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Isle of Man Queen Scallop 2021 Stock Survey Report

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Fisheries Report

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Contents

1. Fishery Management:

A fishery for queen scallops, *Aequipecten opercularis*, has been prosecuted in and around the Isle of Man's territorial waters since the 1950s. Within the territorial waters Manx vessels now fish for queen scallops (QSC) exclusively with otter trawls. UK vessels also predominately fish with otter trawls although a limited toothless dredge fishery does still occur in October with five UK vessels licenced to participate. The fishery within the Isle of Man's territorial waters is regulated by several management measures. For the 2020 fishing season these included:

- Two temporary scallop closed areas where fishing for king and queen scallops was prohibited (Figure 1).
- Two temporary scallop restricted areas where fishing for king and queen scallops was restricted (Figure 1).
- An experimental research area on the east coast closed to king and queen scallop fishing for a minimum of 3 years (closed since July 2017) (Figure 1).
- Queen conservation zones where dredging for queen scallops is prohibited.
- Spawning protection closure (1st April to 31st May)
- Statutory Irish Sea closure (1st April to 30th June)
- Weekend ban
- Daily curfew (fishing permitted 06:00 – 18:00)
- Minimum landing size (55 mm)
- Weekly catch limits for trawl fishery:
    - maximum of 2695 kg per vessel Weeks 1 -4;
    - maximum of 3150 kg per vessel from Week 5;
- Individual vessel quotas for dredge fishery (14575 kg per vessel for season)
- Total Allowable Catch:
    - Trawl fishery 557 t (Week 1 – 10)
    - Trawl fishery 90 t extension to 647 t (Week 11)
    - Dredge fishery 58.3 t (Opened October)

These management measures were covered by the Fisheries Act 2012 and through restrictive licencing conditions.

Outside of the territorial sea, although a minimum landing size of 40 mm is enforced, the fishery is subject to very few additional management measures except a statutory 3 month closure (April, May and June) for ICES areas VIa and VIIa which came into effect in 2018 following two years of industry voluntary closures.

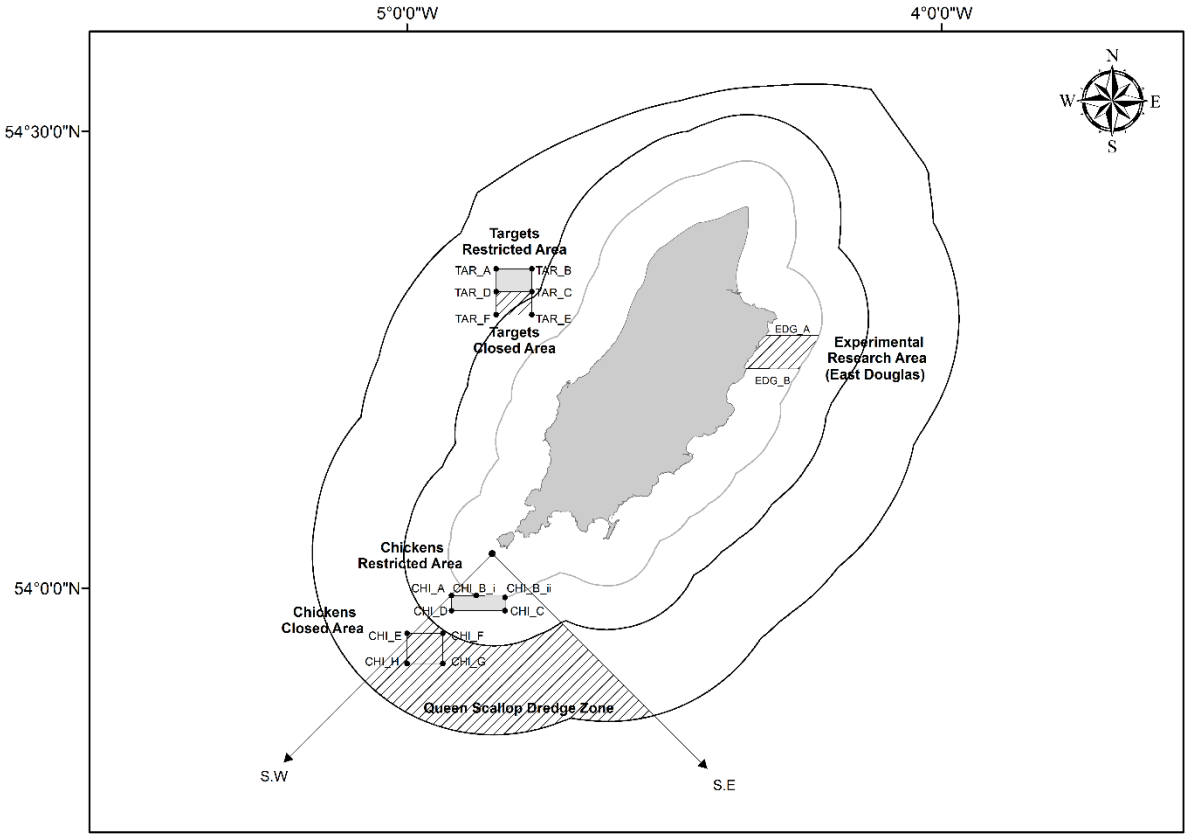

Figure 1: Map showing closed areas and restricted areas for the 2020 queen scallop fishing seasons

2. Annual Landings and Fishing Effort:

2.1 Irish Sea

Annual landings of queen scallops from the Irish Sea (Area VIIa) over the period 1950 – 2018 are shown in Figure 2 (ICES 2021a,b). Since 2008, landings have increased rapidly peaking in 2011 at > 20,000 t. In the early part of the Irish Sea fishery (1950 – 1973), boats from the Isle of Man recorded the majority of catch (> 75%), but between 1997 and 2018 the average annual Manx share has declined to around 20%, with United Kingdom vessels (Scotland, England, Wales and Northern Ireland) landing the remaining proportion (~80%). Whilst there are some management measures in place within Area VIIa (i.e. Minimum landing size of 45 mm [55 mm in Isle of Man territorial waters], closed season for *A. opercularis* which runs from 1st April to 30th June [initially voluntary in 2016 (May only) and 2017 and made statutory from 2018]), the increase in landings from the Irish Sea (VIIa) (2011-2013) was unprecedented and of concern, given the general lack of management of the wider stock and knowledge of the impact of such high fishing rates. Reported landings in 2018 for queen scallops from the Irish Sea were over 85% lower than landings recorded at the peak in 2011.

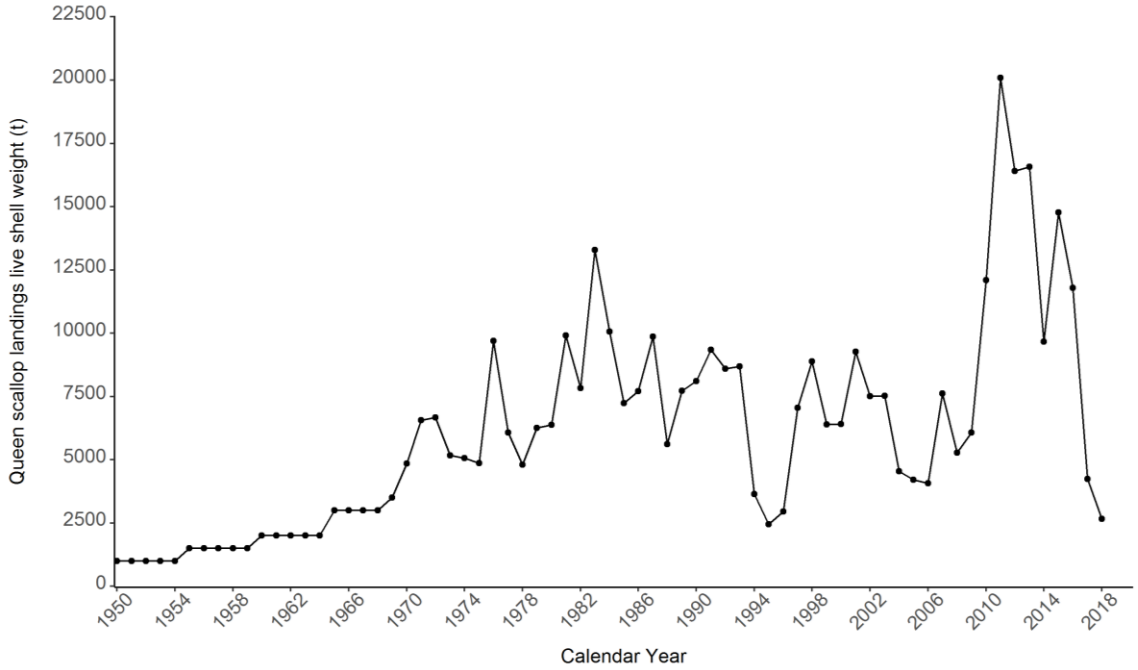

Figure 2: Annual live shell weight queen scallop landings (tonnes) from ICES Area VIIa for 1960 to 2018 using scallop landings from species Aequipecten opercularis (ICES 2021a,b).

2.2 ICES Rectangles 36E5, 37E5 and 38E5

The annual landings of queen scallops from ICES Rectangles 36E5, 37E5 and 38E5, which cover the main extent of the Isle of Man's territorial waters, show a similar pattern of landings to those from the wider Irish Sea (Area VIIa) over the period 2000 – 2020 (Figure 3). Landings increased rapidly from 2009 to 2011 tripling over that period from 5015 t in 2009 to 16957 t in 2011. There has been a decreasing trend in landings since 2011 with landings of only 920 t in 2020 the lowest within the period (2000 to 2020; Figure 3).

Landings by both dredge and trawl have declined dramatically since 2011 (Figure 4). The dredge fishery has seen a reduction in landings from a peak of 12612 t in 2011 to only 290 t in 2020. The trawl fishery has seen a reduction in landings from a peak of 4515 t in 2013 to 579 t and 629 t in 2019 and 2020 respectively. In 2020 the trawl fishery had a higher proportion of landings than the dredge fishery for the first time (2011 to 2020; Figure 4).

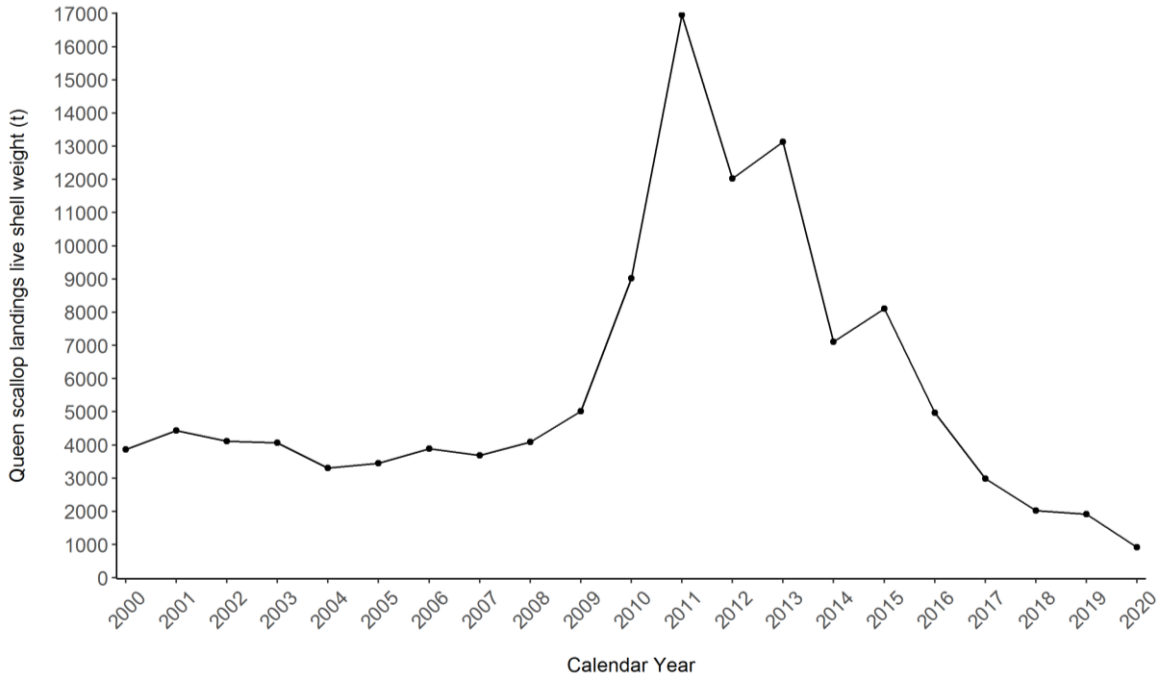

Figure 3: Annual live shell weight queen scallop landings (tonnes) from ICES Rectangles 36E5, 37E5 and 38E5 (Source: Paper logbook data DEFA and IFISH 2 Database).

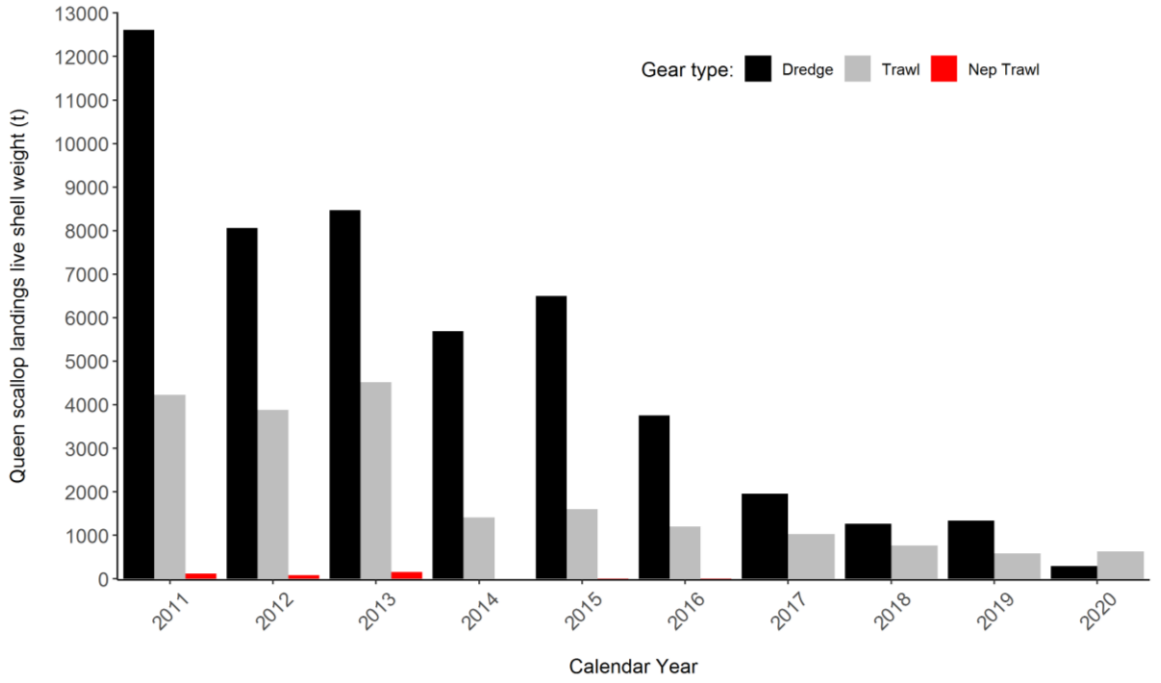

Figure 4: Annual live shell weight queen scallop landings (tonnes) from ICES Rectangles 36E5, 37E5 and 38E5 (Source: IFISH 2 Database) split by Gear type.

3. Seasonal Landings and Fishing Effort:

3.1 Isle of Man territorial waters

A requirement of the queen 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 almost real-time fisheries dependent data for the fishery for monitoring total allowable catches (TACs) and catch rates (i.e. landings per unit effort [LPUE]).

The 2020 Isle of Man queen scallop fishery had a TAC of 705 t. The TAC was fished by two separate metiers: Trawl fishery (39 eligible vessels) and dredge fishery (5 eligible vessels).

The trawl fishery had a sub TAC of 647 t and opened on 1st July 2020 and closed on 30th September 2020. For the trawl fishery a weekly catch limit of 2695 kg was implemented for Weeks 1-4. For socio-economic reasons, from Week 5 of the fishery the weekly catch limit was increased to 3150 kg per vessel (implemented midday on 28th July 2020). Total reported landings for the trawl fishery during the 2020 fishing season were ~ 660.34 t with 26 unique vessels reporting landings. The majority of landings came from Targets, followed by Chickens and then East Douglas (Table 1). An additional 0.8 t was landed from the Ramsey Bay permit only fishery which has its own total allowable catch and a further 0.39 t was landed from Chickens as part of the dredge fishery in October 2020.

Table 1: Landings by ground for the 2020 queen scallop fishery (trawl and dredge)

Area	Landings (t)
IS9: Targets	301
IS21: Chickens	214
IS15: East Douglas	137
IS10: Maughold	5
IS6: Point of Ayre	0.5

Weekly LPUE, standardised to 35 kg bags per hour fished per 10 fathoms of net, are displayed for each of the main fishing grounds in Figure 5. Chickens (IS21) had the highest LPUE across the season within the newly opened restricted area (median weekly LPUE values of ~ 20 – 35). Targets (IS 9) had the second highest LPUE across the season within the newly opened restricted area (median weekly LPUE values of ~ 9 – 18). The mean weekly LPUE for all other grounds (EDG, POA, RAM and MGH) was typically below 6 bags (35 kg) per hour fished per 10 fathom of net (Figure 5).

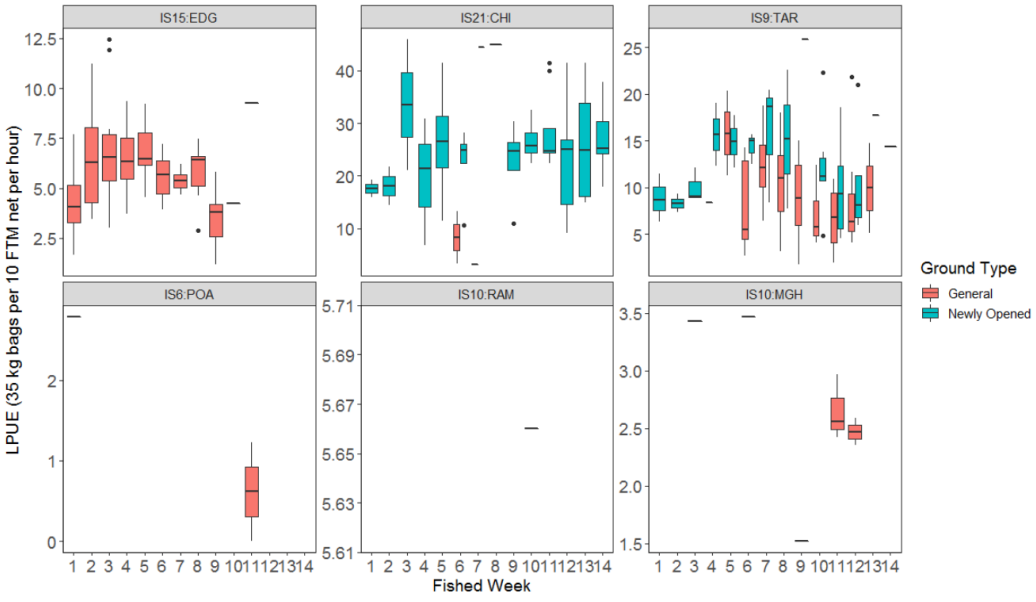

Figure 5: A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for the 2020 queen scallop trawl fishing season displayed by week and main fished ground. For TAR and CHI fishing grounds the vessel trips are split further into the general fishing area and the newly opened restricted fishing areas. Note: Different scales on Y-axes.

Seasonal landings per unit effort, standardised to 35 kg bags per hour fished per 10 fathoms of net, is displayed for each fishing season from 2014 to 2020 in Figure 6. The boxplot indicates that with the

exception of 2015, the median LPUE for the 2020 fishery was higher than all other years for this period (Figure 6). Fishing within the high density newly opened areas at Chickens and Targets largely contributed to the increase in median LPUE for 2020 (Figure 5).

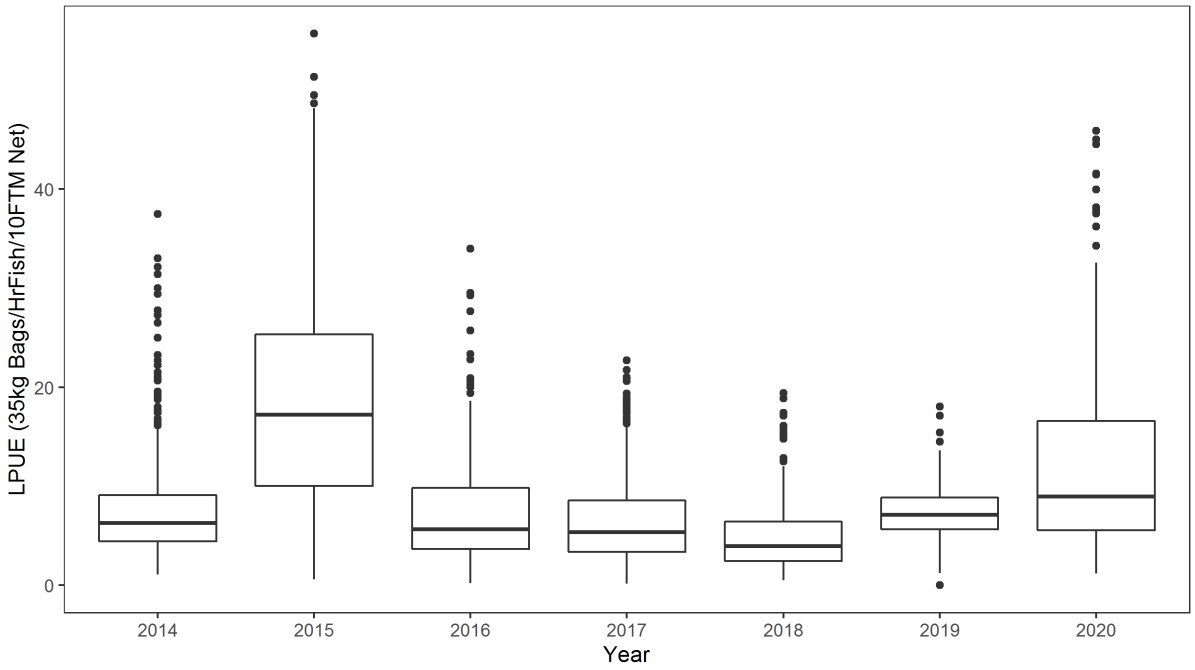

Figure 6: A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for all vessel trips by fishing season from 2014 to 2020.

When the data is displayed by fishing ground and season the median LPUE at Chickens for 2020 was the highest in the seven years that there is data (Figure 7). The median LPUE at Targets and East Douglas were also the second highest recorded in the seven year period (Figure 7). However the EDG ground was closed mid-season due to substantial declines in LPUE during the 2020 fishing season. The median LPUE for Point of Ayre in 2020 was the lowest it has been during the seven year period and the fishing ground was closed mid-season in 2020 due to the very low LPUE (Figure 7).

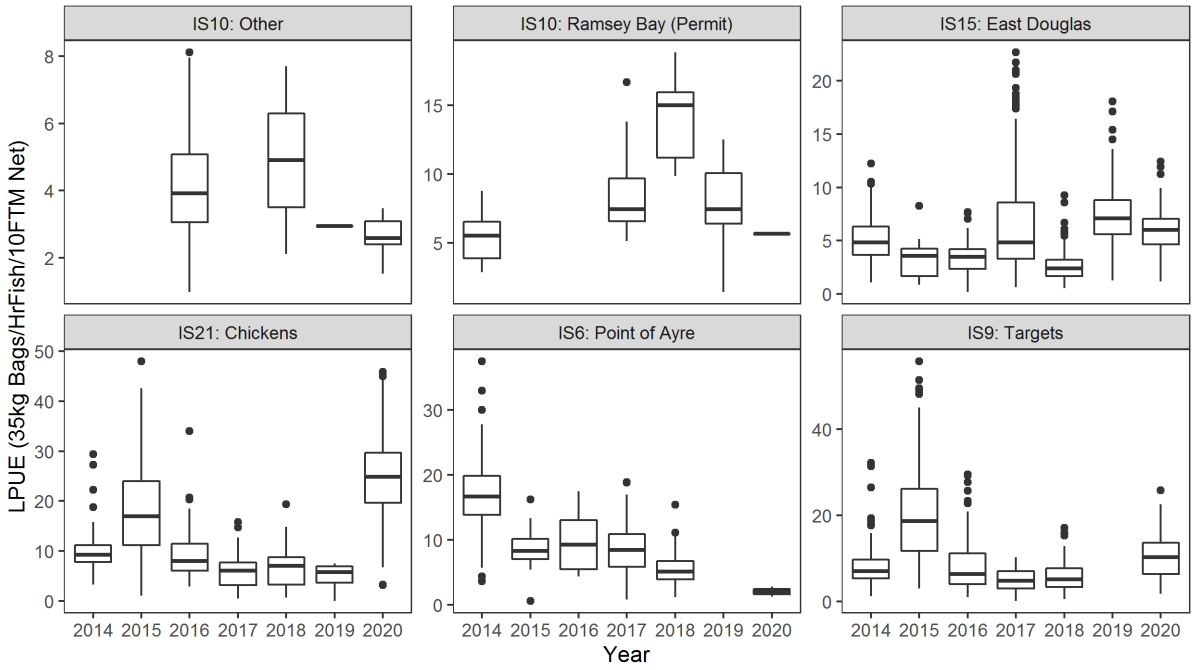

Figure 7: A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for all vessel trips by season and split by fishing ground.

The dredge fishery had a sub TAC of ~58.3 t and opened on 1st October 2020. For the dredge fishery each eligible vessel was allocated an individual quota of 14,575 kg which could be fished during the season as and when suited by the vessel. Total reported landings for the dredge fishery during the 2020 season were ~ 0.391 t with only 1 of the 5 licenced vessels licenced reporting landings on a single trip. LPUE for the dredge fishery has seen annual declines in LPUE with the lowest value (based on a single trip) recorded in 2020 (Figure 8).

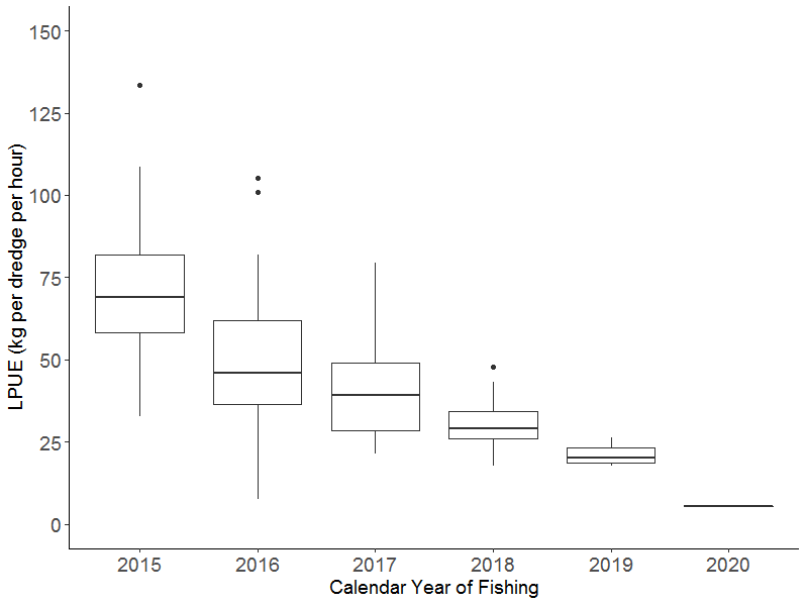

Figure 8: LPUE standardised to kg per dredge per hour for dredge vessels participating in the Isle of Man queen scallop dredge fishery which occurs within the dredge box located within the CHI fishing ground.

4. Scallop Surveys:

4.1 Background:

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

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 but data was collected in April 2021.

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 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. 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 long-term survey data has been used annually to undertake a quantitative stock assessment to estimate biomass. Following the recommendations of the scallop management board (SMB), the data has also 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 has not been calculated following the 2021 scientific survey due to a missing year of data in 2020. There is therefore no analysis of this value included within this current report.

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).

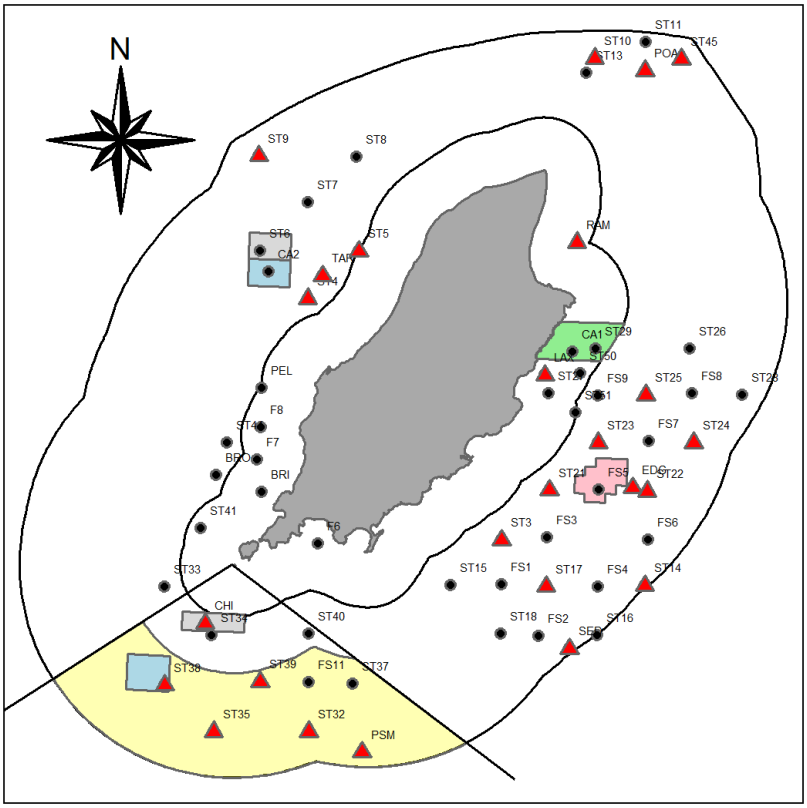

Figure 9: A map showing the location of all 2021 survey stations (red triangles = Stations used in stock assessment; black circles = Additional survey stations). During the 2020 queen scallop fishing season light grey boxes indicate areas with restricted management; light blue boxes indicate closed areas, light green box indicates the experimental research area at East Douglas closed for 3 years to allow recovery, the pink box indicates a previous hotspot area of queen scallops in 2019 and the yellow box indicates the area within which dredging for queen scallops is permitted.

4.2.2 Size Frequency:

A frequency-density plot of queen scallop size data is presented in Figure 10 from samples measured at all stock assessment stations (queen scallop dredge data only). Scallops > 55 mm represent post-recruits (queen scallops that are already at the minimum landing size (MLS) of 55 mm). Scallops < 55 mm represent recruits (queen scallops under MLS), some of which will be large enough to grow into the fishery during the upcoming fishing season (i.e. > 45 mm) and some which will not reach MLS until next year's fishery.

In 2019 there was a well-defined peak in recruiting queen scallops in the data that by 2020 had either grown into the fishery (i.e. ≥ 55mm) or within the size band of scallops that would likely grow into the fishery during the season (i.e. between 45 - 55 mm) increasing the density of larger recruited scallops in the 60-70 mm size range in 2020 (Figure 10). The data indicate a lack of a well-defined peak in recruiting queen scallops (i.e. 25-45 mm) in 2021 compared to 2019, this is an important consideration when looking at sustainable management over a > 1 year period.

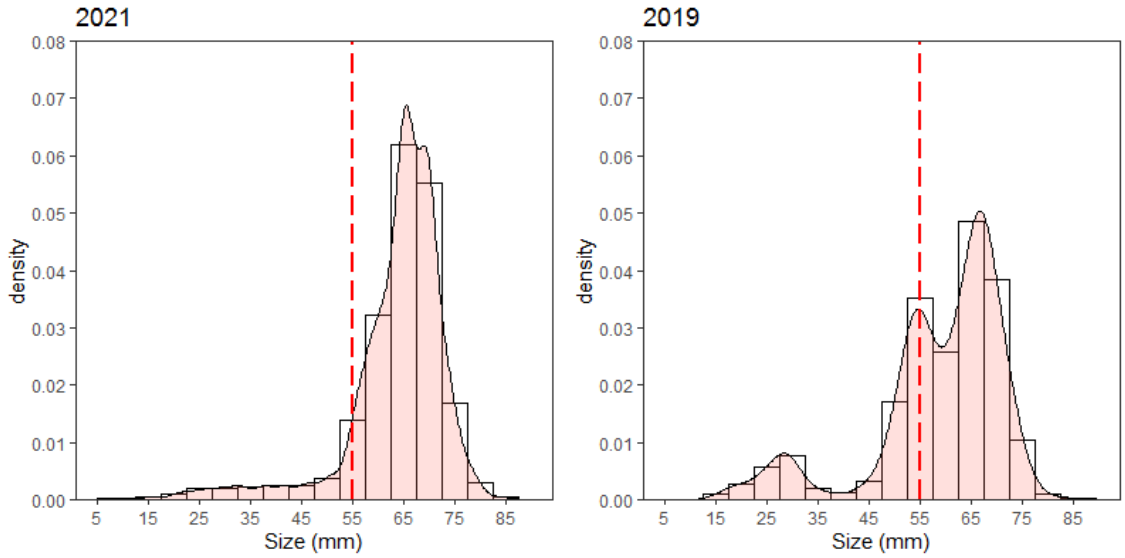

Figure 10: Queen Scallop size frequency-density plot for 2021 and 2019 Prince Madog survey data (no survey in 2020 due to CV-19). Data from stock assessment sites and queen scallop dredges only.

By splitting the data into main fished grounds (i.e. individual stations grouped into fishing grounds), the pattern of recruitment indicates low level quantities of pre-recruits at the majority of fishing grounds (EDG has the lowest densities of pre-recruits) with CHI and TAR having the largest peaks in scallops under 55 mm (Figure 11).

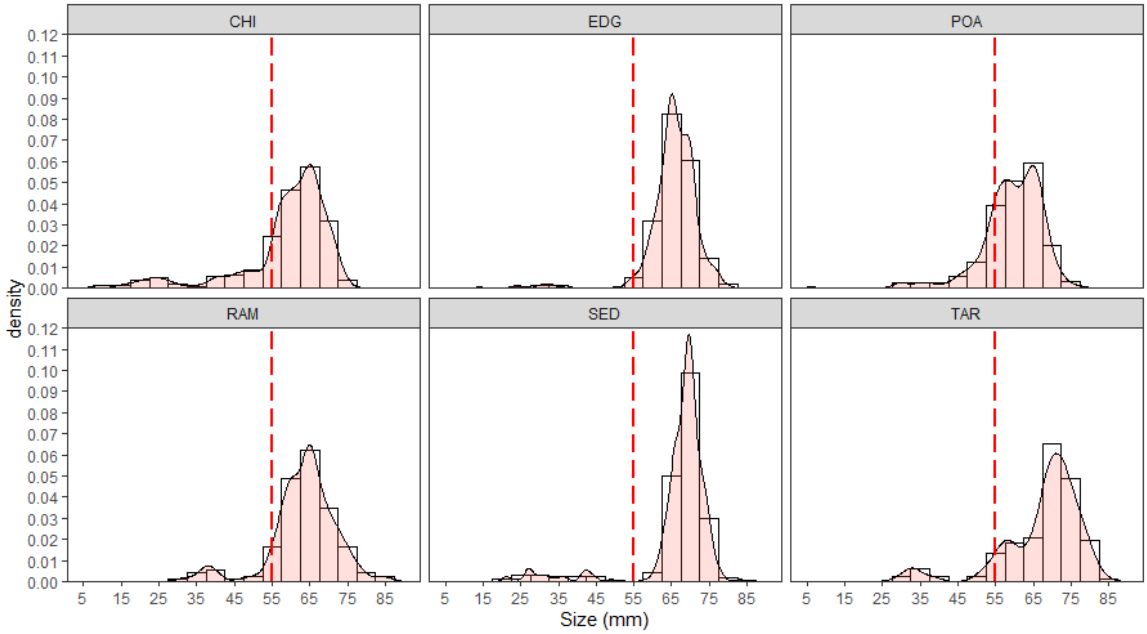

Figure 11: Queen Scallop size frequency-density plot for each ground for the 2021 Prince Madog survey data. Data from stock assessment sites and queen scallop dredges only. CHI: Chickens, EDG: East of Douglas, POA: Point of Ayre, RAM: Ramsey Bay, SED: South East of Douglas and TAR: Targets.

4.2.3 Density estimates:

The mean density (scallops per 100 m^2) of queen scallops from queen scallop dredges for all stations surveyed is displayed in Figure 12. The four survey sites with the highest densities are CHI and ST 38 (south coast) and CA2 and ST6 (west Coast) which are all located in closed or restricted access areas

(Figure 9 and Figure 12). These stations all have densities ranging between 44 – 139 scallops per 100 m^2.

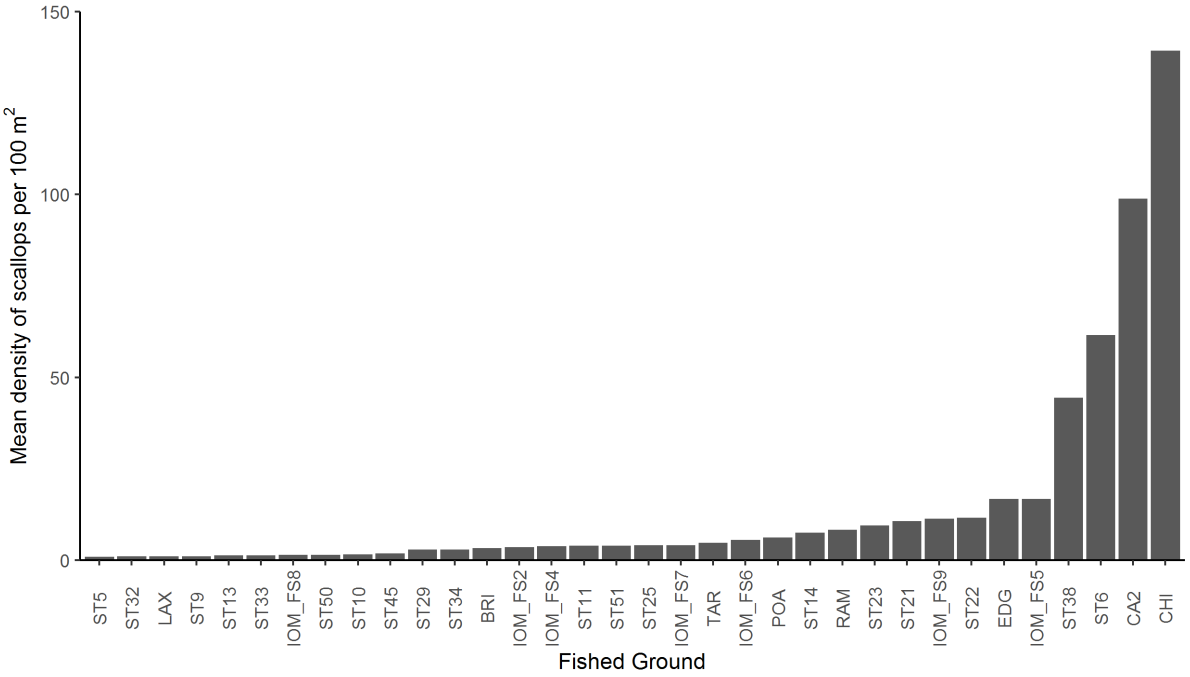

Figure 12: Average survey density (scallops per 100m²) of queen Scallops from queen scallop dredges from all sites surveyed during the 2021 Prince Madog survey. For plotting purposes sites where QSC density was > 0.45 scallops per 100 m^2 are not displayed. CA2 = an additional site surveyed within the 2020 closed area at TAR (see Figure 9).

Stations that have been sampled over at least two years and at which queen scallops are present (3, 4, 5, 9, 10, 14, 17, 20, 21, 22, 23, 24, 25, 32, 35, 36, 38, 39 and 45), in addition to the standard historical queen scallop survey stations (CHI, EDG, LAX, POA, PSM, RAM, SED and TAR), were included in the current stock assessment (Figure 9). Since 2016 the model has been run at a smaller spatial scale using landings and survey data exclusive to the Isle of Man territorial sea.

The difference in mean survey density (scallops per 100 m^2) of queen scallops from queen scallop dredges between 2019 and 2021 (survey cancelled in 2020 due to CV-19) is displayed for all stations used in the stock assessment in Figure 13. The highest density difference is in the south of the Island where densities have increased at CHI and ST38 by 131 and 40 scallops per 100 m^2 respectively (these sites are both located within managed areas (Restricted Access and Closed)). It should also be noted as seen in Figure 12, that two other stations that are not traditionally included in the stock assessment analysis (ST6 and CA2), but are located within managed areas (Restricted Access and Closed) also have very high densities of queen scallops.

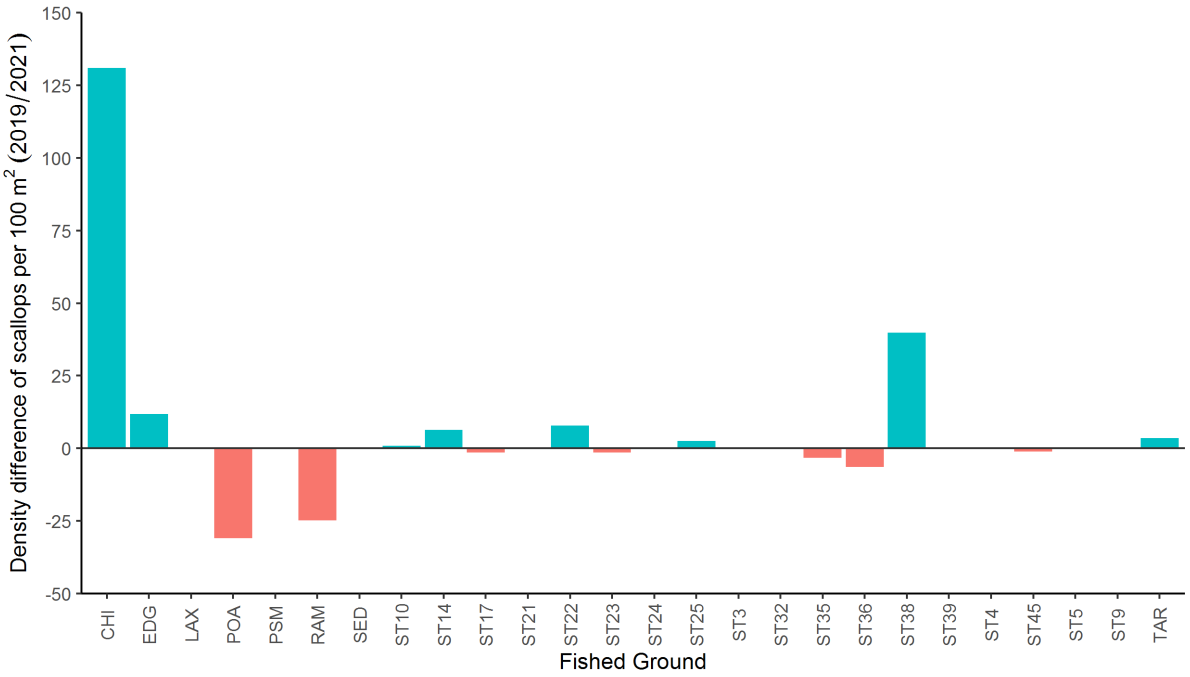

Figure 13: Difference in average survey density (scallops per 100 m^2) of queen scallops from queen scallop dredges between 2019 and 2021 (no survey in 2020 due to CV-19). Red bars indicate decreases in scallop density from 2019 to 2021 and turquoise bars indicate increases in scallop density from 2019 to 2021.

4.2.4 Survey Abundance Indices:

The abundance index (derived from the survey data using the geometric mean of queen scallop densities) for recruits (scallops < 55 mm) had a general declining trend from 2009 to 2019 with slight increases observed in 2012, 2014 and 2018. The data for 2021, although still well below the long-term mean (~69), is the highest recorded for recruits since 2016 (Figure 14).

The abundance index for post-recruits (scallops ≥ 55 mm) had an increasing trend from 2007 to 2010, reaching the highest levels on record in 2010. From 2011 to 2019 there has been a declining trend in post-recruit abundance (slight increase observed in 2011), returning to a similar level to that recorded prior to 2007. The data for 2021, although still well below the long-term mean (~399), is the highest recorded for post-recruits since 2017 (Figure 15).

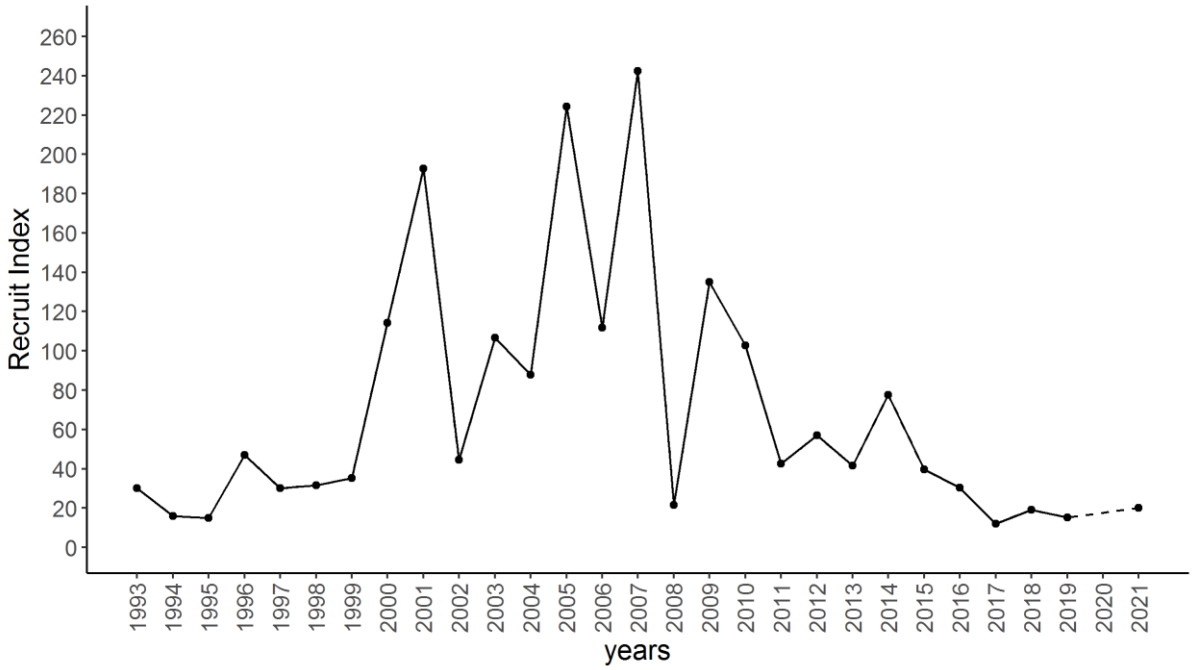

Figure 14: Abundance index (based on geometric mean) for recruits (under 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account for zero data values. Dashed line represents missing values

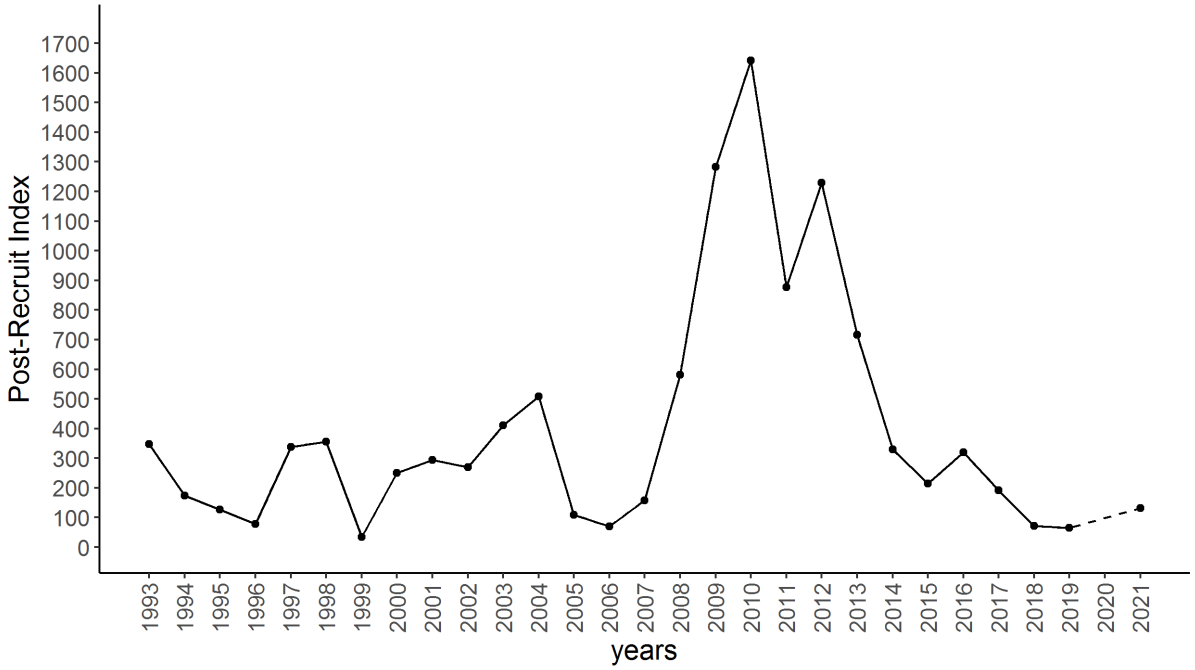

Figure 15: Abundance index (based on geometric mean) for post-recruits (over 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account for zero data values. Dashed line represents missing values.

When viewed spatially and temporally by site over the time period of the survey, anomalies where exceptional densities of queen scallop recruits or post-recruits occur at a site in a given year can be identified. The boxplots in Figure 16 indicate the typical ranges (box indicates inter-quartile range) of recruit density for each site along with the median value (horizontal line). The red line indicates a density of 10 scallops per 100 m^2 which is above typical values and indicates a good recruitment event

at that site within that year. The data for 2021 is also plotted as blue points on the figure and indicates that there have been exceptional localised recruitment events at CA2 and ST6 (Closed and Restricted Area on the West Coast within Targets fishing ground) and ST38 (Closed area on the South Coast within Chickens fishing ground). It may be appropriate to consider separate management for the 2021 fishing season for these three areas. Note also a fourth site (CHI) with high recruit densities (~5 per 100 m^2) which is identified below as a site with high post-recruit densities.

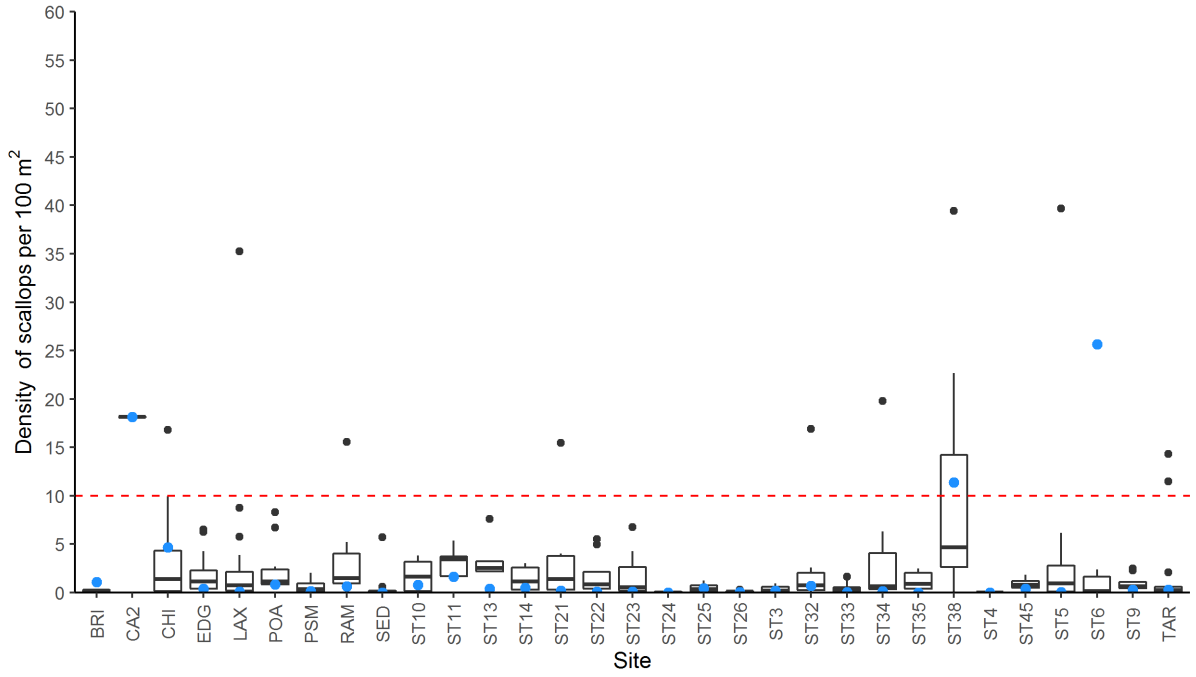

Figure 16: Boxplot of recruit (< 55 mm) queen scallop density per 100 m^2 for stations where queen scallops are typically present. Outliers over 10 (which appear as points above the red dashed line) are exceptional years of recruitment for which management should be considered separately to the rest of the stock. The blue points are the data from the current 2021 survey.

The boxplots in Figure 17 indicate the typical ranges (box indicates inter-quartile range) of post-recruit density for each site along with the median value (horizontal line). The red line indicates a density of 50 scallops per 100 m^2 which is above typical values and indicates an exceptional density of post-recruits at that site within that year. The data for 2021 is also plotted as blue points on the figure and indicates that the four highest localised high densities of queen scallops are at CA2 and ST6 (Closed and Restricted Area on the West Coast within Targets fishing ground) and CHI and ST38 (Closed and Restricted Area on the South Coast within Chickens fishing ground). It may be appropriate to consider separate management for the 2021 fishing season for these four areas.

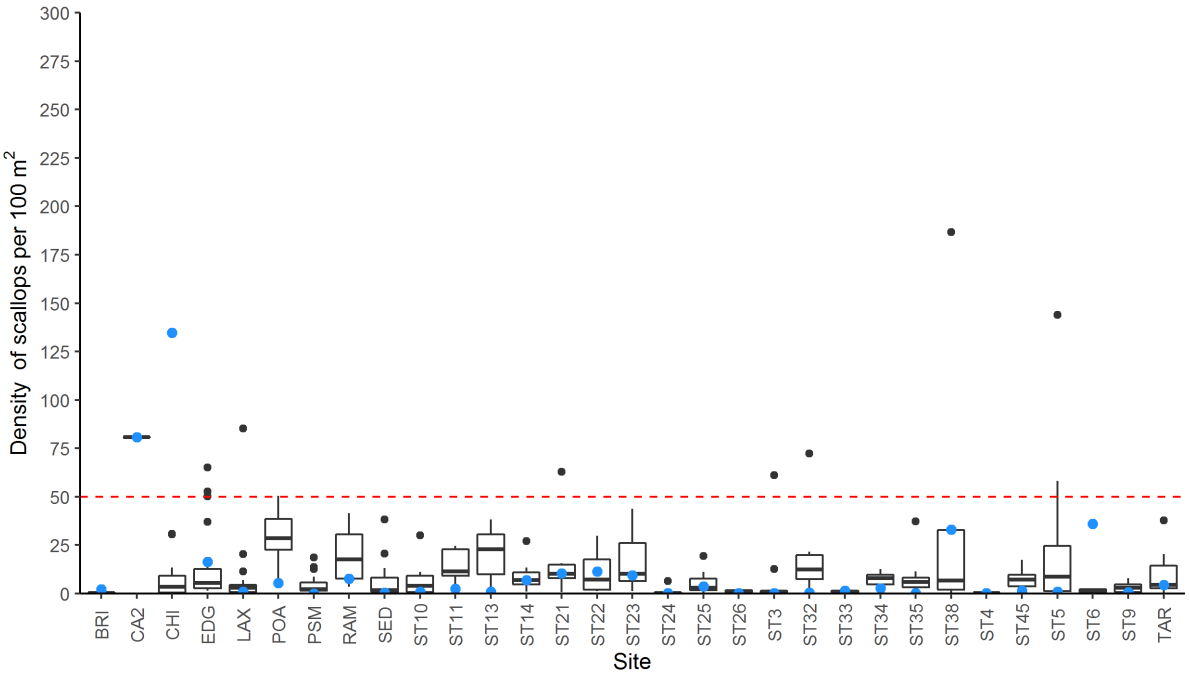

Figure 17: Boxplot of post-recruit (≥ 55 mm) queen scallop density per 100 m² for stations where queen scallops are typically present. Outliers over 50 (which appear as points above the red dashed line) are exceptional years of post-recruits for which management should be considered separately to the rest of the stock. The blue points are the data from the current 2021 survey.

4.3 Industry Juvenile Spring Scallop Survey:

4.3.1 Survey Methods:

A survey for 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 the three main queen scallop fishing grounds and one transient bed (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	Transient

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 refinement: As the main survey grid was defined to include both king and queen scallop at each fishing ground the outer survey extent for each ground was further refined for queen scallops using vessel monitoring system data (VMS) amalgamated from 2011 – 2019. In order to identify queen scallop fishing activity VMS data from the queen fishing season were filtered to only include vessels moving at fishing speed (i.e. 1.0-4.0 knots). In addition, depth and sediment profiles were also considered when refining each survey ground.

Ground inclusion: POA and the transient bed at 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 sites at BRA [Survey Cell: 4250] and 2 sites at TAR [Survey Cells: 1995 and 2067] were surveyed in those areas 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. In addition, the juvenile dredges appear to be more efficient for catching both post recruits (i.e. ≥ 55 mm) and recruits (i.e. < 55 mm) and so the analysis within this report focuses on that data set.

Survey timing: It should be noted that the 2019 survey was undertaken in June whilst the 2020 survey was undertaken in April and the 2021 survey in May. Size data is presented here as a snap shot at the time of the survey and the data has not been adjusted for size increase due to growth between these periods.

4.3.2 Size Frequency:

A size frequency plot of queen scallop size data is presented in Figure 18 from samples measured at all industry scallop survey stations (queen scallop dredge data only). Scallops > 55 mm represent post-recruits (queen scallops that are already at the minimum landing size (MLS) of 55 mm). Scallops < 55 mm represent recruits (queen scallops under MLS), some of which will be large enough to grow into the fishery during the upcoming fishing season (i.e. > 45 mm) and some which will not reach MLS until next year's fishery.

As indicated in the scientific survey data in 2019 there was a well-defined peak in recruiting queen scallops in the juvenile dredge data that by 2020 had either grown into the fishery (i.e. ≥ 55mm) or within the size band of scallops that would likely grow into the fishery during the season (i.e. between 45 - 55 mm) (Figure 18). The juvenile dredge data also indicates a lack of peak of recruiting queen scallops (i.e. 25-45 mm) in 2021 compared to 2020 and 2019, this is an important consideration when looking at sustainable management over a > 1 year period.

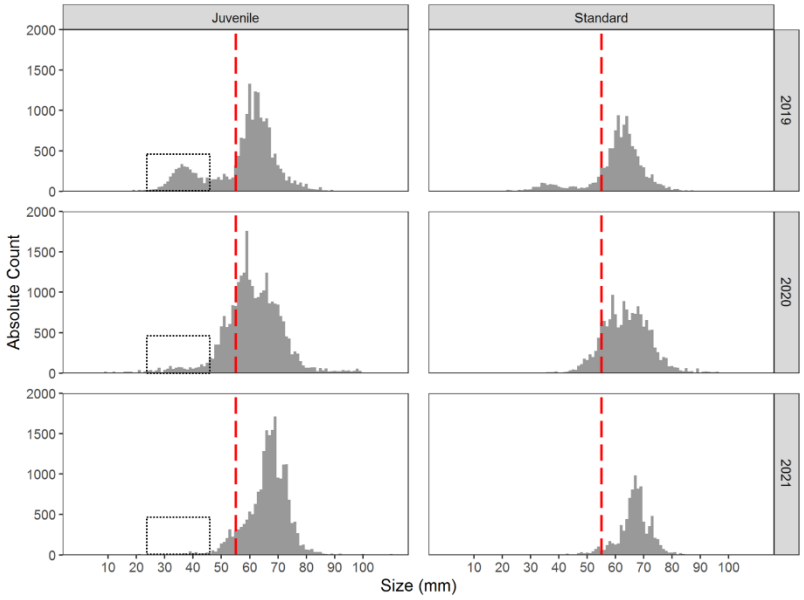

Figure 18: Size frequency (absolute counts) of sampled queen scallops from all surveyed stations compared by survey year and gear type. The red dotted line indicates the current MLS of 55 mm and the black dotted box is highlighting areas where new recruitment would be coming through.

4.3.3 Density estimates:

The Industry survey index data presented here is based on the geometric mean due to the skew in the data and based on juvenile dredges as these appear the most efficient gear for both post-recruits and recruits.

4.3.3.1 Territorial Waters:

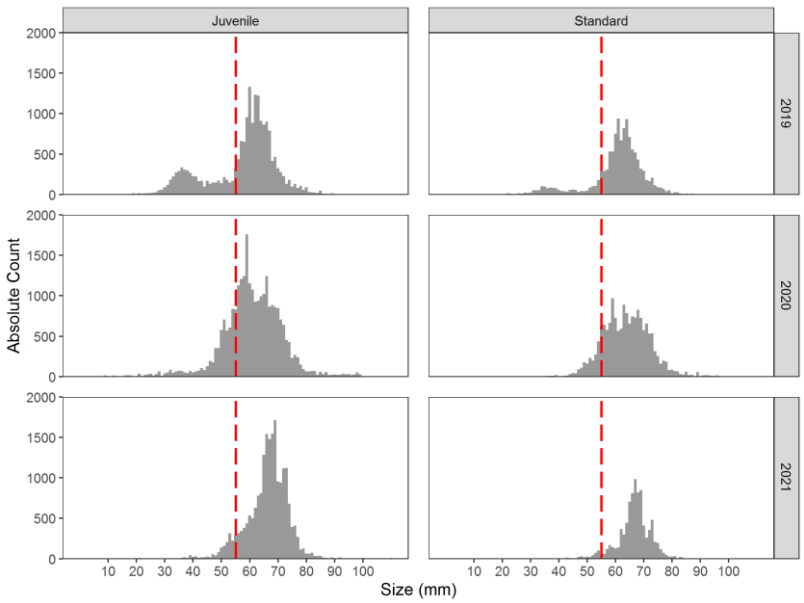

Figure 19: Size frequency distribution of absolute counts of queen scallops displayed by survey year and survey dredge type (red dotted line indicates the MLS of 55 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions. The black dotted box highlights a new recruitment peak (i.e. queenies of ~ 25 – 45 mm) indicating new recruitment coming through from that year (i.e. these queen scallops are 1 year old). Note recruitment peak absence in 2020 and 2021.

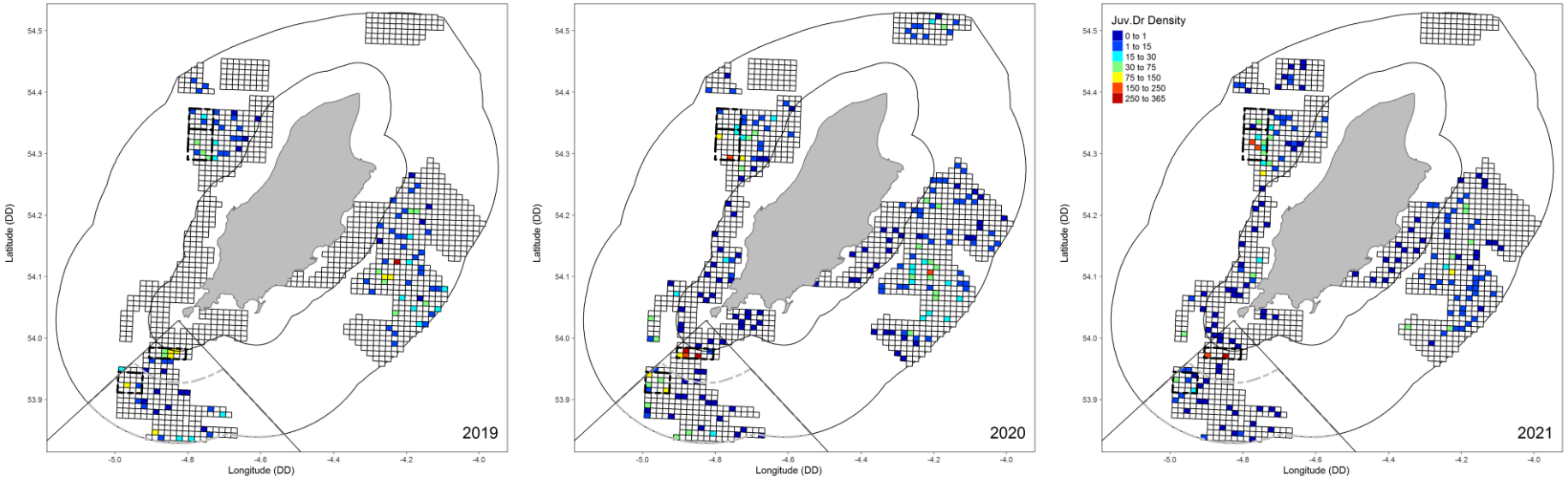

Figure 20: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (top left), 2020 (middle) and 2021 (right), Point of Ayre in the north of the TS and Bradda offshore to the west of the TS were only surveyed for the first time in 2020. The black borders indicate 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 closed area or hotspot analysis).

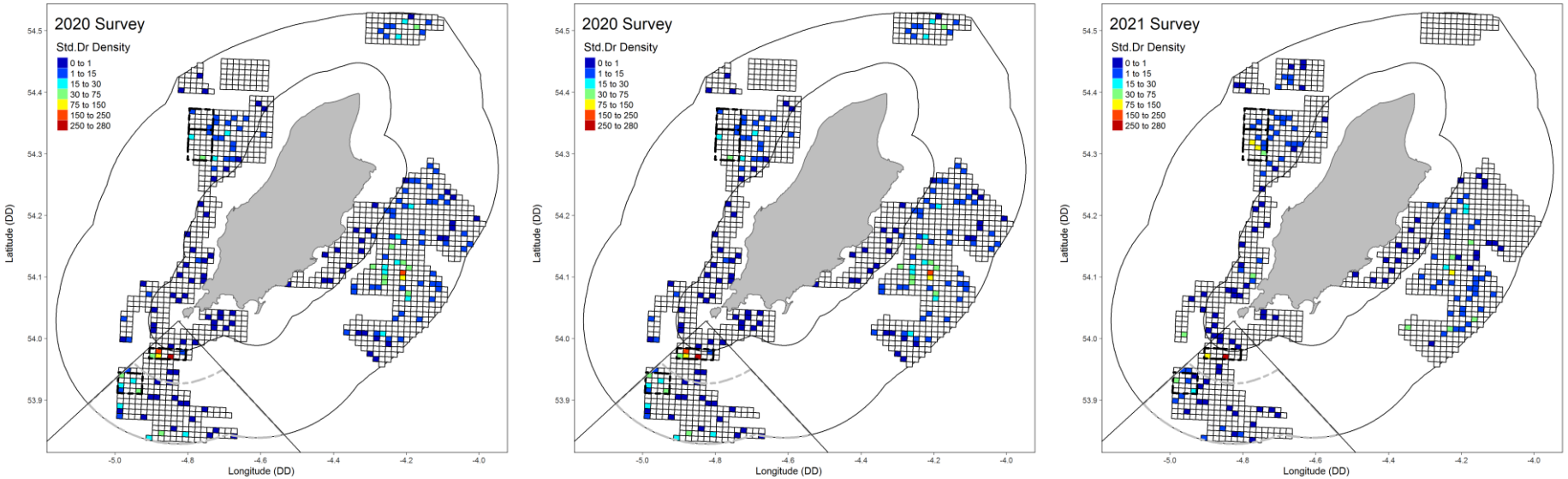

Figure 21: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left), 2020 (middle) and 2021 (right), Point of Ayre in the north of the TS and Bradda offshore to the west of the TS were only surveyed for the first time in 2020. The black borders indicate 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 closed area or hotspot analysis).

Table 3: Juvenile dredge density of QSC per 100 m^2 split by over and under MLS for the territorial sea (EDG, CHI, TAR); note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm
Cells Surveyed	85	78	96	85	78	96
Min	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	**0.81**	**0.55**	**0.11**	**3.16**	**5.83**	**1.84**
Max	72.03	96.79	24.89	235.52	273.01	356.85

The overall data for the TS indicates that the survey index has decreased for both post-recruits (over 55 mm) from **5.83 in 2020 to 1.84 in 2021** and recruits (under 55 mm) **from 0.55 in 2020 to 0.11 in 2021**. A recruitment peak (i.e. new recruits ~ 25-45 mm or 1 year olds) can be seen in the 2019 survey data, this peak was focused in two key areas at Chickens and Targets which were protected by closures and by 2020/2021 this peak had grown into the fishery (Figure 19). However, **no new recruitment peak is present in 2021** (Figure 19), this is an important consideration when looking at sustainable management over a > 1 year period.

4.3.3.2 Fishing Grounds:

4.3.3.2.1 Targets:

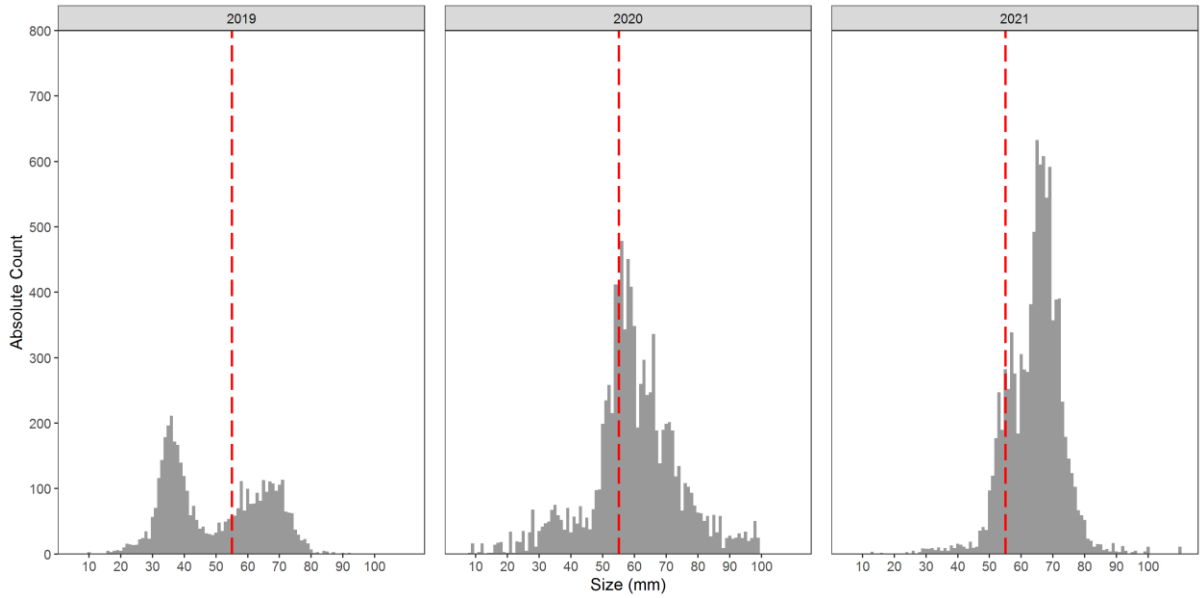

Figure 22: Size density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type for Targets (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Table 4: Juvenile dredge density of QSC per 100 m² split by over and under MLS for the Targets; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm
Cells Surveyed	22	20	24	22	20	24
Min	0.00	0.00	0.00	0.09	0.26	0.09
Geometric Mean	**1.88**	**1.62**	**0.36**	**1.44**	**7.05**	**4.84**
Max	44.82	96.79	24.89	23.19	105.27	182.21

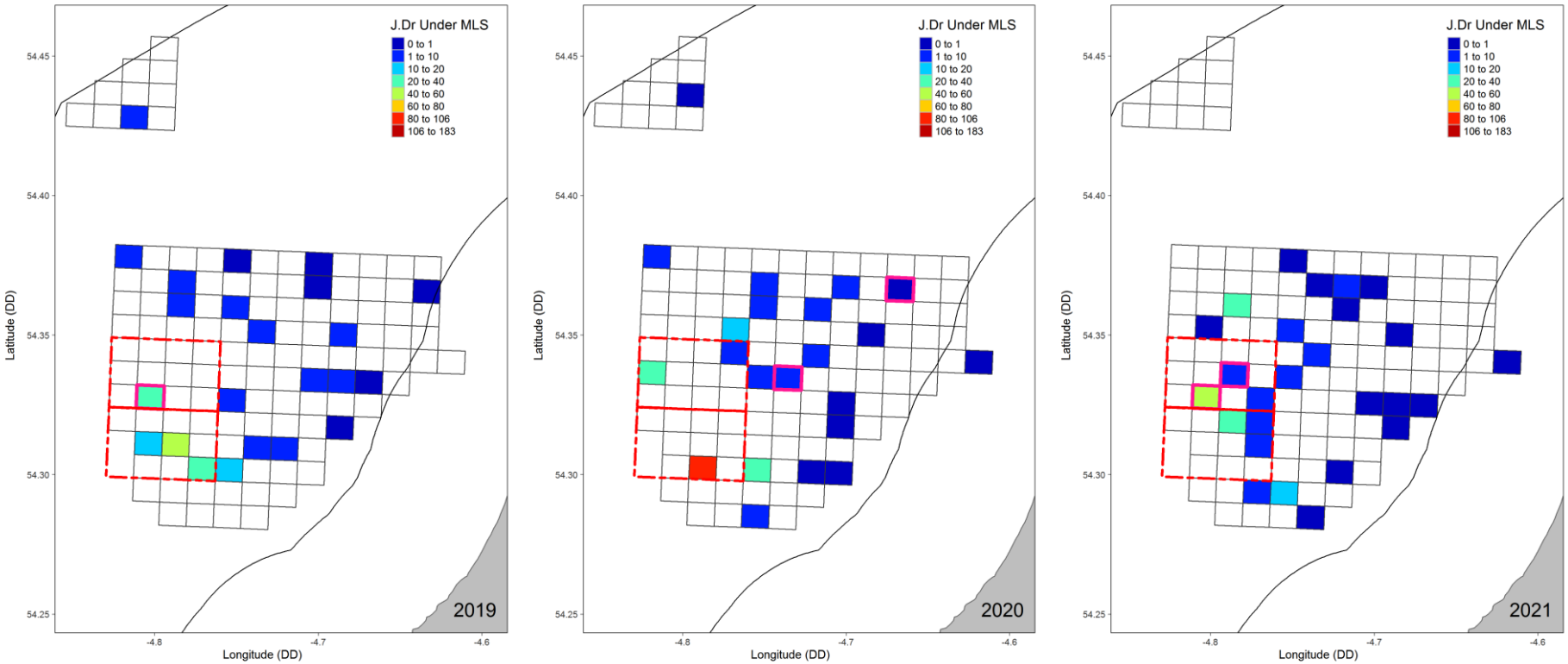

Figure 23: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (left), 2020 (middle) and 2021 (right) at Targets (West coast). The red box indicates the areas closed or with restricted access to scallop fishing in 2019. Pink borders indicate cells that were 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 closed area or hotspot analysis.

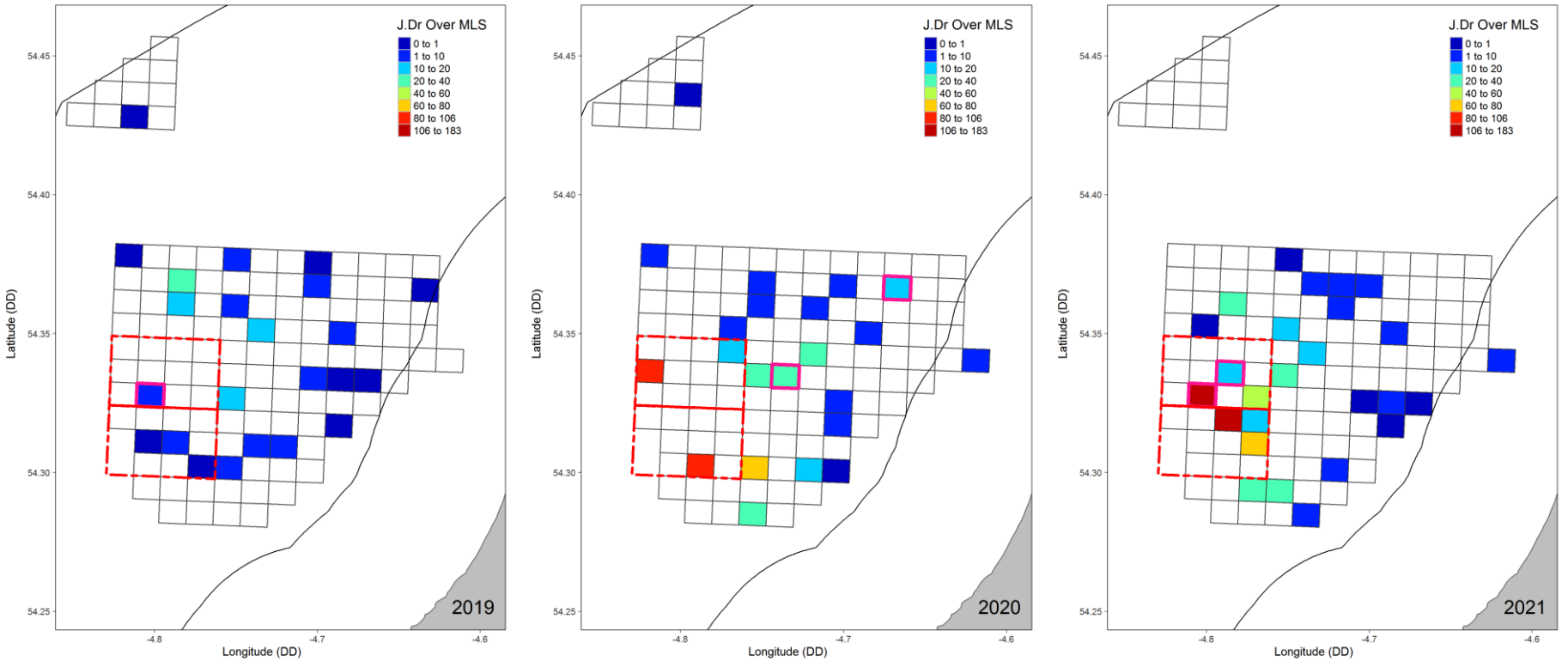

Figure 24: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left), 2020 (middle) and 2021 (right) at Targets (West coast). The red box indicates the areas closed or with restricted access to scallop fishing in 2019. Pink borders indicate cells that were 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 closed area or hotspot analysis).

TAR Managed Areas

Table 5: Juvenile dredge density of QSC per 100 m² split by over and under MLS for TAR Managed Areas; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's)

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm
n	4	3	6	4	3	6
Min	10.04	4.09	2.66	0.09	19.01	14.57
GeoMean	**27.7**	**23.6**	**7.95**	**0.80**	**54.60**	**51.10**
Max	44.82	96.79	45.80	8.79	105.27	182.21

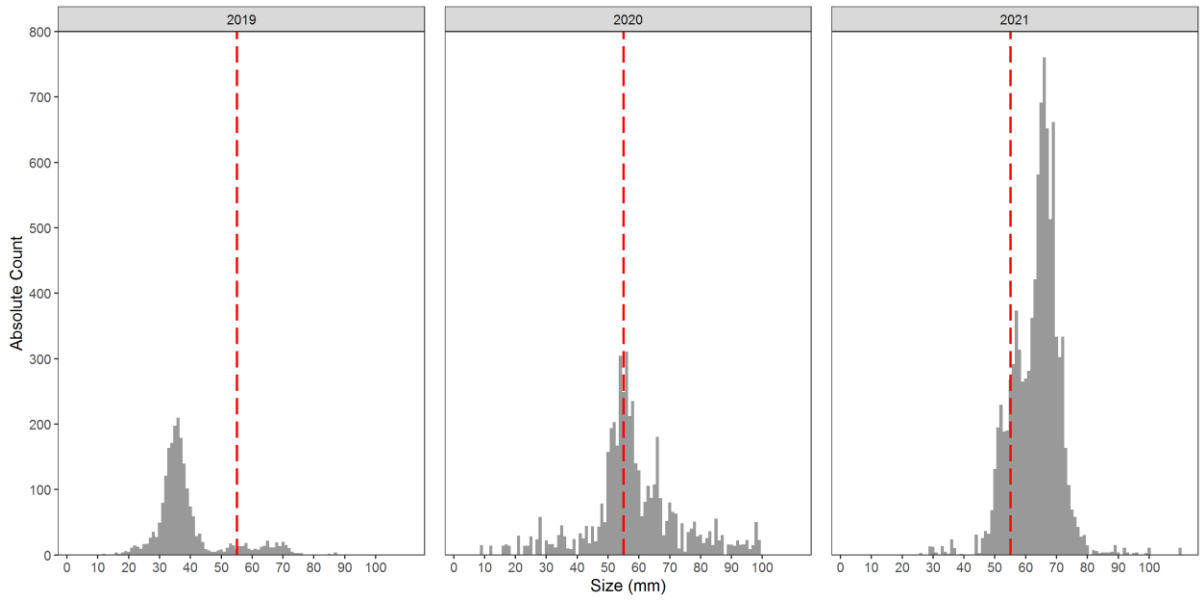

Figure 25: TAR managed area size frequency of absolute counts of queen scallops by cell for 2020 and 2021 using data from all random and targeted survey cells.

For TAR, which supported the largest quantity of landings from 2020 (301 t), the survey index has decreased for both post-recruits (over 55 mm) from **7.05 in 2020 to 4.84 in 2021** and recruits (under 55 mm) **from 1.62 in 2020 to 0.36 in 2021**.

The survey index for the managed areas at TAR (closed area [southern box] and restricted area [northern box] combined), which was closed in 2018 and 2019 to protect high densities of recruit scallops (king and queen), increased significantly for post-recruits for 2020 and 2021 (0.80 in 2019 to 54.60 and 51.10 in 2020 and 2021 respectively) and decreased for recruits (27.7 in 2019 to 23.6 in 2020 to 7.95 in 2021). The shift in abundance indices for recruits and post-recruits is a result of growth within the cohort identified in the 2019 survey, which was protected during the 2019 and 2020 seasons by full closed or restricted access.

The data indicate that there are high densities of queen scallops ≥ 55 mm in both the closed and restricted area with little new recruitment evident (i.e. queen scallops ≤ 55 mm). For the 2021 fishing season it would therefore be appropriate to open both boxes to fishing. It is noted that some form of managed opening (voluntary or statutory) for this high density area should be considered to avoid over fishing within the area.

4.3.3.2.2 Chickens:

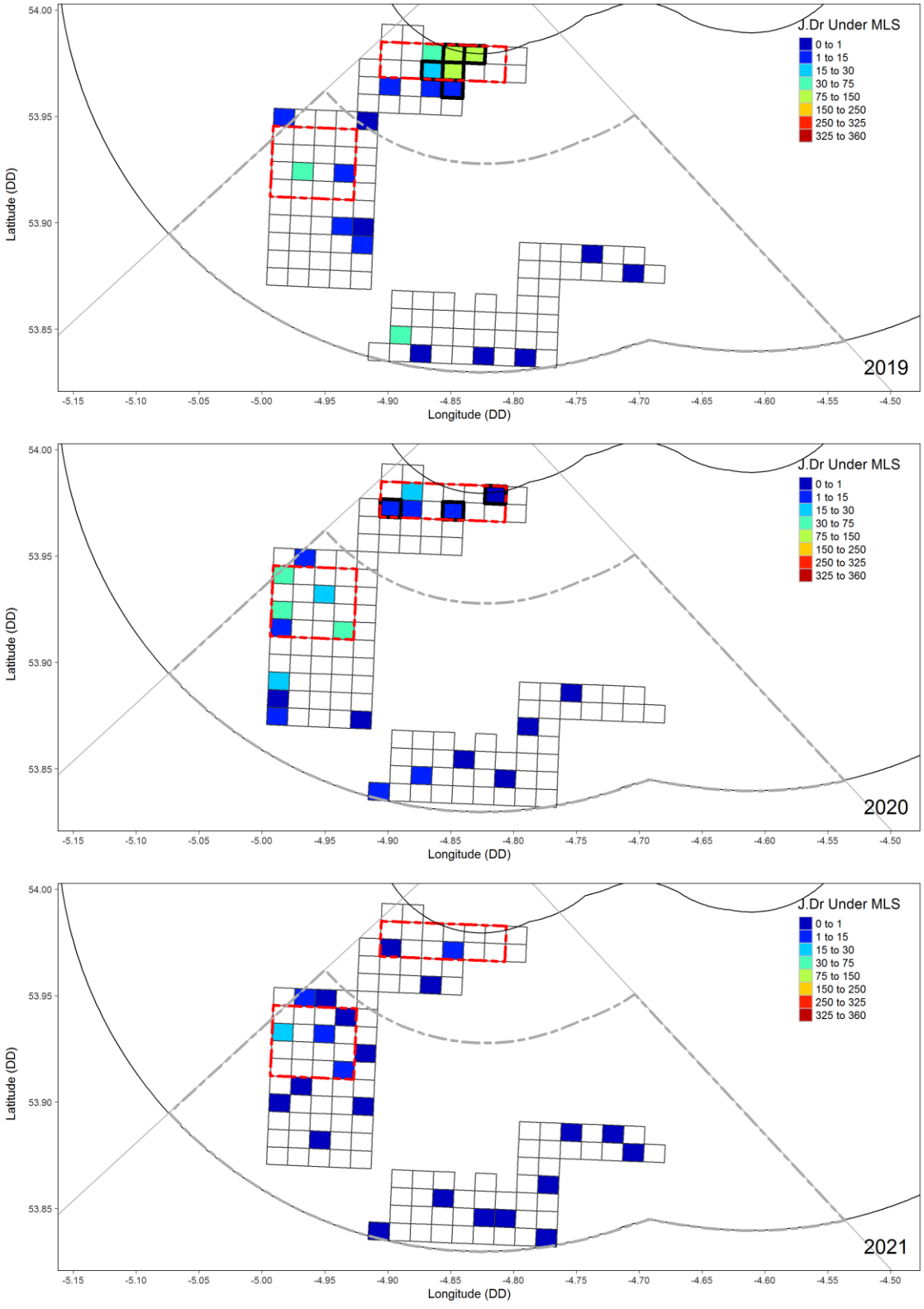

Figure 26: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (top), 2020 (middle) and 2021 (bottom) at Chickens (South coast). The red box indicates the areas closed or with restricted access to scallop fishing in 2019. Black borders indicate cells that 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 closed area or hotspot analysis). The grey dashed lines indicate the area within which queen scallop dredging can occur.

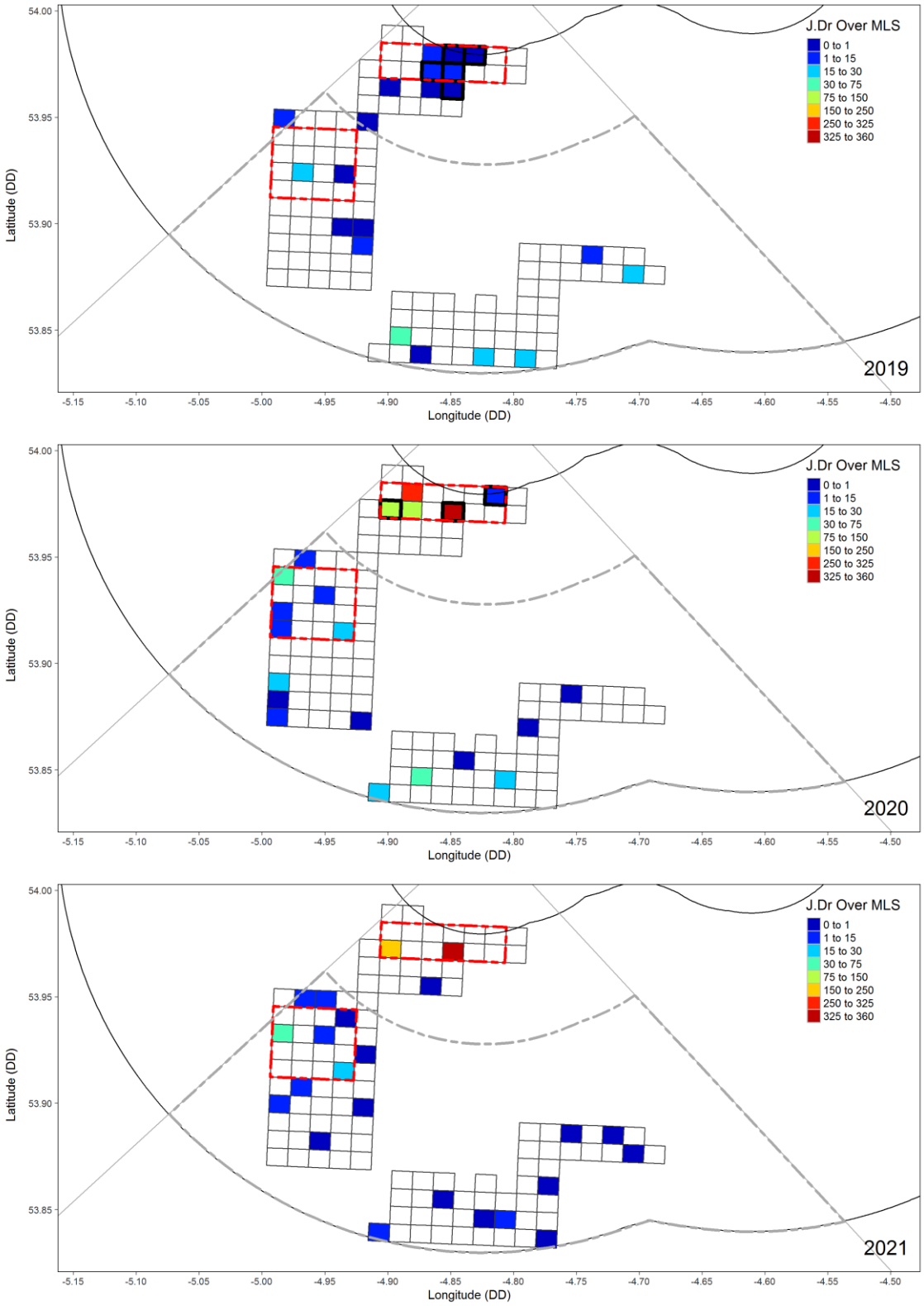

Figure 27: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left), 2020 (middle) and 2021 (right) at Chickens (South coast). The red box indicates the areas closed or with restricted access to scallop fishing in 2019. Black borders indicate cells that 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 closed area or hotspot analysis. The grey dashed lines indicate the area within which queen scallop dredging can occur.

Table 6: Juvenile dredge density of QSC per 100 m^2 split by over and under MLS for the Chickens; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm
Cells Surveyed	16	18	23	16	18	23
Min	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	**1.18**	**1.66**	**0.10**	**1.22**	**3.43**	**0.63**
Max	72.03	72.21	15.20	51.88	273.01	356.85

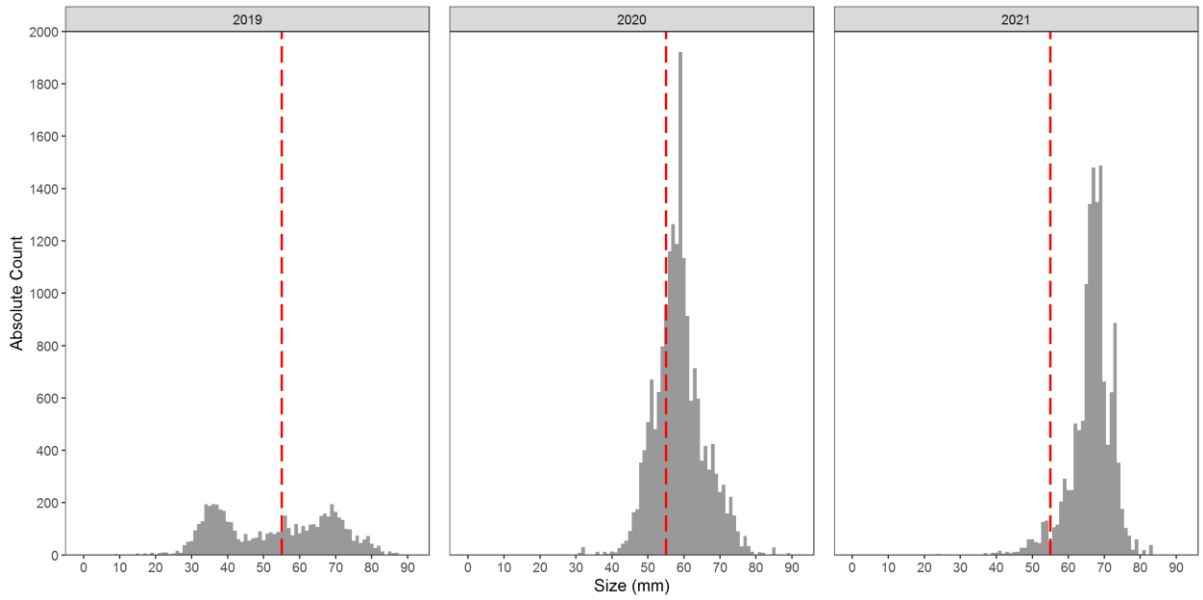

Figure 28: Size density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type for Chickens (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

CHI Managed Areas

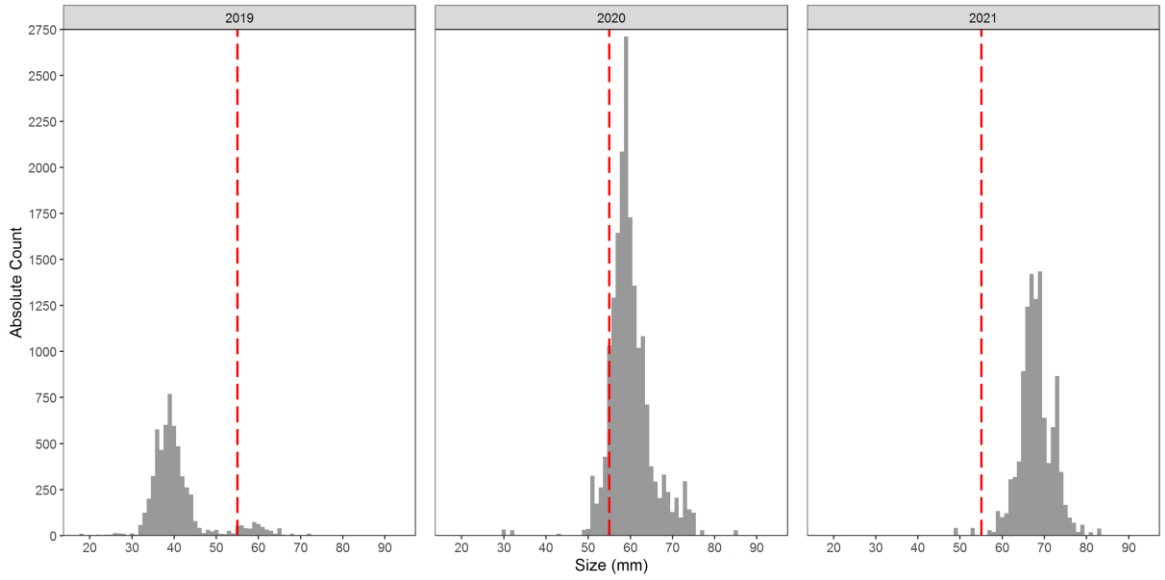

Figure 29: CHI Restricted Area size frequency of absolute counts of queen scallops by cell for 2020 and 2021 using data from all random and targeted survey cells.

Table 7: Juvenile dredge density of QSC per 100 m² split by over and under MLS for the Chickens Restricted Area; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells included.

Restricted Area	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm
Cells Surveyed	5	5	2	5	5	2
Min	27.09	0.43	0.00	0.00	1.71	198.40
Geometric Mean	**62.6**	**6.24**	**0.27**	**0.58**	**71.20**	**266.00**
Max	103.25	20.61	7.36	13.84	326.92	356.85

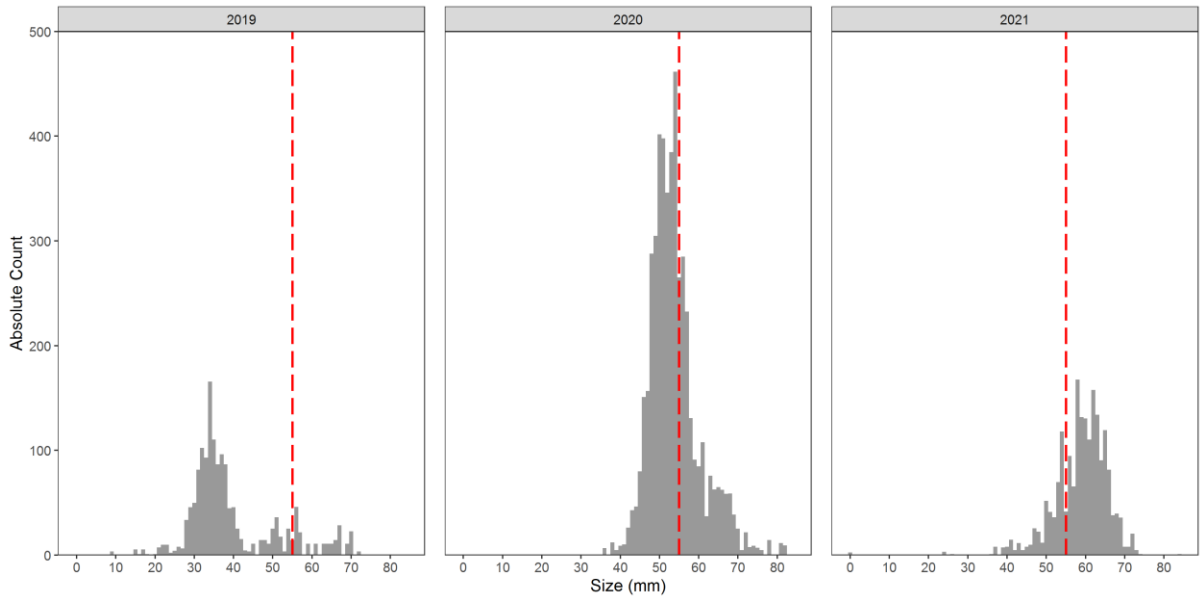

Figure 30: CHI Closed area size frequency of absolute counts of queen scallops by cell for 2020 and 2021 using data from all random and targeted survey cells.

Table 8: Juvenile dredge density of QSC per 100 m² split by over and under MLS for the Chickens Closed Area; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells included.

Closed Area	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm
Cells Surveyed	2	5	4	2	5	4
Min	8.27	2.22	0.18	0.09	2.05	0.36
Geometric Mean	**24.4**	**24.3**	**2.56**	**1.25**	**12.2**	**7.95**
Max	72.03	72.21	15.20	15.69	34.53	48.03

For CHI, which supported the second largest landings in 2020 (214 t), the survey index has decreased for both post-recruits (over 55 mm) from **3.43 in 2020 to 0.63 in 2021** and recruits (under 55 mm) **from 1.66 in 2020 to 0.10 in 2021**.

The survey index for within the area closed during the 2020 fishing season, closed to protect high densities of recruit scallops (queen), saw an decrease for post-recruits (**12.2 in 2020 to 7.95 in 2021**) and a large decrease for recruits (**24.3 in 2020 to 2.56 in 2021**). The shift in abundance indices for recruits is likely a result of growth within the cohort. The decrease in the post-recruit index given that the area was closed to fishing could have been affected by either the laying of a cable through the area during 2020 or a large scale operation by industry to remove queen scallops from the cable route with displacement to other areas of the closed box prior to the cable laying.

The survey index for within the area with restricted access during the 2020 fishing season, where access was restricted to prevent over fishing within this high density area, saw a continued increase for post-recruits (**71.20 in 2020 to 266.00 in 2021**) and a continued decrease for recruits (**6.24 in 2020**

to 0.27 in 2021). The shift in abundance indices for recruits and post-recruits is a result of growth within the cohort identified in the 2019 and 2020 surveys, which was protected during the 2019 season by a closure and the 2020 season through restricted access (*note: the highest recorded densities for from the industry survey were recorded for post-recruits in a closed area targeted tow: 357 queenies per 100 m^2*). The continued high density of post-recruit density in the restricted area would indicate that for queen scallops the area should be again open for fishing during the 2021 fishing season. It is noted that some form of managed opening (voluntary or statutory) for this high density area should be considered to avoid over fishing within the area.

Further declines in survey density within the fishable area (i.e. not within the current closed area) of the queen scallop dredge box from 2019 to 2021 combined with annual decreases in LPUE for dredge vessels within the area (Figure 8) should prompt a discussion on the viability of opening this area to dredge or net fishing in the 2021 season. In addition, a longer term management plan for this fishing area and the dredge metier should be established and implemented as soon as is possible.

4.3.3.2.3 East of Douglas:

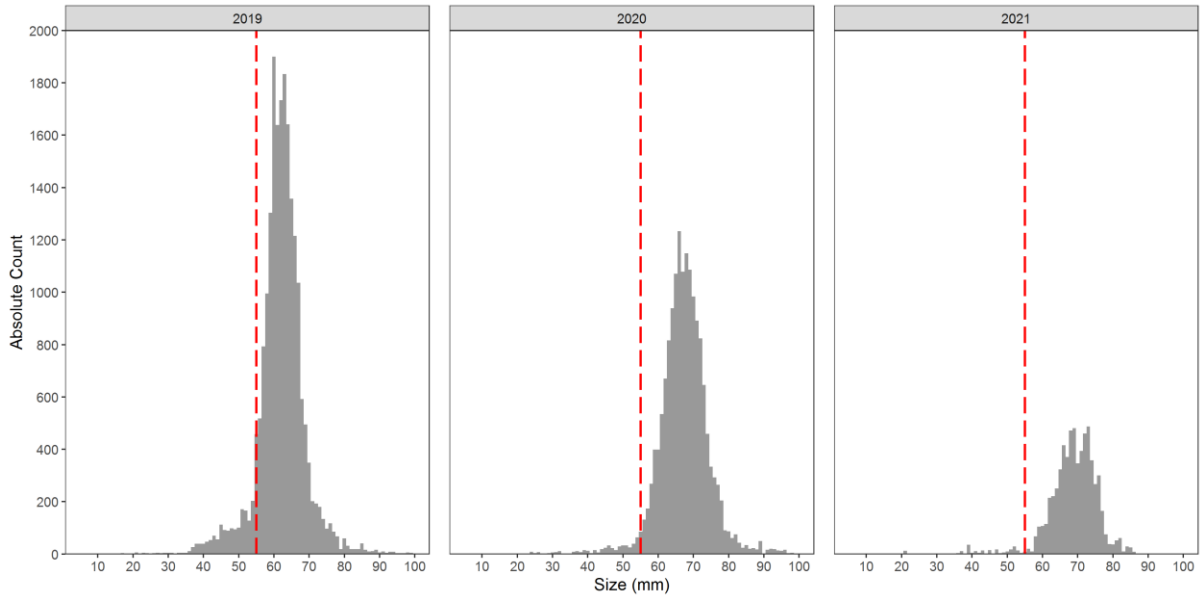

Figure 31: Size density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type for East Douglas (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Table 9: Juvenile dredge density of QSC per 100 m² split by over and under MLS for East Douglas; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm
Cells Surveyed	47	40	49	47	40	49
Min	0.00	0.00	0.00	0.09	0.00	0.00
Geometric Mean	**0.48**	**0.20**	**0.07**	**6.32**	**6.74**	**1.89**
Max	16.30	4.18	10.11	235.52	166.00	135.94

For EDG, which had landings of only 137 t during the 2020 fishing season and was closed to fishing before the end of the season, both the post-recruit (**6.74 for 2020 and 1.89 for 2021**) and recruit index (**0.20 for 2020 and 0.07 for 2021**) declined.

Given the reduction in post-recruit and recruit densities following removal of only ~ 137 t in 2020 and the closure of the EDG ground towards the end of the 2020 fishing season due to declining LPUE it is recommended that a lower amount is harvested from this fishing ground during the 2021 fishing season and that LPUE for this ground is closely monitored against the set thresholds to limit any further significant decline across the entire fishing ground

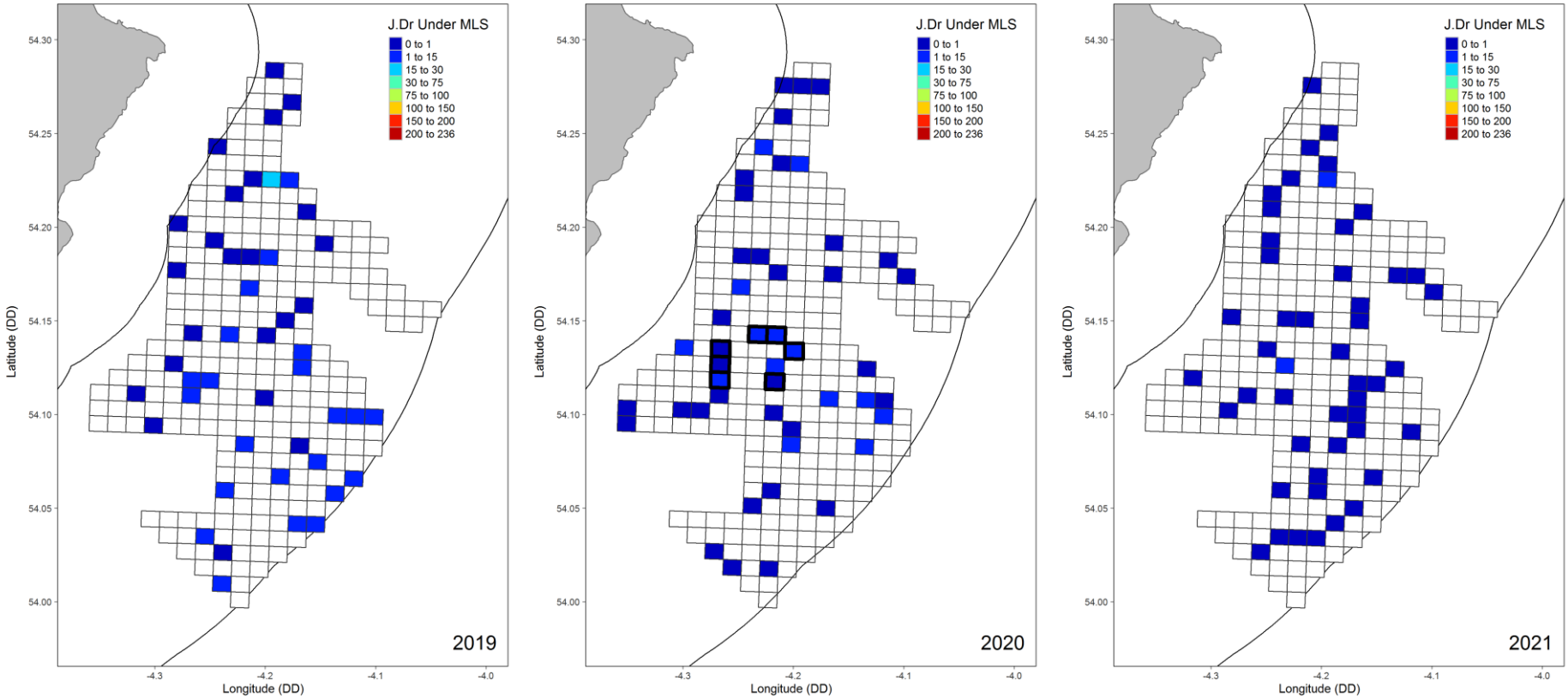

Figure 32: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (left), 2020 (middle) and 2021 (right) at East Douglas (East coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis.

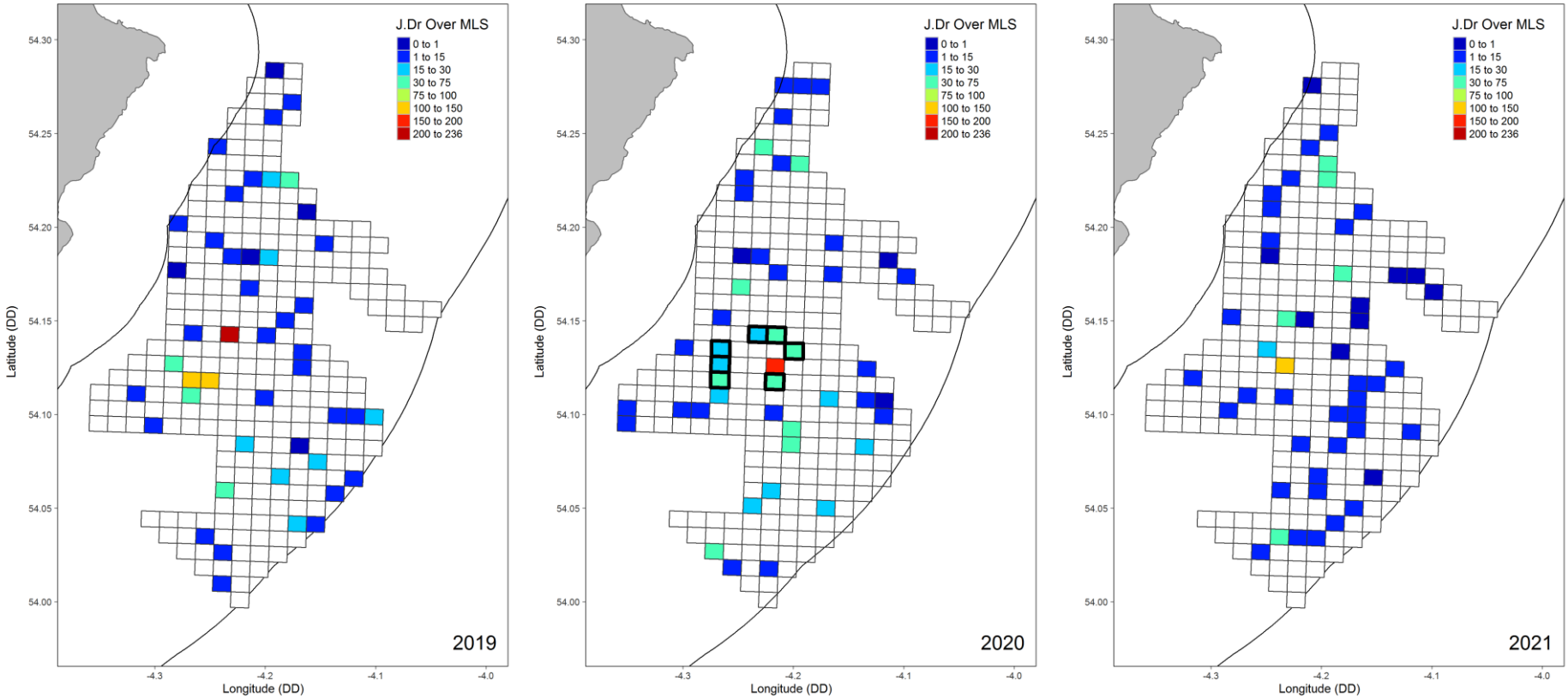

Figure 33: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left), 2020 (middle) and 2021 (right) at East Douglas (East coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis.

4.3.3.2.4 Bradda:

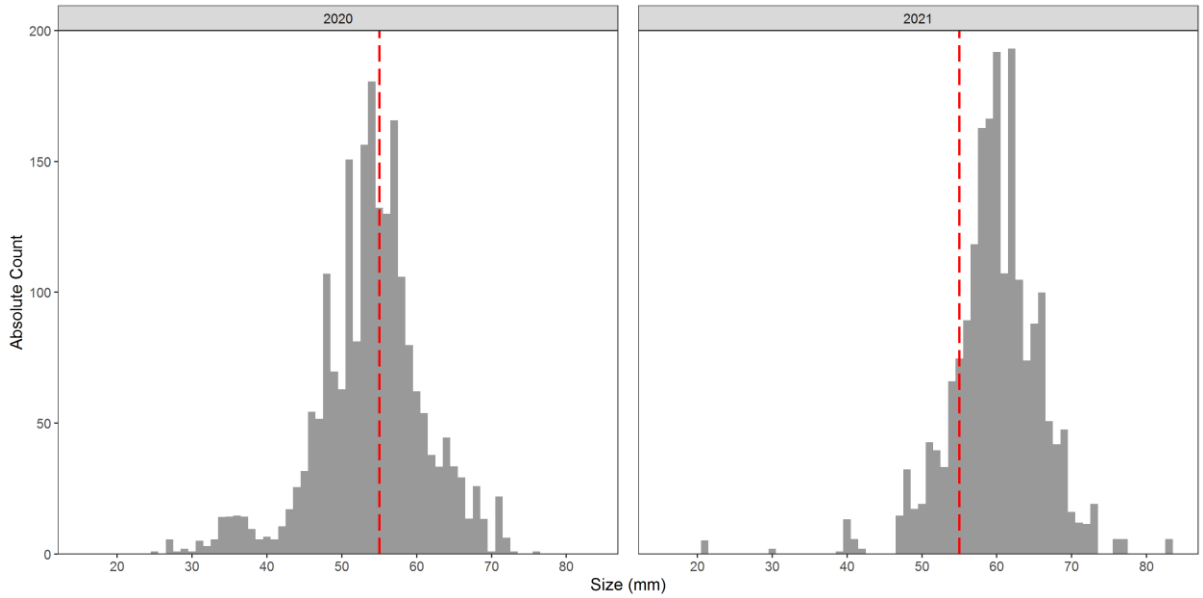

Figure 34: Size density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type for Bradda (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Table 10: Juvenile dredge density of QSC per 100 m^2 split by over and under MLS for Bradda; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2020 < 55 mm	2021 < 55 mm	2020 > 55 mm	2021 > 55 mm
Cells Surveyed	11	8	11	8
Min	0.00	0.00	0.00	0.00
Geometric Mean	**0.69**	**0.34**	**0.55**	**2.25**
Max	37.39	8.09	32.22	47.38

For BRA, which has not had any quantity of recent fishing activity for queen scallops (though historically there has been activity and densities recorded in the longer term survey), there was an increase in the post-recruit index (0.55 in 2020 to 2.25 in 2021) and a decrease in the recruit index (0.69 in 2020 to 0.34 in 2021). For queen scallops this area seems to be a transient rather than permanent bed as it doesn't recruit annually and should be considered as such in any management decisions.

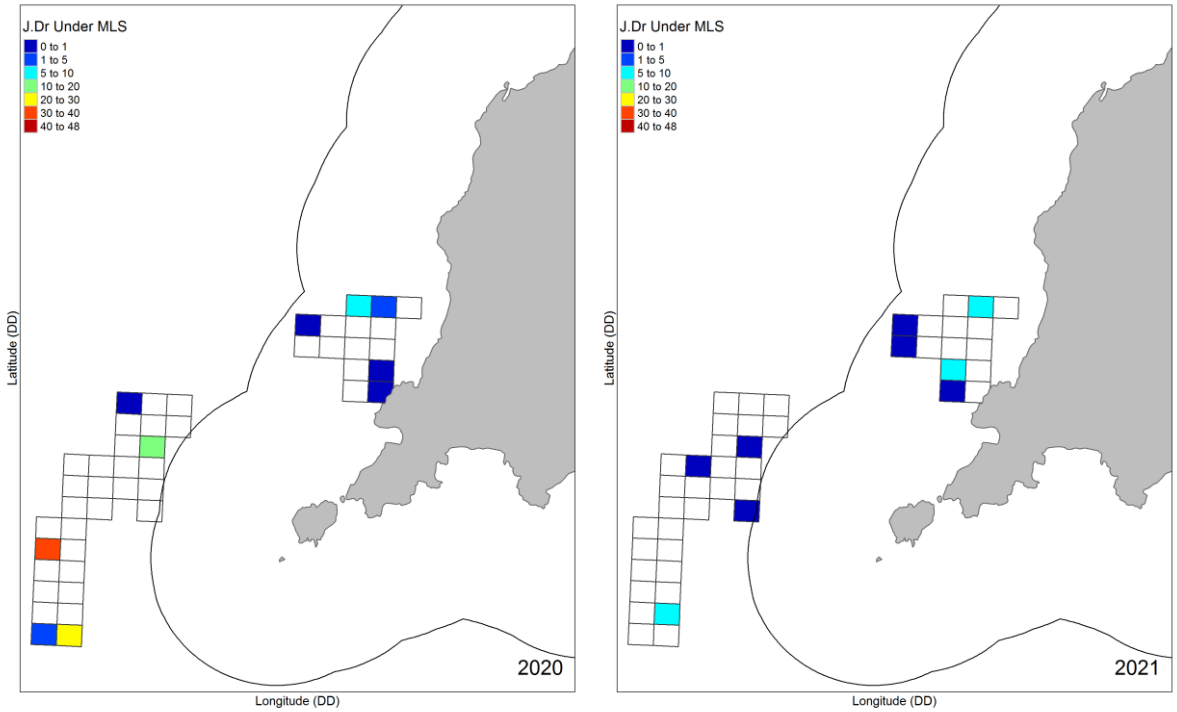

Figure 35: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2020 (left) and 2021 (right) at Bradda (South-west coast).

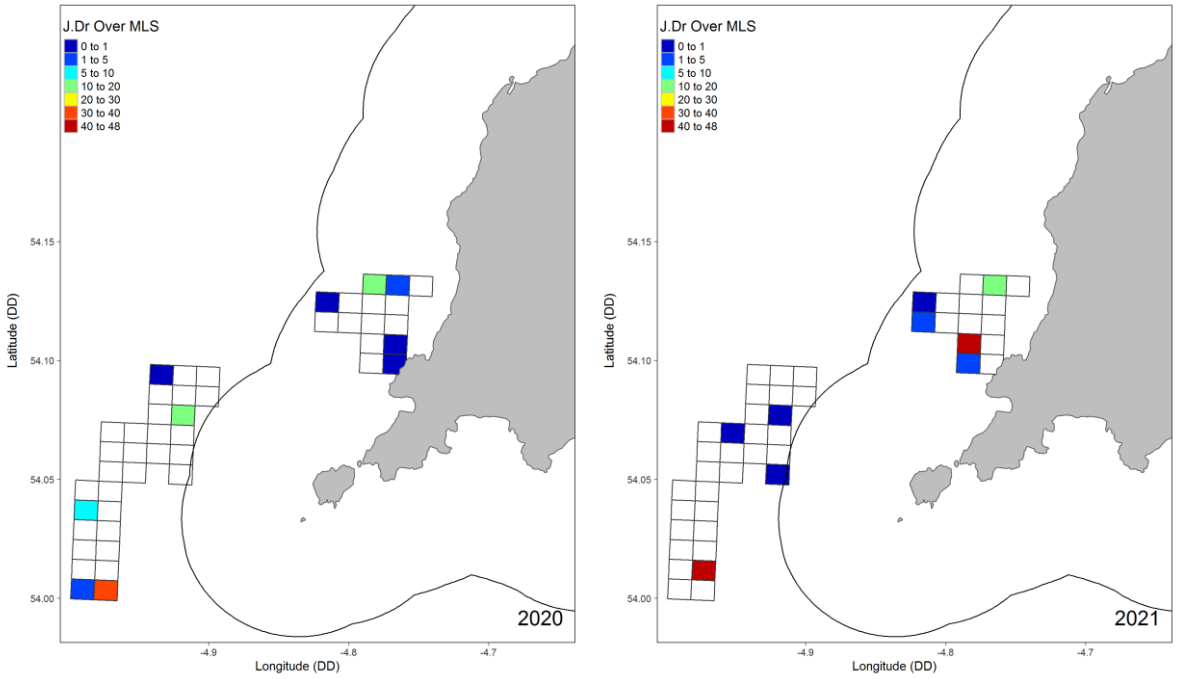

Figure 36: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2020 (left) and 2021 (right) at Bradda (South-west coast).

5. Stock Assessment (CSA):

An annual assessment of the Isle of Man queen scallop stock has been undertaken since 2012 using the Catch-Survey Analysis (CSA) method, first developed by Collie and Sissenwine (1983). Further information on this method and the results from previous stock assessment are presented by Murray and Kaiser (2012a, 2012b), Murray (2013) and Bloor et al., (2014, 2015, 2016, 2017, 2018 and 2019). CSA has been advocated as a valuable method to support management advice where age data is not available (Mesnil, 2003). The CSA method estimates stock size using abundance indices and is generally well-suited to the data available for the Isle of Man's queen scallop fishery. Absolute estimates of stock size and fishing mortality derived from CSA are sensitive to input parameters, although trends over time are more robust to changes in these input parameters (Mesnil, 2003). The stock assessment was implemented using CSA v4.3 (NOAA, 2014). The timing of the survey in spring allows data collection before the main queen scallop fishing season and at a time of year when seawater temperatures mean dredges are a more effective means of sampling queen scallops (Jenkins *et al*., 2003).

Within the stock assessment unit (Isle of Man's territorial waters), the trend from the model output indicates that following five years of increasing biomass (2006-2010), total biomass has decreased during each of the subsequent nine years (2011–2019) before slight increases in both 2020 and 2021 (2021: 2004 t) (Figure 37). *Note, that there is a missing year of survey data for 2020 in the input data.*

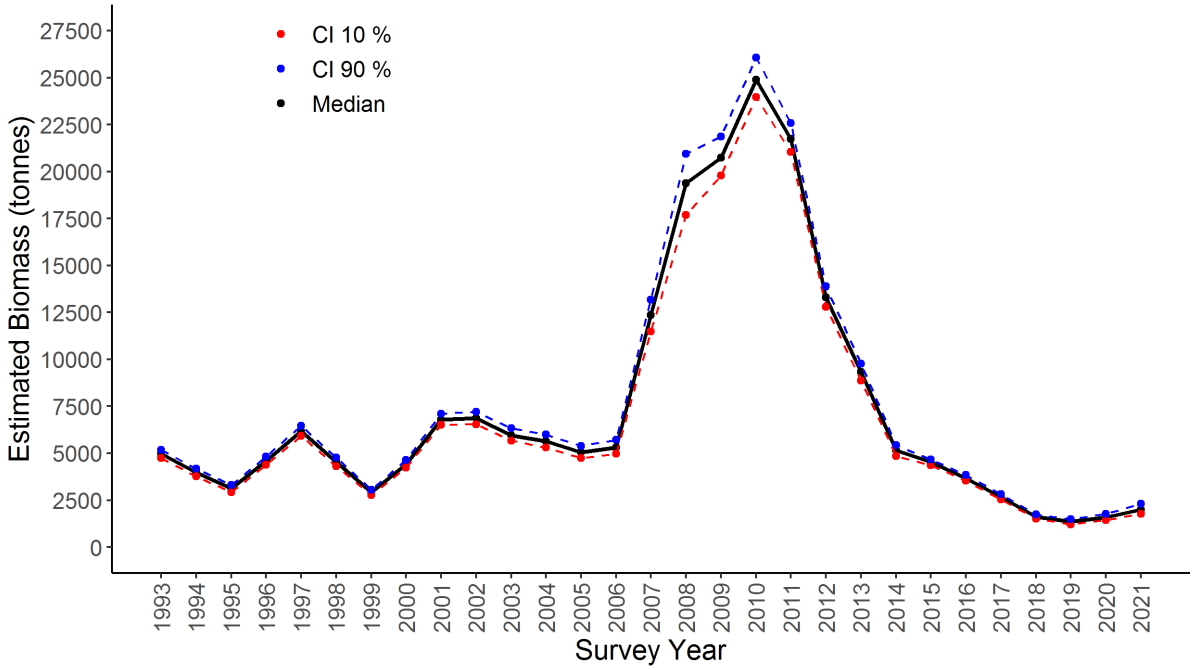

Figure 37: Estimated biomass for the stock assessment unit (Isle of Man territorial waters) MCMC results from CSA Version 4.3

The management currently in place for queen scallops within the Isle of Man's territorial waters has included closing areas of high density juvenile scallops for on-growing which has created spatially discrete high density areas within several fishing grounds. The methods used for the stock assessment down-weights high density isolated patches of queen scallops when calculating the overall stock biomass. As such, assessing the stock at the territorial sea level may be less applicable for the current fine scale spatial management that is in place for queen scallops. Whilst the densities among general fishing grounds remains low and the model indicates only a slight increase in biomass, there are spatially discrete areas within grounds with exceptionally high densities of post-recruits. In this

scenario data assessment and management at a fishing ground level may provide a better basis for on-going spatial management than assessment of the overall stock biomass.

6. Recommendations:

It is not possible to accurately calculate a TAC for the 2021 fishing season using the ICES Category 3 data limited approach due to the year of missing data in the survey abundance index for 2020.

Within the territorial waters there were four temporary managed areas for queen scallops during the 2020 fishing season, for which access has been restricted or prohibited over the last two fishing seasons. These areas, located at CHI and TAR, have the highest densities of post-recruit queen scallops recorded in the 2021 surveys.

Recommendations for the management approach for the 2021 queen scallop fishing season are as follows:

- A precautionary management approach should be considered due to the lack of a TAC calculation and indications of continued low biomass and decreases in the industry survey index for both recruits and post-recruits at the scale of the Isle of Man territorial waters.
- Starting TAC to remain at 2020 fishing levels for the trawl fishery (i.e. 647 t) with the flexibility of decrease or increase depending on the monitoring of high density areas.
- Restricted access and management of the two high density fishing areas at Chickens and Targets that were defined as newly opened areas in 2020. With monitoring of LPUE and fishing intensity (swept area) to ensure that overfishing of these spatially discrete areas does not occur.
- Regular monitoring and triggered reviews of all fishing areas throughout the fishing season in terms of LPUE thresholds that were established for 2020 and total catch.
- Temporary closed areas implemented to protect any high densities of recruits identifies in the survey (i.e. CHI and TAR).
- Closure of POA: The fishing ground was closed during the 2020 fishing season due to low LPUE and the scientific survey data indicates a further reduction in queen scallop density in 2021.
- Closure of the dredge box: LPUE from dredge vessels within the dredge box has been declining annually since 2014 with the lowest value recorded in 2020 and only 1 of the 5 licenced vessels fishing. The current survey data from both the scientific and industry survey in the dredge box indicate lower densities (except for the closed area represented by ST38) for 2021 compared to 2020 and thus a closure for both net and dredge boats is recommended in order to enable stock recovery within this area.

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