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## **Isle of Man Queen Scallop 2022 Stock Survey Report**

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## 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 can 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 2021 fishing season these included:

- Two temporary scallop closed areas where fishing for king and queen scallops was prohibited (Figure 1; hashed boxes at TAR and CHI labelled as Closed Areas).
- Two temporary scallop restricted areas where fishing for king and queen scallops was restricted (Figure 1; grey boxes at TAR and CHI labelled as Restricted Areas).
- Partial closure of East Douglas due to low LPUE (out to 6 nm limit) (start of Week 12)
- 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 (i.e. dredging for queen scallops can only occur within the defined dredge zone; Figure 1).
- Spawning protection closure (1<sup>st</sup> April to 31<sup>st</sup> May)
- Statutory Irish Sea closure (1<sup>st</sup> April to 30<sup>th</sup> June)
- Weekend ban
- Daily curfew (fishing permitted 06:00 – 18:00)
- Minimum landing size (55 mm)
- Weekly catch limits for trawl fishery:
  - maximum of 3150 kg per vessel Weeks 1 - 5;
  - maximum of 4550 kg per vessel from Week 6;
  - maximum of 3640 kg per vessel from Week 12;
  - industry voluntary maximum of 3150 kg per vessel (limit TAC overshoot) for Week 13
- Individual vessel quotas for dredge fishery (11,660 kg per vessel for season)
- Total Allowable Catch:
  - Trawl fishery 661.7 t (Week 1 – 10)
  - Trawl fishery 132 t extension to 793 t (Week 11)
  - Dredge fishery 58.3 t (Season: 1<sup>st</sup> – 31<sup>st</sup> 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.

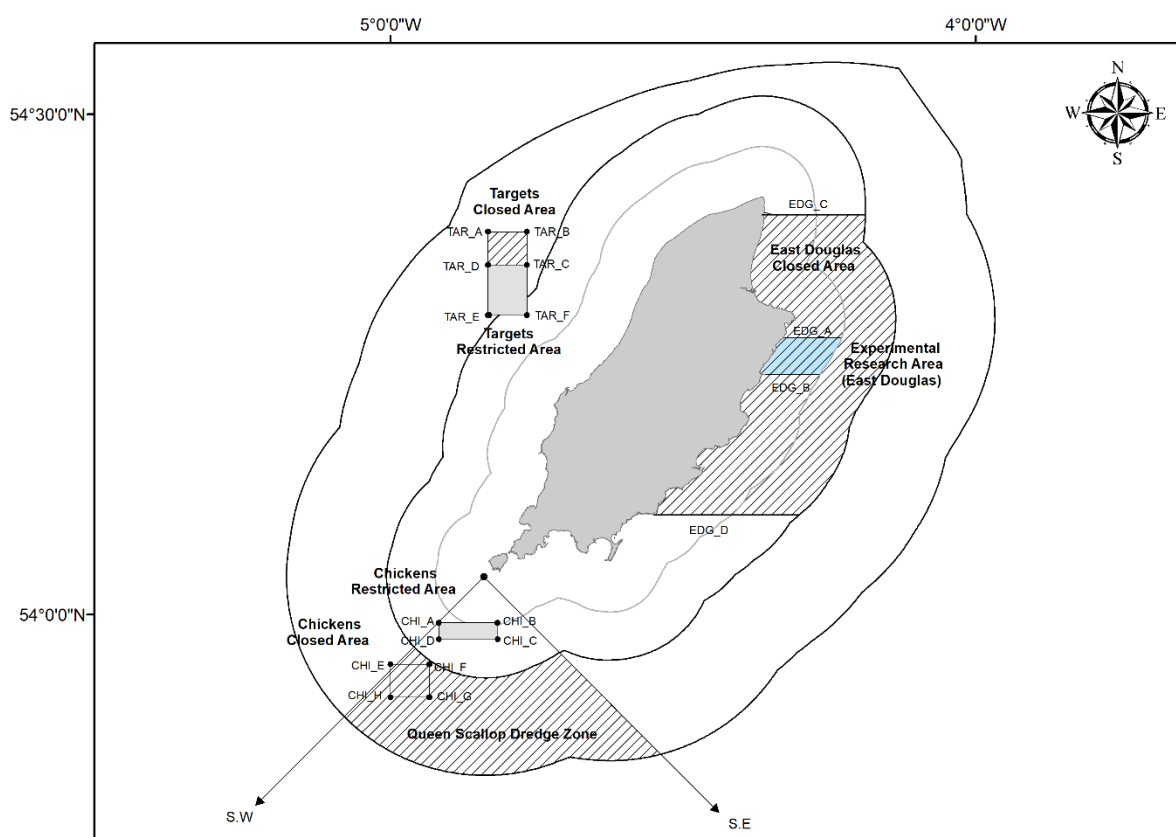


Figure 1: Map showing closed areas (hashed boxes), restricted areas (grey boxes) and EDGERA (blue hatched box) for the 2021 queen scallop fishing season

## 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 – 2019 (data lag of around 2 years) are shown in Figure 2 (ICES 2022a,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 2019 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 1<sup>st</sup> April to 30<sup>th</sup> 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 2019 for queen scallops from the Irish Sea were over 83% lower than landings recorded at the peak in 2011.

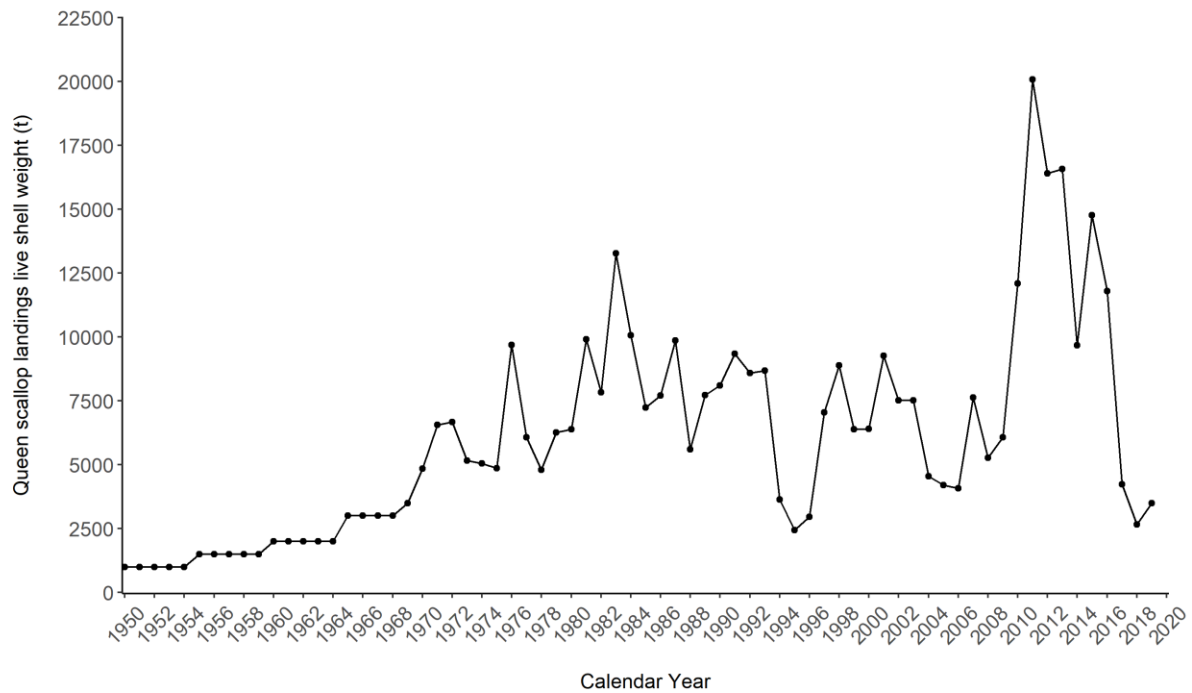


Figure 2: Annual live shell weight queen scallop landings (tonnes) from ICES Area VIIa for 1950 to 2019 using scallop landings from species *Aequipecten opercularis* (ICES 2022a,b).

## 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) followed by an increase in 2021 to 1872 t.

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 before increasing again to 997 t in 2021. The trawl fishery has seen a reduction in landings from a peak of 4517 t in 2013 to 579 t, 629 t and 875 t in 2019, 2020 and 2021 respectively. In 2020 the trawl fishery had a higher proportion of landings than the dredge fishery for the first time with almost 50 % of landings contributed by either gear in 2021 (2011 to 2021; Figure 4).

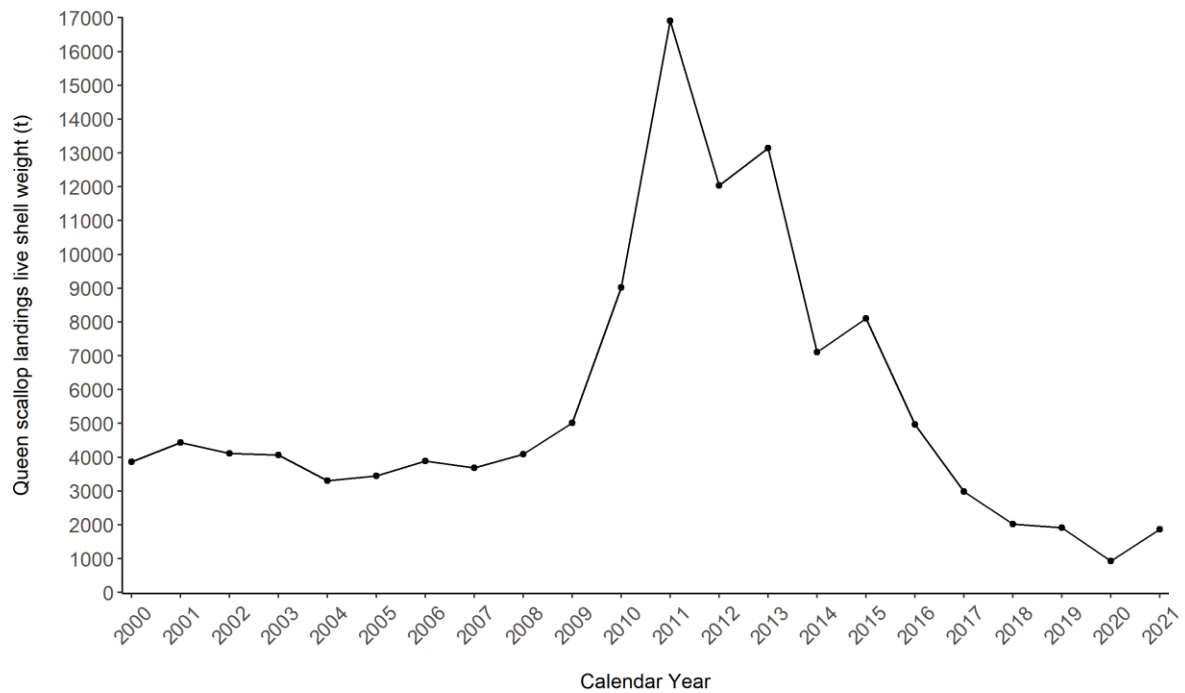


Figure 3: Annual live shell weight queen scallop landings (tonnes) from ICES Rectangles 36E5, 37E5 and 38E5 for 2000 to 2021 (Source: Paper logbook data DEFA and IFISH 2 Database).

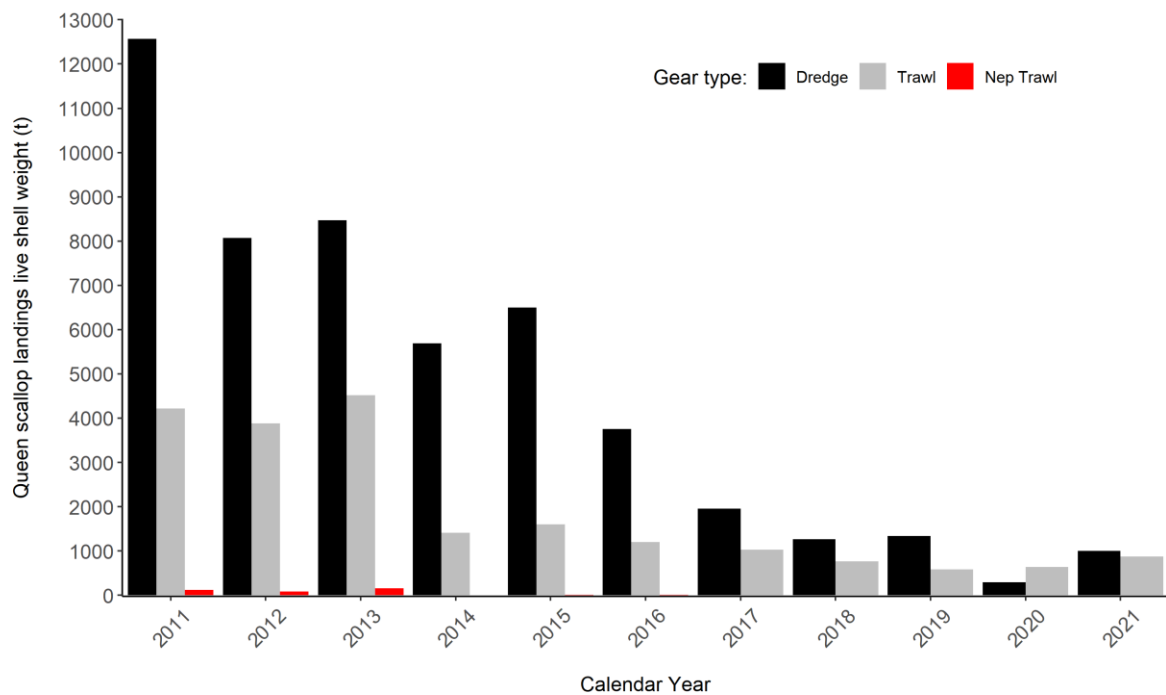


Figure 4: Annual live shell weight queen scallop landings (tonnes) from ICES Rectangles 36E5, 37E5 and 38E5 for 2011 to 2022 (Source: IFISH 2 Database) split by Gear type.

### 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 2021 Isle of Man queen scallop fishery had a TAC of 851.3 t. The TAC was fished by two separate metiers: Trawl fishery (32 eligible vessels) and dredge fishery (5 eligible vessels).

The trawl fishery had an initial sub TAC of 661.7 t (increased to 793 t during Week 11 of the trawl fishery for socio-economic reasons) and opened on 1<sup>st</sup> July 2021 and closed on 27<sup>th</sup> September 2021. For the trawl fishery a weekly catch limit of 3150 kg was implemented for Weeks 1-5. For socio-economic reasons, from Week 6 of the fishery the weekly catch limit was increased to 4550 kg per vessel which was then decreased to 3640 kg from Week 12 (a voluntary reduced catch limit of 3150 kg was then established by industry for Week 13 to limit any TAC overshoot). Total reported landings for the trawl fishery during the 2021 fishing season were ~ 818.36 t with 24 unique vessels reporting landings. The majority of landings came from Chickens and Targets (Table 1). In 2021 0 t was landed from the Ramsey Bay permit only fishery which has its own total allowable catch and 0 t was landed from Chickens as part of the dredge fishery in October 2021.

*Table 1: Landings by ground for the 2021 queen scallop fishery (trawl and dredge)*

Area	Landings (t)
IS21: Chickens	517.9
IS9: Targets	264.6
IS10: Maughold	17.6
IS15: East Douglas	16.7
IS14: BRA/PSM	1.5

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) and Targets (IS 9) had the highest LPUE across the season within the newly opened restricted area (median weekly LPUE values of ~ 10 – 20 for CHI and 9 – 26 for TAR). The mean weekly LPUE for all other grounds (EDG, BRA, PSM and MGH) was typically below 5 bags (35 kg) per hour fished per 10 fathom of net (Figure 5).

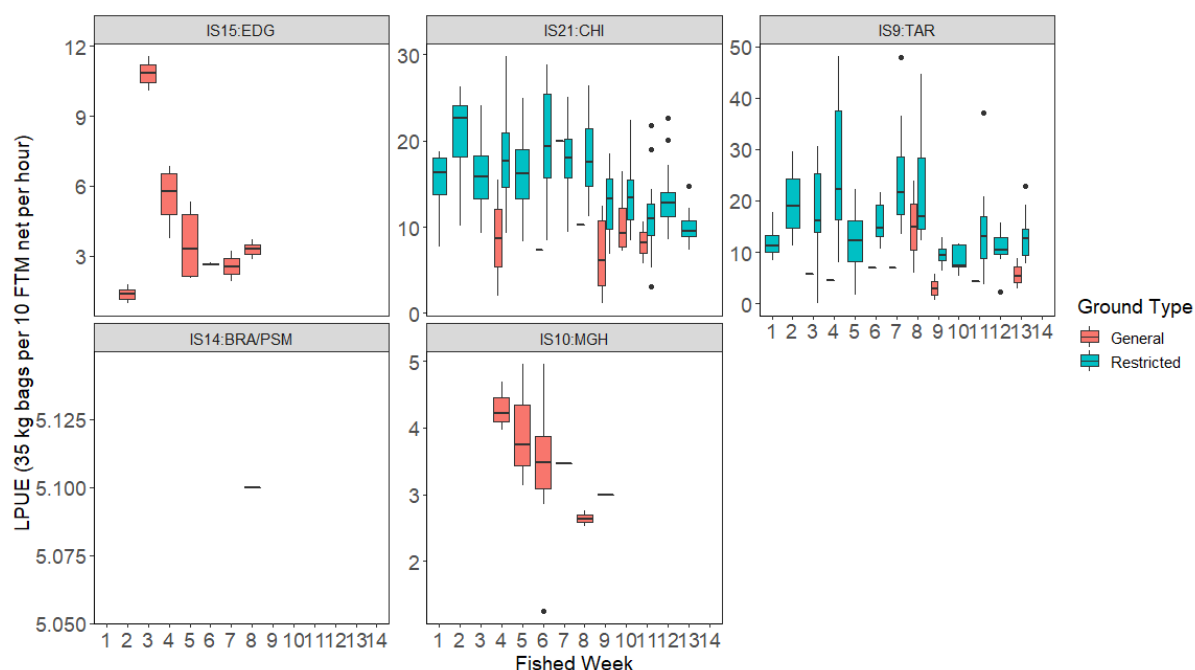


Figure 5: A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for the 2021 queen scallop trawl fishing season displayed by week and main fished ground. For TAR and CHI fishing grounds the vessel trips are split further into the general fishing area and the newly opened 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 2021 in Figure 6. The boxplot indicates that with the exception of 2015, the median LPUE for the 2021 fishery was higher than all other years for this period (Figure 6). Fishing within the high density newly opened restricted access areas at Chickens and Targets largely contributed to the increase in median LPUE for 2021 (Figure 5).

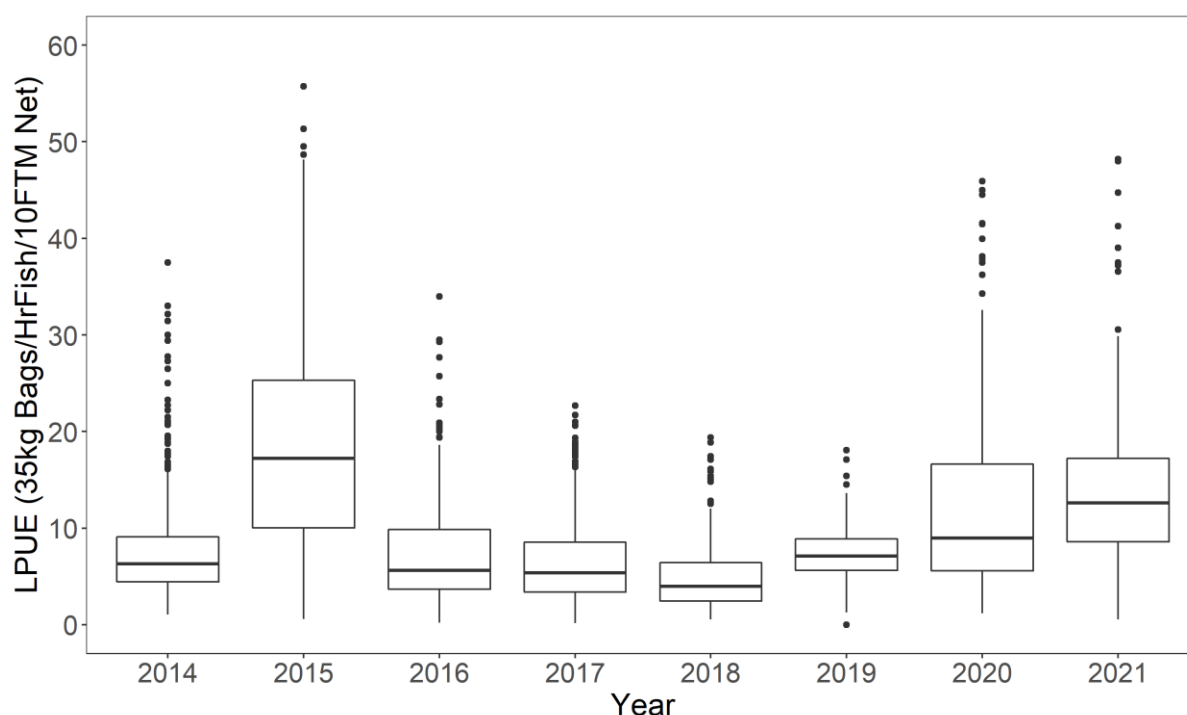


Figure 6: A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for all vessel trips by fishing season from 2014 to 2021.



When the data is displayed by fishing ground and season, the median LPUE at Targets was the second highest recorded in the eight year period (Figure 7). The median LPUE at Chickens for 2021 was the third highest in the eight years that there is data (Figure 7). However the East Douglas ground was closed out to the 6 nm limit mid-season due to substantial declines in LPUE during the 2021 fishing season. There was no fishing at Point of Ayre or Ramsey Bay during the 2022 season (Figure 7).

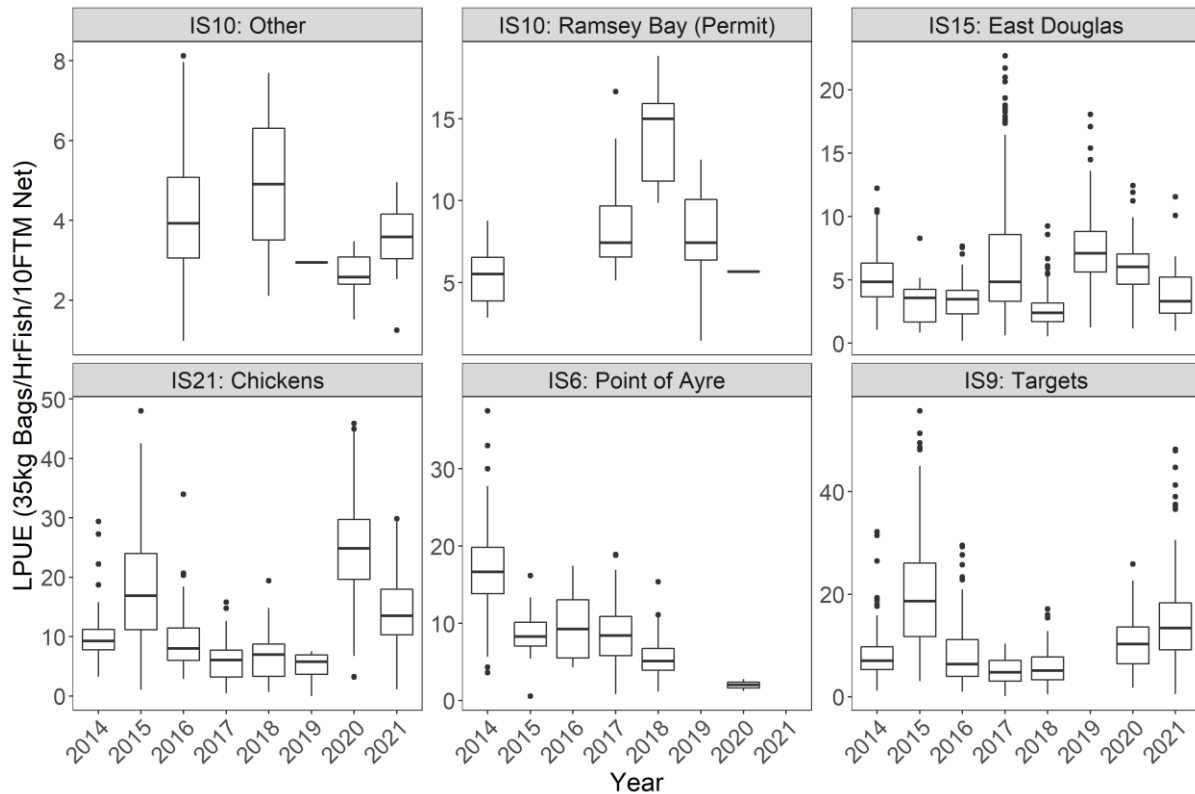


Figure 7: A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for all vessel trips by season and split by fishing ground from 2014 to 2021.

The dredge fishery had a sub TAC of ~58.3 t and opened on 1<sup>st</sup> October 2021. For the dredge fishery each eligible vessel was allocated an individual quota of 11,660 kg which could be fished during the season as and when suited by the vessel. Total reported landings for the dredge fishery during the 2021 season were 0 t with 0 of the 5 licenced vessels licenced reporting landings. Prior to 2021, LPUE for the dredge fishery had seen annual declines in LPUE with the lowest value (based on a single trip) recorded in 2020 (Figure 8).

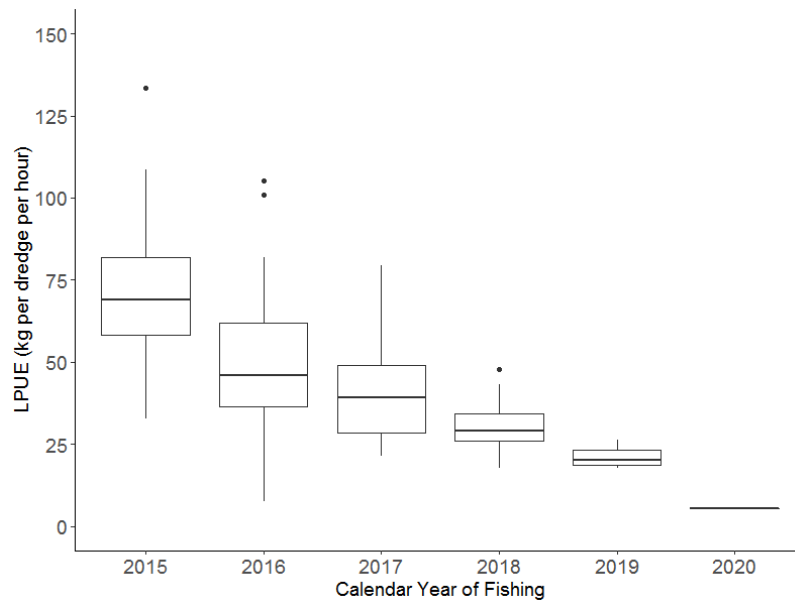


Figure 8: LPUE standardised to kg per dredge per hour for dredge vessels participating in the Isle of Man queen scallop dredge fishery which occurs within the dredge box located within the CHI fishing ground from 2015 to 2020 (note no landings reported in 2021).

## 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 collection has continued since 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 2022 survey included the four main fishing grounds (East of Douglas [EDG], Chickens [CHI], Targets [TAR] and Point of Ayre [POA]), and further survey work was also undertaken at a transient ground at Bradda [BRA] and within the East of Douglas Experimental Research Area [EDGERA] which has been closed since July 2017.

The long-term survey data has been used annually to undertake a quantitative length-based stock assessment using the catch survey analysis (CSA) approach 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.

## 4.2 Prince Madog Annual Spring Survey:

### 4.2.1 Survey Methods:

Spring surveys of the Isle of Man's scallop populations have been undertaken annually since 1992 (Beukers-Stewart et al., 2003). The 2022 spring scallop survey was undertaken by the R.V. Prince Madog over 9 days from 2<sup>nd</sup> – 10<sup>th</sup> April 2022. A total of 47 survey stations were sampled (Figure 9). The standard survey gear comprises of a set of four Newhaven dredges: two with 75 mm belly ring diameter and 9 teeth of 110 mm [king dredges] and two with 55 mm belly ring diameter and 10 teeth of 60 mm [queen dredges]. At each station the dredges are towed at 2.5 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).

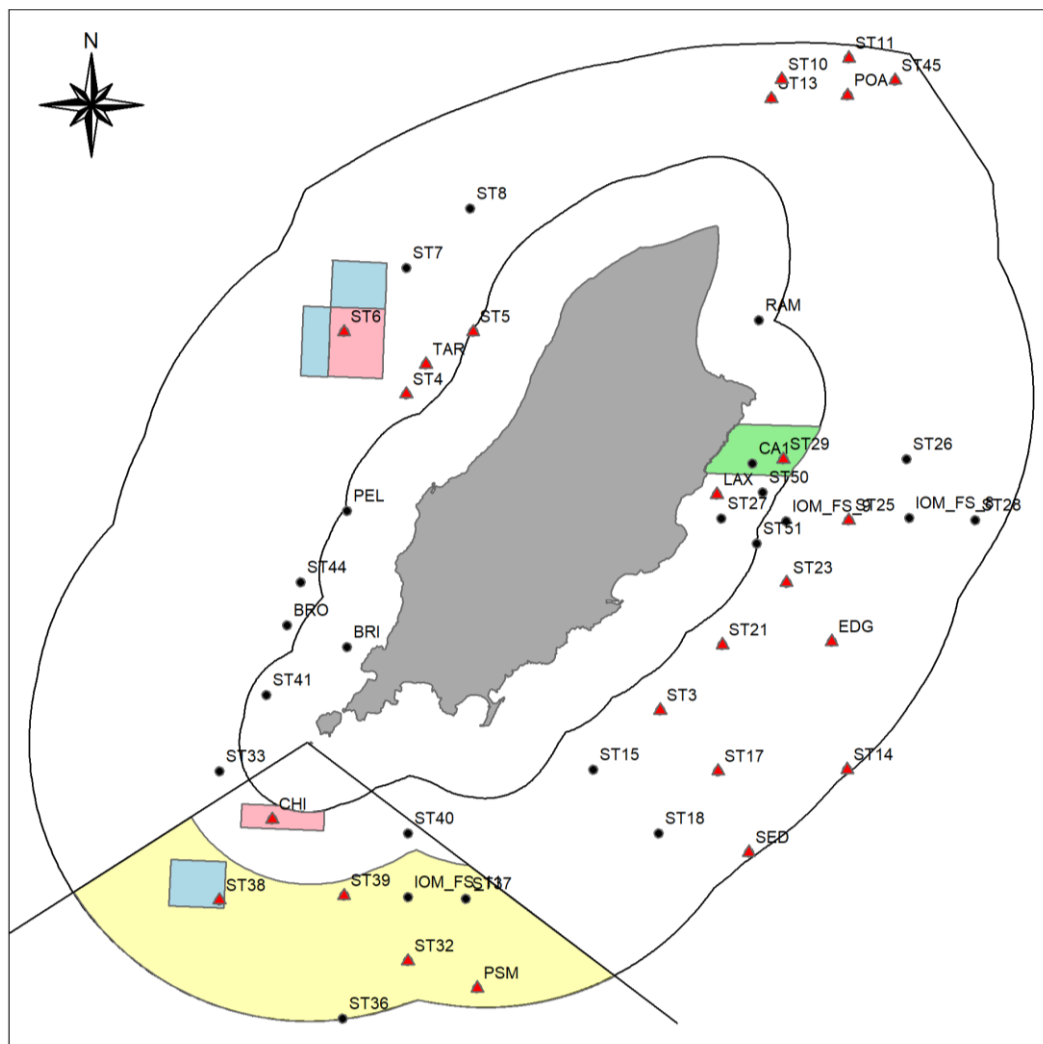


Figure 9: A map showing the location of all 2022 survey stations (red triangles = Stations used in stock assessment and survey abundance indices; black circles = Additional survey stations). During the 2021 queen scallop fishing season light pink boxes indicate areas with restricted management; light blue boxes indicate closed areas, the green box indicates the experimental research area at East Douglas closed since July 2017 to allow recovery 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 stock assessment stations (queen scallop dredge data only). Queen scallops  $\geq 55$  mm represent post-recruits (i.e. queen scallops that are already at or above the minimum landing size (MLS) of 55 mm). Queen scallops  $< 55$  mm represent recruits (i.e. queen scallops under MLS), some of which will be large enough to grow into the fishery during the upcoming fishing season (i.e.  $\geq 45$  mm) and some of which will not reach MLS until next year's fishery.

In 2021 and 2022 there is a well-defined peak in post-recruit queen scallops (55 – 85 mm) in the data. In 2022 there is also a proportion of queen scallops within the size range that might grow into the fishery during the season (i.e. between 45 - 55 mm) (Figure 10).

In 2022, the data indicates a well-defined peak in recruiting queen scallops (i.e. 15-45 mm) which was absent in 2021, this should be considered when looking at sustainable management over a  $> 1$  year period and when discussing potential closures for areas containing high densities and proportions of queen scallop recruits.

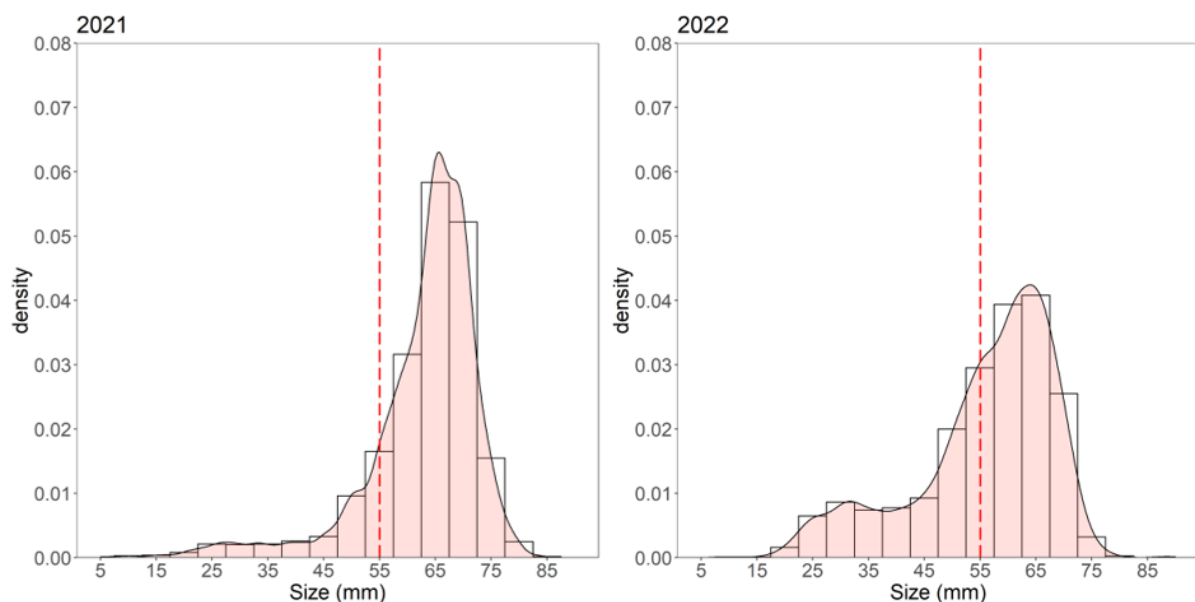


Figure 10: Queen Scallop size frequency-density plot for 2021 and 2022 Prince Madog survey data. Data from stock assessment sites and queen scallop dredges only.

By splitting the data into main fished grounds (i.e. individual stations grouped into fishing grounds), the pattern of recruitment indicates peaks of recruits at the majority of fishing grounds (TAR has the lowest densities of recruits) with CHI, EDG, SED and POA all having substantial proportions of queen scallops under 55 mm (Figure 11).

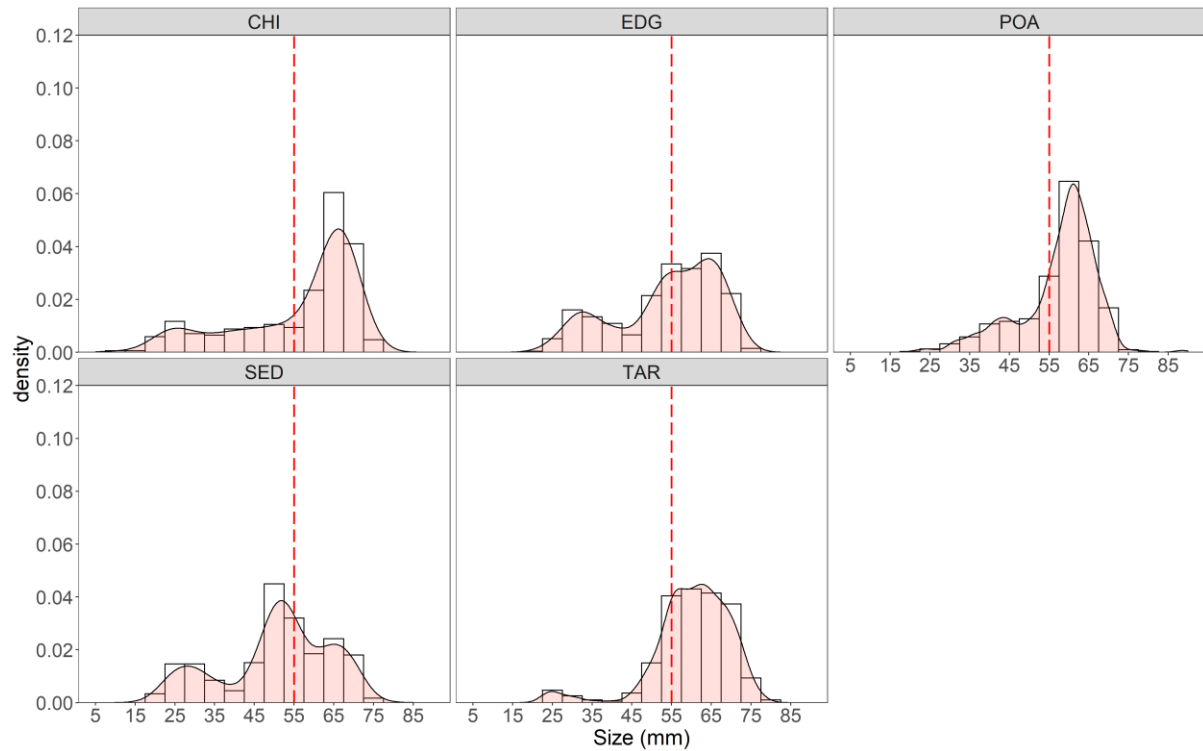


Figure 11: Queen Scallop size frequency-density plot for each ground for the 2022 Prince Madog survey data. Data from stock assessment sites and queen scallop dredges only. CHI: Chickens, EDG: East of Douglas, POA: Point of Ayre, RAM: Ramsey Bay, SED: South East of Douglas and TAR: Targets.

#### 4.2.3 Density estimates:

The mean density (scallop per 100 m<sup>2</sup>) of queen scallops from queen scallop dredges for all stations surveyed is displayed in Figure 12. The two survey sites with the highest densities are ST6 (west coast; 192 queen scallops per 100m<sup>2</sup>) and POA (north coast; 49 queen scallops per 100m<sup>2</sup>). ST6 is located within a current restricted access area (Figure 9 and Figure 12).

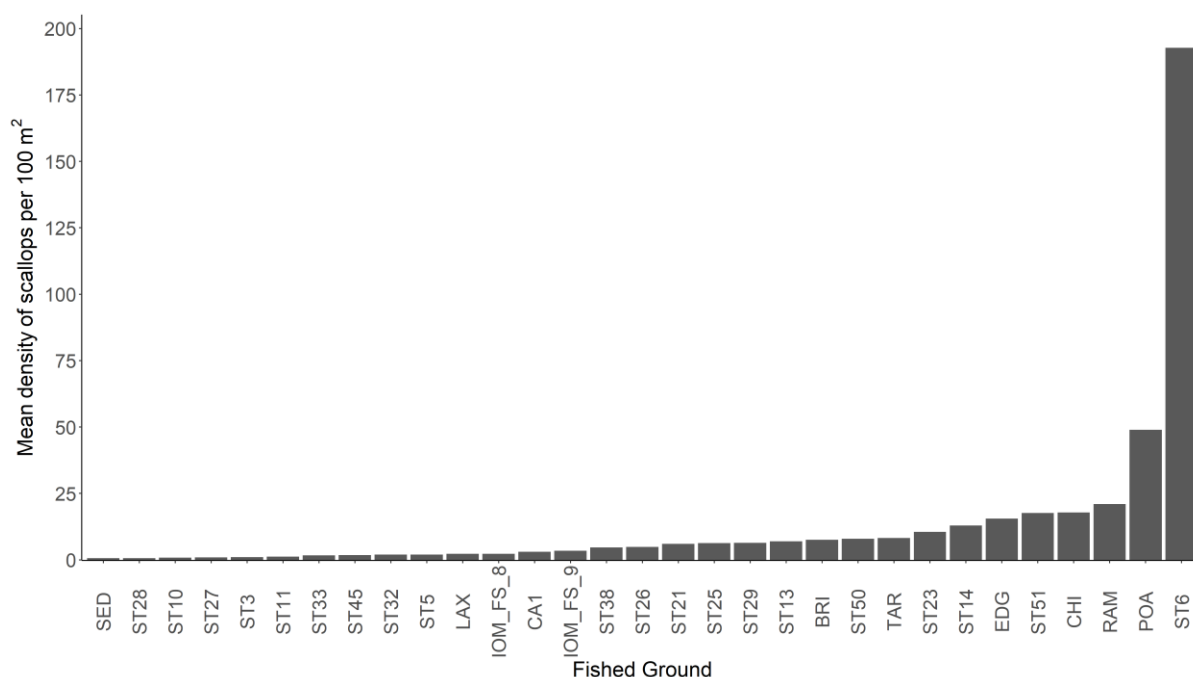


Figure 12: Average survey density (scallops per 100m<sup>2</sup>) of queen Scallop from queen scallop dredges from all sites surveyed during the 2022 Prince Madog survey. For plotting purposes sites where QSC density was > 0.45 scallops per 100 m<sup>2</sup> are not displayed (see figure 9 for station locations)

Stations that have been sampled over at least three years and at which queen scallops are present (3, 4, 5, 6, 9, 10, 11, 13, 14, 17, 21, 22, 23, 24, 25, 29, 32, 35, 38, 39 and 45), in addition to the standard historical queen scallop survey stations (CHI, EDG, LAX, POA, PSM, SED and TAR), were included in the current stock assessment (Figure 9). Please note that the inclusion of stations has been updated for 2022 to include or exclude relevant stations (Table 2). 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.

Table 2: Changes to sites included in the stock assessment stations for 2022 with reasons for removal or addition

Site	Action	Reason
ST36	Removed	Historically consistently low QSC densities
RAM	Removed	Separate survey and TAC (permit only fishery)
ST20	Removed	Brittle Star bed that can't be surveyed; removed from survey
ST6	Added	In first three years of surveying low QSC densities but has consistently had higher densities in recent survey years (at least 3 years)
ST11	Added	Now has over three years of data and consistently supports QSC densities
ST13	Added	Now has over three years of data and consistently supports QSC densities
ST29	Added	Now has over three years of data and consistently supports QSC densities

The differences in mean survey density (scallops per 100 m<sup>2</sup>) of queen scallops from queen scallop dredges between 2021 and 2022 are displayed for all stations used in the stock assessment in Figure 13. The highest density increases are on the west and north of the Island where densities have increased at ST6 and POA by 131 and 42 scallops per 100 m<sup>2</sup> respectively (Station 6 is located within a managed area that had restricted access [i.e. max 5 vessels fishing per day] during the 2021 queen scallop fishing season due to high densities recorded in the 2021 survey). The highest decreases in density are on the south of the Island where densities have decreased at CHI and ST36 by 121 and 39 scallops per 100 m<sup>2</sup> respectively (the high density station of CHI was located within a managed area

during the 2021 season [i.e. max 5 vessels fishing per day] but landings across the season were still relatively high (483 t) leading to a decrease in density recorded at this station in 2022).

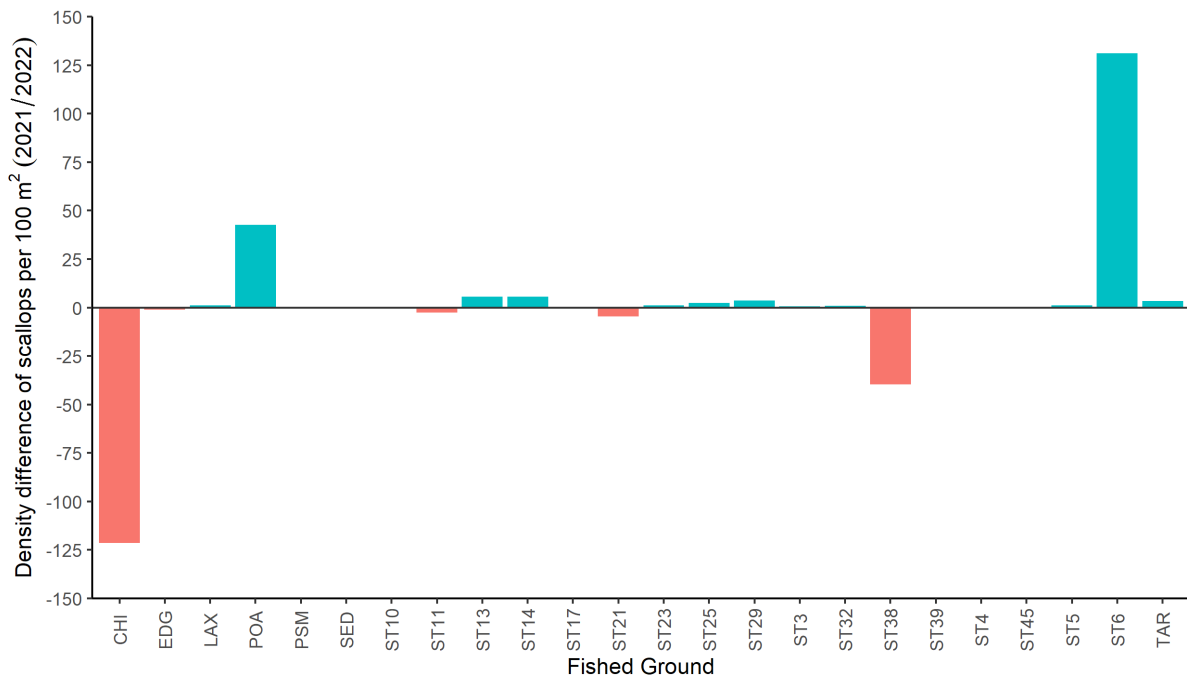


Figure 13: Difference in average survey density (scallops per 100 m<sup>2</sup>) of queen scallops from queen scallop dredges between 2021 and 2022. Red bars indicate decreases in scallop density from 2021 to 2022 and turquoise bars indicate increases in scallop density from 2021 to 2022.

#### 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) is typically very variable but has been consistently low since 2011. The data for 2022 (91.7) is the highest recorded for recruits since 2009 and is above the long-term mean of 79.4 (Figure 14). As seen in Figure 16 there are several sites with relatively high recruit densities around the island (i.e. EDG, ST21, ST23 and POA) the highest density of recruits is at a single station on the west coast (ST6) and is mixed with high densities of post-recruits (Figure 17).

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 2012 to 2019 there has been a declining trend in post-recruit abundance (slight increase observed in 2016). The data for 2022 (132.9), although still well below the long-term mean (~399), is the highest recorded for post-recruits since 2017 (Figure 15).

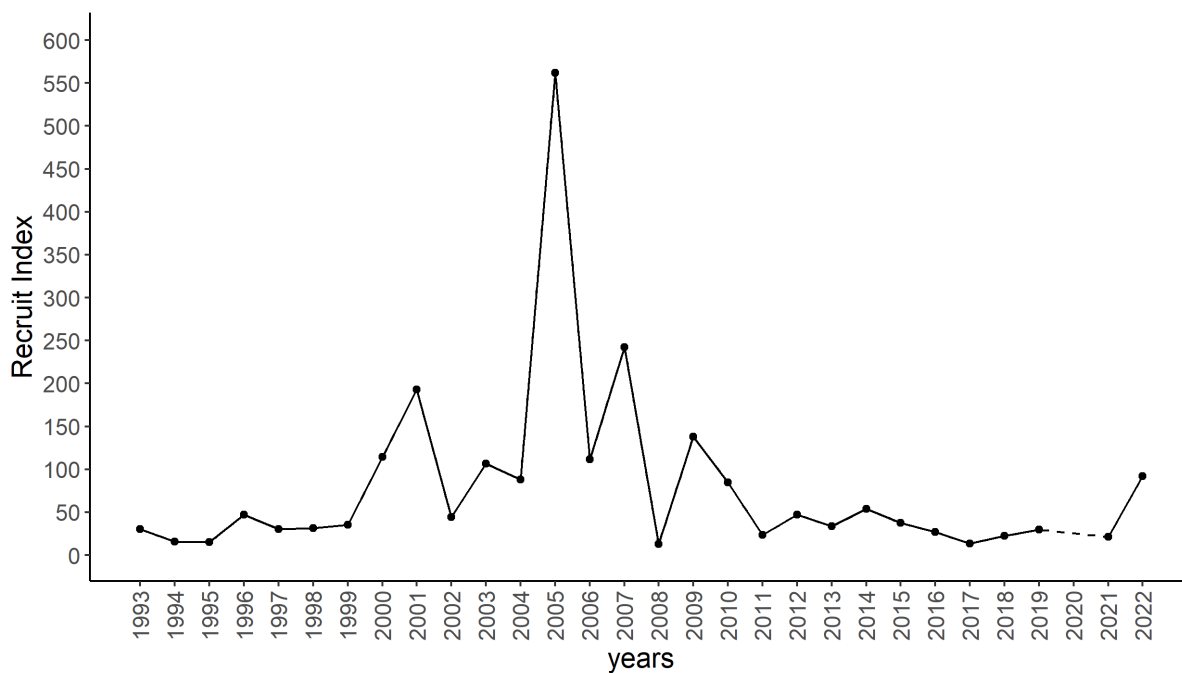


Figure 14: Abundance index (based on geometric mean) for recruits (under 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account for zero data values. Dashed line represents missing values. Note that in 2005 there were only three historic sites surveyed of which one (LAX) had a very high density of recruits recorded which is driving the spike in that year.

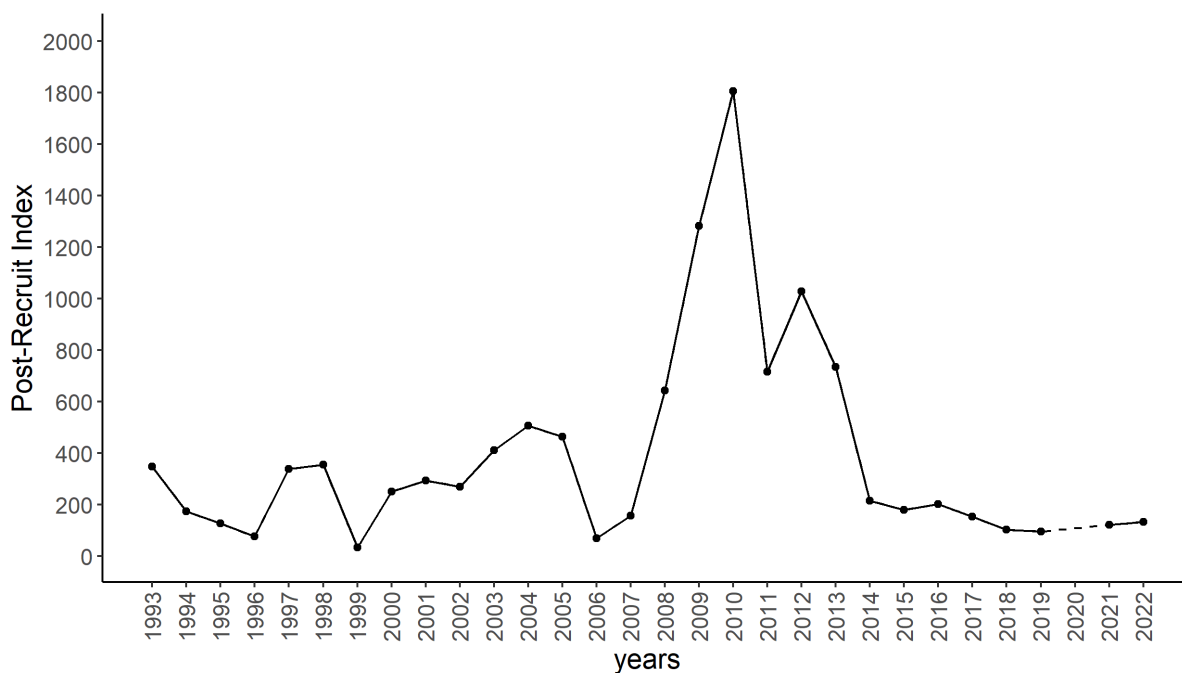


Figure 15: Abundance index (based on geometric mean) for post-recruits (over 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account 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<sup>2</sup> which is above typical values and indicates a good recruitment event at that site within that year. The data for 2022 is plotted as blue points on the figure and indicates that there have been an exceptional localised recruitment event at ST6 (Restricted Area on the West Coast within Targets fishing ground). It may be appropriate to consider separate management for the 2022 fishing season of this area.

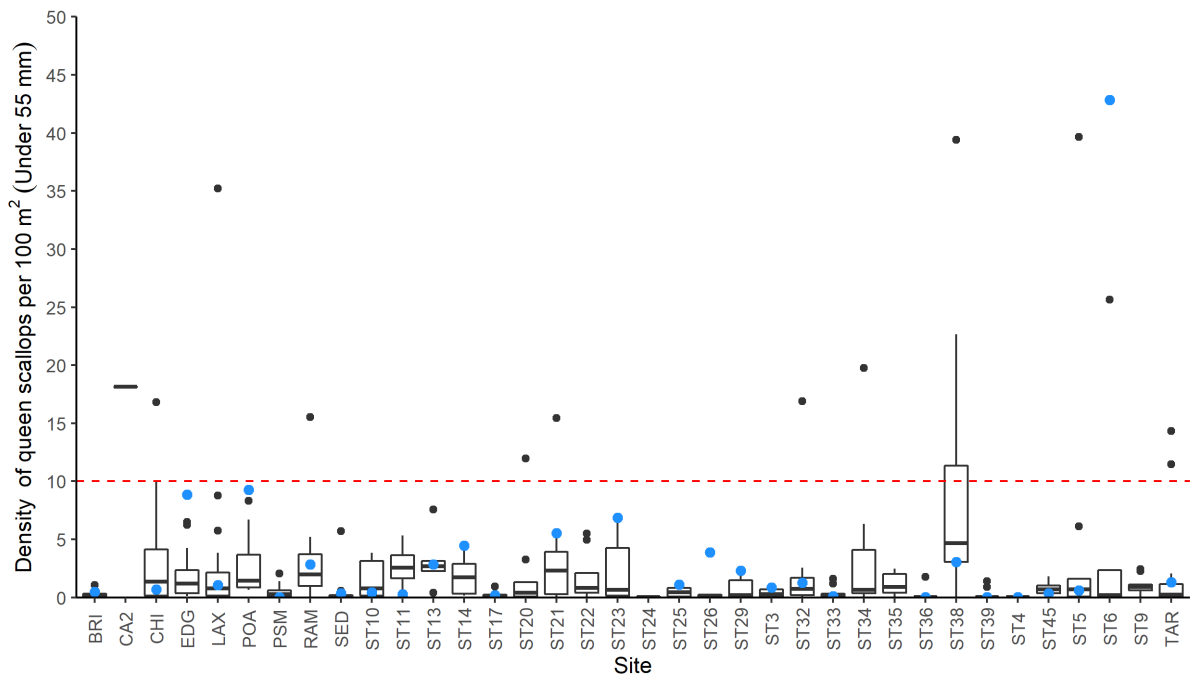


Figure 16: Boxplot of recruit (< 55 mm) queen scallop density per 100 m<sup>2</sup> for stations where queen scallops are typically present. Outliers over 10 (which appear as points above the red dashed line) are exceptional years of recruitment for which management should be considered separately to the rest of the stock. The blue points are the data from the current 2022 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<sup>2</sup> which is above typical values and indicates an exceptional density of post-recruits at that site within that year. The data for 2022 is also plotted as blue points on the figure and indicates that the highest localised density of queen scallops is at ST6 (Restricted Area on the West Coast within Targets fishing ground). It would be appropriate to consider separate management for the 2022 fishing season for this area.

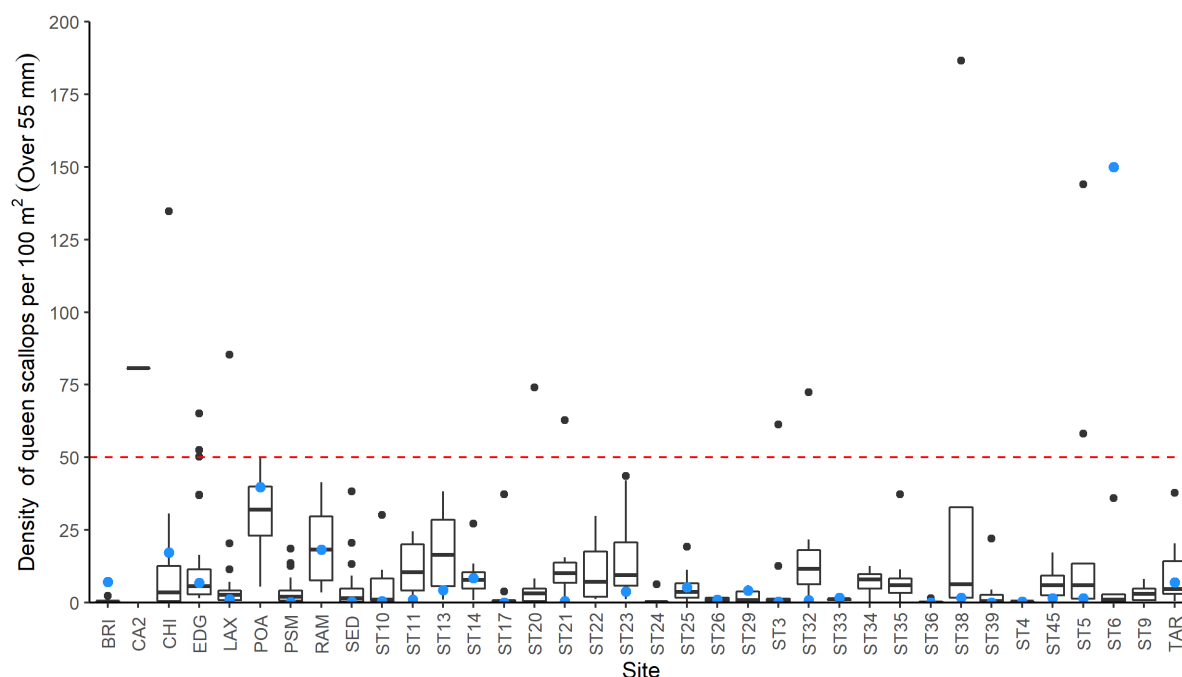


Figure 17: Boxplot of post-recruit ( $\geq 55$  mm) queen scallop density per 100 m<sup>2</sup> for stations where queen scallops are typically present. Outliers over 50 (which appear as points above the red dashed line) are exceptional years of post-recruits for which management should be considered separately to the rest of the stock. The blue points are the data from the current 2022 survey.

#### 4.2.5 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 eight years (2011–2018) before slight annual increases in each of the last 4 years (2019 – 2022) (2022: median estimated biomass of 3322 t) (Figure 18). *Note, that there is a missing year of survey data for 2020 in the input data.* The median biomass across the whole time series is 5568 t. Despite annual increases over the last four years biomass remains below that level.

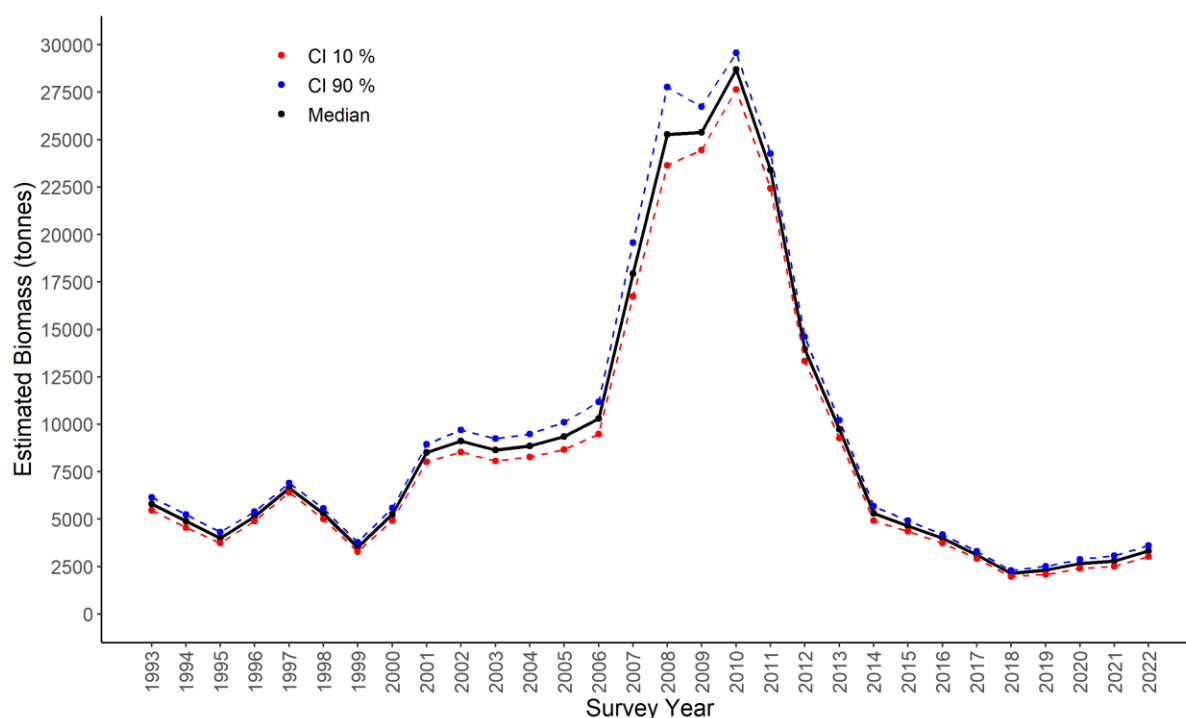


Figure 18: Estimated biomass for the stock assessment unit (Isle of Man territorial waters) MCMC results from CSA Version 4.3

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.

#### 4.2.6 Trawl TAC calculation (ICES Category 3 approach and biomass linked approach):

The TAC advice for the trawl fishery is based on a trend analysis of a survey index (last 2 years average over previous 3 years average or other range of years). If one of the last two years is missing, the ratio can be calculated by treating that value as missing. This would mean that the last 2-year average would be based on the one available estimate. As there is now data for 2022 and 2021 and it is known that the industry survey abundance index increased in 2020 (no scientific data due to Covid restrictions preventing surveying) then 2020 has been estimated as a mean value between 2019 and 2021 for the purpose of this calculation.

For the Isle of Man Queen Scallop fishery the TAC advice following the ICES Category 3 approach is indicated in Table 14.

Table 3: Queen scallops in Isle of Man territorial waters, TAC calculation for the trawl fishery based on ICES Category 3 stock approach for 2020/2021 advice treating 2020 as a missing data value. Based on an index ratio of 1.3, the maximum uplift recommended under this approach (20%) has been applied.

	<b>2021 Start of season TAC</b>	<b>2021 End of season TAC</b>
Index A (2022 & 2021)	184	184
Index B (2020-2018; no data for 2020)	141	141
Index ratio (A/B)	1.3	1.3
Uncertainty cap	Applied  0.8	Applied  0.8
Advised catch for 2021 (trawl)	661.7 tonnes	793 tonnes
Precautionary buffer	Not applied  NA	Not applied  NA
Catch advice for 2022 (trawl)	794 tonnes	952 tonnes
% advice change relative to prior season	+ 20 %	+ 20 %

In considering the output of the ICES Category 3 approach, which would give a recommended TAC of 794 t (based on 2021 SOS TAC) or 952 t (based on 2022 EOS TAC) (equating to an uplift of 20%), the following points should be noted:

- In the case of the Isle of Man queen scallop fishery the original TAC, which is then adjusted each season, was not biomass linked.
- The trawl TAC was increased within the 2021 season for socio-economic reasons from 661.7 t (start of season; SOS) to 793 t (end of season; EOS).
- The largest increase in the index based on this year's survey was as a result of recruits (i.e. under MLS and not available to the fishery in 2022) and not post-recruits (i.e. over MLS and fishable in 2022).
- The highest density of post-recruits identified in the 2022 survey were spatially restricted to the west coast. Setting a TAC for the territorial sea does not take into account the spatial variability in fishing opportunities.
- Median estimated biomass for 2022 based on the stock assessment is 3322.4 t. A TAC of 794 t (SOS) or 952 t (EOS) would approximate to removing ~24 % or ~ 29 % respectively of the estimated biomass (any dredge TAC, which would be in addition to the trawl TAC, would also increase these percentages). This is higher than the proportion of biomass (20%) that was assumed could be sustainably be removed annually from the queen scallop stock during the period of Marine Stewardship Council (MSC) certification (20% of estimated biomass equates to ~ 665 t).

### 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 10<sup>th</sup> – 19<sup>th</sup> April 2022. The survey was undertaken at the four main queen scallop fishing grounds and one transient bed as well as within the EDGERA (Table 4):

Table 4: Grounds surveyed during the 2022 industry scallop survey with ground type and number of survey tows detailed. EDGERA = East of Douglas Experimental Research Area (closed since July 2017). Not all tows are within queen scallop ground as king scallop grounds are surveyed at the same time (i.e. BRA only 14 tows within queen scallop grounds)

Ground	Survey Tows	Type
Targets (TAR)	40	Permanent
Chickens (CHI)	33	Permanent
East of Douglas (EDG)	49	Permanent
Point of Ayre (POA)	10	Permanent
Bradda (BRA)	53	Transient
EDGERA	5	Closed

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' and a 'juvenile survey dredge bar'. The standard bar had two King and two Queen dredges interspersed along the bar (Queen dredges had 10 teeth) while the juvenile bar was of the same design but using Queen dredges with 17 teeth and 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 under 90 mm 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 as well as skippers comments when undertaking the survey.

**Ground inclusion:** POA and the transient bed at BRA were only surveyed for first time in 2020 (& POA was not surveyed in 2021). 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 (2 sites at BRA [Survey Cells: 4034 and 4322] and 3 sites at CHI [Survey Cells: 5127, 5130 and 5132] 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.  $\geq 55$  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 and 2022 surveys were undertaken in April and the 2021 survey in May. Size data is presented here as a snapshot 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 and Density estimates:

##### 4.3.2.1 Territorial Waters:

A size frequency plot of queen scallop size data is presented in Figure 19 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.

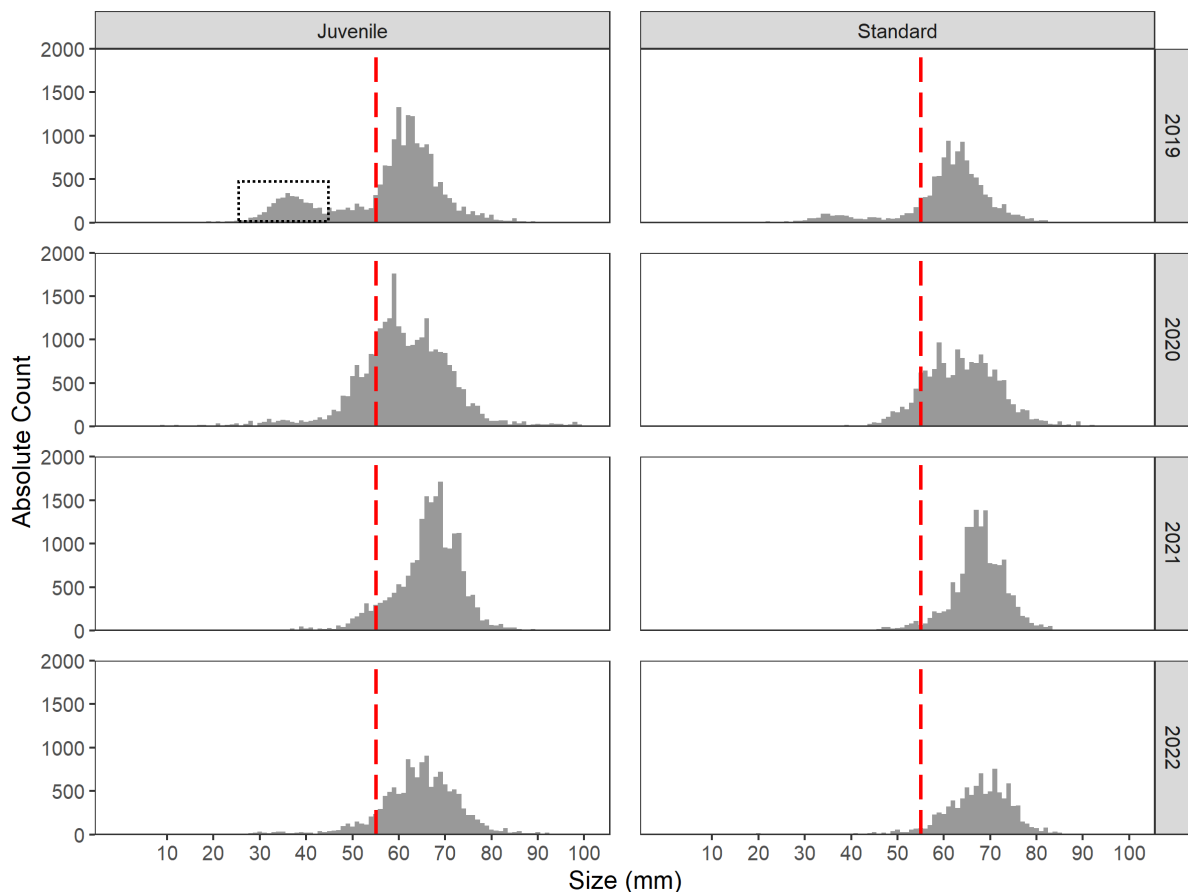


Figure 19: Size frequency distribution (by 1 mm size bin) of absolute counts of queen scallops displayed by survey year and survey dredge type (red dotted line indicates the MLS of 55 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions. The black dotted box in 2019 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, 2021 and 2022.

As indicated in the scientific survey data in 2019 there was a well-defined peak in recruiting queen scallops in the juvenile dredge data. This peak was focused in two key areas at Chickens and Targets which were protected by closures and by 2020 this peak had grown into the fishery (i.e.  $\geq 55$ mm) or within the size band of scallops that would likely grow into the fishery during the season (i.e. between

45 - 55 mm) (Figure 19). The juvenile dredge data also indicates **a lack of peak of recruiting queen scallops (i.e. 25-45 mm) in 2021 and 2022** compared to 2020 and 2019. This is an important consideration when looking at sustainable management over a > 1 year period (Figure 19).

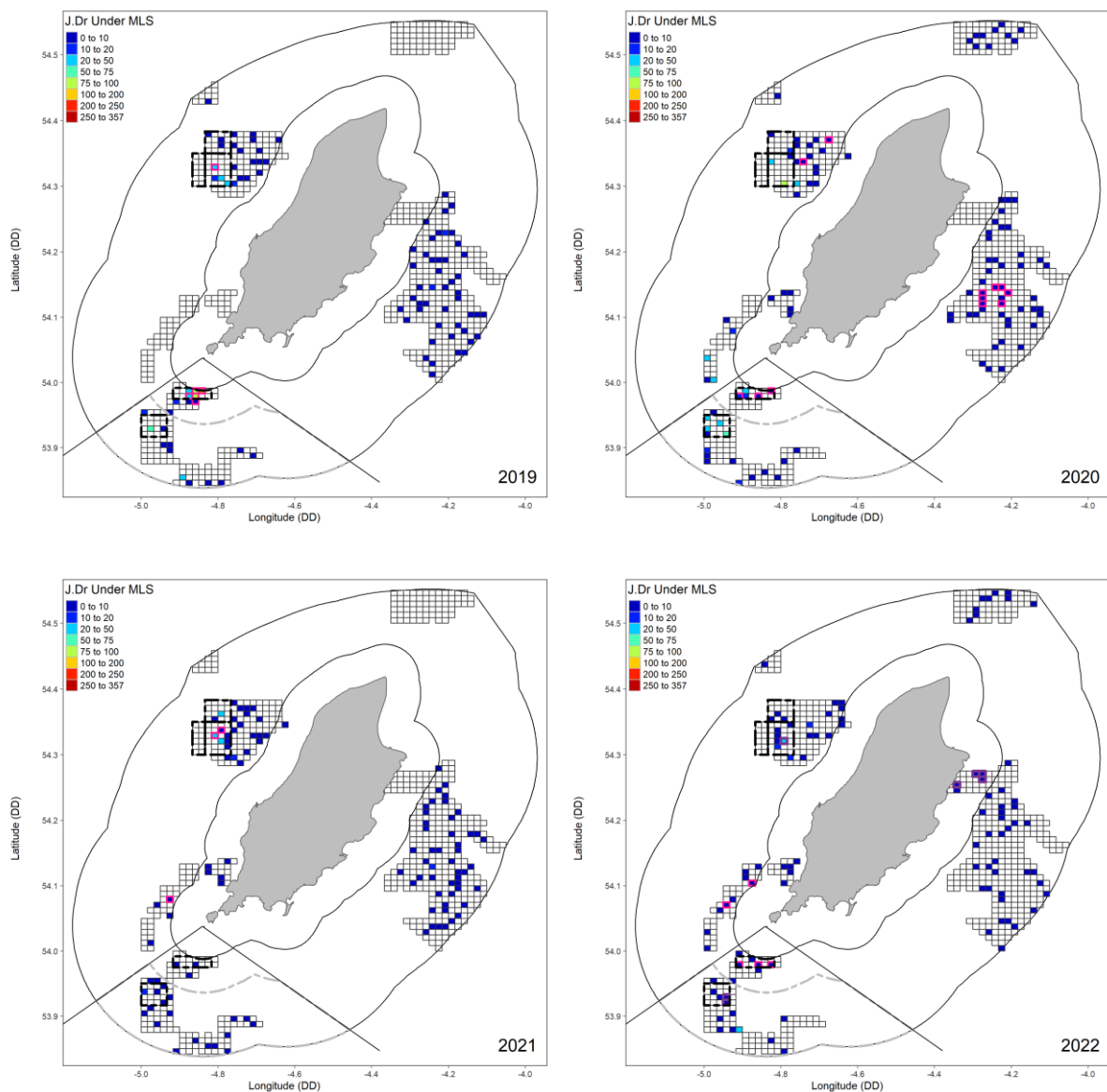


Figure 20: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right), Point of Ayre in the north of the TS and Bradda offshore to the west of the TS were only surveyed for the first time in 2020. The pink cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis). In 2022, the purple cell borders indicate cells where size data was not collected due to faults with the electronic measuring boards and so are split into under and over MLS based on an average for all other cells surveyed at that ground. The black dashed boxes indicate closed or managed areas for the 2021 queen scallop fishery and the 2021/2022 king scallop fishery. The grey dashed line and solid black lines indicate the queen scallop dredge zone.



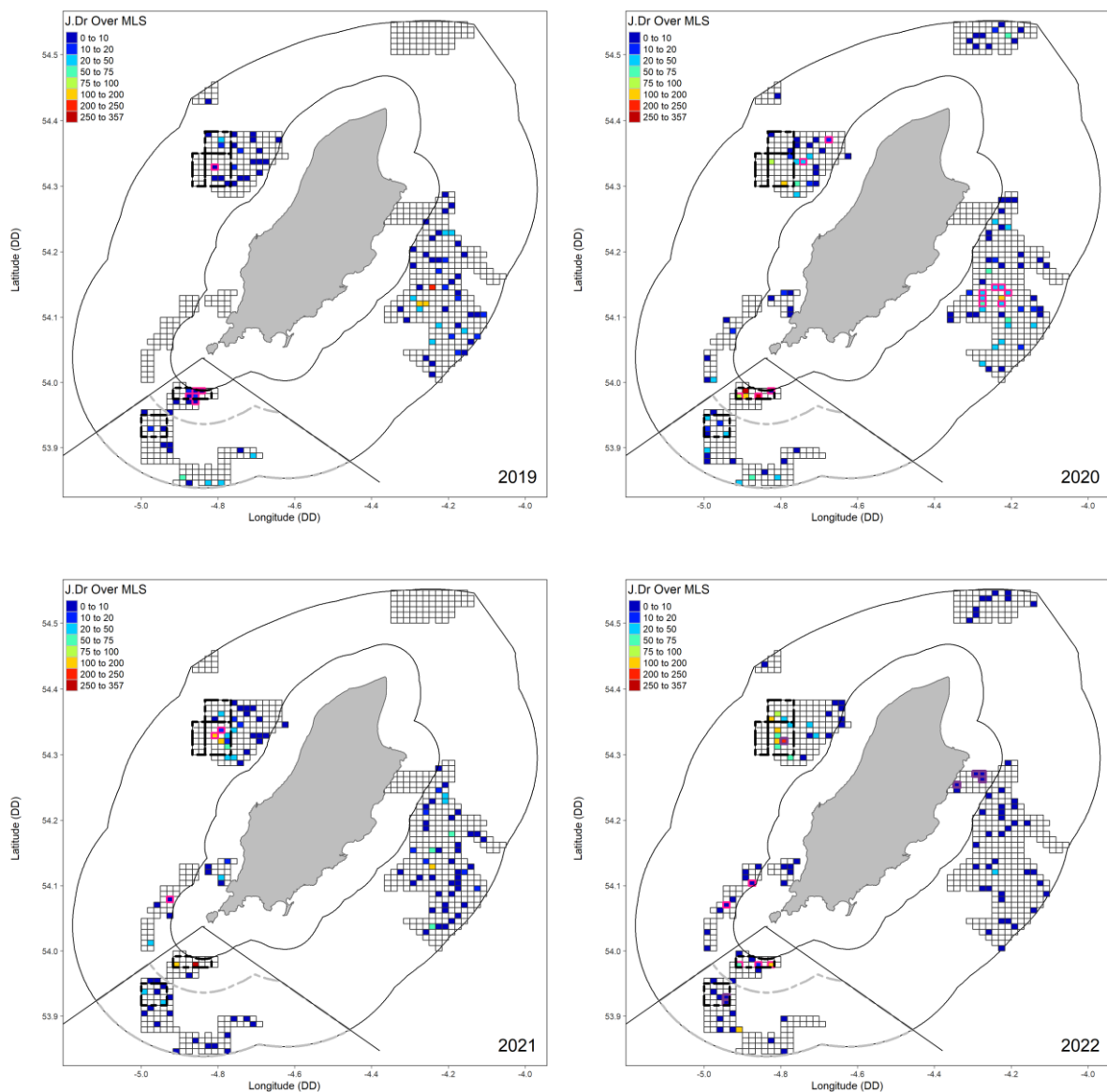


Figure 21: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right), Point of Ayre in the north of the TS and Bradda offshore to the west of the TS were only surveyed for the first time in 2020. The pink cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis). In 2022, the purple cell borders indicate cells where size data was not collected due to faults with the electronic measuring boards and so are split into under and over MLS based on an average for all other cells surveyed at that ground. The black dashed boxes indicate closed or managed areas for the 2021 queen scallop fishery and the 2021/2022 king scallop fishery. The grey dashed line and solid black lines indicate the queen scallop dredge zone.

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.

Table 5: Juvenile dredge density of QSC per 100 m<sup>2</sup> 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	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	85	78	96	73	85	78	96	73
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Geometric Mean</b>	<b>0.81</b>	<b>0.55</b>	<b>0.11</b>	<b>0.14</b>	<b>3.16</b>	<b>5.83</b>	<b>1.84</b>	<b>1.52</b>
Max	72.03	96.79	24.89	36.60	235.52	273.01	356.85	236.31

The overall data for the TS indicates that the survey index has decreased for post-recruits (over 55 mm) from **1.84 in 2021 to 1.52 in 2022** and increased for recruits (under 55 mm) **from 0.11 in 2021 to 0.14 in 2022**.

### 4.3.2.2 Fishing Grounds:

#### 4.3.3.2.1 Targets:

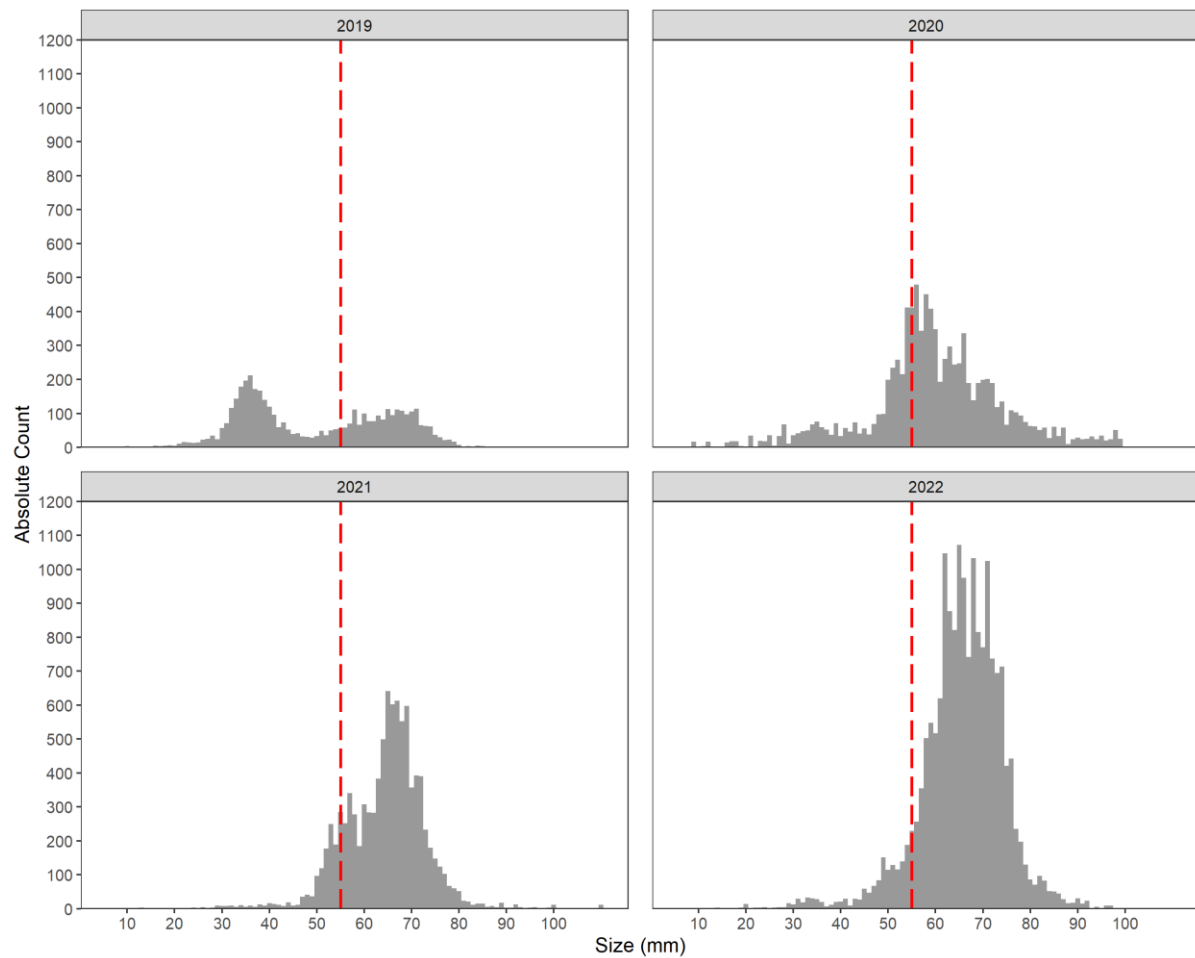


Figure 22: Size density histogram of absolute counts of queen scallops displayed by survey year for Targets (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Table 6: Juvenile dredge density of QSC per 100 m<sup>2</sup> 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. Please note in 2022 Cell 2141 (highest density cell) is missing size data and so is split into under and over MLS based on an average for all other cells surveyed at TAR.

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	22	20	24	22	22	20	24	22
Min	0.00	0.00	0.00	0.00	0.09	0.26	0.09	0.00
Geometric Mean	1.88	1.62	0.36	1.16	1.44	7.05	4.84	8.35
Max	44.82	96.79	24.89	36.60	23.19	105.27	182.21	236.31

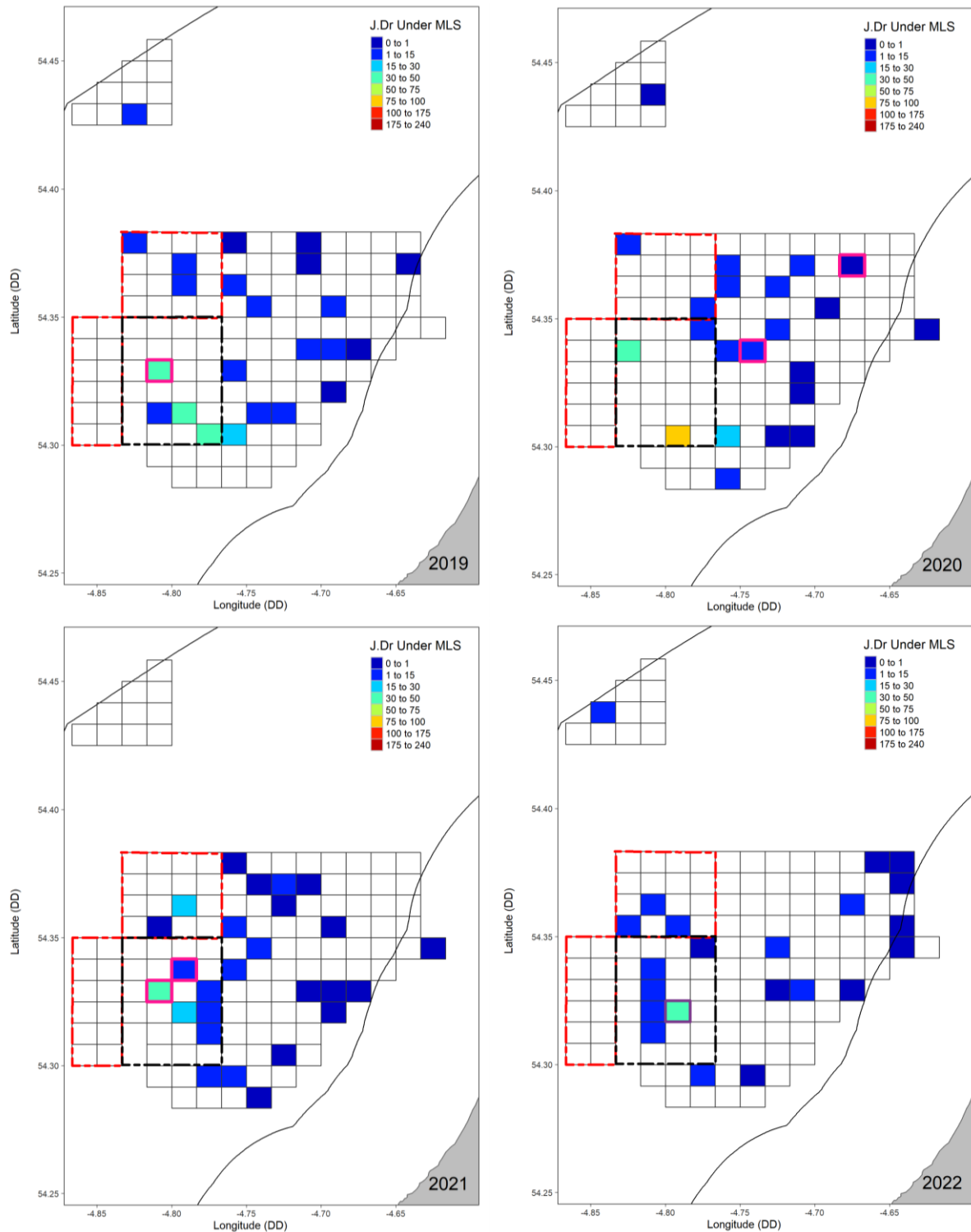


Figure 23: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at Targets (West coast). The red box indicates the areas closed and black box indicates areas with restricted access to scallop fishing in 2021. 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 and hotspot analysis). **In 2022, the purple cell borders indicate cells where size data was not collected due to faults with the electronic measuring boards and so are split into under and over MLS based on an average for all other cells surveyed at TAR.**

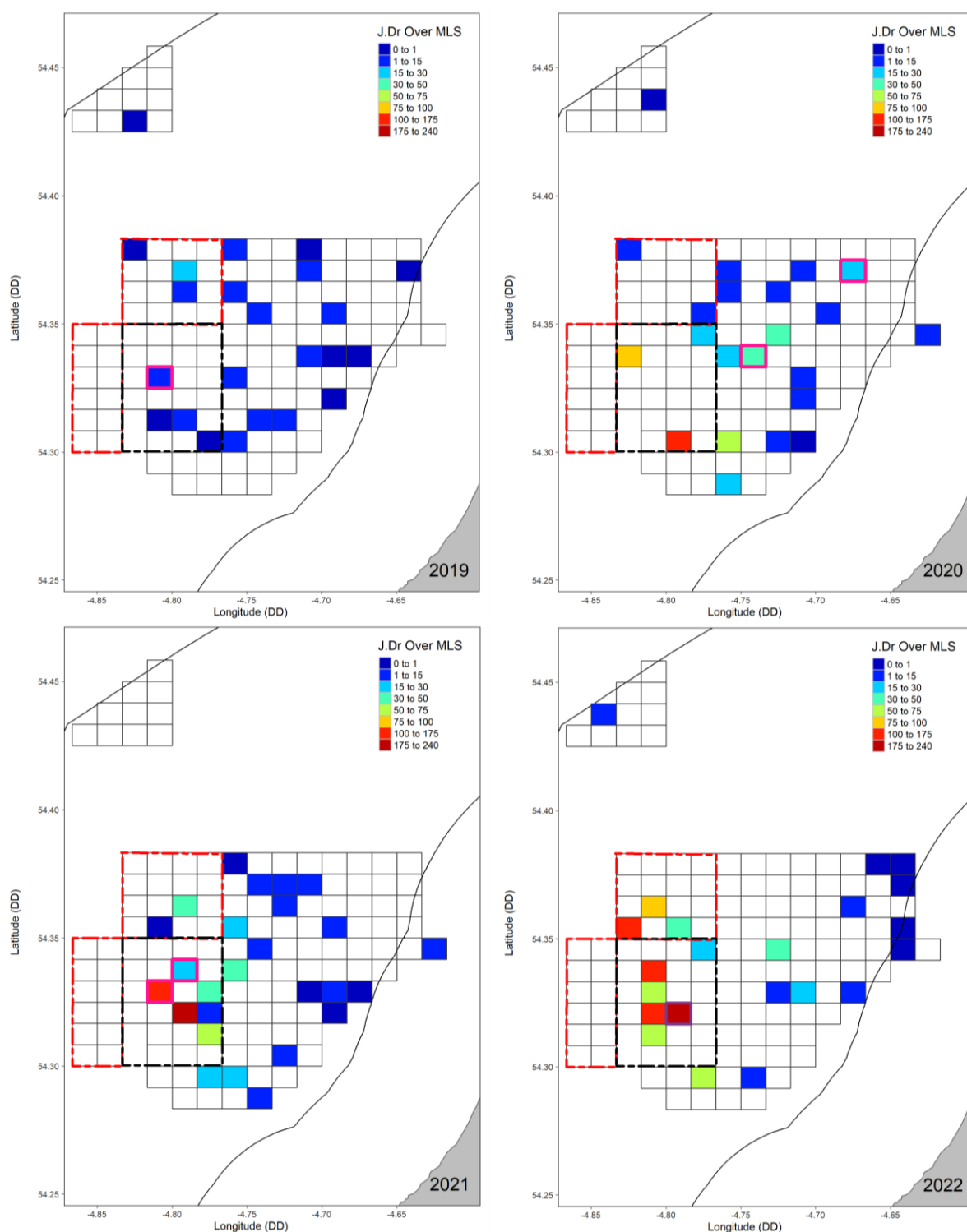


Figure 24: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at Targets (West coast). The red box indicates the areas closed and black box indicates areas with restricted access to scallop fishing in 2021. 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). **In 2022, the purple cell borders indicate cells where size data was not collected due to faults with the electronic measuring boards and so are split into under and over MLS based on an average for all other cells surveyed at TAR.**

## TAR Managed Areas

Table 7: Juvenile dredge density of QSC per 100 m<sup>2</sup> split by over and under MLS for TAR **Restricted Area**; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). **Please note in 2022 Cell 2141 (highest density cell) is missing size data and so is split into under and over MLS based on an average for all other cells surveyed at TAR.**

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
n	4	3	6	6	4	3	6	6
Min	10.04	4.09	2.66	0.62	0.09	19.01	14.57	20.52
GeoMean	27.7	23.6	7.95	6.58	0.80	54.60	51.10	83.2
Max	44.82	96.79	45.80	36.60	8.79	105.27	182.21	236.31

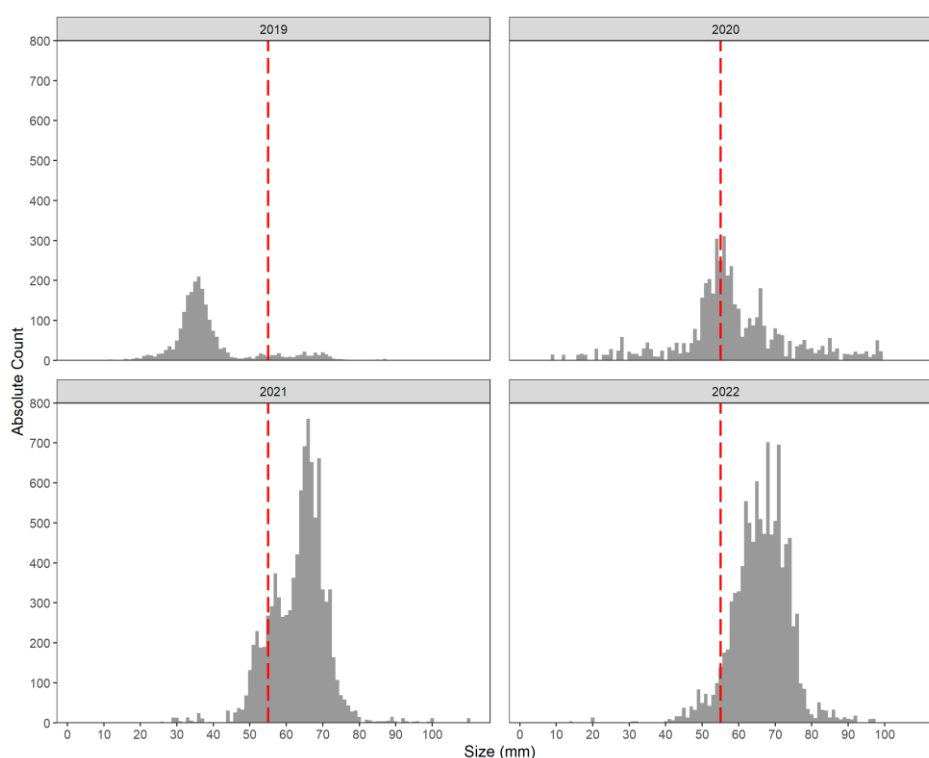


Figure 25: TAR **restricted area** size frequency of absolute counts of queen scallops by cell for 2020 and 2021 using data from all random and targeted survey cells. **Please note in 2022 Cell 2141 (highest density cell) is missing size data and so is not included in this figure.**

Table 8: Juvenile dredge density of QSC per 100 m<sup>2</sup> split by over and under MLS for TAR **Closed Area** (North area only); 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	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
n	3	2	2	3	3	2	2	3
Min	2.68	5.97	0.09	3.51	0.34	5.54	0.62	32.64
GeoMean	4.44	8.39	1.44	5.73	4.37	6.71	5.01	75.00
Max	6.65	11.77	20.69	7.33	23.19	8.10	39.88	156.97

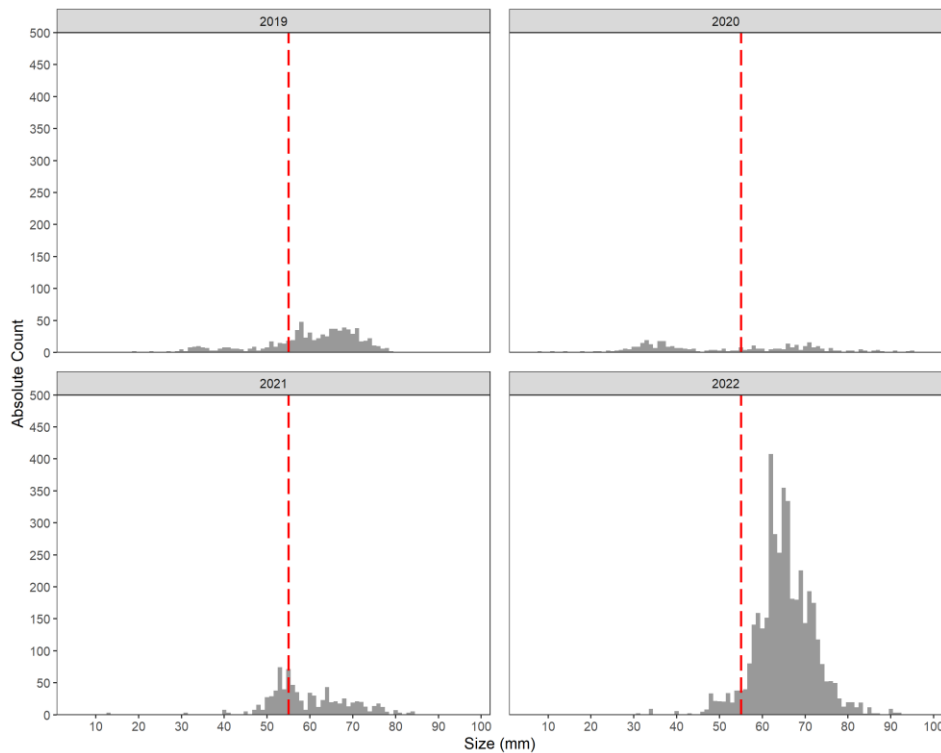


Figure 26: TAR **Closed area** (North area only) size frequency of absolute counts of queen scallops by cell for 2020 and 2021 using data from all random and targeted survey cells.

For TAR, which supported the 2<sup>nd</sup> largest quantity of landings from 2021 (264.6 t), the survey index for the whole ground has increased for both post-recruits (over 55 mm) from **4.84 in 2021 to 8.35 in 2022** and recruits (under 55 mm) **from 0.36 in 2021 to 1.16 in 2022**. Please note in 2022 Cell 2141 (highest density cell) is missing size data and so is split into under and over MLS based on an average for all other cells surveyed at TAR and will impact slightly the recruit and post-recruit indices.

The survey indices for the managed areas at TAR: closed area (northern box only – closed in 2021) and restricted area (closed in 2018 and 2019 to protect high densities of recruit scallops (king and queen) and restricted access in 2021), have both increased significantly for post-recruits in 2022 (83.2 for restricted area and 75 for closed areas). The restricted area has also decreased for recruits in 2022 (6.52) whilst the closed area increased relative to 2021 (5.73). The shift in abundance index for recruits and post-recruits in the restricted area is likely 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  $\geq 55$  mm in both the closed and restricted area with little new recruitment evident (i.e. queen scallops  $\leq 55$  mm); Please note in 2022 Cell 2141 (highest density cell) is missing size data and so is split into under and over MLS based on an average for all other cells surveyed at TAR and will impact slightly the recruit and post-recruit indices. For the 2022 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. The second closed area to the west of the restricted area is in muddy ground and should remain closed (with a follow up survey from industry to assess densities).

#### 4.3.3.2.2 Chickens:

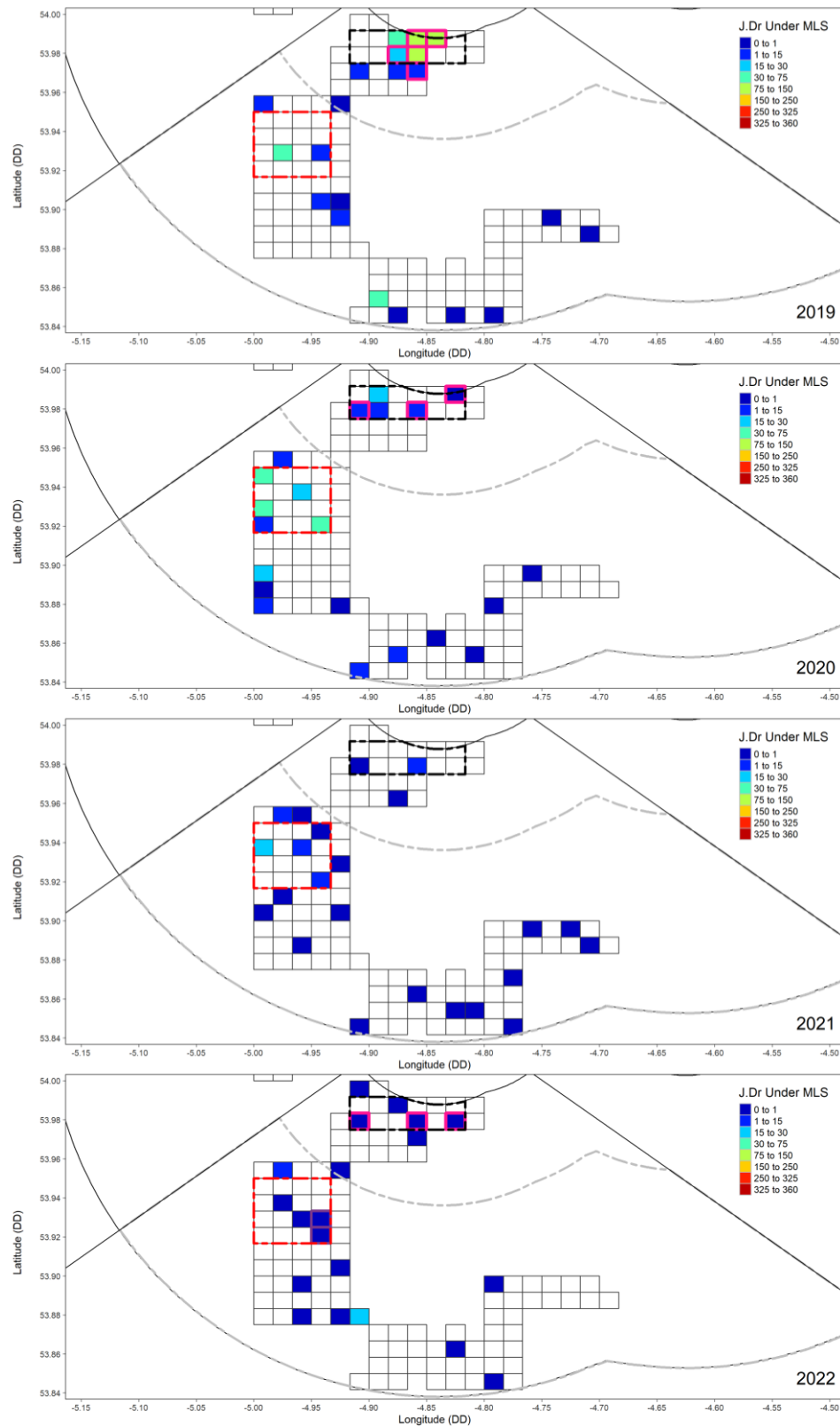


Figure 27: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2019 to 2022 at Chickens (South coast). The red and black box indicates the areas closed or with restricted access respectively to scallop fishing in 2021. Pink borders indicate cells that were 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). Purple borders indicate cells missing size data. The grey dashed lines indicate the area within which queen scallop dredging can occur.



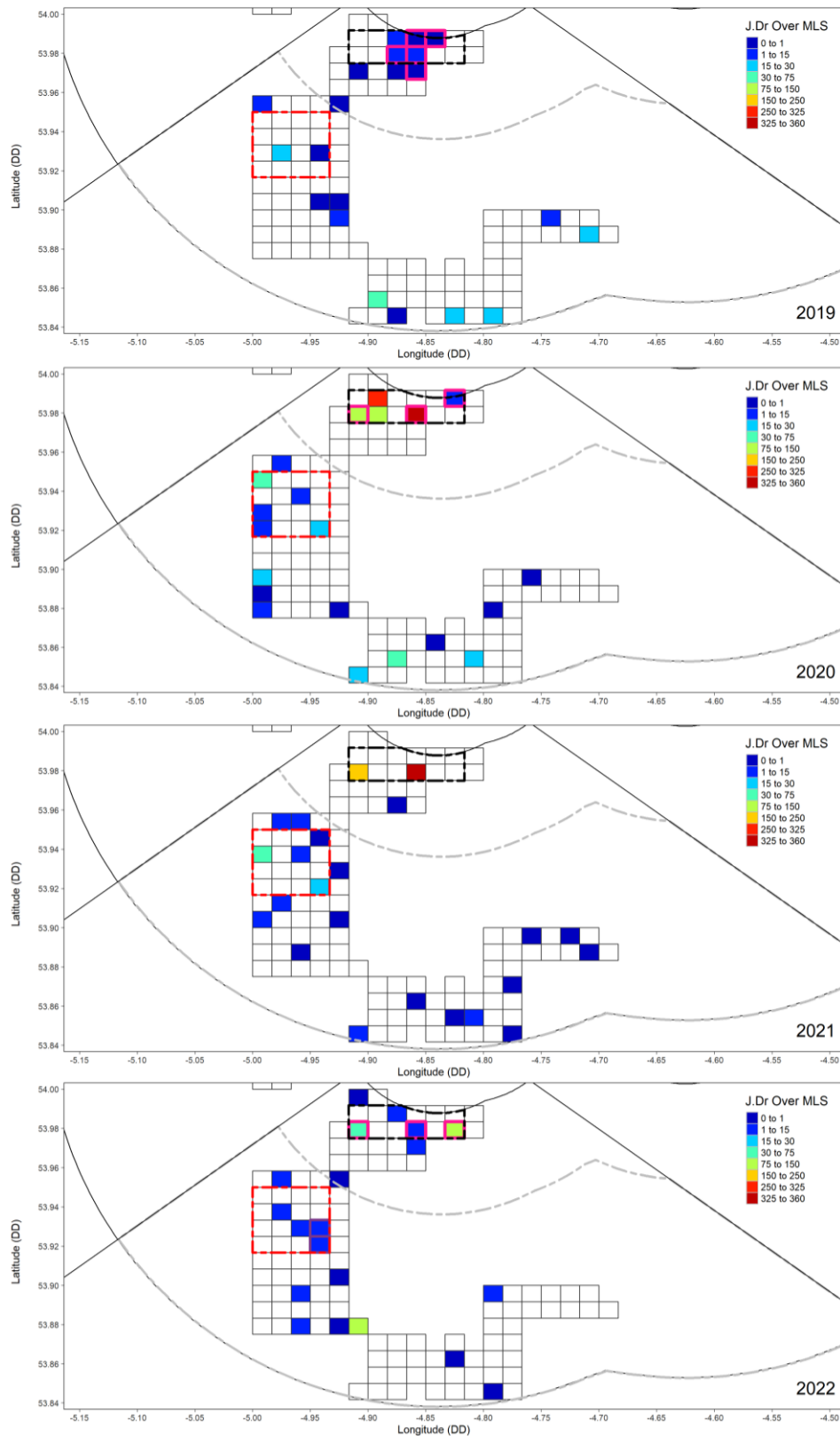


Figure 28: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2019 to 2022 at Chickens (South coast). The red and black box indicates the areas closed or with restricted access respectively to scallop fishing in 2021. Pink borders indicate cells that were 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). Purple borders indicate cells missing size data. The grey dashed lines indicate the area within which queen scallop dredging can occur.

Table 9: Juvenile dredge density of QSC per 100 m<sup>2</sup> 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. Please note in 2022 two low density cells within the closed area are missing size data and so are split into under and over MLS based on an average for all other cells surveyed at CHI.

	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	16	18	23	17	16	18	23	17
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	1.18	1.66	0.10	0.06	1.22	3.43	0.63	0.70
Max	72.03	72.21	15.20	22.40	51.88	273.01	356.85	119.75

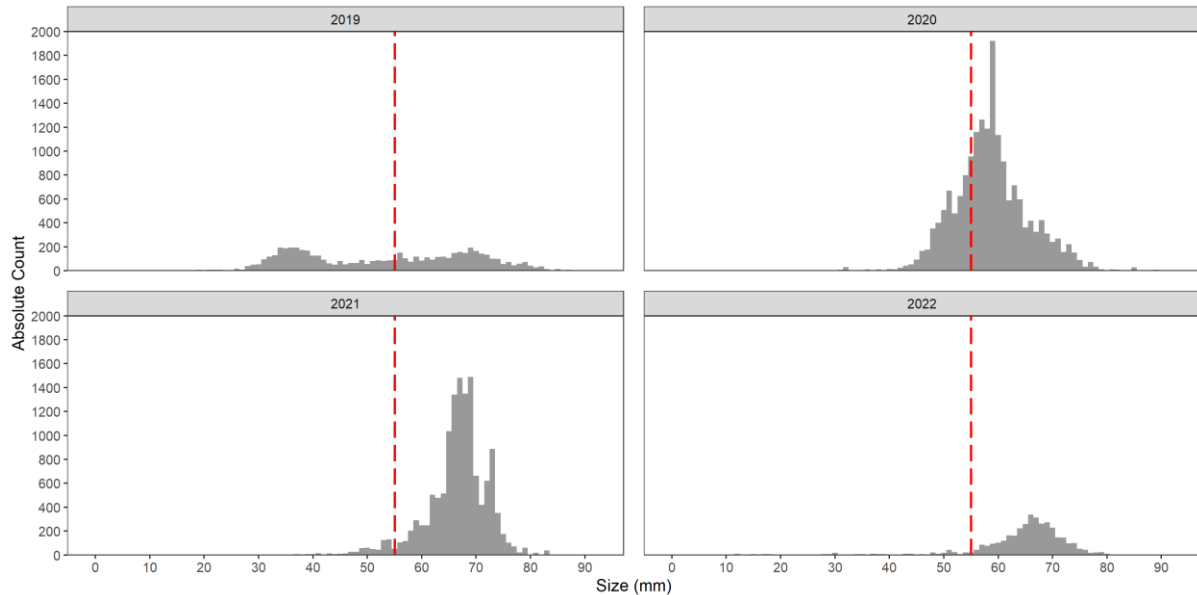


Figure 29: Size density histogram of absolute counts of queen scallops displayed by survey year for Chickens (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells. Two survey cells with missing size data in 2022 are also not represented within this figure.

### CHI Managed Areas

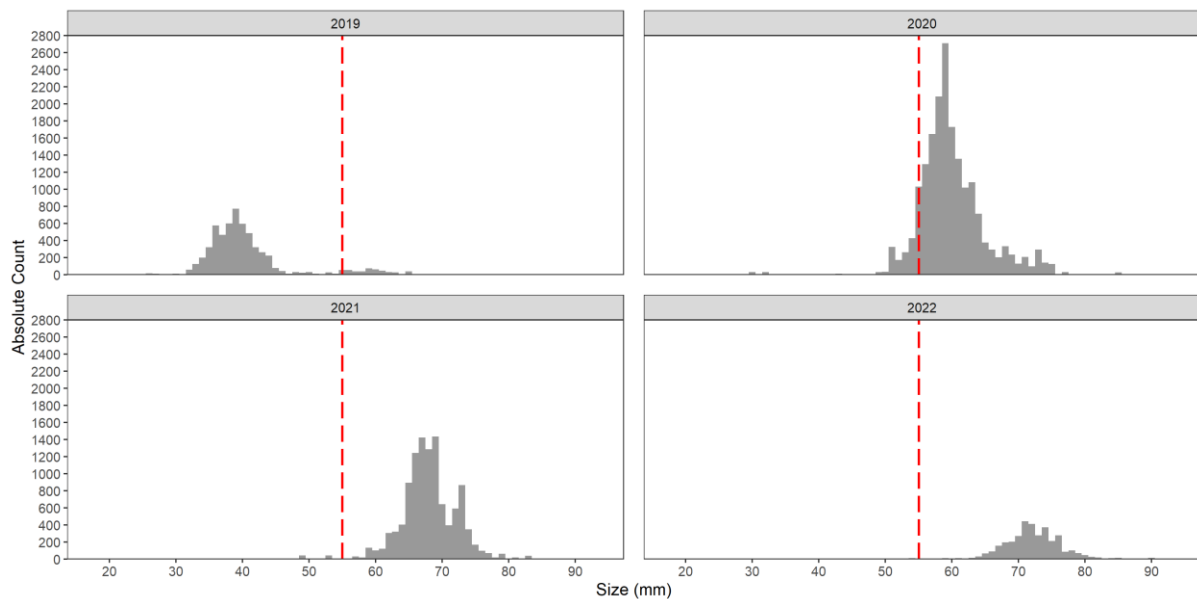


Figure 30: CHI Restricted Area size frequency of absolute counts of queen scallops by cell for 2019 to 2022 using data from all random and targeted survey cells.

Table 10: Juvenile dredge density of QSC per 100 m<sup>2</sup> 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.

<b>Restricted Area</b>	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	5	5	2	4	5	5	2	4
Min	27.09	0.43	0.00	0.00	0.00	1.71	198.40	6.95
<b>Geometric Mean</b>	<b>62.6</b>	<b>6.24</b>	<b>0.27</b>	<b>0.02</b>	<b>0.58</b>	<b>71.20</b>	<b>266.00</b>	<b>28.00</b>
Max	103.25	20.61	7.36	0.09	13.84	326.92	356.85	123.62

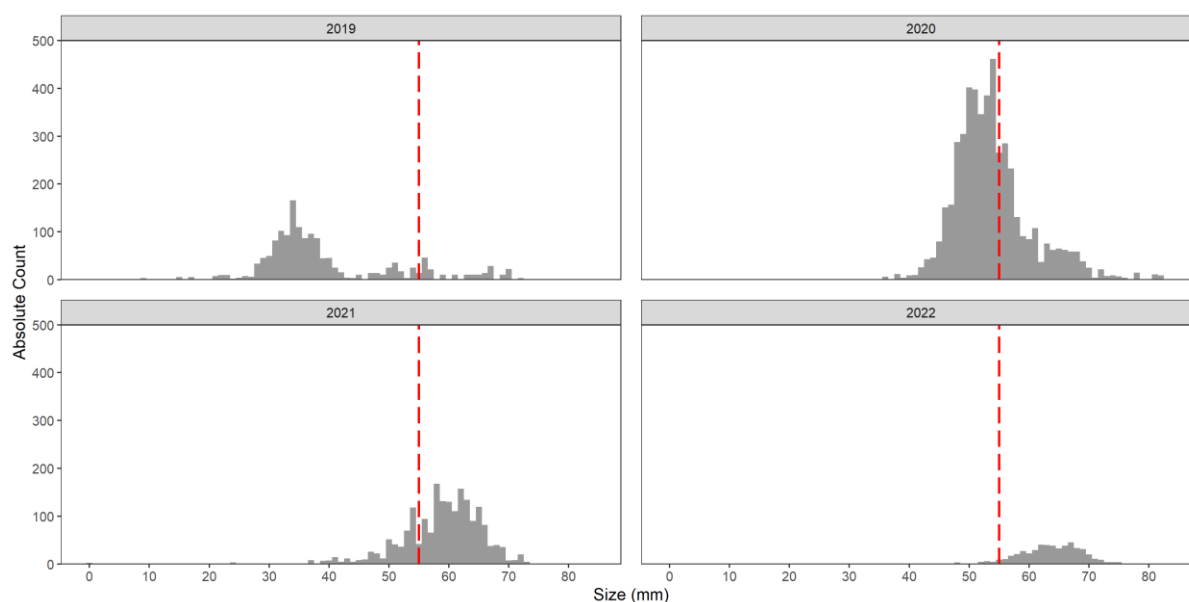


Figure 31: CHI Closed area size frequency of absolute counts of queen scallops by cell for 2019 to 2022 using data from all random and targeted survey cells. Please note in 2022 two low density cells within the closed area are missing size data and so not included in the 2022 plot for this figure.

Table 11: Juvenile dredge density of QSC per 100 m<sup>2</sup> 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. Please note in 2022 two low density cells within the closed area are missing size data and so are split into under and over MLS based on an average for all other cells surveyed at CHI.

<b>Closed Area</b>	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	2	5	4	5	2	5	4	5
Min	8.27	2.22	0.18	0.29	0.09	2.05	0.36	5.31
<b>Geometric Mean</b>	<b>24.4</b>	<b>24.3</b>	<b>2.56</b>	<b>0.50</b>	<b>1.25</b>	<b>12.2</b>	<b>7.95</b>	<b>6.22</b>
Max	72.03	72.21	15.20	0.84	15.69	34.53	48.03	6.94

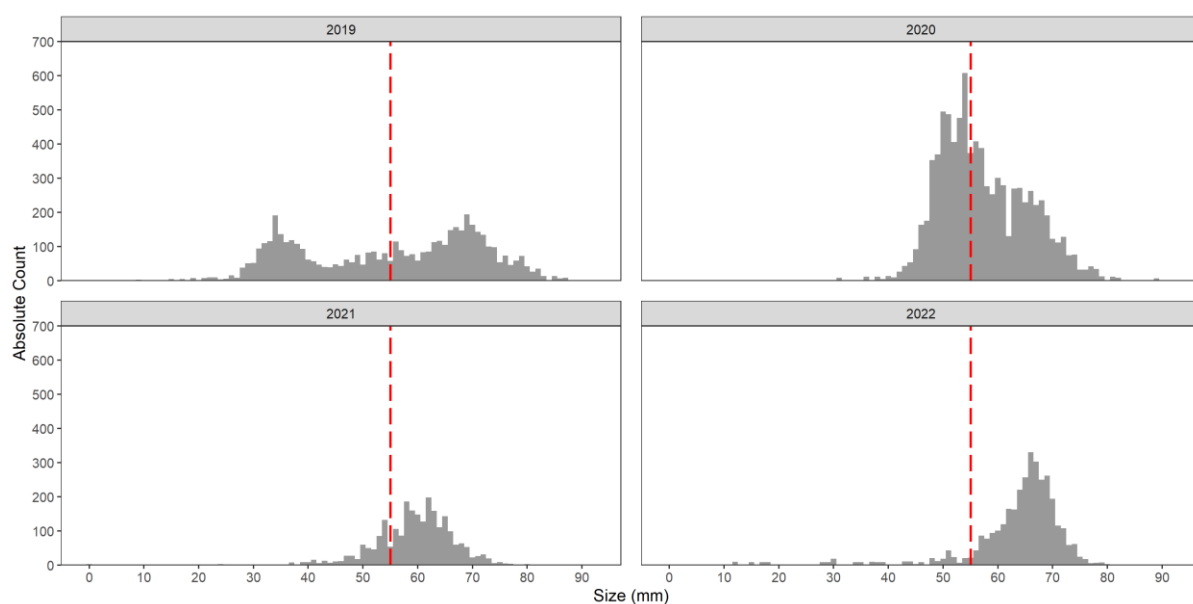


Figure 32: CHI Dredge Zone size frequency of absolute counts of queen scallops by cell for 2019 to 2022 using data from all random and targeted survey cells. Please note in 2022 two low density cells within the closed area are missing size data and so not included in the 2022 plot for this figure.

Table 12: Juvenile dredge density of QSC per 100 m<sup>2</sup> split by over and under MLS for the Chickens Dredge Zone; note that a constant of 0.01 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells included. Please note in 2022 two low density cells within the closed area are missing size data and so are split into under and over MLS based on an average for all other cells surveyed at CHI.

<b>Dredge Zone</b>	2019 < 55 mm	2020 < 55 mm	2021 < 55 mm	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	13	16	20	14	13	16	20	14
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	0.74	1.26	0.10	0.09	1.62	2.07	0.43	0.68
Max	72.03	72.21	15.20	22.10	51.88	64.07	48.03	119.75

For CHI, which supported the largest landings in 2020 (517.9 t), the survey index has increased slightly for post-recruits (over 55 mm) from **0.63 in 2021 to 0.70 in 2022** and decreased slightly for recruits (under 55 mm) **from 0.10 in 2021 to 0.06 in 2022**.

The survey index for within the area closed during the 2021 fishing season saw a decrease for post-recruits (**7.95 in 2021 to 6.22 in 2022**) and recruits (**2.56 in 2021 to 0.50 in 2022**). The decrease in the post-recruit index, given that the area was closed to fishing, could, in part, be the result of ongoing impacts from 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 within the area with restricted access during the 2021 fishing season, where vessel access was restricted (i.e. max of 5 vessels per day) to prevent over fishing within this high density area, saw a large decrease for post-recruits (**266.00 in 2021 to 28.00 in 2022**) and a continued decrease for recruits (**0.27 in 2021 to 0.02 in 2022**). The restricted area was subject to high fishing pressure and landings (~483 t) which likely explains the decrease in the post-recruit abundance index. It is noted that two survey cells (targeted) at the edges of the restricted area recorded reasonable densities. The restrictions in this area could be lifted for the 2022 fishing season as it is unlikely to be subject to high fishing pressure that will require management due to the low densities observed in the 2022 survey.

The survey index within the dredge fishing zone saw a slight increase for post-recruits (**0.43 in 2021 to 0.68 in 2022**) and a essentially no change or a very slight decrease for recruits (**0.10 in 2021 to 0.09 in 2022**). Continued low densities within the fishable area (i.e. not within the current closed area) of the queen scallop dredge box combined with annual decreases in LPUE for dredge vessels within the area from 2015 to 2020 (Figure 8) and no dredge fishing in 2021 should prompt a discussion on a longer-term management plan for this fishing area, and in particular the dredge metier which is restricted to fishing within this area. Given the annual decreases in commercial LPUE for the dredge metier from 2014 to 2020 (Figure 8) and the lack of any fishing in 2021 combined with no significant improvements in survey data for the dredge zone it is recommended that the current dredge TAC is not increased for the 2022 fishing season.

#### 4.3.3.2.3 East of Douglas:

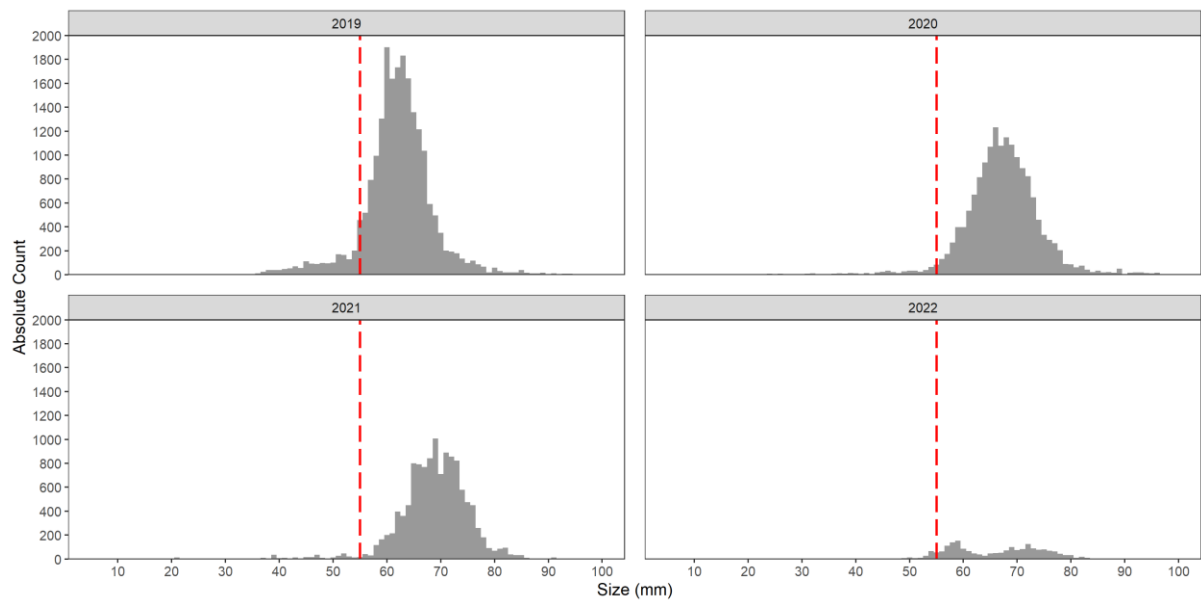


Figure 33: Size density histogram of absolute counts of queen scallops displayed by survey year for East Douglas (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Table 13: Juvenile dredge density of QSC per 100 m<sup>2</sup> 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	2022 < 55 mm	2019 > 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	47	40	49	34	47	40	49	34
Min	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
Geometric Mean	0.48	0.20	0.07	0.05	6.32	6.74	1.89	0.74
Max	16.30	4.18	10.11	6.25	235.52	166.00	135.94	39.72

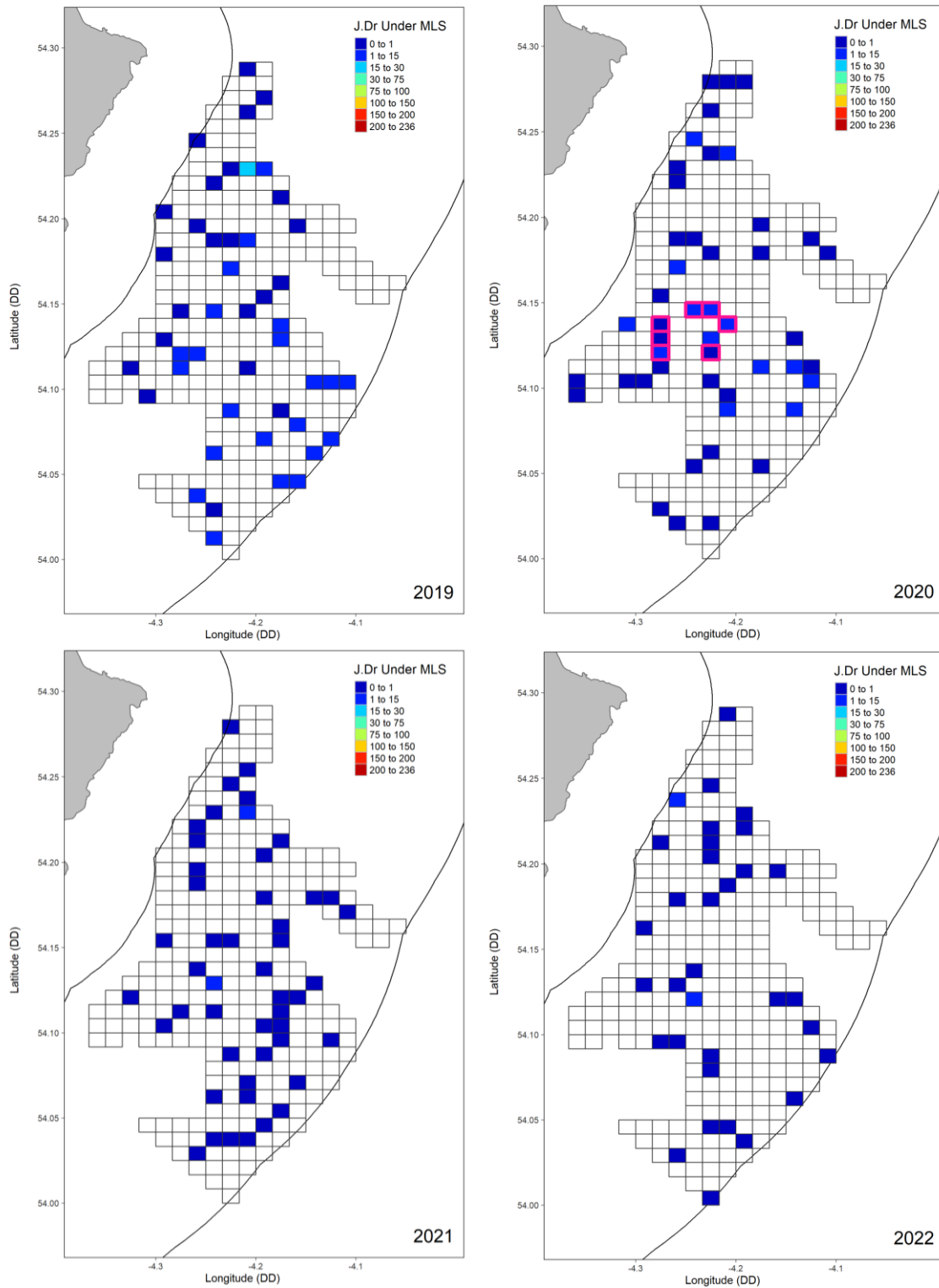


Figure 34: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at East Douglas (East coast). Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis).

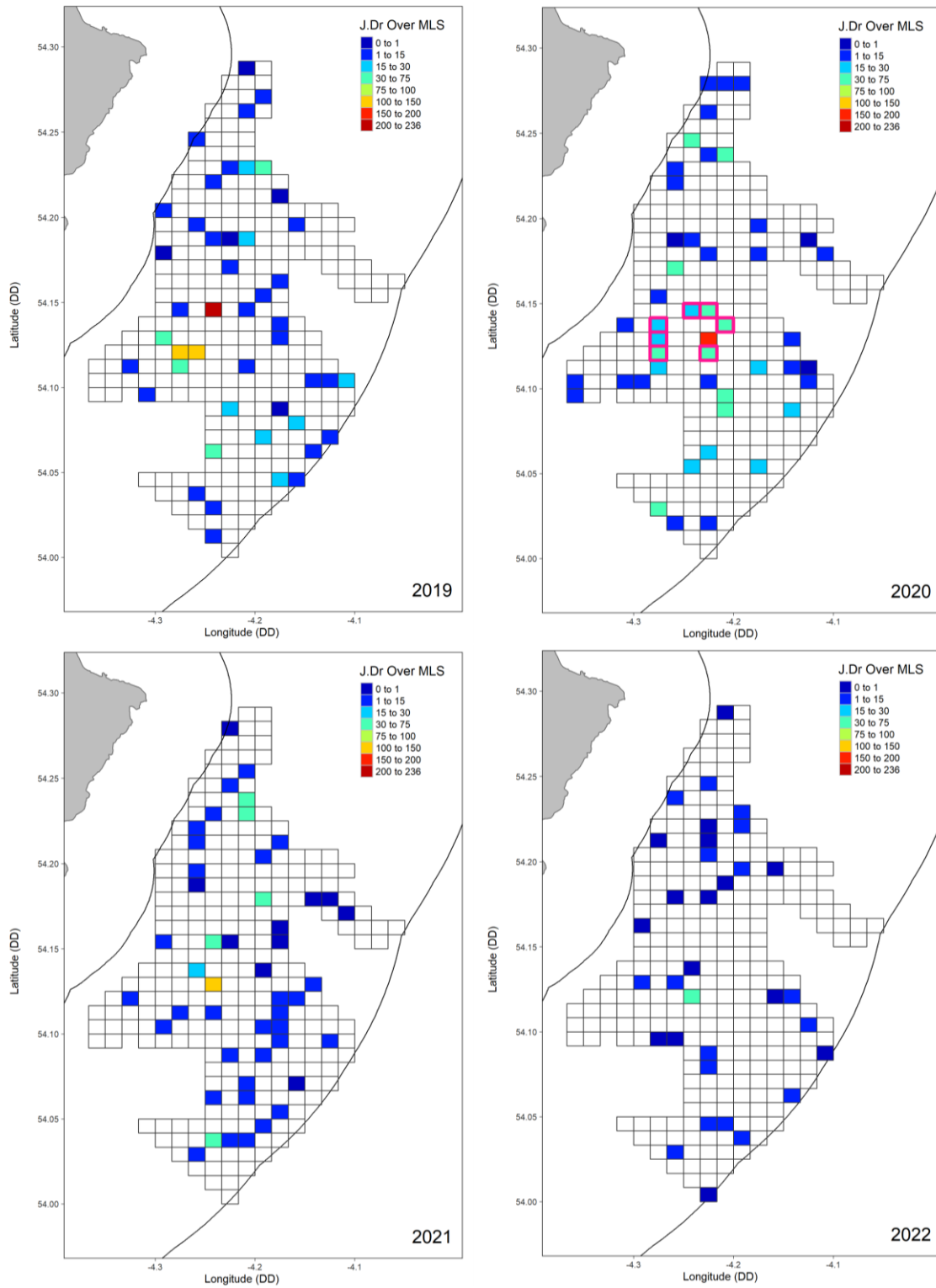


Figure 35: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2019 (top left), 2020 (top right), 2021 (bottom left) and 2022 (bottom right) at East Douglas (East coast). Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis).



## EDG Managed Areas

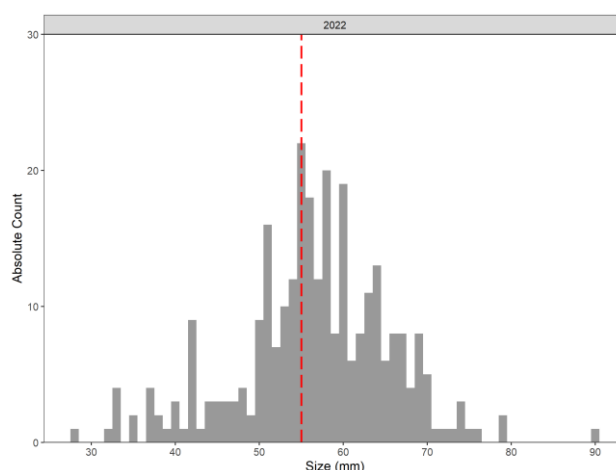


Figure 36: East Douglas Experimental Research Area: size frequency of absolute counts of queen scallops by cell for 2022 using data from all random and targeted survey cells.

Table 14: Juvenile dredge density of QSC per 100 m<sup>2</sup> split by over and under MLS for the East Douglas Experimental Research 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.

EDGERA	2022 < 55 mm	2022 > 55 mm
Cells Surveyed	5	5
Min	1.93	2.78
Geometric Mean	3.66	5.38
Max	6.13	9.95

For EDG, which had landings of only 16.7 t during the 2021 fishing season and a section of which was closed to fishing before the end of the season, both the post-recruit (**1.89 for 2021 and 0.74 for 2022**) and recruit index (**0.07 for 2021 and 0.05 for 2022**) declined.

For EDGERA there is only one year of data (2022) but the data indicates a good spread across recruits and post-recruits and a post-recruit density higher than for the EDG fishing ground (i.e. 5.38 vs 0.74 respectively for EDGERA and EDG).

Given the reduction in post-recruit and recruit densities following removal of only ~ 16.7 t in 2021 and the closure of the EDG ground towards the end of the 2020 and 2021 fishing seasons due to declining LPUE it is recommended that the LPUE for this ground is closely monitored against the set thresholds to limit any further significant decline across the entire fishing ground.

The EDGERA should be opened following five years of closure to monitor natural recovery. The area is not high density and so may not require additional restrictions in place on opening.

#### 4.3.3.2.4 Point of Ayre:

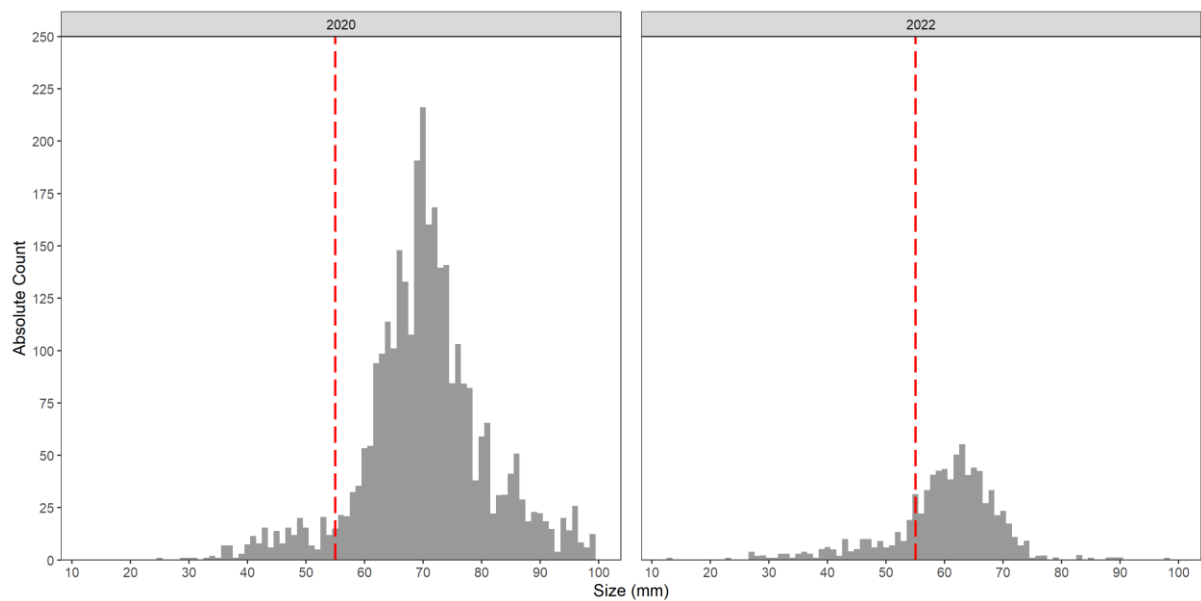


Figure 37: Size density histogram of absolute counts of queen scallops displayed by survey year for Point of Ayre (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Table 15: Juvenile dredge density of QSC per 100 m<sup>2</sup> split by over and under MLS for Point of Ayre; 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	2022 < 55 mm	2020 > 55 mm	2022 > 55 mm
Cells Surveyed	10	9	10	9
Min	0.20	0.30	0.51	0.18
<b>Geometric Mean</b>	<b>0.77</b>	<b>0.80</b>	<b>4.59</b>	<b>1.72</b>
Max	2.95	4.08	52.13	9.41

For POA, which has not had any quantity of recent fishing activity (0 t in 2021) for queen scallops (though historically there has been regular fishing activity in the area), there was a decrease in the post-recruit index (4.59 in 2020 to 1.72 in 2022) and a slight increase in the recruit index (0.77 in 2020 to 0.80 in 2022). POA was not surveyed in 2019 or 2020.

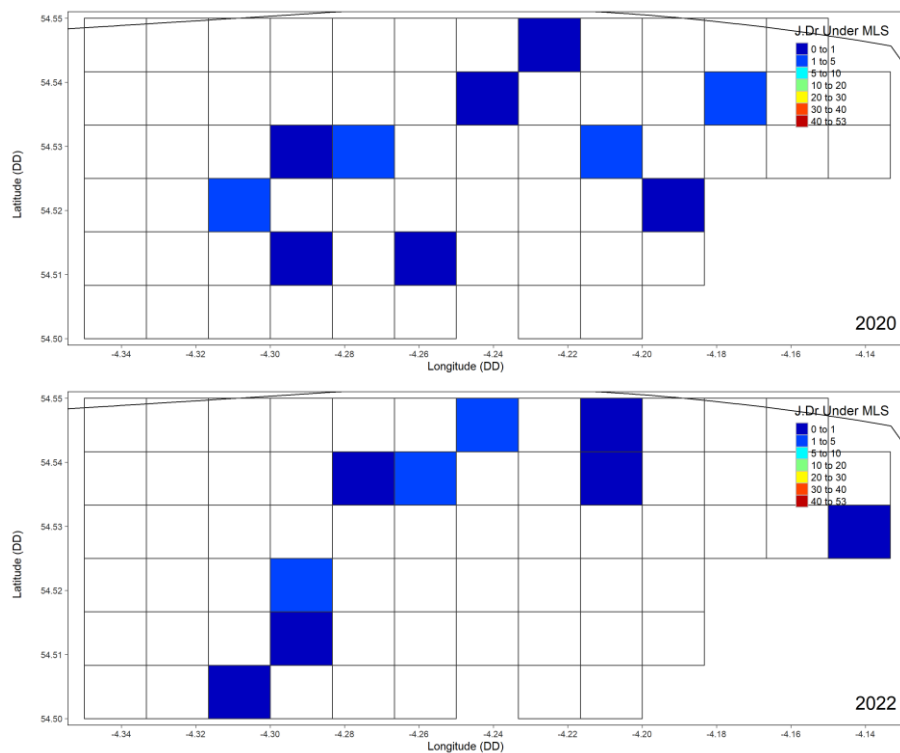


Figure 38: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2020 and 2022 (bottom) at Point of Ayre (North coast).

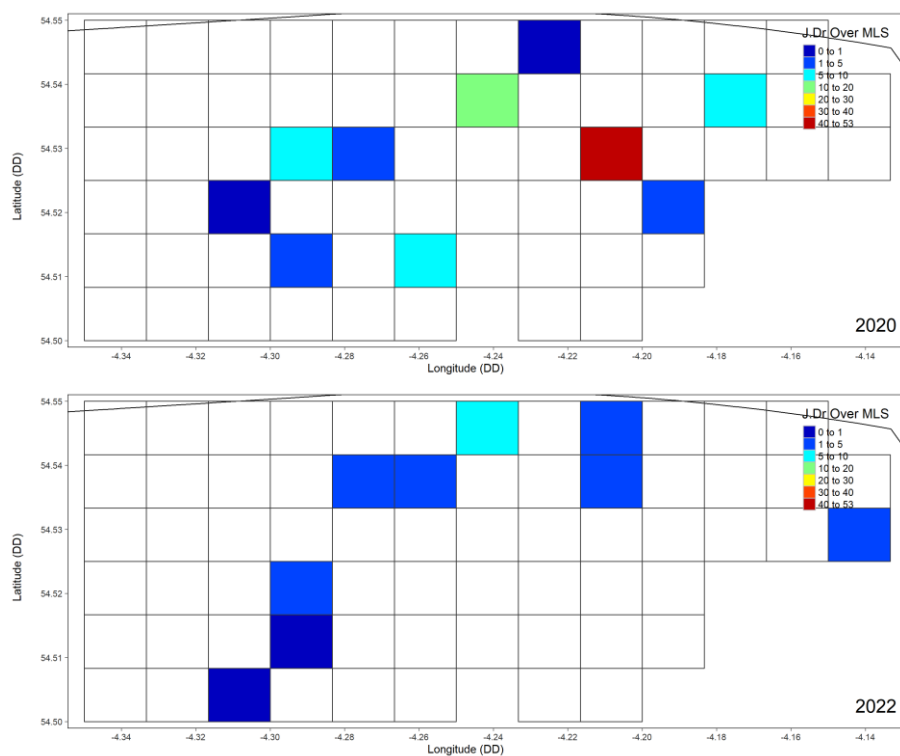


Figure 39: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2020 and 2022 (bottom) at Point of Ayre (North coast).

#### 4.3.3.2.4 Bradda:

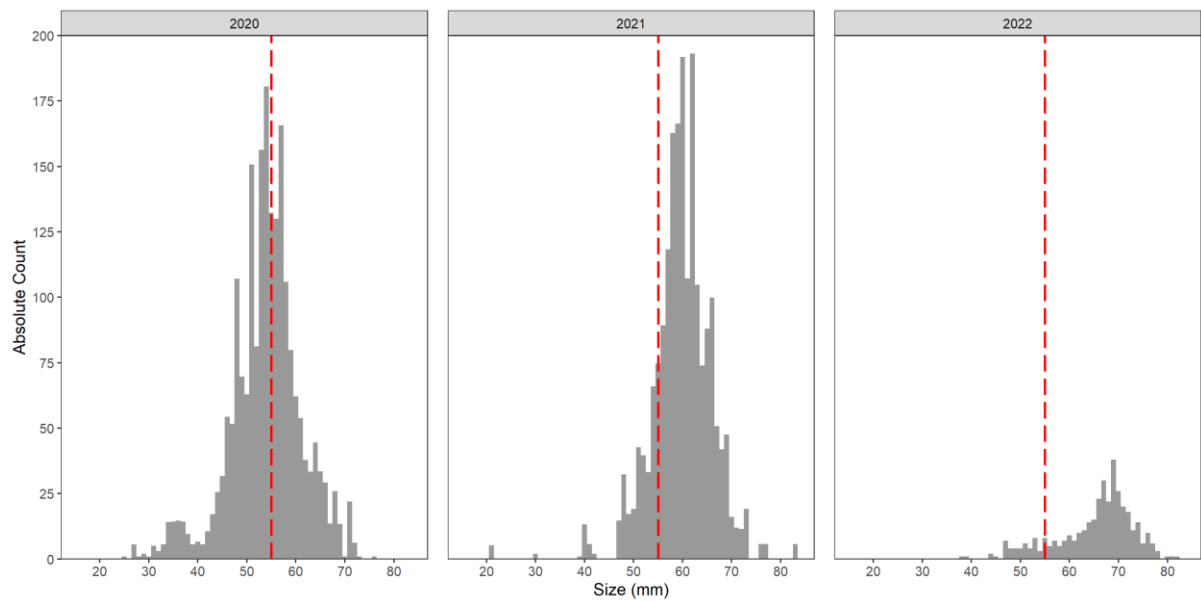


Figure 40: Size density histogram of absolute counts of queen scallops displayed by survey year for Bradda (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Table 16: Juvenile dredge density of QSC per 100 m<sup>2</sup> 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	2022 < 55 mm	2020 > 55 mm	2021 > 55 mm	2022 > 55 mm
Cells Surveyed	11	8	12	11	8	12
Min	0.00	0.00	0.00	0.00	0.00	0.00
Geometric Mean	0.69	0.34	0.03	0.55	2.25	0.10
Max	37.39	8.09	1.95	32.22	47.38	4.54

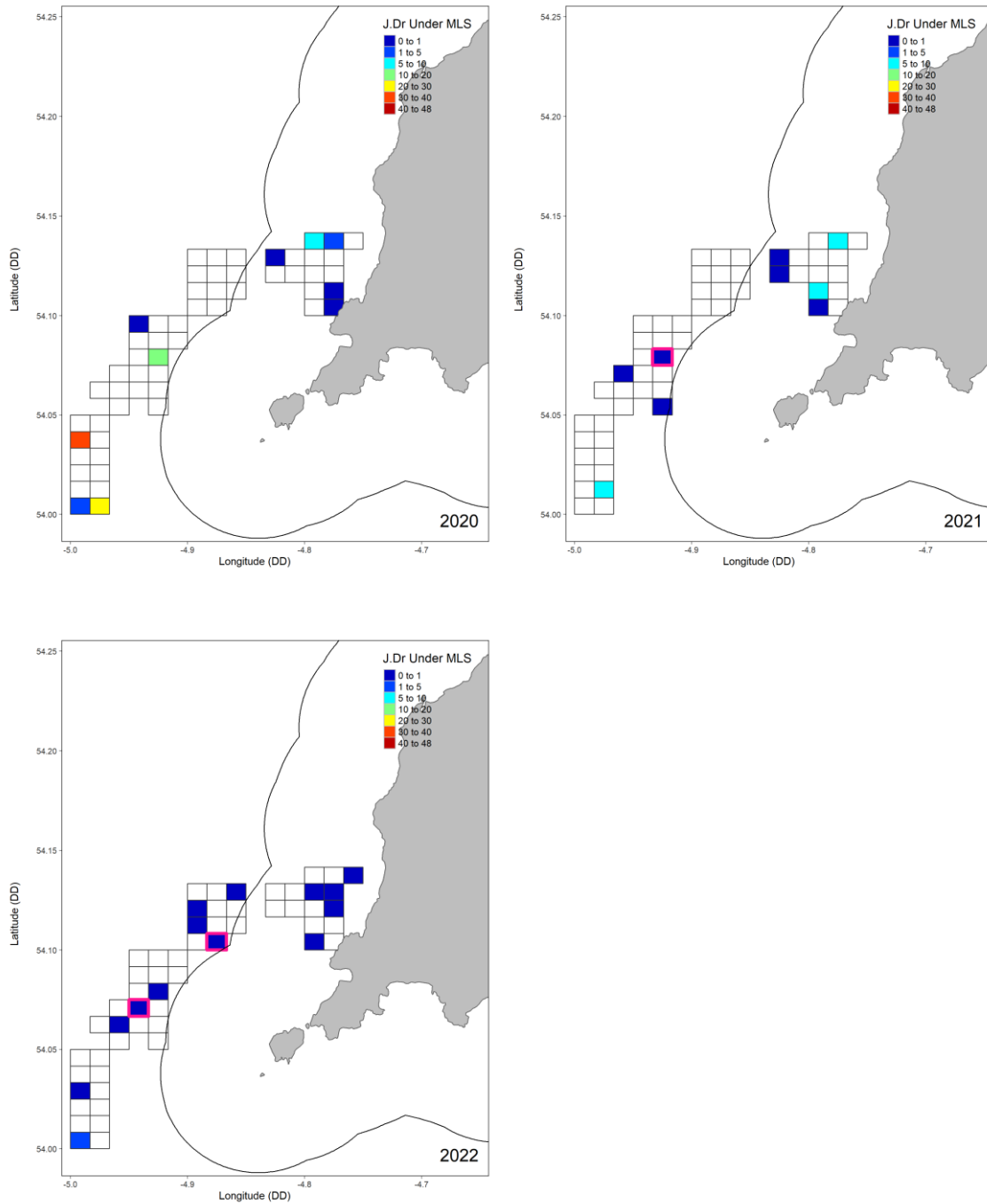


Figure 41: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2020 (top left), 2021 (top right) and 2022 (bottom left) at Bradda (South-west coast).

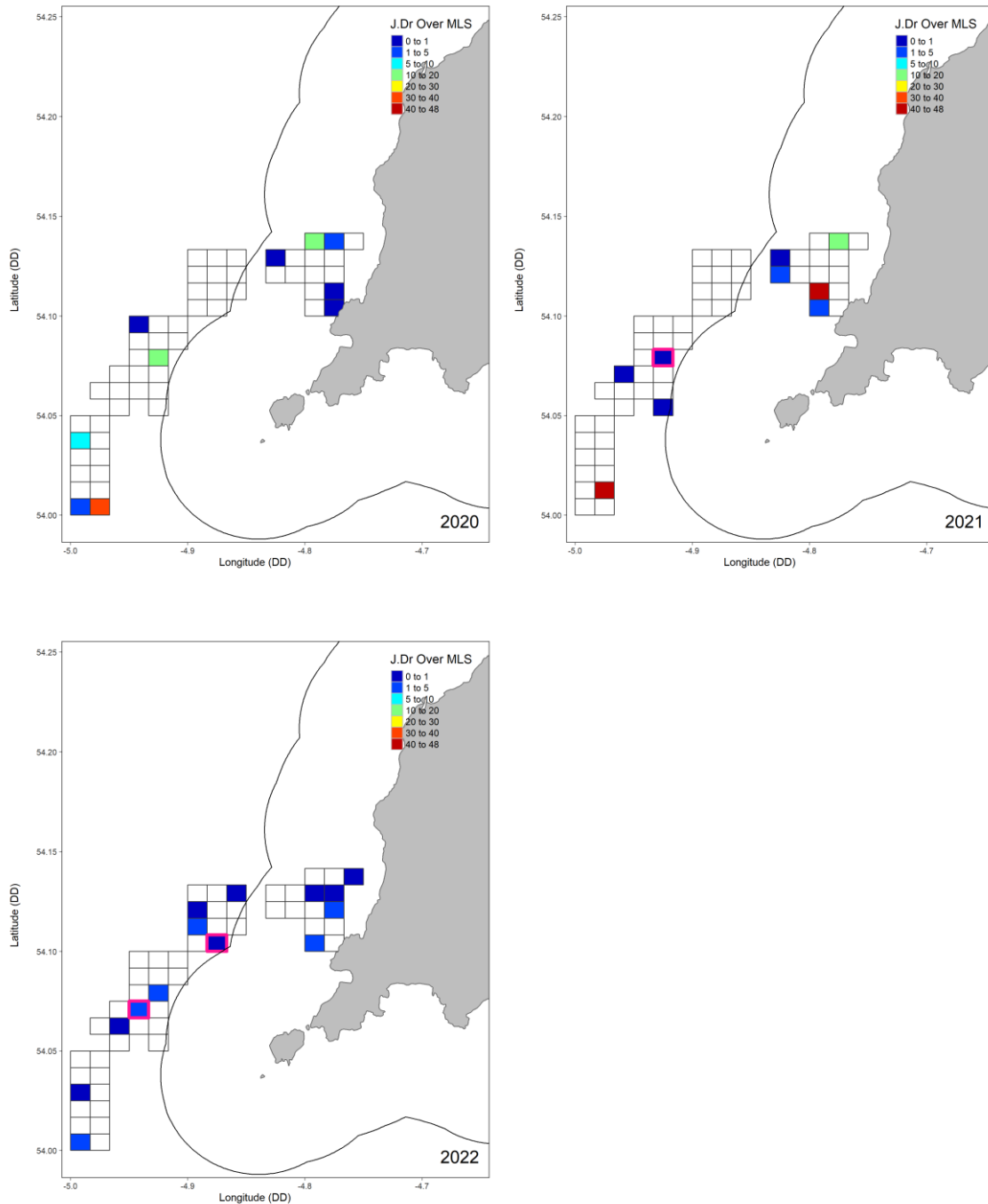


Figure 42: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2020 (top left), 2021 (top right) and 2022 (bottom left) at Bradda (South-west coast).

For BRA, which has not had any quantity of recent fishing activity (up to 1.5 t in 2021) for queen scallops (though historically there has been activity and densities recorded in the longer term survey), there was a decrease in both the post-recruit index (2.25 in 2021 to 0.10 in 2022) and the recruit index (0.34 in 2021 to 0.03 in 2022). 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.

## 5. Summary:

### Summary of findings

At the territorial sea level the scientific survey shows an increase in both the recruit (under 55 mm) and post-recruit (over 55 mm) indices whilst the industry survey indicates a slight increase in recruits but a slight decrease for post-recruits at the territorial sea scale (i.e. using data from EDG, TAR and CHI which are the only grounds which have been surveyed continuously since 2019). The numbers and size ranges of recruits detected in the scientific survey were higher than in the industry survey which uses targeted juvenile dredges. This probably indicates a patchy distribution of recruitment not consistently observed between the two surveys. The scientific and industry surveys show similar spatial trends for high density areas with a high density hotspot identified by both surveys at the Targets (TAR) fishing ground on the west of the island. The industry survey indicates that the hotspot covers a large area through both the current restricted, and the northern closed area. Both surveys indicate that within this area there is a high proportion of queen scallops of fishable size. Both surveys also indicated that the Chickens (CHI) fishing ground in the south of the island had significant declines in the post-recruit survey index within the current restricted area following relatively high fishing pressure and landings (~ 483 t). The scientific survey indicated good densities at stations in the North of the Island (Point of Ayre; POA) which weren't picked up in the industry survey and may therefore indicate localised and patchy densities within the ground. At East of Douglas (EDG) which is on the east coast of the Island the fishing ground was partially shut during both the 2020 and 2021 fishing seasons due to low commercial LPUE. Both surveys also indicate relatively low recruit and post-recruit values for the 2022 surveys within this ground. The industry survey also indicates relatively low densities at Bradda (BRA) on the south west of the island which is typically a transient bed for queen scallops (i.e. it does not consistently recruit for this species).

### Recommendations

A harvesting reference point (TAC) has been calculated for the 2022 fishing season using the ICES Category 3 data limited approach which calculates a 20% increase in the trawl TAC compared to the season prior. It should be noted that the scientific survey was not completed due to Covid restrictions in 2020. The mean of 2019 and 2021 data was used to replace this missing value. This is justified based on the industry data indicating an increased survey abundance index for the territorial sea for 2020 compared to 2019). Several points should be highlighted when discussing the calculation of the TAC for 2022 mainly that the increase in survey abundance for 2022 (based on scientific survey data) was predominately from an increase in the recruit index (i.e. queen scallops under MLS); that high densities of post-recruits are spatially restricted to the west coast and that the estimated 20% increase in TAC for 2022 would equate to removing ~24 % or ~ 29 % respectively of the estimated biomass for 2022, depending on whether the 2021 SOS or EOS TAC is used (any dredge TAC, which would be in addition to the trawl TAC, would also increase these percentages), which would be considered high.

Within the territorial waters there were five temporary managed areas for queen scallops during the 2021 fishing season, for which access was restricted or prohibited. Of these areas, located at CHI (closed and restricted area), TAR (closed and restricted area) and EDG (experimental research area), the TAR restricted area has the highest densities of post-recruit queen scallops recorded in the 2022 surveys (industry and scientific), whilst the restricted area at CHI, which was subject to relatively high fishing pressure and landings (~483 t) during the 2021 fishing season, has substantially decreased in density in the 2022 surveys. Improvements have been seen in queen scallop densities within the EDGERA since its closure in July 2017 from data collected as part of a separate monitoring survey (Bloor et al., 2022).

Recommendations for the management approach for the 2022 queen scallop fishing season are as follows:

- Whilst at the territorial sea level the scientific survey indicated a slight increase in post-recruit biomass (queen scallops over MLS) the industry survey showed a slight decrease. As such, a precautionary management approach should be considered.
- The ICES Category 3 approach estimates a trawl TAC increase of 20% compared to the 2021 fishing season. However, it should be noted this increase is largely driven by increases in the scientific recruit index (i.e. below 55 mm), that there was a slight decrease in post-recruits in the overall industry survey index and that there are multiple values for the 2021 TAC that could be used as the starting point (i.e. starting TAC or the end of season TAC). For these reasons it is recommended that any uplift at the start of the season should be carefully considered and that any TAC set at the start of the season should remain flexible and adaptive to the in-season commercial data (i.e. it should be reviewed regularly through the season and modified as appropriate in line with LPUE thresholds and other monitoring values).
- Separate management for high density hotspots should be considered (i.e. restricted access and management of the high density fishing area at Targets for the 2022 fishing season). This high density area includes the current restricted area and the current closed area to its north (but does not include the current closure to the west of the restricted area situated in a muddy habitat). A days at sea regime and a daily catch limit for the high density area at TAR (outside of the weekly catch limit for the rest of the territorial sea) should be considered. Monitoring of LPUE and fishing intensity (swept area) is also required to ensure that overfishing of these spatially discrete areas does not occur which could lead to negative impacts for future fishing seasons. Separate LPUE thresholds for hotspot areas should be considered.
- Regular monitoring and triggered reviews of all fishing areas throughout the fishing season in terms of LPUE thresholds and total catch.
- The implementation of temporary closed areas for queen scallop in areas of high densities of recruits identified in the surveys. For 2022 this includes a patch of sites on the east coast where high proportions of under MLS queen scallops were identified in the scientific survey (i.e. EDG, ST21 and ST23). In season monitoring of commercial catch in these areas could determine whether an in season closure is useful in this area. In addition, consideration should be given to the continued closure of the current two closures at TAR and CHI situated in muddy habitats just off the typical fishing ground.
- Opening of the EDG ERA: The EDG ERA was closed in July 2017 to monitor natural recovery of queen scallop densities within the area this monitoring has now concluded (improved densities of queen scallops have been recorded although the densities are not sufficiently high to be considered hotspots). Although this area is not considered high density, whether any managed opening of this area is required should be discussed by the SMB.
- Discussion of the dredge box and dredge fishery: 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 in 2020 (~ 250 kg) and no dredge fishing occurring in 2021. The current survey data in the dredge box continues to indicate low densities across the area (except for one survey cell for post-recruits). Given the annual decreases in commercial LPUE for the dredge metier from 2014 to 2020 (Figure 8) and the lack of any fishing in 2021 combined with no significant improvements in survey data for the dredge zone it is recommended that the current dredge TAC is not increased for the 2022 fishing season.



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