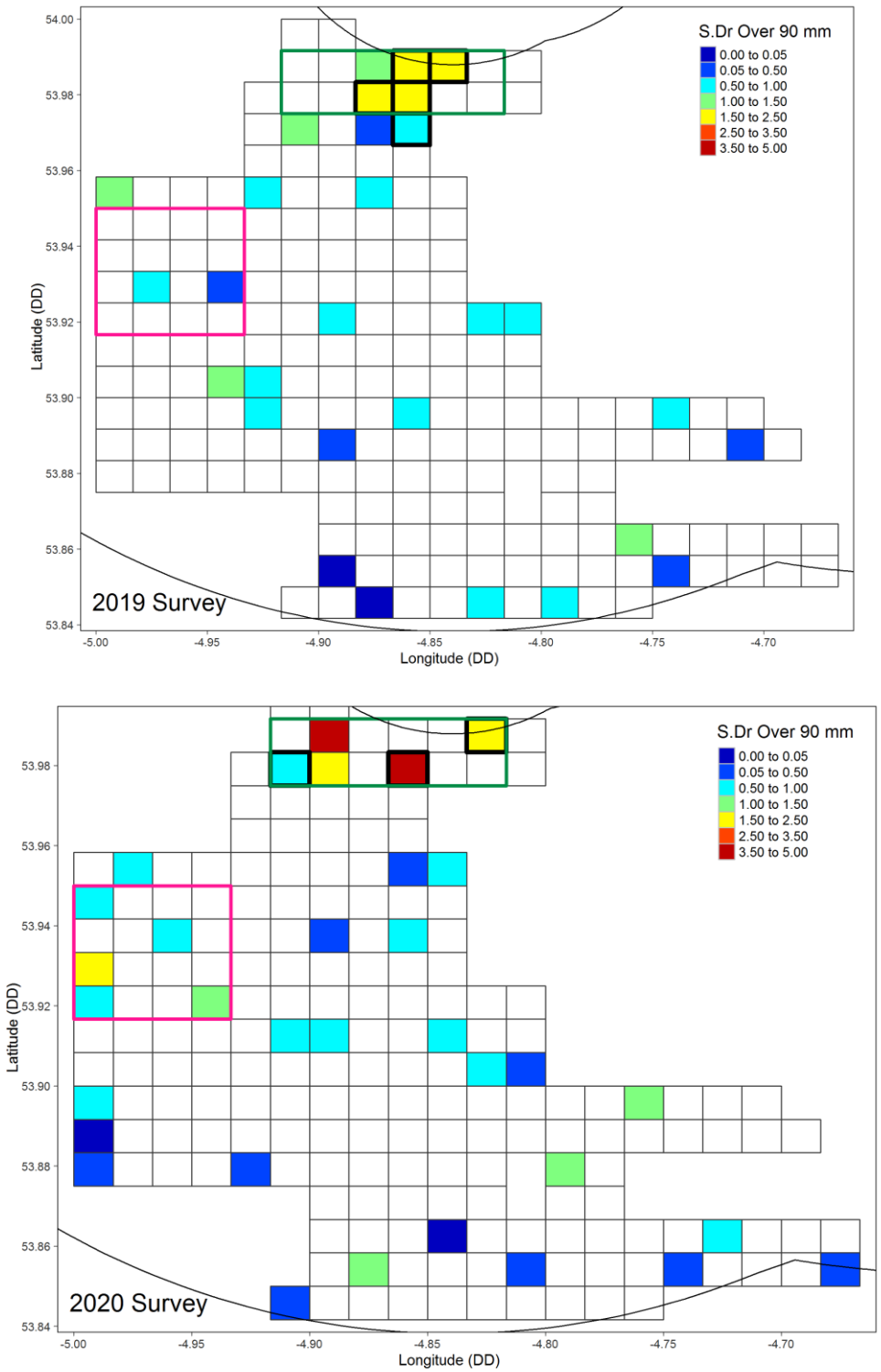

Figure 14: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 90 mm from standard queen and standard king scallop dredges for 2019 (left) and 2020 (right) at Chickens (South coast). The green box indicates an area newly opened during the queen scallop fishing season (i.e. 2019 closed areas that are now open) and the pink box indicates an area currently closed for queen scallop fishing in 2020. 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 NOA analysis).

Table 3: Density 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) 90 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 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	24	30	24	30
Min	0.00	0.00	0.00	0.00
Median	0.45	5.95	0.67	0.00
Mean	0.17	0.15	0.69	0.84
Geometric Mean	**0.11**	**0.09**	**0.60**	**0.60**
Max	2.60	2.56	1.48	4.95

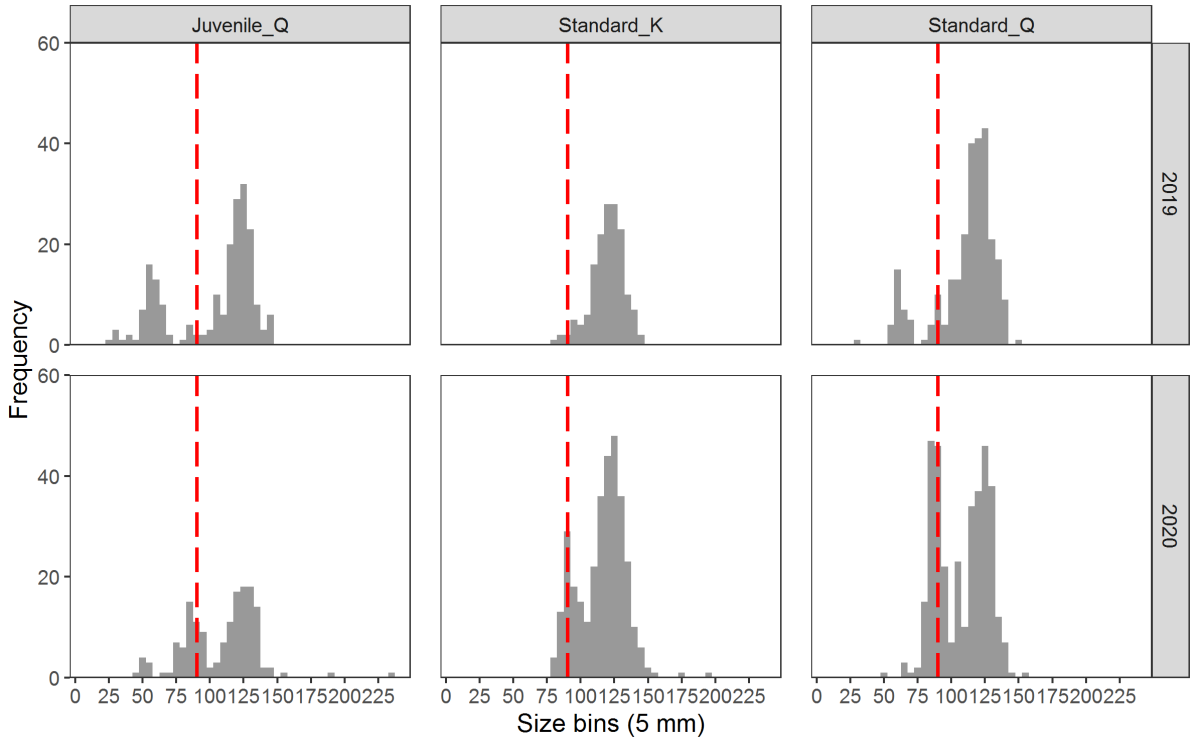

Figure 15: Size: density histogram of absolute counts of king scallops at Chickens displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 90 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

CHI Newly Opened Area

Table 4: Density 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) 90 mm for Chickens Newly Opened Area; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's).

	2019 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	5	5	5	5
Min	0.94	0.18	1.20	0.94
Median	2.35	0.94	1.73	2.20
Mean	2.01	1.11	1.65	2.78
Geometric Mean	**1.90**	**0.75**	**1.68**	**2.46**
Max	2.86	2.56	1.94	4.95

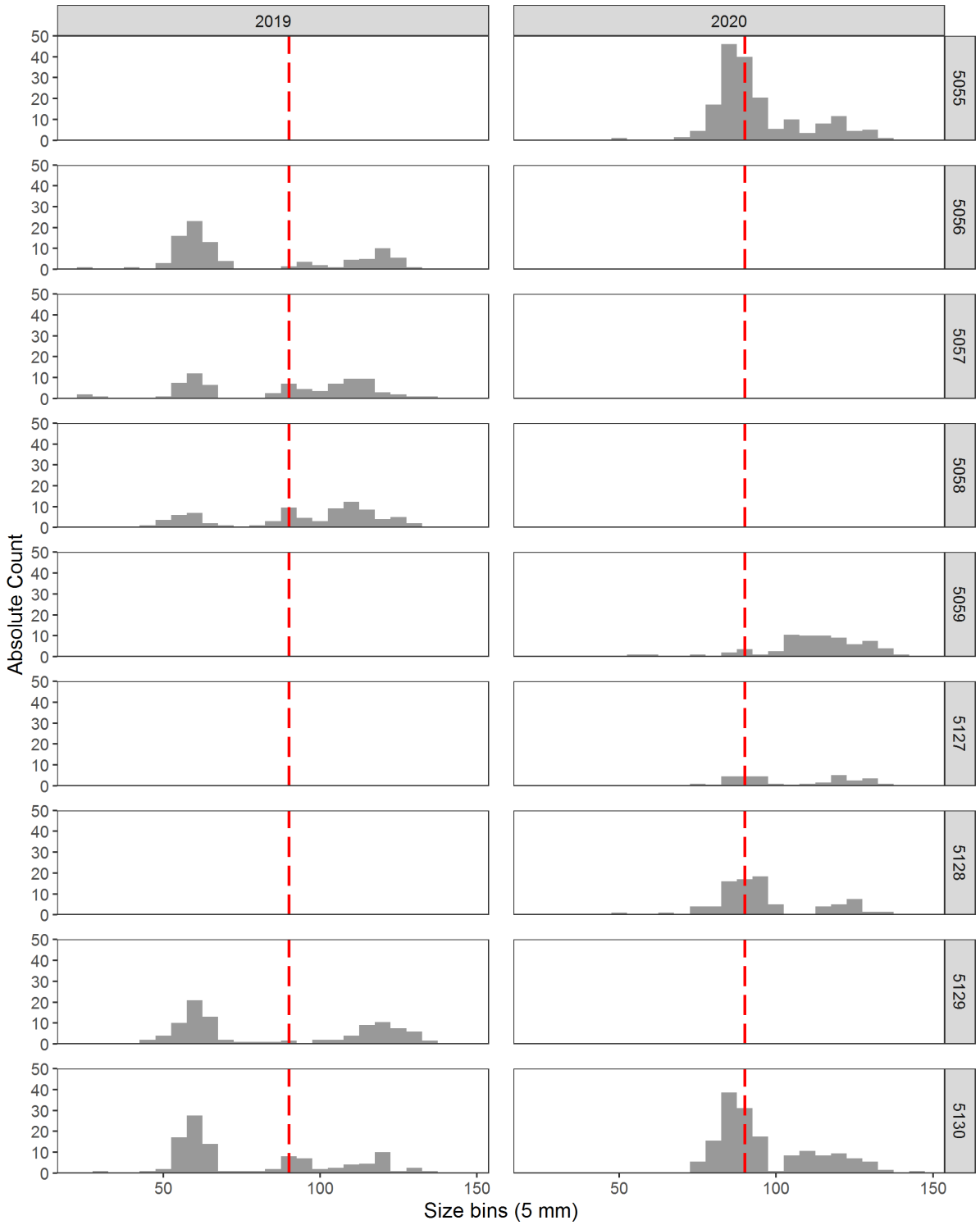

Figure 16: CHI Newly Opened Area size frequency of absolute counts of king scallops by survey cell for 2019 and 2020 using data from all random and targeted survey cells and all dredge types.

The data from CHI indicates that the survey index within the whole fishing ground has decreased for recruits (under 90 mm) from **0.11 in 2019 to 0.09 in 2020** and remained constant for post-recruits (over 90 mm) **from 0.60 in 2019 and 2020.**

The survey index for within the 2020 newly opened area (NOA) which was closed for the 2019 king and queen scallop fishing seasons to protect high densities of recruit scallops (king and queen), saw an increase for post-recruits (**1.68 in 2019 to 2.46 in 2020**) and a decrease for recruits (**1.90 in 2019 to 0.75 in 2020**). The shift in abundance indices for recruits and post-recruits is likely a result of growth within the cohort identified in the 2019 survey, which was protected during the 2019 season by a closed area.

The large increase in post-recruit density in this NOA would indicate that for king scallops the area could also be opened for fishing during the 2020/2021 king scallop fishing season, though some form of managed opening (voluntary or statutory), similar to that undertaken in the queen scallop fishery, should be considered to avoid over fishing within the area. *However, there are still high numbers of king scallop recruits recorded within some survey cells (i.e. 5055 and 5130) so consideration should also be given to the benefit of protecting these recruits during the 2020/2021 king scallop fishing season.*

3.2.2.3 East of Douglas

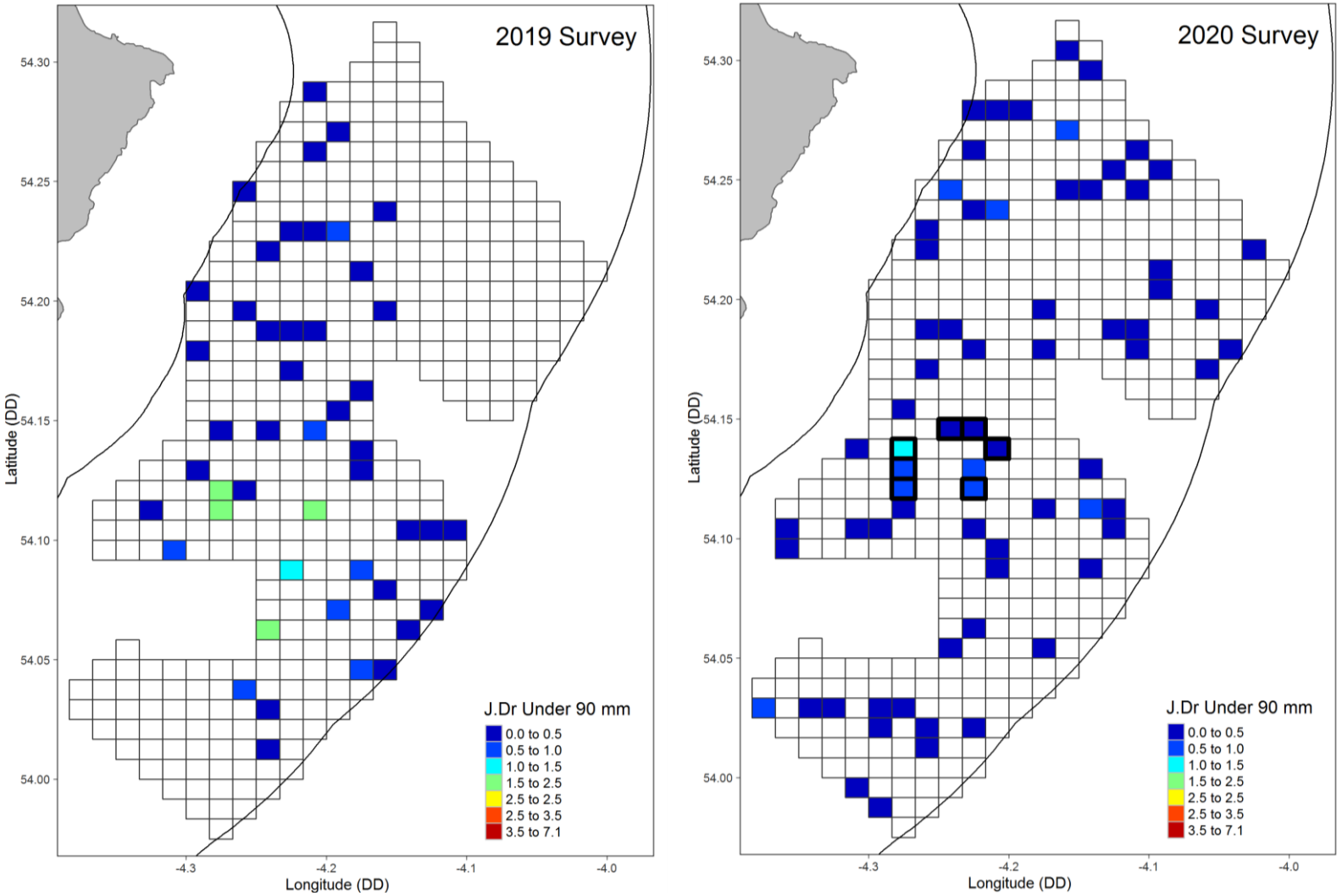

Figure 17: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile queen and standard queen scallop dredges for 2019 (left) and 2020 (right) at East of Douglas (East coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing area analysis at East of Douglas (although they are used in the targeted survey analysis).

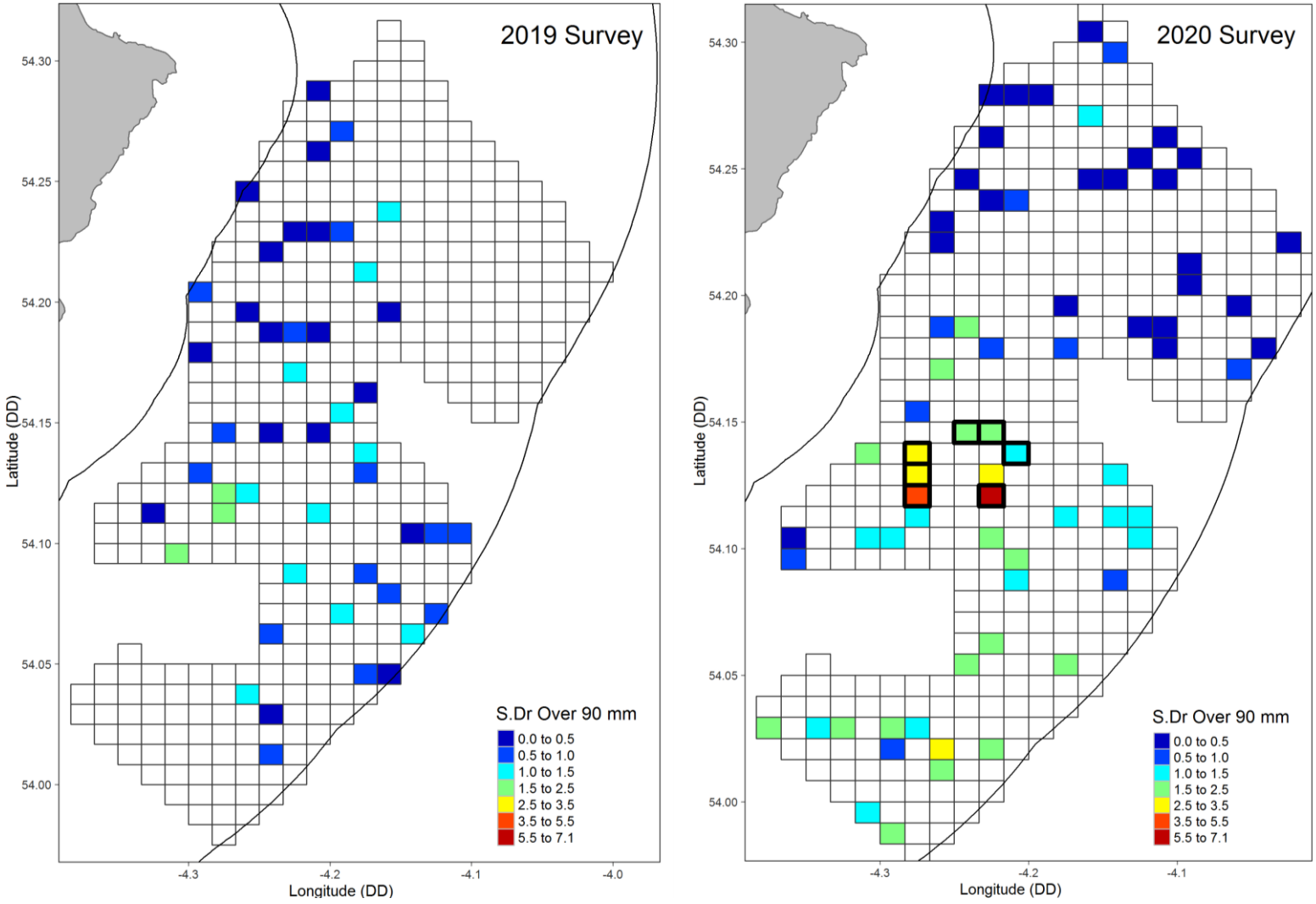

Figure 18: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops over 90 mm from standard queen and standard king scallop dredges for 2019 (left) and 2020 (right) at East of Douglas (East coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing area analysis at East of Douglas (although they are used in the targeted survey analysis).

Table 5: Density 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) 90 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 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	48	63	48	63
Min	0.00	0.00	0.00	0.00
Median	0.26	0.09	0.63	0.92
Mean	0.43	0.15	0.73	0.98
Geometric Mean	**0.30**	**0.15**	**0.59**	**0.72**
Max	2.25	0.64	2.26	2.84

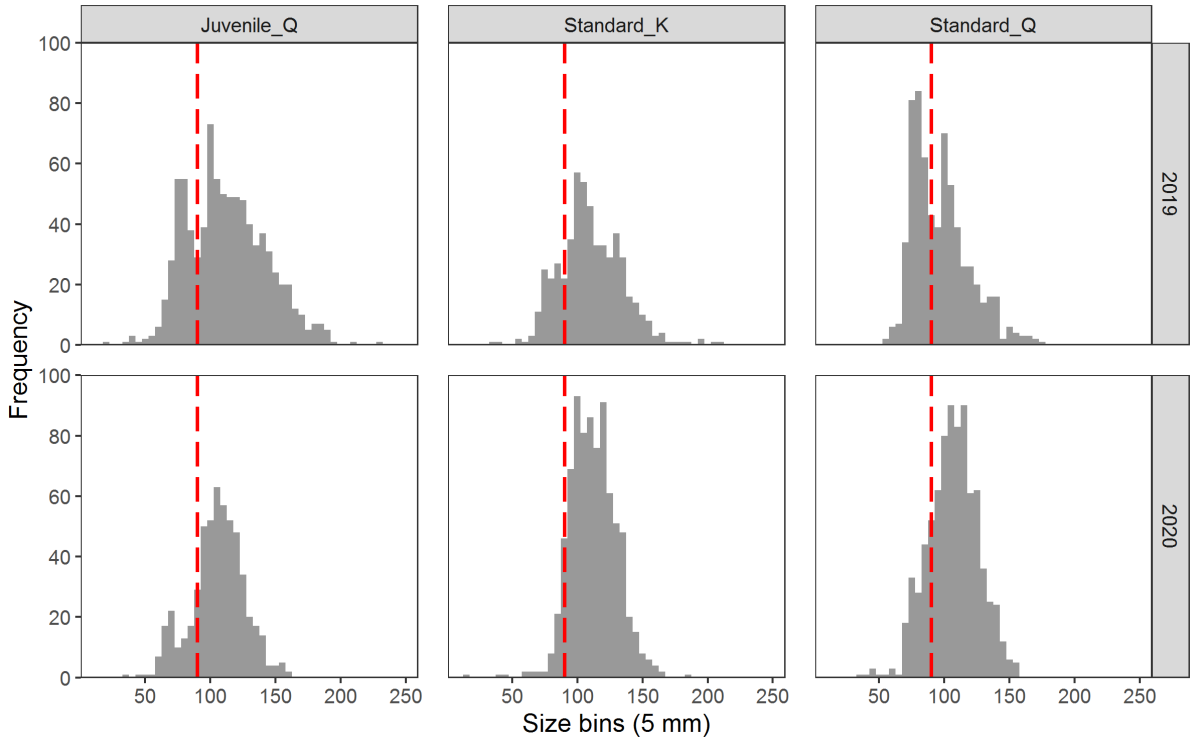

Figure 19: Size: density histogram of absolute counts of king scallops at East of Douglas displayed by survey year and survey dredge type (red dotted line indicates the estimated recruit cut-off of 90 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions.

EDG Targeted Survey Area

Table 6: Density 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) 90 mm for targeted survey cells (previous hotspot area for queen scallops 2019); note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's).

	2019 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	-	7	-	7
Min	-	0.09	-	1.05
Median	-	2.13	-	2.56
Mean	-	0.48	-	3.26
Geometric Mean	**-**	**0.40**	**-**	**2.83**
Max	-	1.02	-	7.03

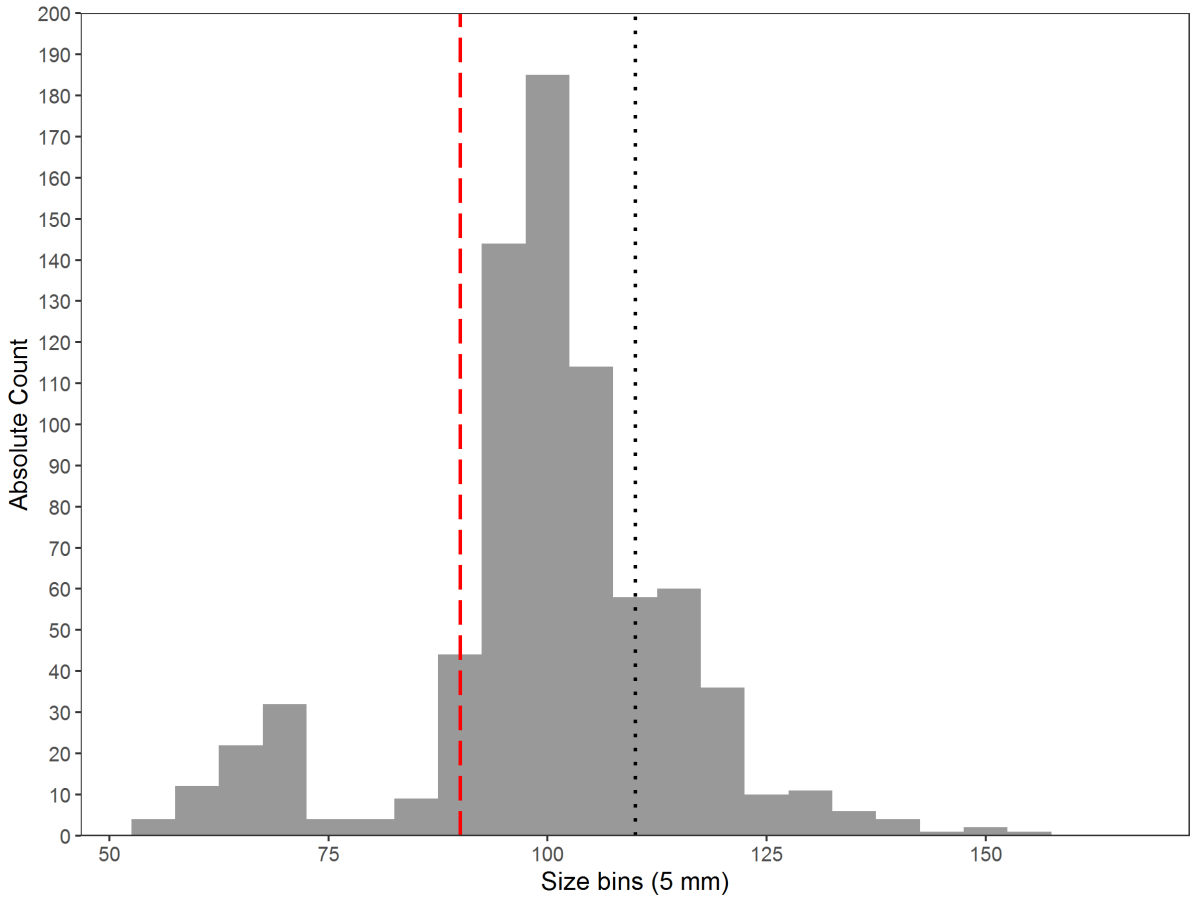

Figure 20: EDG targeted survey cells: size frequency of absolute counts of king scallops for 2020 using data from targeted survey cells and all dredge types. The red dashed line indicates the estimated recruit cut-off of 90 mm whilst the black dotted line indicates the current MLS of 110 mm.

The data from EDG indicates that the survey index within the whole fishing ground has decreased for recruits (under 90 mm) from **0.30 in 2019 to 0.15 in 2020** and increased for post-recruits (over 90 mm) **from 0.59 in 2019 to 0.72 in 2020.**

The survey index for targeted survey cells (which were located within a hotspot area for queen scallops in 2019), indicates high densities of post-recruits in this area (**geometric mean of 2.83 and a maximum recorded density of 7.03 in 2020**) following relatively high levels of recruits recorded in 2019 (Figure 13). The high density of post-recruits in this area should provide high landings per unit effort with the caveat that these scallops were largely recorded within the 90 – 110 mm size range during the April 2020 survey (63 % between 90 – 110 mm, 75 % < 110 mm and 25 % ≥ 110 mm) so this will depend on the growth rates achieved within this fishing ground as to whether they recruit for into the 2020/2021 fishery. Given that they will be on the smaller end of the post-recruit size range consideration should be given to closure of this area for the 20120/2021 king scallop fishing season to allow on-growing for the 2021/2022 fishing season. This should also be considered within the economic context of the 2020/21 fishery, where markets and prices are expected to be significantly affected due to a number of reasons (e.g. covid-19 impact on consumer market demand, significant market supply and price depreciation due to of king scallop landings in the north sea).

3.2.2.4 Point of Ayre

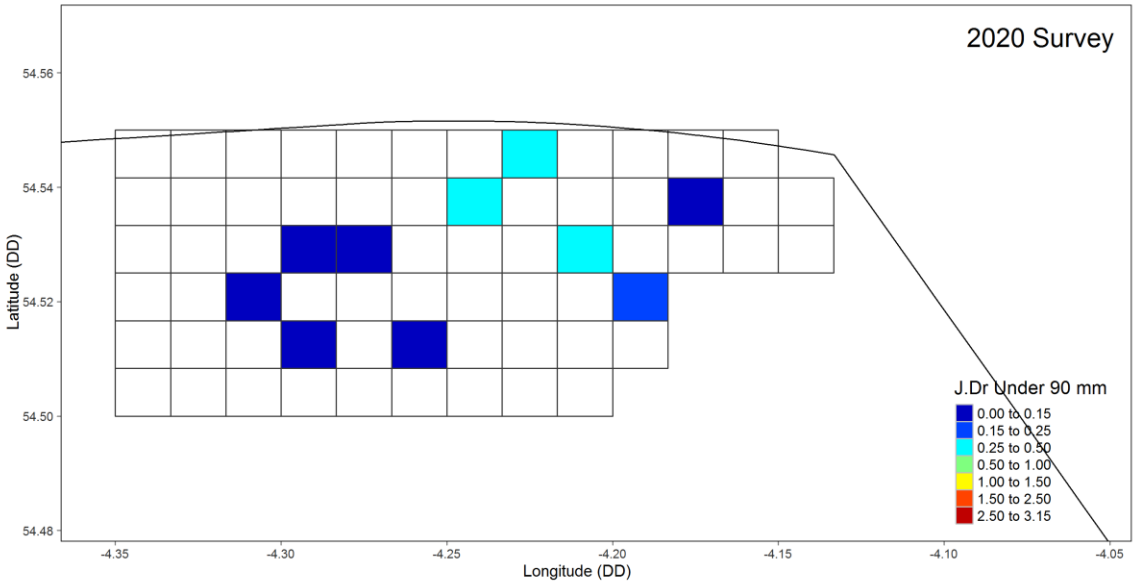

Figure 21: Map illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile queen and standard queen scallop dredges for 2020 at Point of Ayre (North coast).

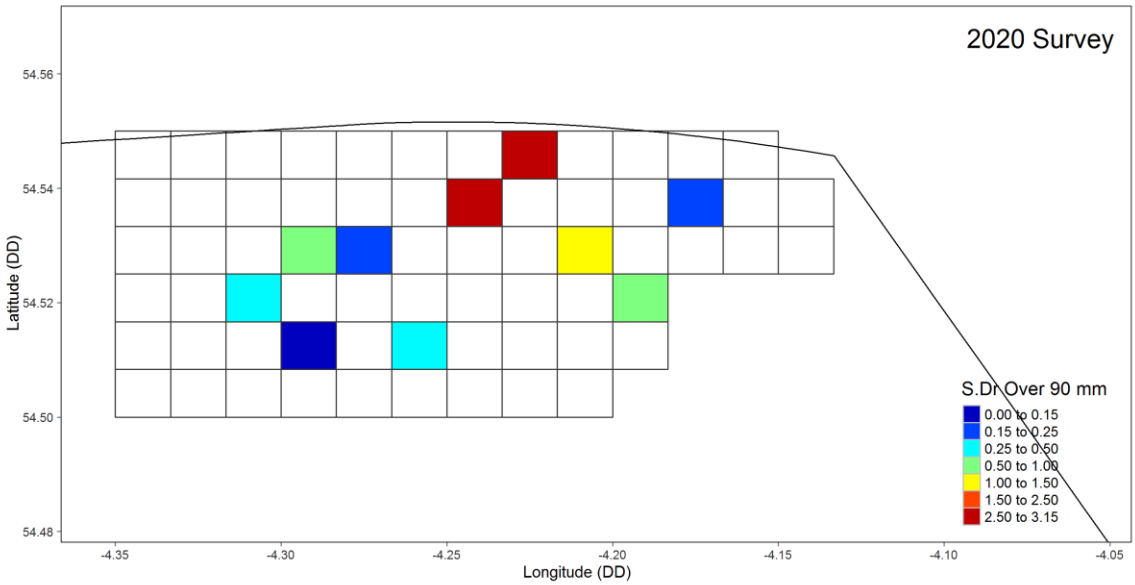

Figure 22: Map illustrating the survey densities (scallops per 100 m^2) for king scallops over 90 mm from standard queen and standard king scallop dredges for 2020 at Point of Ayre (North coast).

Table 7: Density 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) 90 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).

	2019 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	-	10	-	10
Min	-	0.00	-	0.13
Median	-	0.13	-	0.60
Mean	-	0.13	-	1.02
Geometric Mean	**-**	**0.13**	**-**	**0.67**
Max	-	0.37	-	3.15

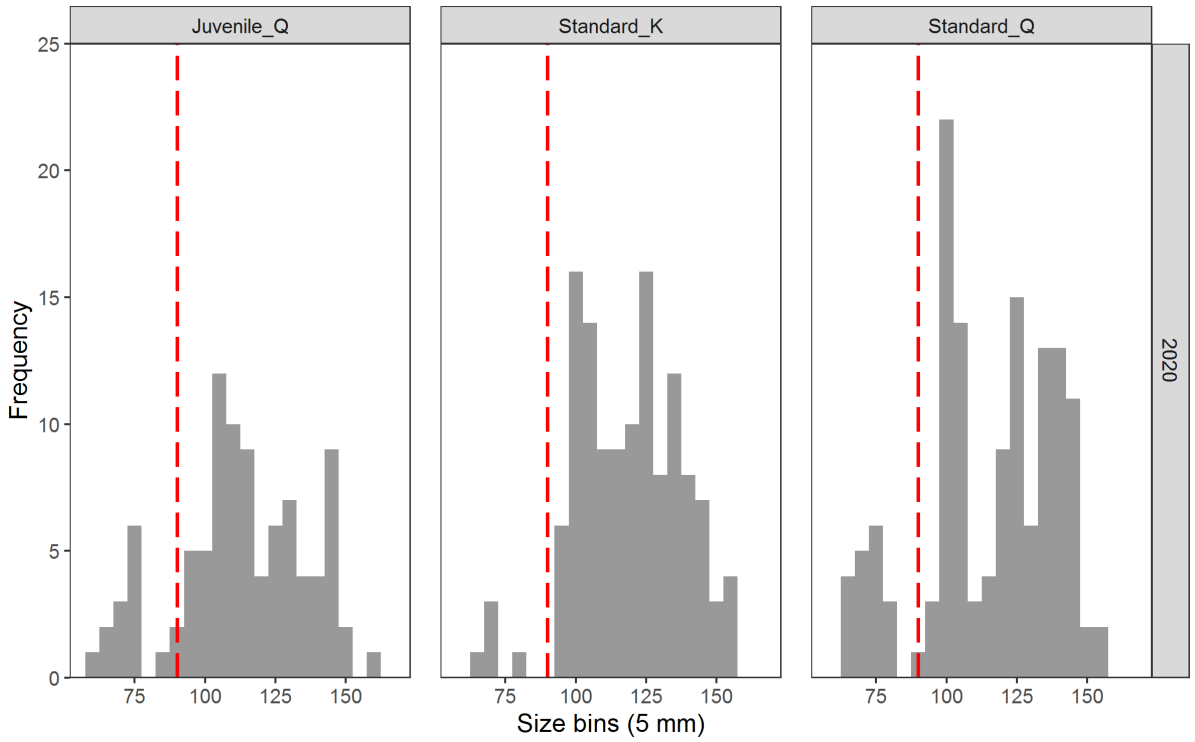

Figure 23: Size frequency of absolute counts of king scallops by dredge type for Point of Ayre 2020. The red dashed line indicates the estimated recruit cut-off of 90 mm.

For POA, which has no comparative data for 2019, the **post-recruit index for 2020 was 0.67** and the **recruit index for 2020 was 0.13**.

3.2.3 Fishing Grounds (0- 3 nm)

3.2.3.1 East Coast

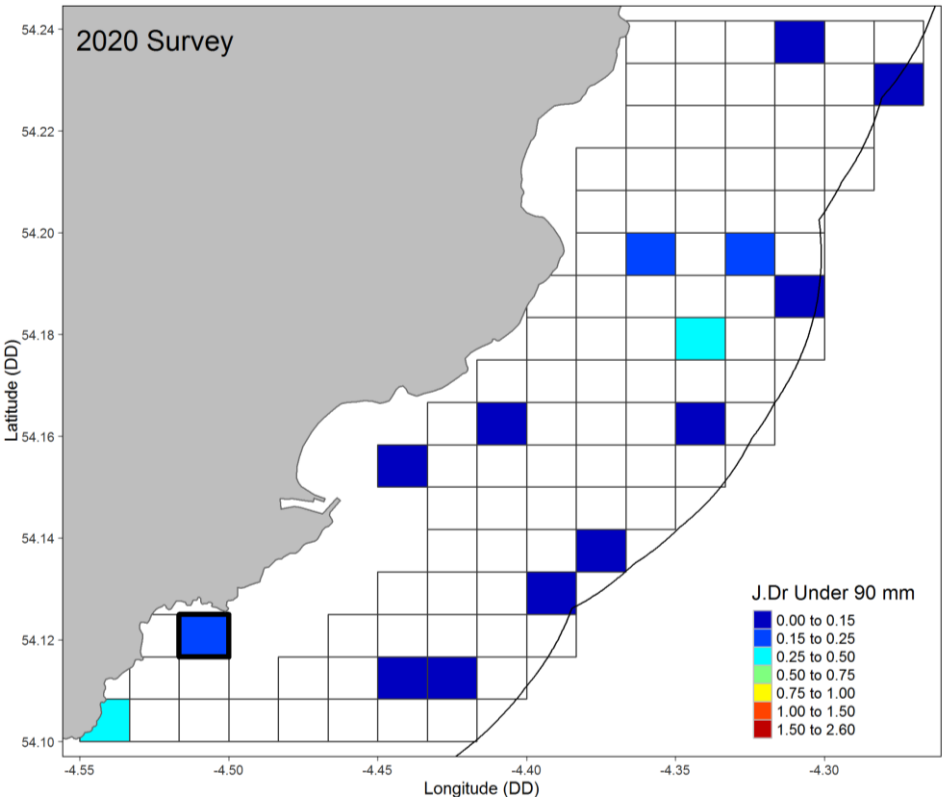

Figure 24: Map illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile queen and standard queen scallop dredges for 2020 at East Coast 0 – 3 nm (East coast).

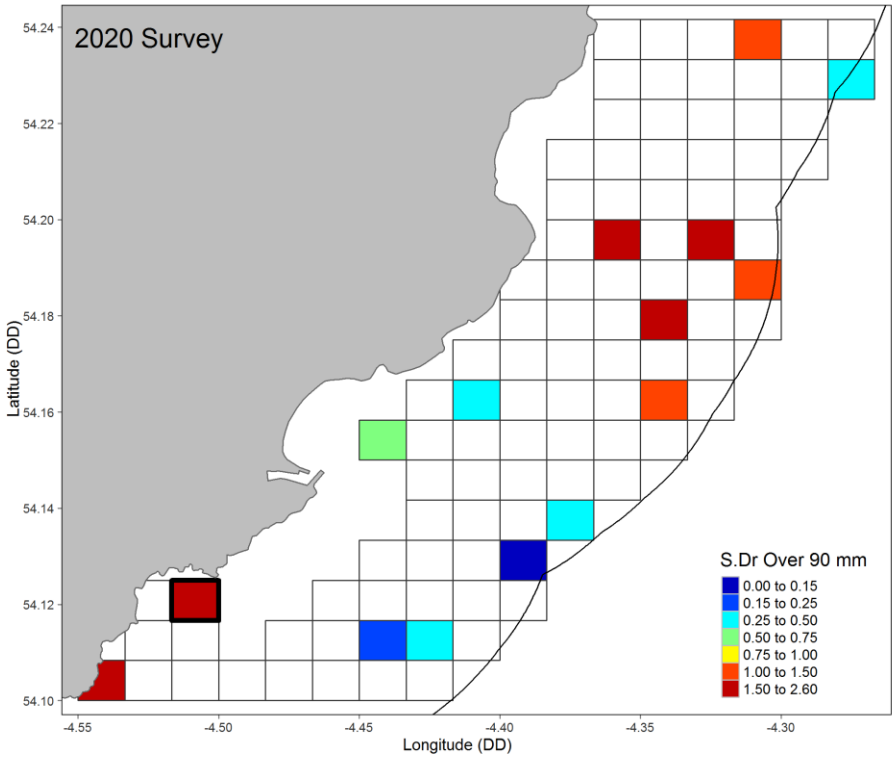

Figure 25: Map illustrating the survey densities (scallops per 100 m^2) for king scallops over 90 mm from standard queen and standard king scallop dredges for 2020 at East Coast 0 – 3 nm (East coast).

Table 8: Density 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) 90 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).

	2019 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	-	15	-	15
Min	-	0.00	-	0.00
Median	-	0.09	-	0.75
Mean	-	0.10	-	0.90
Geometric Mean	**-**	**0.12**	**-**	**0.60**
Max	-	0.26	-	2.55

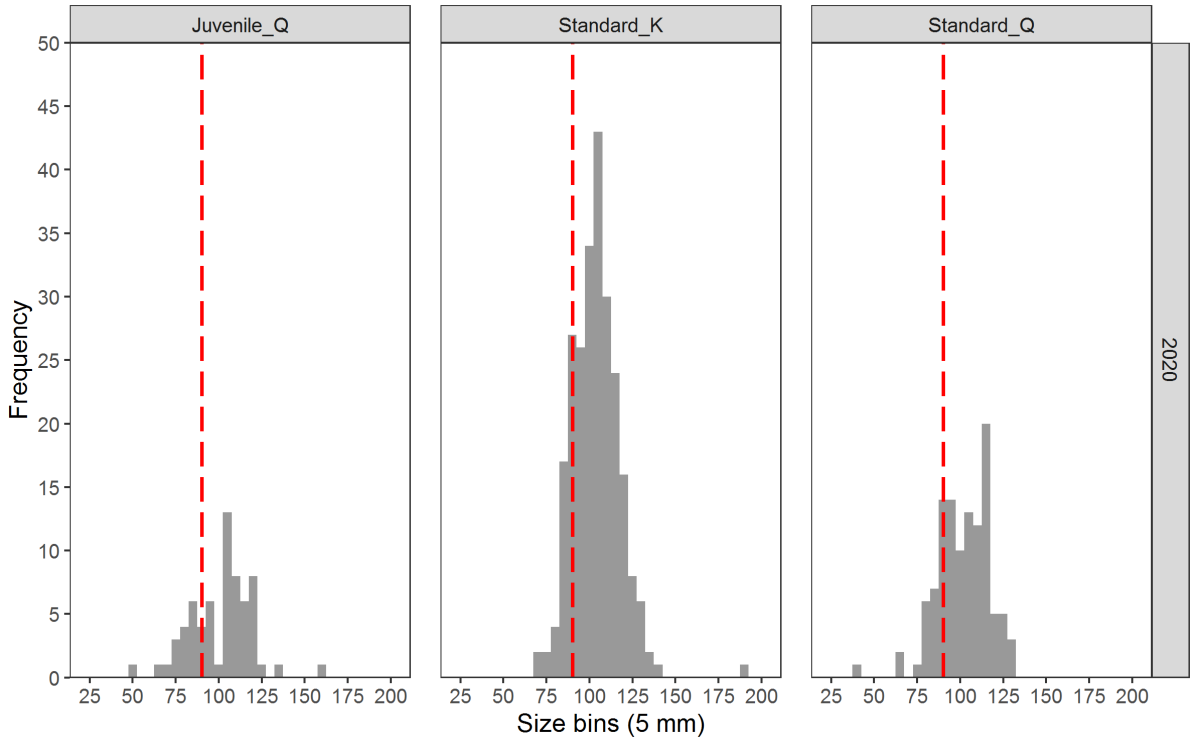

Figure 26: Size frequency of absolute counts of king scallops by dredge type for East Coast 0 – 3 nm 2020. The red dashed line indicates the estimated recruit cut-off of 90 mm.

For ECO, which has no comparative data for 2019, the **post-recruit index for 2020 was 0.60** and the **recruit index for 2020 was 0.12**.

3.2.3.2 Bradda (0-3nm and offshore)

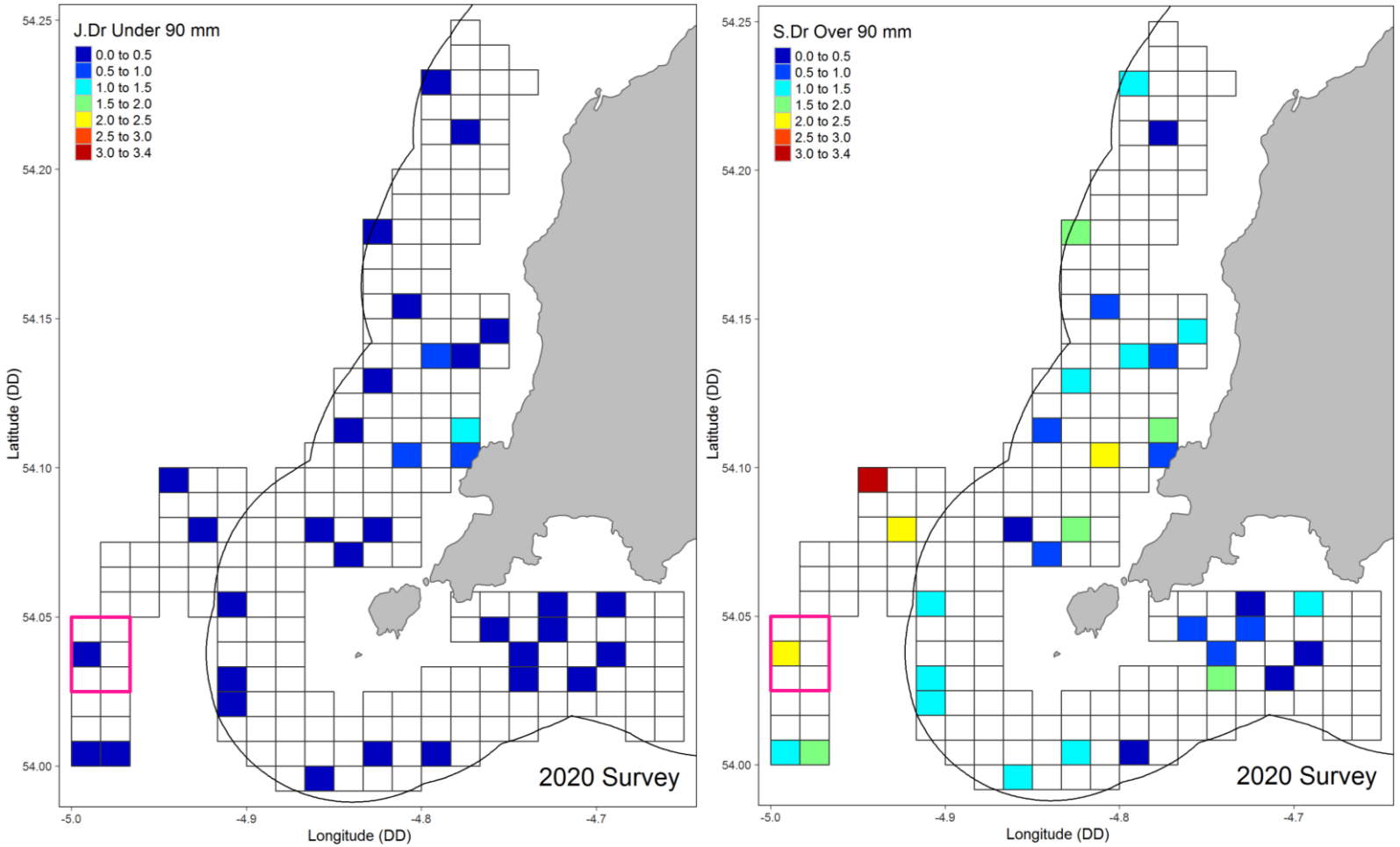

Figure 27: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile queen and standard queen scallop dredges (left) and over 90 mm from standard queen and standard king scallop dredges for 2020 (right) for 2020 at Bradda (0 – 3 nm and offshore) (South-west coast).

Table 9: Density 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) 90 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).

	2019 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	-	35	-	35
Min	-	0.00	-	0.00
Median	-	0.17	-	1.13
Mean	-	0.23	-	1.18
Geometric Mean	**-**	**0.19**	**-**	**0.96**
Max	-	1.24	-	3.37

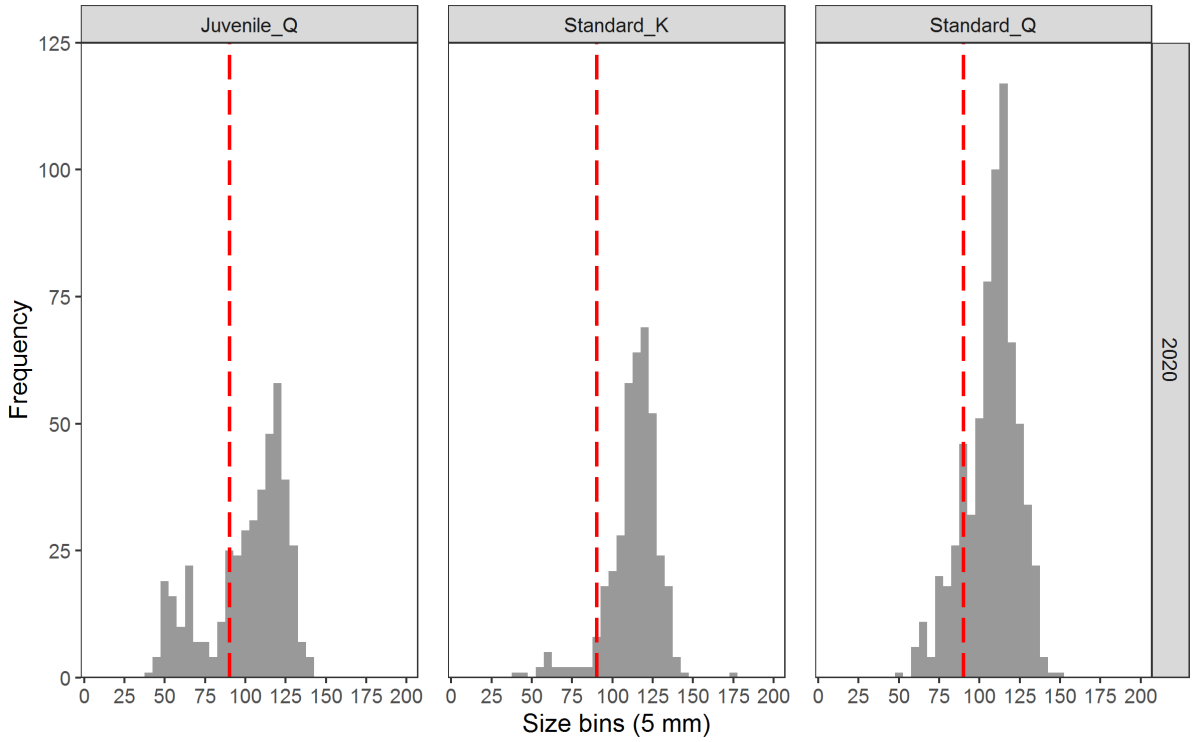

Figure 28: Size frequency of absolute counts of king scallops by dredge type for Bradda (0 – 3 nm and offshore) 2020. The red dashed line indicates the estimated recruit cut-off of 90 mm.

For BRA, which has no comparative data for 2019, the **post-recruit index for 2020 was 0.96** and the **recruit index for 2020 was 0.19**.

3.2.3.3 Maughold 0-3nm

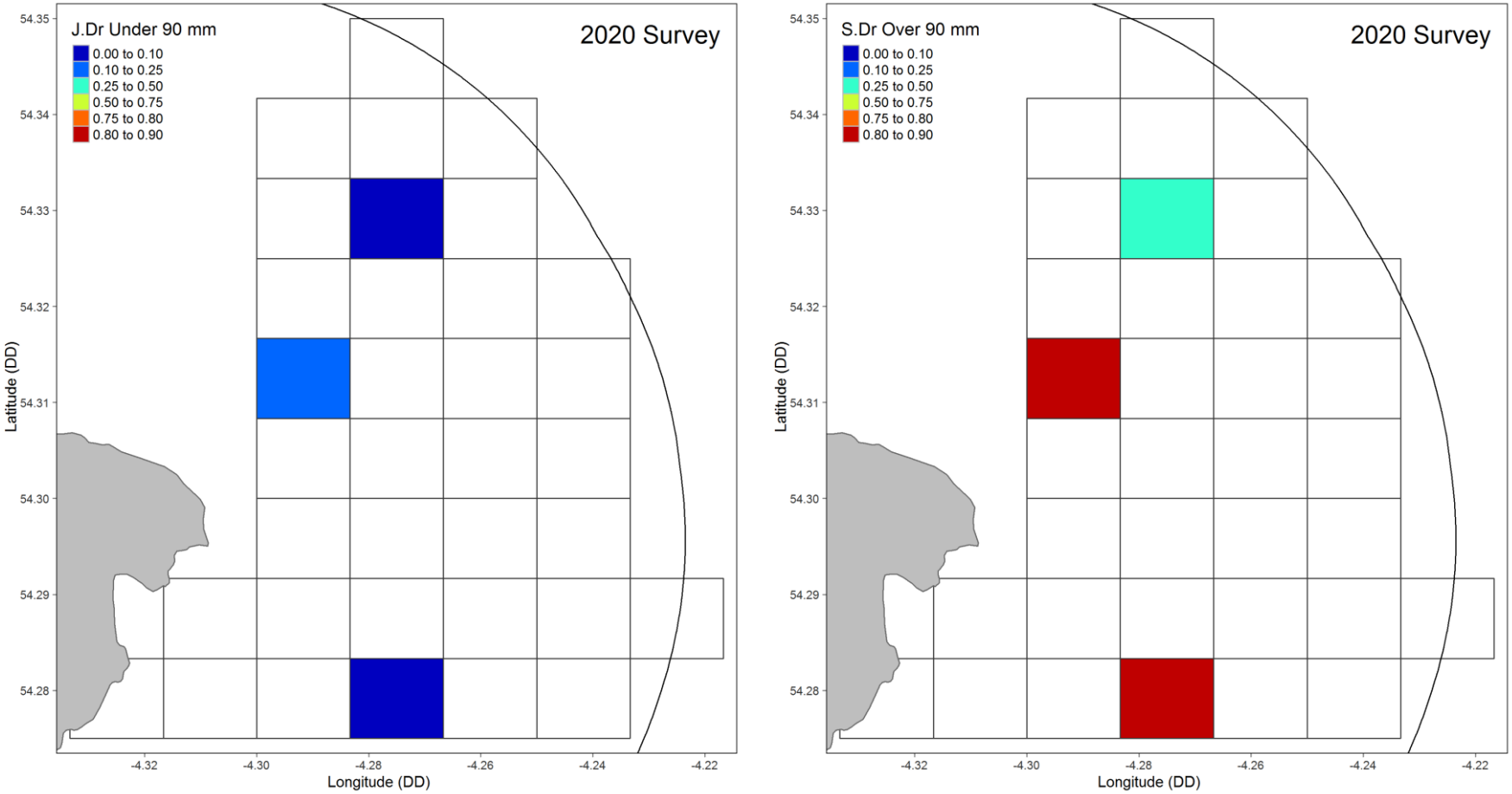

Figure 29: Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 90 mm from juvenile queen and standard queen scallop dredges (left) and over 90 mm from standard queen and standard king scallop dredges for 2020 (right) for 2020 at Maughold 0-3 nm (North-east coast).

Table 10: Density 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) 90 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).*

	2019 < 90 mm	2020 < 90 mm	2019 > 90 mm	2020 > 90 mm
Cells Surveyed	-	3	-	3
Min	-	0.05	-	0.45
Median	-	0.05	-	0.81
Mean	-	0.07	-	0.69
Geometric Mean	**-**	**0.12**	**-**	**0.72**
Max	-	0.13	-	0.81

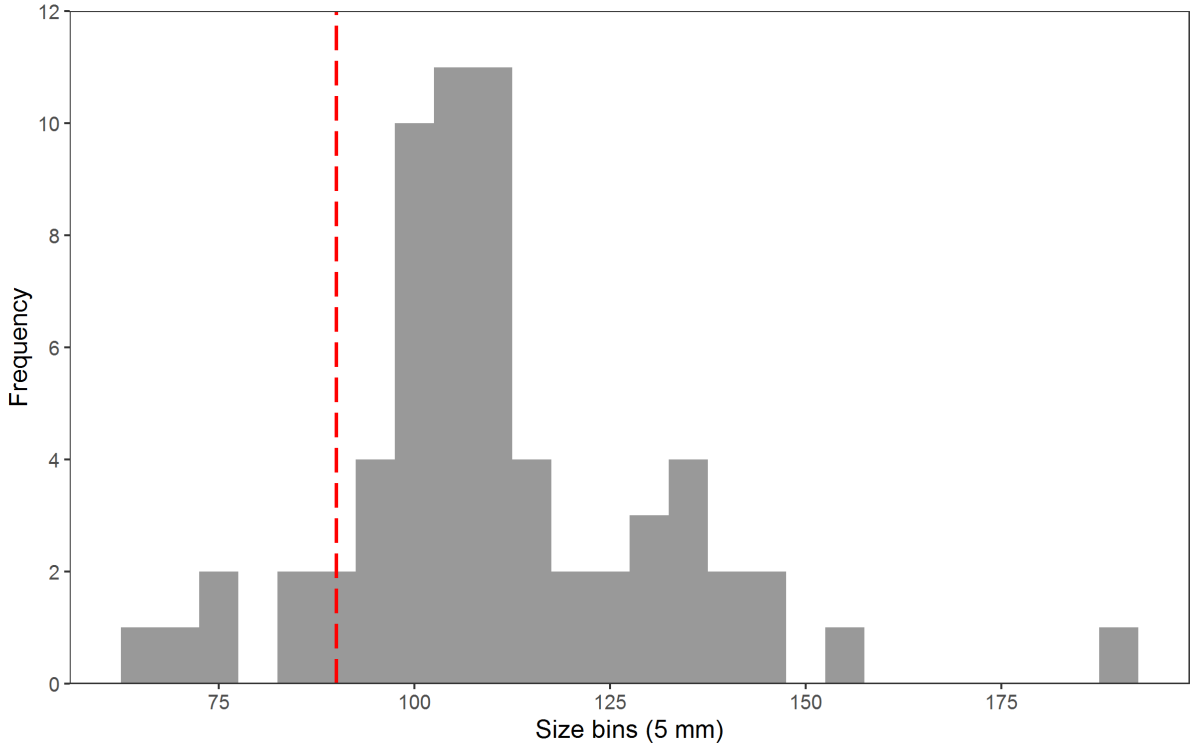

Figure 30: Size frequency of absolute counts of king scallops for Maughold 0 – 3 nm 2020 for all dredges combined due to low n. The red dashed line indicates the estimated recruit cut-off of 90 mm.

For MGH, which has no comparative data for 2019, the **post-recruit index for 2020 was 0.72** and the **recruit index for 2020 was 0.12**.

4. Overall Spatial and Temporal Comparison

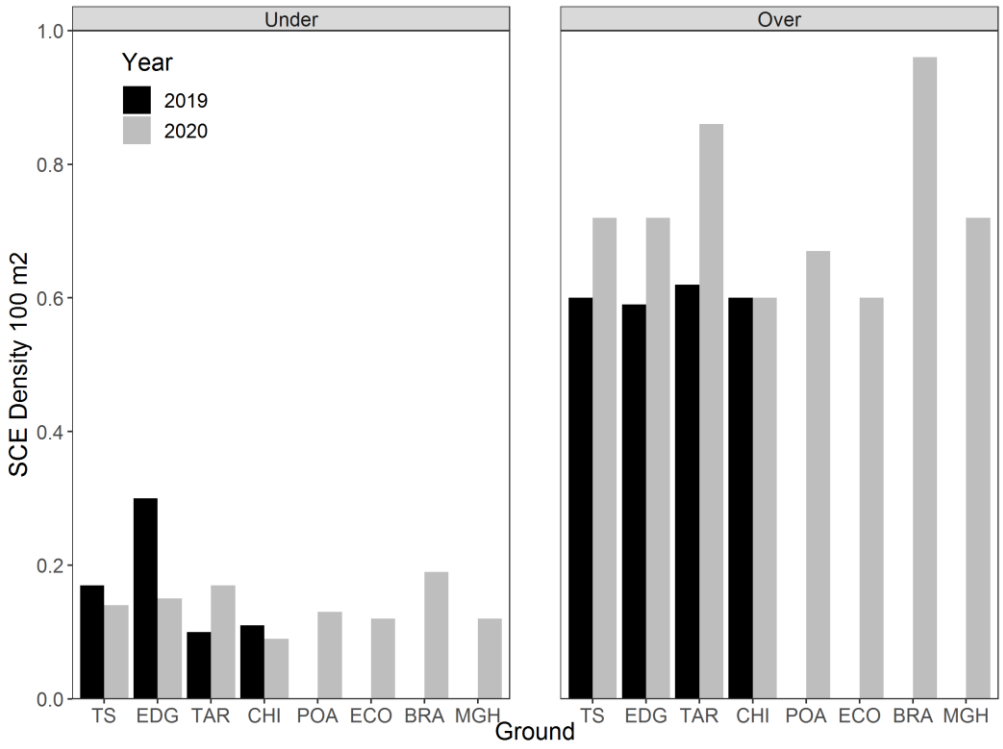

Figure 31: Comparison of king scallop densities (over and under 90 mm) by year and by ground

Within the territorial sea (EDG, TAR and CHI) the survey index has increased for post-recruits and decreased for recruits following 1186 t of landings reported during the 2019/2020 fishing season. Of the three grounds surveyed in both years EDG and TAR have seen increases in the post-recruit abundance for 2020 whilst there has been no change at CHI. In terms of recruits TAR was the only ground where the survey index had increased from 2019. BRA in the 0-3 nm and TAR in the 3-12 nm have the highest survey densities for post-recruits and recruits.

Given the lack of long-term data from this survey then the landings from last year could provide starting soft TAC values for each ground (on the basis that there were no observed declines in post-recruit survey density at these landing values). These soft TACs would then provide a trigger for review at each ground using real-time fisheries dependent data submitted through Daily Catch Return (DCRs) Forms enabling LPUE and fishing effort to be assessed.

Table 11: A summary of the changes in survey density for over and under 90 mm by survey ground. Landings are also displayed in t from the 2019/2020 season for each ground based on data from the Daily Catch Return Forms and indications of fishing inside or outside of the 3nm limit.

Area	Ground	2019 <90 mm	2020 <90 mm	Change	2019 >90 mm	2020 >90 mm	Change	Landings 2019/20 (t)
TS	T.S.	0.17	0.14	-	0.60	0.72	+	1186
3-12 nm	EDG	0.30	0.15	-	0.59	0.72	+	401
	TAR	0.10	0.17	+	0.62	0.86	+	218
	CHI	0.11	0.09	-	0.60	0.60	=	179
	POA	NA	0.13	NA	NA	0.67	NA	44
0-3 nm	ECO	NA	0.12	NA	NA	0.60	NA	24
	BRA	NA	0.19	NA	NA	0.96	NA	288
	MGH	NA	0.12	NA	NA	0.72	NA	31

5. Recommendations:

The 2020/2021 season sees a change in the data used to support management from a long-term large scale data set to a short-term fine scale dataset. The lack of historical trends or comparative data for many fishing grounds leads us to recommend a precautionary approach to the start of the fishing season. One of the key points for the king scallop fishery is a need for a long-term management plan to guide fisheries management decisions for short, medium and long-term sustainability both from a stock and an economic perspective. One aspect of a sustainable longer-term approach is to assess not only fluctuations in the current fishable portion of the stock (i.e. post-recruits or over 90 mm king scallops in April that may recruit during the next season) but also fluctuations in the newly recruiting portion of the stock that will support the fishery next year (i.e. recruits or under 90 mm king scallops). Assessing and managing both components of the stock should help reduce the fluctuations in the fishery and aid with long-term sustainability of both the stock and fishery. As such the data and analysis has been split into recruit (under 90 mm) and post-recruit (over 90 mm) sections.

The short-term high-resolution survey indices for 2020 recorded an increase for post-recruits and a decrease for recruits compared to 2019 in the areas where inter-annual comparisons are available.

Although survey data suggests that abundance of king scallops has increased in areas of Isle of Man territorial waters, a precautionary approach is recommended for management of the 2020/21 king scallop fishing season, due to;

- The lack of long-term (5+ years) data required for the ICES Cat 3 data limited approach;
- The observed decrease in the recruit density in the 2020 survey compared to 2019 (with the exception of a small area in TAR);
- Absence of directly comparable 2019 survey data for several fishing grounds (0-3 NM zone areas, and POA), and
- The 2019/20 fishing season landing only 58% of the allocated TAC (1186 t out of 2049 t).

A key consideration for the precautionary approach for 2020/2021 is that although there was a general increase in the post-recruit abundance within the comparative areas of the Isle of Man territorial waters, the TAC from 2019/2020 was set at 2049 t but only 1186 t landed. Thus although we have seen some recovery this is based on harvesting of 1186 t and not 2049 t. This should be considered when deciding on a TAC for the 2020/2021 fishing season. Scope for adjusting 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, should be included in the precautionary approach. Market conditions may be variable due to both competition from other scallop stocks and species on the market as well as supply and market issues resulting from corona virus restrictions.

Whilst the scope of this analysis and report does not consider specific market conditions and economic factors, it acknowledges that good management of natural resources should necessarily look to minimise wasteful resource practices and maximise economic and ecological benefits at all stages of the supply chain. It is important to consider the opportunity cost of harvesting long-lived, sessile natural resources (e.g. king scallops) during poor market conditions (i.e. fishing mortality that returns low instantaneous profit) compared to multiple benefits of delaying harvests for more favourable market conditions. For king scallops, these benefits include additional growth of individuals and therefore increased stock biomass, additional reproduction/spawning opportunities and therefore greater chances of good recruitment, and improved profitability as market conditions stabilise at ‘normal’ prices.

The unprecedented economic context of the 2020/21 scallop fishery must also be viewed with a socio-economic perspective of the fishing industry and the unique challenges therein; however, the scientific advice provided for the 2020/21 king scallop fishery must also highlight the potential benefits of scallop conservation that are available, particularly in the context of a stock-rebuilding programme that coincides with poor market demand, significant quantities of supply from the Dogger Bank fishery in the North Sea, and therefore presently unfavourable market opportunities.

It is recommended that the precautionary management approach for 2020/2021 king scallop fishery 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 for each ground 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 EDG) may require additional fine scale management to avoid high fishing intensities and excessive fishing mortality.
- **Closed area management:** The continued management of NOA 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 2020/2021 king scallop fishery based on the survey data analysis produced here therefore include:

TAC:

- When considering the setting of a TAC for 2020/2021 fishing season consideration should be given to the fact that although some recovery has been seen within the territorial waters this is based on harvesting of 1186 t rather than the 2049 t set as the TAC for 2019/2020.
- Scope for adjusting 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.
- Soft set TACs for each ground using last year's landings data (i.e. for EDG the initial soft TAC would be 401 t when this was reached then a review of that fishing ground would automatically be triggered.

In-season reviews:

- Monthly reviews of the TAC and fishery with consideration of LPUE and fishing intensity within each fishing ground.

- ***Triggered Reviews:*** As per the current management trial for queen scallops during the 2020 fishing season, near real-time monitoring of "soft" TACs and "soft" LPUE thresholds for individual grounds could also be used for king scallops to trigger an immediate review by the SMB of an individual fishing ground (i.e. if the "soft" TAC for a ground is met then the LPUE and fishing activity in the area would be assessed to see if the ground should be closed or the "soft" TAC extended to enable the ground to remain open).

Closed Area management:

- The NOA at CHI and TAR contains high densities of queen scallops and king scallop post-recruits (1- 5 king scallops per 100 m^2. Continued management of this NOA should be discussed by the SMB to ensure that the number of vessels and fishing effort within the area is constrained.

- The closed area at BRA was put in place to protect juvenile queen scallops within a transient bed (i.e. there is not regular recruitment of queen scallops within this area). The benefits of the continued closure of this area during the king scallop fishing season should be discussed by the SMB.
- The closed area at TAR was put in place to protect high densities of juvenile queen scallops within a ground that has been recovering over recent years. The benefits of the continued closure of this area during the king scallop fishing season should be discussed by the SMB. In addition, its extension (or replacement) of the area to the east of the current closure which has the highest density of king scallop recruits recorded during the 2020 survey is recommended.
- Management or closure of the hotspot area at EDG, which has a high density of scallops the majority of which (~ 75 %) were below 110 mm at the time of the April survey, should be discussed by the SMB. One recommendation would be to close this area at the start of the fishery and to undertake additional survey tows within the area to ascertain the size range of the scallops (i.e. have they grown to MLS) before any additional management is considered.

Future work on recruitment:

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 two 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).

Long-term fisheries management plan:

A long-term management plan (LTMP) for the king scallop fishery is 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. A LTMP would necessarily include and benefit from collaborative input from industry, including both catching and processing sector considerations.

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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