Isle of Man Queen Scallop 2023 Stock Survey Report

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Fisheries Report

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1. Fishery Management:

Since the 1950s, fishing for queen scallops (*Aequipecten opercularis*) has occurred within the territorial waters of the Isle of Man. In 2022, 37 vessels were licenced to fish for queen scallops in Isle of Man 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 take place in October with four UK vessels licenced to participate. Various management measures regulate the queen scallop fishery within Isle of Man territorial waters with those applicable during the 2022 queen scallop fishing season indicated in Table 1.

Table 1: Management measures for the Isle of Man queen scallop dredge fishery during the 2022 fishing season

Management measure	Applicable
Total allowable catch of 952 t	Trawl; Weeks 1-13
10 % socio-economic uplift of TAC (to 1047 t)	Trawl; Weeks 14 +
Total allowable catch of 53.8 t	Dredge; 1st – 31st October
Weekly Catch Limit (WCL) 4550 kg per vessel	Trawl; General Territorial Sea
Additional Exploratory WCL 2100 kg per vessel	Trawl; Point of Ayre
Individual vessel quota 14,575 kg	Dredge; Dredge Zone
Queenie conservation zone (dredging prohibited)	0 to 12 nm zone except dredge box
Temporary closed areas	TAR, EDG and EDG ERA
Temporary restricted areas	TAR
Permanent closed areas (i.e. MNRs)	Within 0 to 3 nm zone
Minimum landing size (55 mm)	0 to 12 nm zone
Spawning protection closure (01/04 – 31/05)	0 to 12 nm zone
Irish Sea Closure (01/04 to 30/06)	Irish Sea
Daily Curfew (18:00 to 06:00)	0 to 12 nm zone
Saturday ban (fishing permitted on a Sunday)	0 to 12 nm zone
VMS required for all vessels	0 to 12 nm zone
Submission of EU logbook	0 to 12 nm zone
Submission of IoM daily catch return	0 to 12 nm zone
Under 221 kW (except Grandfather Rights)	0 to 12 nm zone
≤ 15.24 m vessel registered length	0 to 3 nm zone

The Fisheries Act 2012 and restrictive licencing conditions enable the implementation of these management measures.

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.
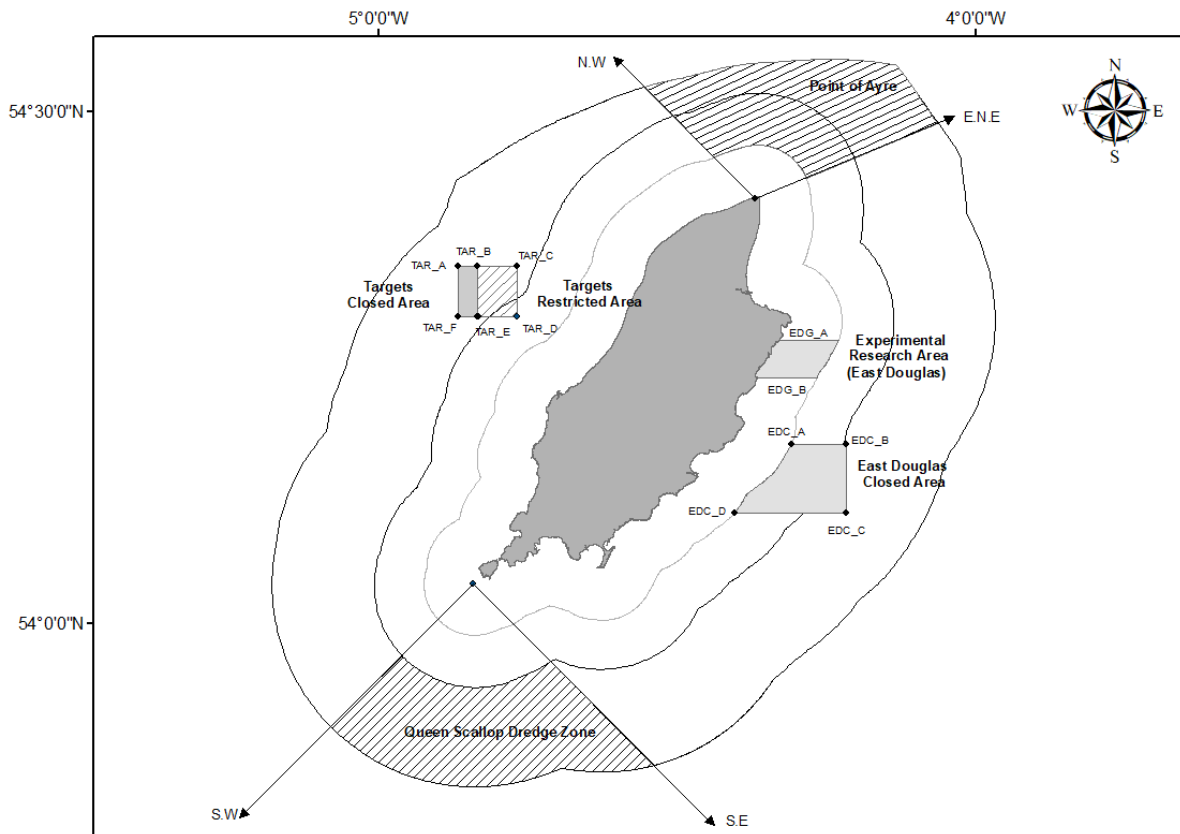
Figure 1: Map showing closed areas (grey boxes) and restricted/management areas (hashed boxes) for the 2022 queen scallop fishing season

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 – 2020 (data lag of around 2 years) are shown in Figure 2 (ICES 2023a,b). 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 2020 the average annual Manx share declined to around 21%, with United Kingdom vessels (Scotland, England, Wales and Northern Ireland) landing the remaining proportion (~79%).

Landings over the last 15 years have shown high variation with a rapid increase from 2008 to a peak of over 20,000 t in 2011 (Figure 2). These unprecedented levels were maintained briefly before declining rapidly. Given the general lack of management of the wider Irish Sea stock and our limited knowledge of the impact of such high fishing rates such a significant increase in landings was of concern. Reported landings in 2020 for queen scallops from the Irish Sea were over 85% lower than landings recorded at the peak in 2011.
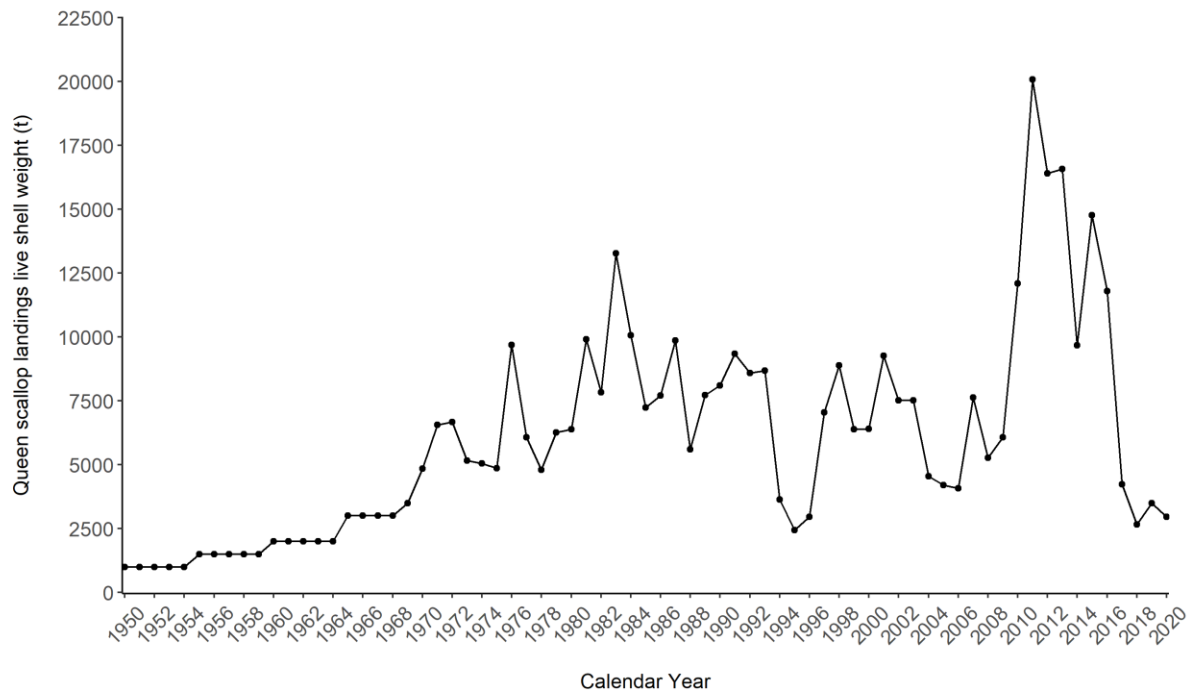
Figure 2: Annual live shell weight queen scallop landings (tonnes) from ICES Area VIIa for 1950 to 2020 using scallop landings from species Aequipecten opercularis (ICES 2023a,b).

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 – 2022 (Figure 3). Landings increased rapidly from 2009 to 2011 tripling over that period from 5015 t in 2009 to 16957 t in 2011. This was followed by a large decline; in 2020 landings reached a low of only 920 t (Figure 3) which represented only 6% of the landings at the 2011 peak. In recent years, there has been a slight recovery (1872 t in 2021 and 2358 t in 2022).

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 1310 t by 2022. The trawl fishery has seen a reduction in landings from a peak of 4517 t in 2013 to 579 t in 2019 before increasing to 1048 t by 2022. In 2020 (Covid lockdown year) the trawl fishery had a higher proportion of landings than the dredge fishery for the first time in the time series, with almost 50 % of landings contributed by either gear in 2021 (Figure 4).
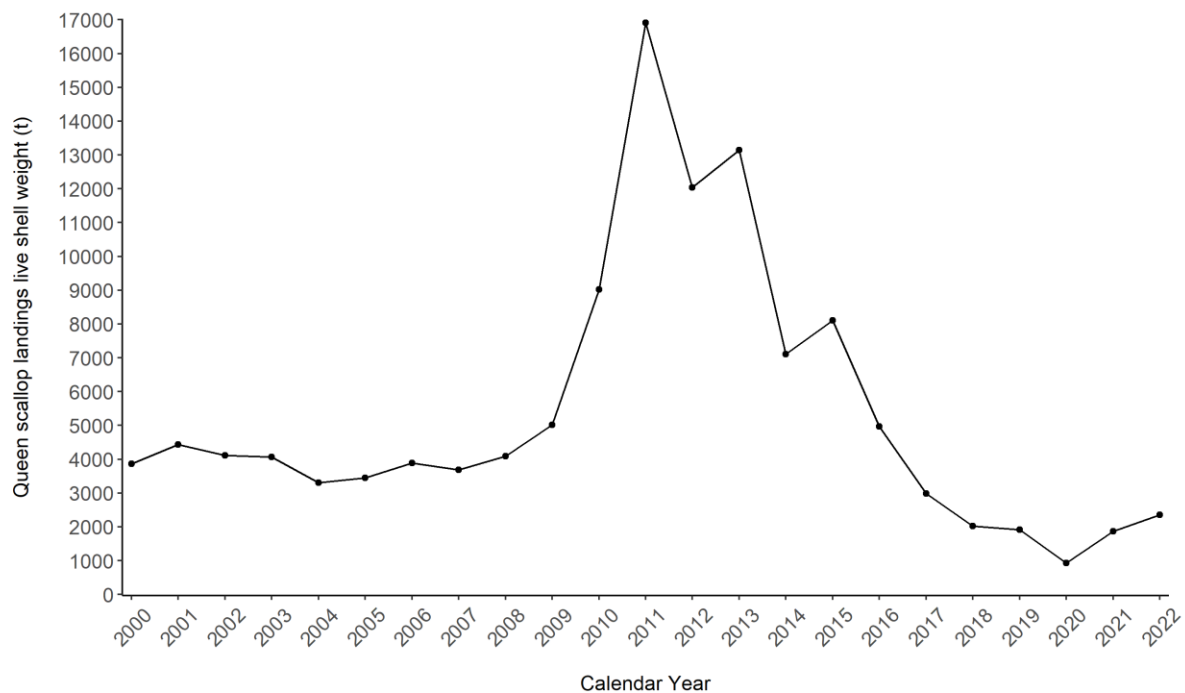
Figure 3: Annual live shell weight queen scallop landings (tonnes) from ICES Rectangles 36E5, 37E5 and 38E5 for 2000 to 2022 (Source: Paper logbook data DEFA and IFISH 2 Database).

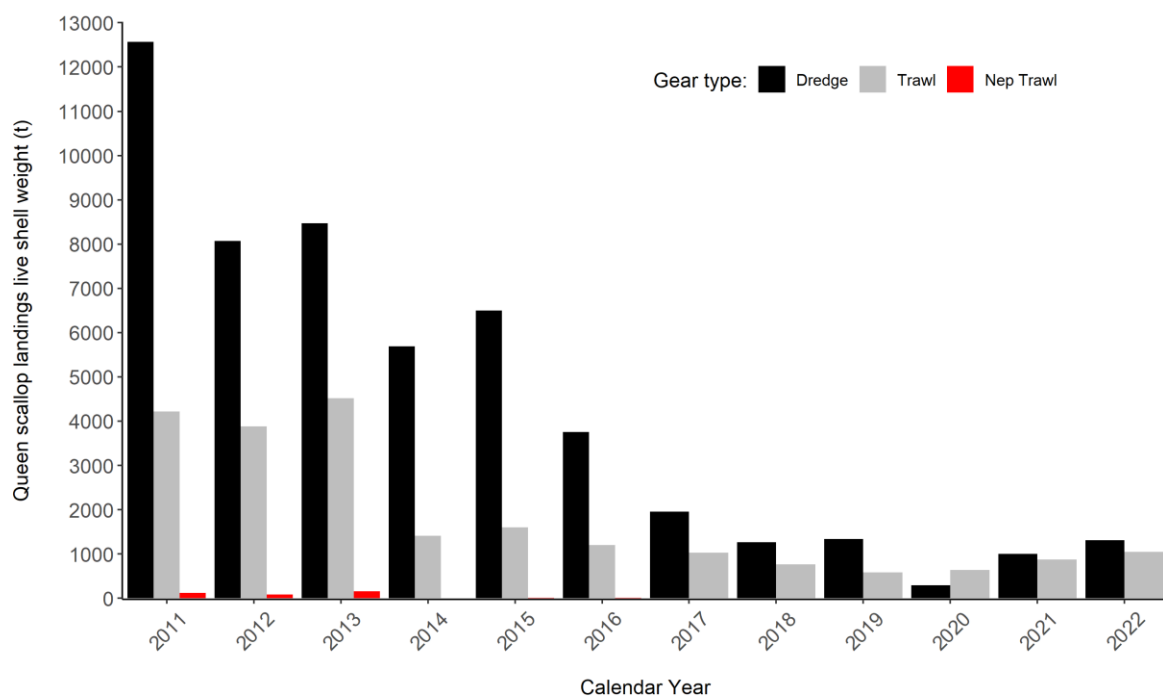*Figure 4: Annual live shell weight queen scallop landings (tonnes) from ICES Rectangles 36E5, 37E5 and 38E5 for 2011 to 2022 (Source: IFISH 2 Database) split by Gear type.*

3. Landings and Fishing Effort in Isle of Man 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 2022 Isle of Man queen scallop trawl fishery, which included 33 licenced vessels, had a starting TAC of 952 t (with a 10% socio-economic uplift agreed in Week 14 = 1047 t). The trawl fishery opened on 1st July 2022 and closed on 31st October 2022. A weekly catch limit of 4550 kg per vessel per week was implemented for the general territorial sea with an additional exploratory catch at Point of Ayre of 2100 kg per week per vessel (hatched area at PoA; Figure 1). Total reported landings for the trawl fishery during the 2022 fishing season were ~ 888.86 t with 23 unique vessels reporting landings. The majority of landings for the 2022 season came from Targets (Table 2). In 2022 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 2022.

Table 2: Landings by ground for the 2022 queen scallop fishery (trawl and dredge; 0 t landed from dredge fishery)

Area	Landings (t)
IS9: Targets	799.6
IS6: Point of Ayre	53.1
IS15: East Douglas	13.3
IS10: Maughold	12.2
IS21: Chickens	10.8

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. Targets (TAR) (IS 9) had the highest LPUE across the season within the restricted area (median weekly LPUE values of ~ 8 – 15). The mean weekly LPUE for all other grounds was typically below 8 bags for Chickens (CHI) and Point of Ayre (POA) and below 5 bags for Maughold (MGH) and East Douglas (EDG) (Figure 5).
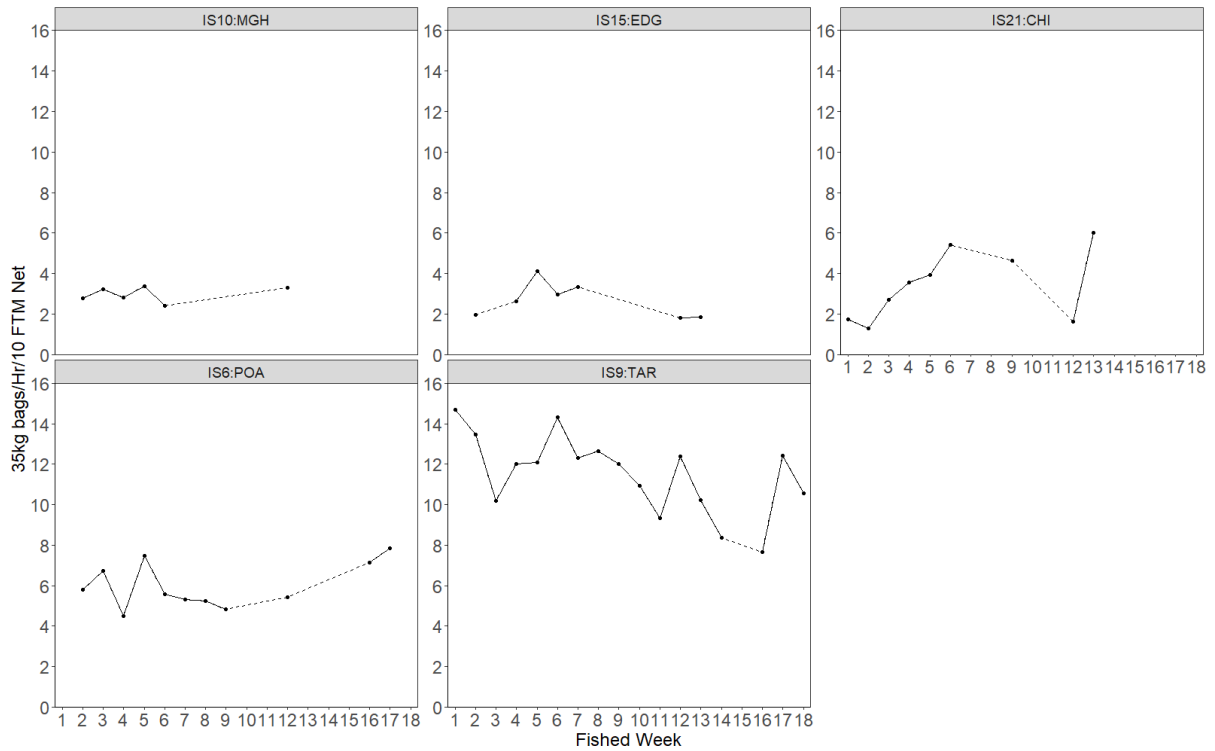
Figure 5: Mean queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for the 2022 queen scallop trawl fishing season displayed by week and main fished ground. Dashed line indicates weeks with no fishing recorded.

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 2022 in Figure 6. The boxplot indicates that the median LPUE for the 2022 fishery was the third highest in the time series (Figure 6). Fishing within higher density restricted access areas at Chickens and Targets in 2021 and Targets in 2022 contributed significantly to increases in median LPUE in these recent fishing seasons (Figure 5).
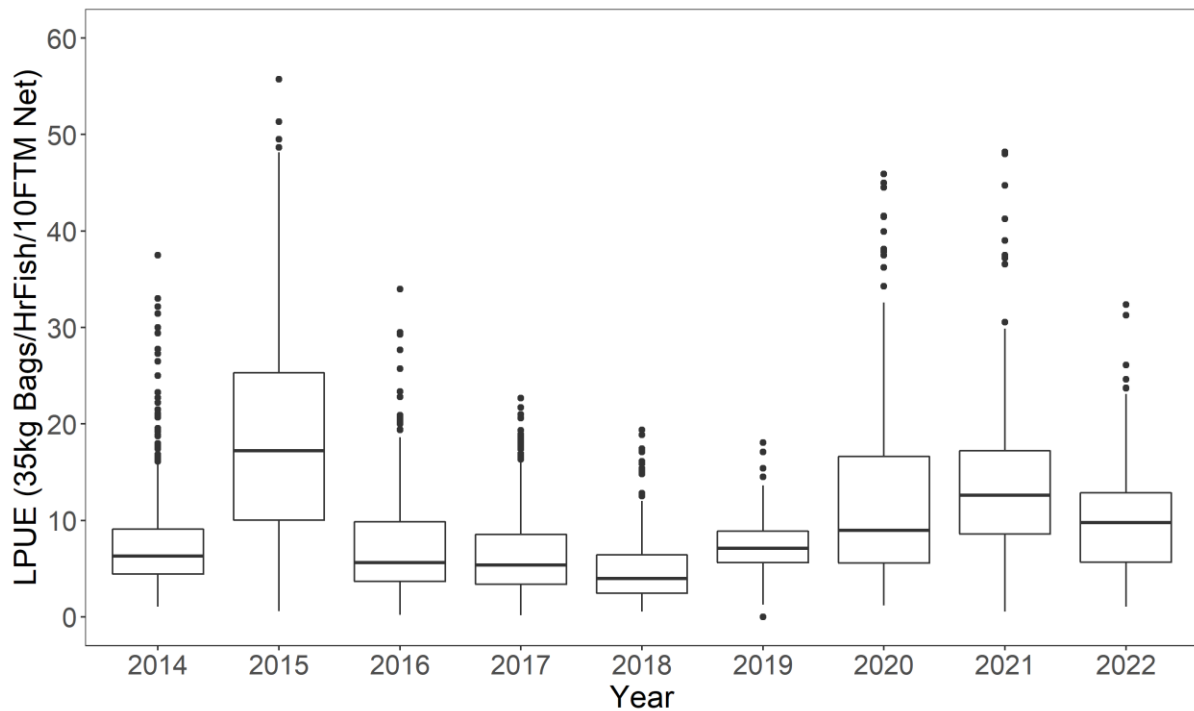
Figure 6: A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for all vessel trips by fishing season from 2014 to 2022.

The dredge fishery had a sub TAC of ~58.3 t and opened on 1ˢᵗ October 2022. For the dredge fishery, each eligible vessel was allocated an individual quota of 14,575 kg that could be fished at any point during the season. Total reported landings for the dredge fishery during the 2022 season were 0 t with none of the 4 licenced vessels reporting landings. Prior to 2021, LPUE for the dredge fishery had seen annual declines with the lowest value (based on a single trip) recorded in 2020 (Figure 7).
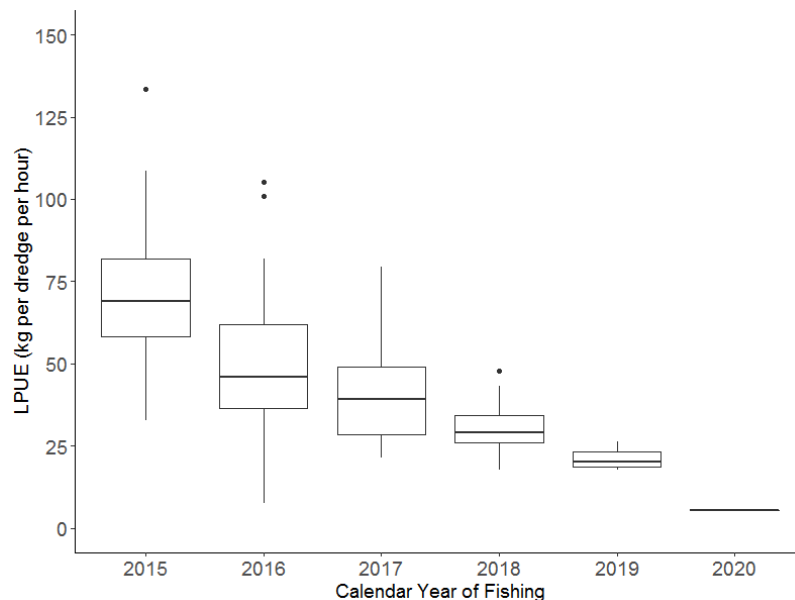

Figure 7: LPUE standardised to kg per dredge per hour for dredge vessels participating in the Isle of Man queen scallop dredge fishery which occurs within the dredge box located within the CHI fishing ground from 2015 to 2020 (note no landings reported in 2021 or 2022).

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 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 2023 spring scallop survey was undertaken by the R.V. Prince Madog over 9 days from 31st March – 8th April 2023. A total of 55 survey stations were sampled (Figure 8). The standard survey gear comprises of a set of four Newhaven dredges: two with 80 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).
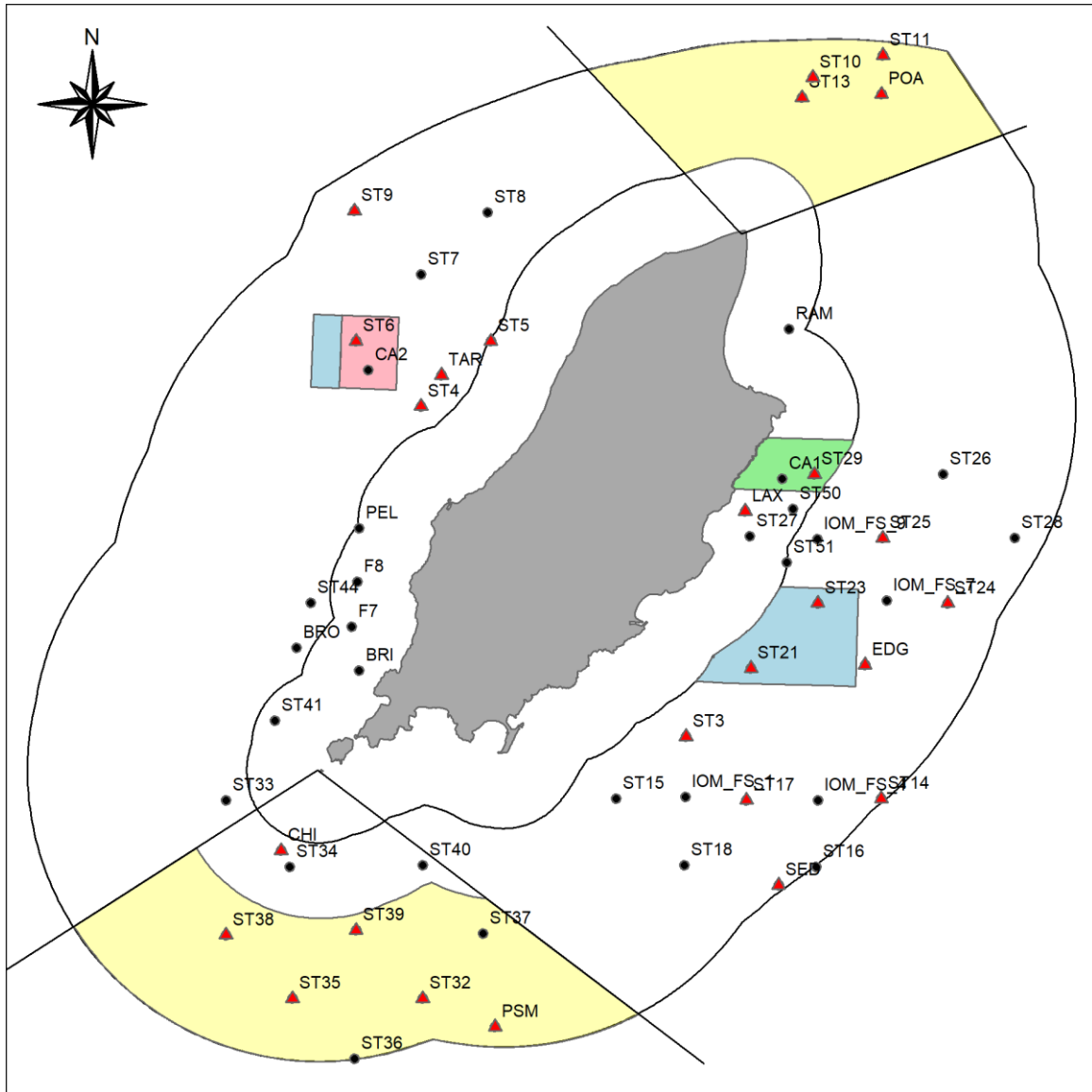
Figure 8: A map showing the location of all 2023 survey stations (red triangles = Stations used in stock assessment and survey abundance indices; black circles = Additional survey stations). During the 2022 queen scallop fishing season light pink boxes indicate areas with restricted management; light 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 boxes indicate the queen scallop dredge zone in the south and the exploratory WCL zone in the north.

4.2.2 Size Frequency:

A frequency plot of queen scallop size data is presented in Figure 9 from samples measured at stock assessment stations (queen scallop dredge data only). In 2023, there is a well-defined peak in queen scallops from 45-70 mm (Figure 9). Queen scallops ≥ 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 ≥ 45 & < 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. In 2023, the data also indicates a proportion of the sampled stock to be pre-recruits queen scallops (i.e. 15-45 mm), which are unlikely to grow into the fishery for the current 2023 fishing season. This cohort, and its spatial distribution, 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.
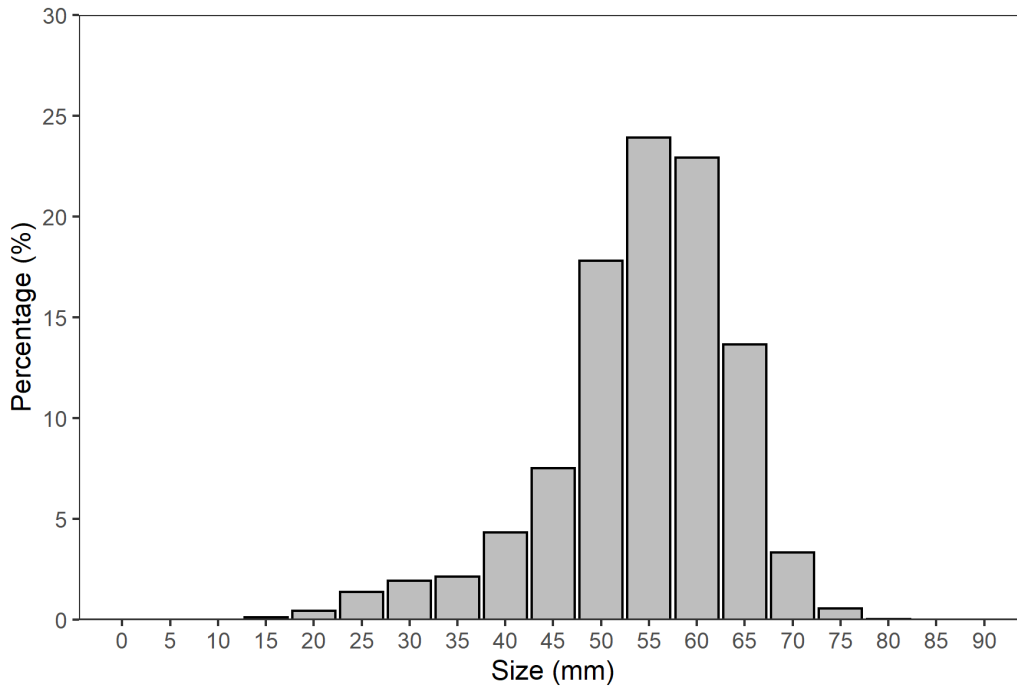
Figure 9: Queen Scallop size frequency plot for 2023 Prince Madog survey data for measured scallops. Data from stock assessment sites and queen scallop dredges only. Percentage under 55 mm = 36% (based on subsamples of n = 3062).

By splitting the data into main fished grounds (i.e. individual stations grouped into fishing grounds), the patterns of recruitment indicate the strongest cohort of smallest recruits (20 – 40 mm) is at TAR with TAR, CHI, EDG and SED all having cohorts of larger recruits (40-50 mm). Conversely, POA lacks any obvious recruitment peaks at either 20-40 mm or 40-50 mm with the majority of scallops sampled measuring ≥ 55 mm (Figure 10).
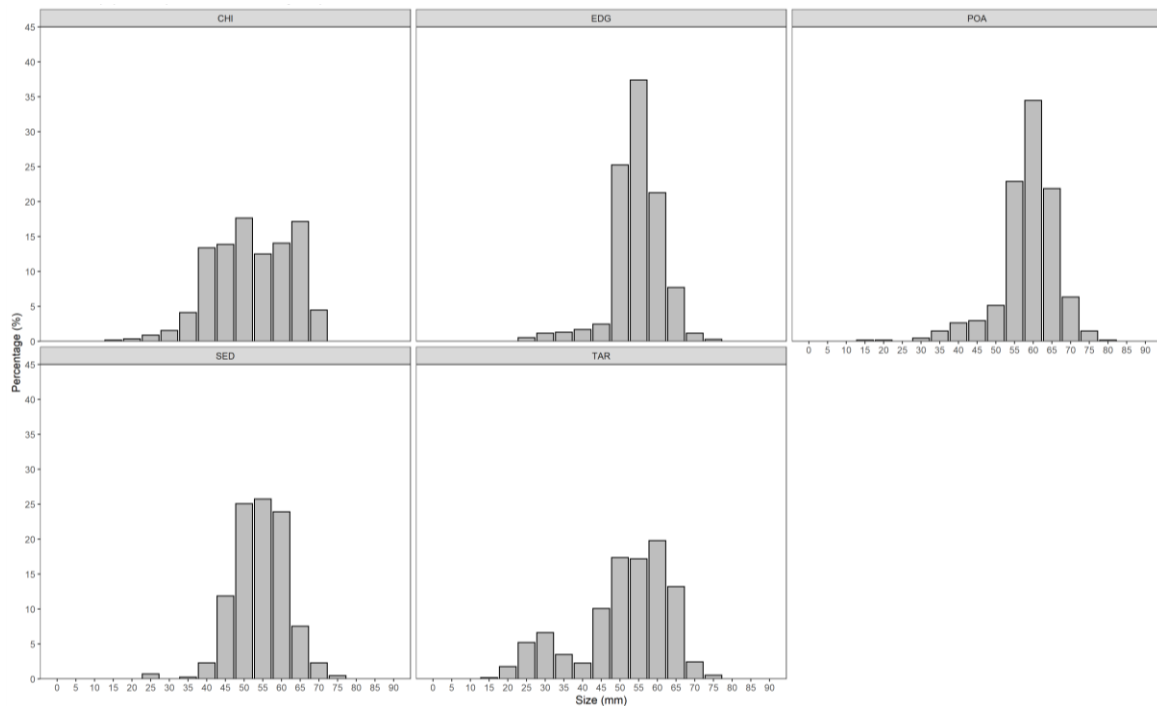

Figure 10: Queen Scallop size frequency-density plot for each ground for the 2023 Prince Madog survey data. Data from stock assessment sites and queen scallop dredges only. CHI: Chickens, EDG: East of Douglas, POA: Point of Ayre, SED: South East of Douglas and TAR: Targets.

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 11. The three survey sites with the highest densities are CA2, TAR and ST6 (west coast; 71- 115 queen scallops per 100m^2). CA2 and ST6 are located within a current restricted access area (Figure 8).
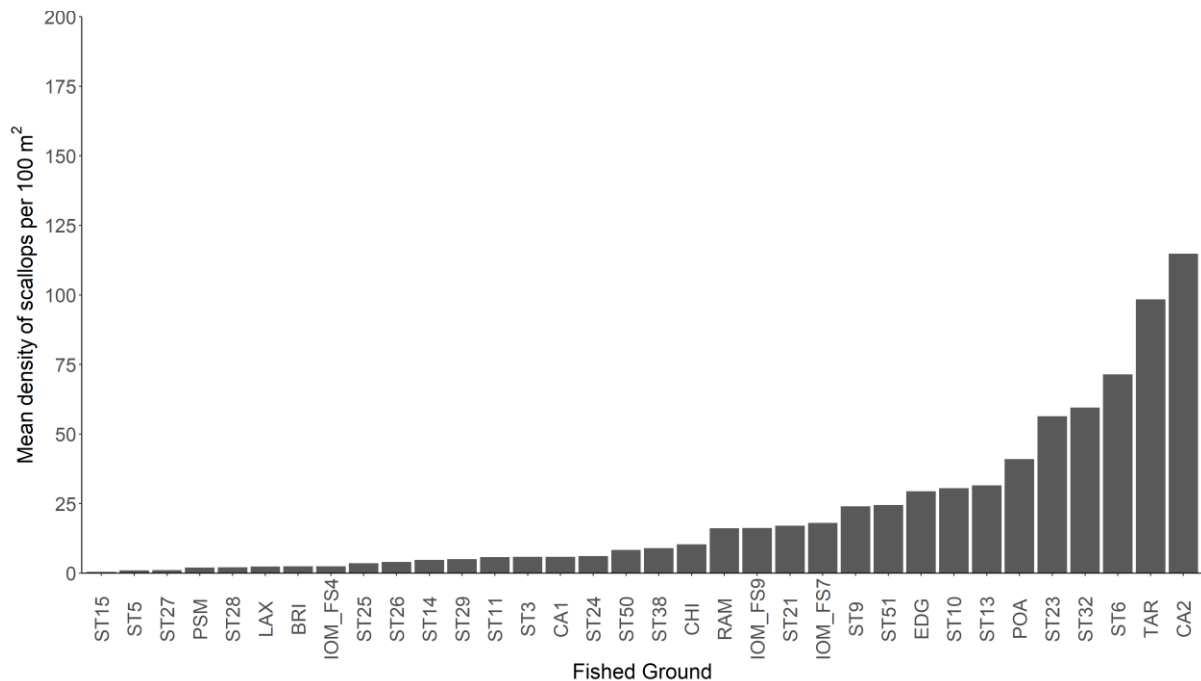

Figure 11: Average survey density (scallops per 100m^2) of queen Scallops from queen scallop dredges from all sites surveyed during the 2023 Prince Madog survey. For plotting purposes sites where QSC density was < 0.45 scallops per 100 m^2 are not displayed (see figure 9 for station locations)

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 8). Please note that the inclusion of stations was updated in 2022 to include or exclude relevant stations (Bloor et al., 2022). 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 differences in mean survey density (scallops per 100 m^2) of queen scallops from queen scallop dredges between 2022 and 2023 are displayed for all stations used in the stock assessment in Figure 12. The highest density increases are on the west and south of the Island where densities have increased at TAR and ST32 by 90 and 58 scallops per 100 m^2 respectively. The highest decrease in density was also on the west of the Island where densities have decreased at ST6 by 121 scallops per 100 m^2.
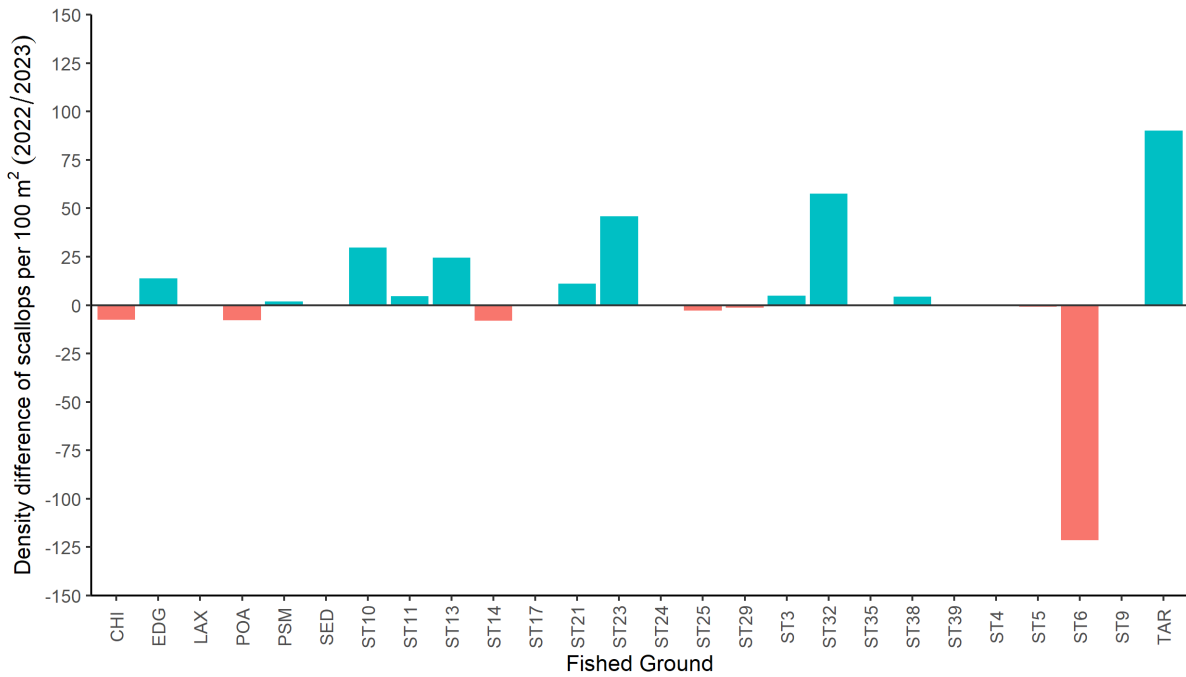
Figure 12: Difference in average survey density (scallops per 100 m²) of queen scallops from queen scallop dredges between 2022 and 2023. Red bars indicate decreases in scallop density from 2022 to 2023 and turquoise bars indicate increases in scallop density from 2022 to 2023.

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 2023 (132) is the highest recorded for recruits since 2009 and is above the long-term mean of 81 (Figure 13). As seen in Figure 15 there are several sites with relatively high recruit densities around the island (i.e. TAR, ST32, S96, CA2 and ST9). Two of these stations on the west coast (TAR and CA2) are also mixed with high densities of post-recruits (Figure 16).

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 (Figure 14). From 2012 to 2019 there has been a declining trend in post-recruit abundance (slight increase observed in 2016). The data for 2023 (285), although still below the long-term mean (~386), is the highest recorded for post-recruits since 2017 (Figure 14).
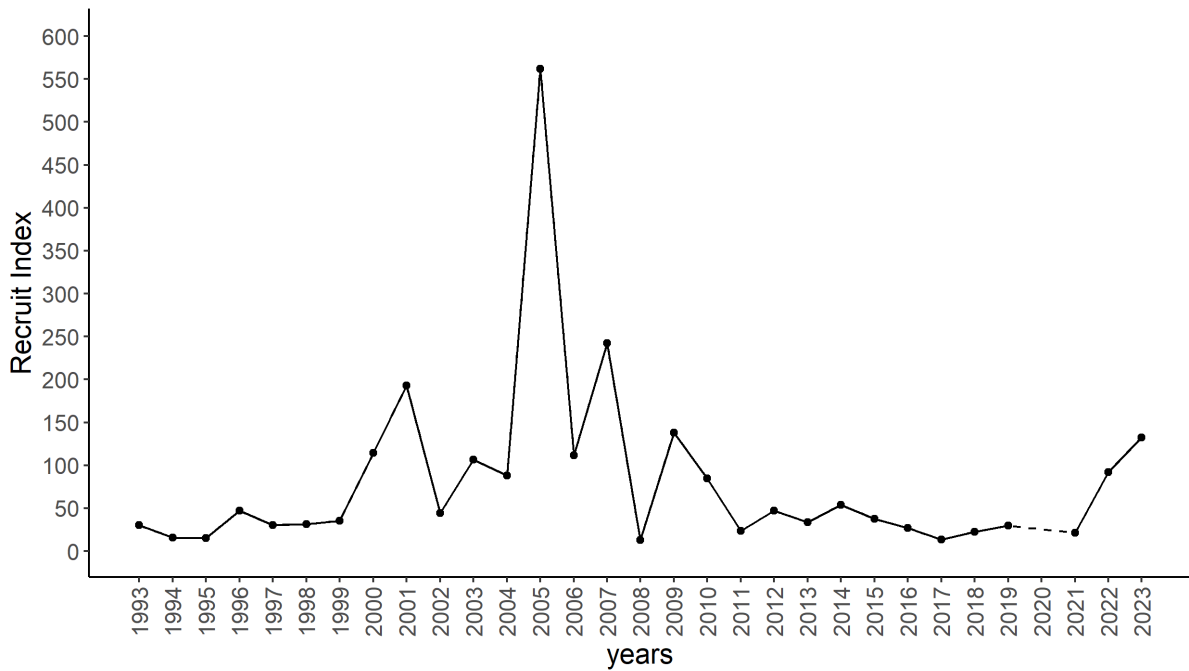
Figure 13: Abundance index (based on geometric mean) for recruits (under 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account for 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.
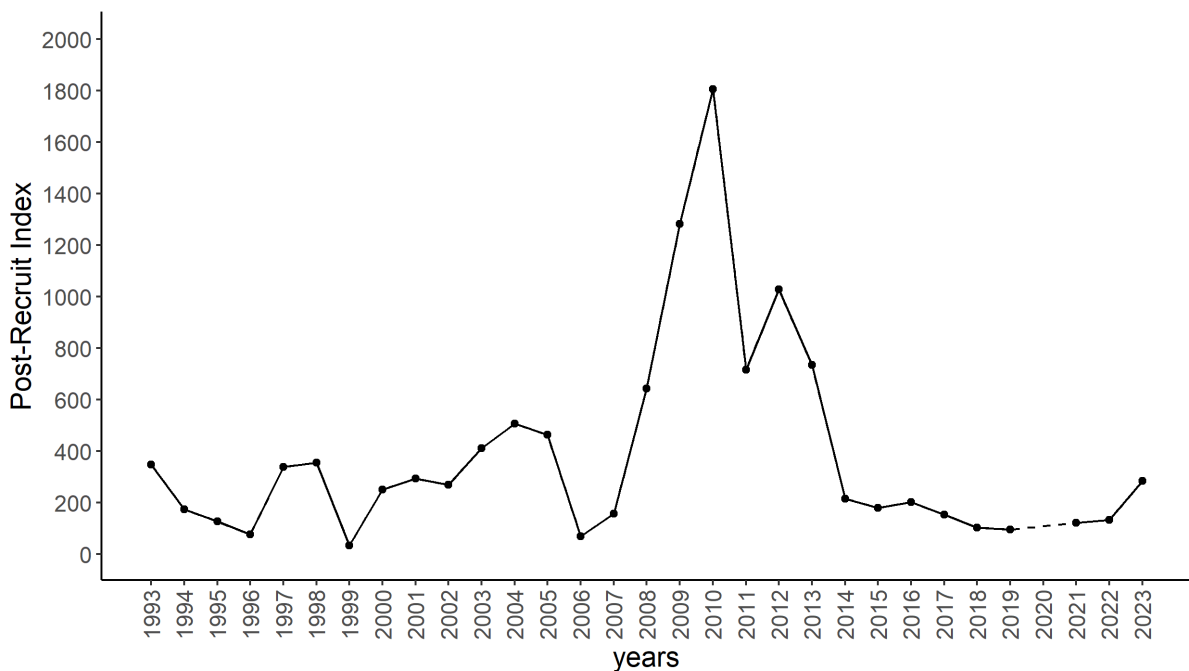

Figure 14: Abundance index (based on geometric mean) for post-recruits (over 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account 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 15 indicate the typical ranges (box indicates inter-quartile range) of recruit density across years (1992 to 2023) for each site along with the median value (horizontal line). The red line indicates a density of 10 scallops per 100 m^2 that is above typical values and indicates a good recruitment event at that site within that year. The data for 2023 are plotted as blue points on the figure and indicate that the highest localised densities of queen scallops are at TAR, ST6, CA2 and ST9 on the West Coast within Targets fishing ground and ST32 on the East Coast within Chickens fishing ground. It would be appropriate to consider separate management for the 2023 fishing season for these high density areas of recruits.
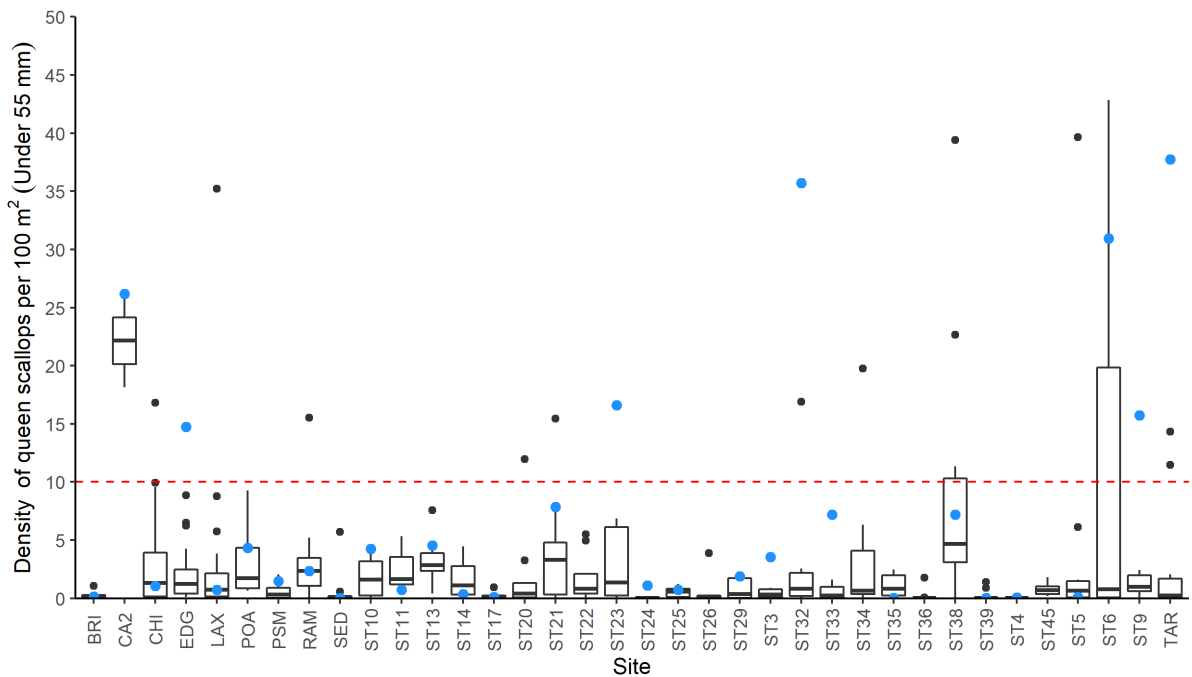

Figure 15: Boxplot of recruit (< 55 mm) queen scallop density per 100 m^2 for stations where queen scallops are typically present. Outliers over 10 (which appear as points above the red dashed line) are exceptional years of recruitment. The data includes all surveys from 1992 to 2023 and the blue points are the data from the current 2023 survey.

The boxplots in Figure 16 indicate the typical ranges (box indicates inter-quartile range) of post-recruit density across years (1992 to 2023) 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 2023 is also plotted as blue points on the figure and indicates that the highest localised densities of queen scallops are at CA2 and TAR on the West Coast within Targets fishing ground. It would be appropriate to consider separate management for the 2023 fishing season for these high density areas of post-recruits, especially as this area overlaps with the high density of recruits.
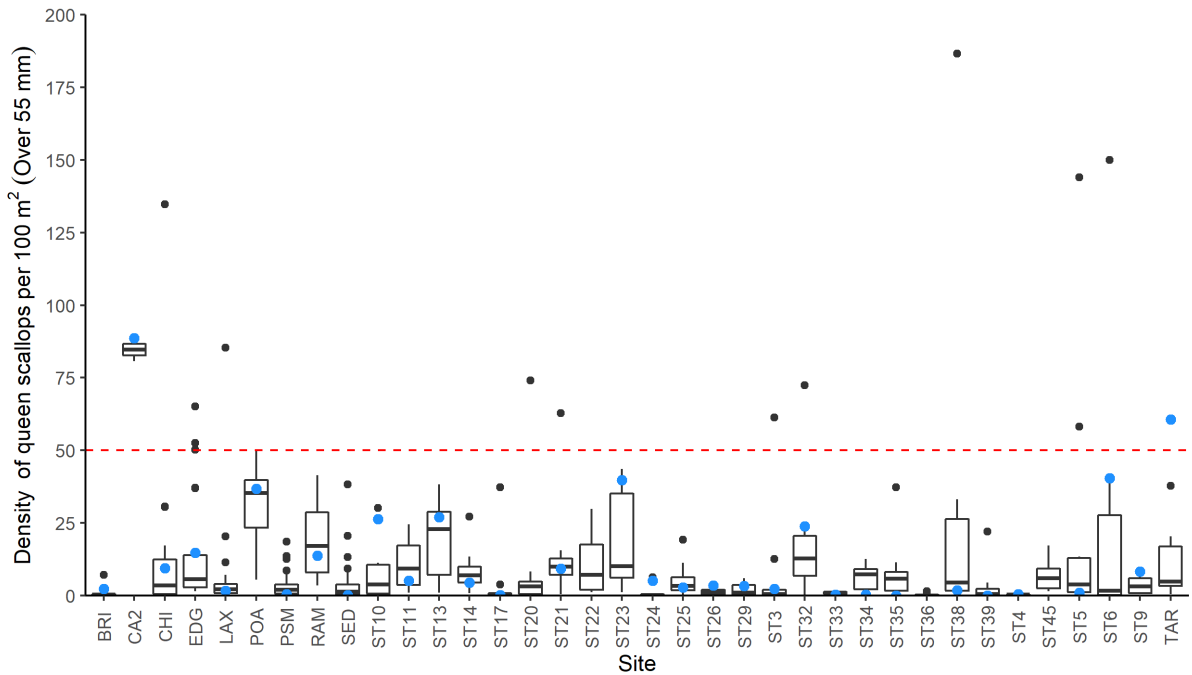
Figure 16: Boxplot of post-recruit (≥ 55 mm) queen scallop density per 100 m² for stations where queen scallops are typically present. Outliers over 50 (which appear as points above the red dashed line) are exceptional years of post-recruits. The data includes all surveys from 1992 to 2023 and the blue points are the data from the current 2023 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 5 years (2019 – 2023) (2023: median estimated biomass of 6592 t) (Figure 18). *Note, that there is a missing year of survey data for 2020 in the input data.*
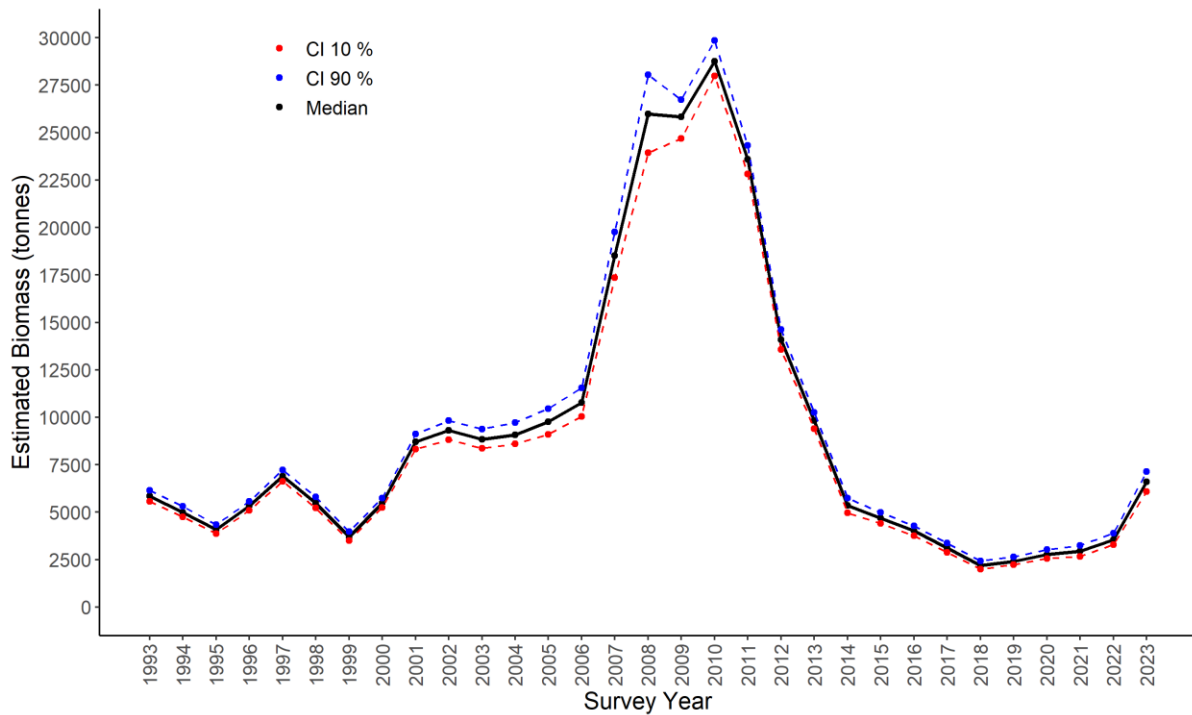
Figure 17: Estimated biomass (all scallop sizes) for the stock assessment unit (Isle of Man territorial waters) MCMC results from CSA Version 4.3.

Estimated biomass can be further subdivided into post-recruit (≥ 55 mm) and recruit (< 55 mm) biomass (Figure 18); for 2023 these values are 4091 t post-recruit and 2501 t recruit. From this data, we can see that peaks in recruit biomass (i.e. 1996, 2001, 2007, 2009) are typically followed by peaks in the post-recruit biomass, with a 1-year lag (Figure 18). Following this pattern, the increase in recruit biomass in 2022 has seen an increase in post-recruit biomass in 2023 (Figure 18). With continued good management hopefully a further increase in post-recruit biomass will be seen in 2024 following the evident increase in recruit biomass in 2023. A 20% harvest rule (proposed as a sustainable proportion for fishing mortality during the period of Marine Stewardship Council certification), using post-recruit (i.e. fishable) biomass, would give a biomass linked TAC for the 2023 fishing season of 818 t.
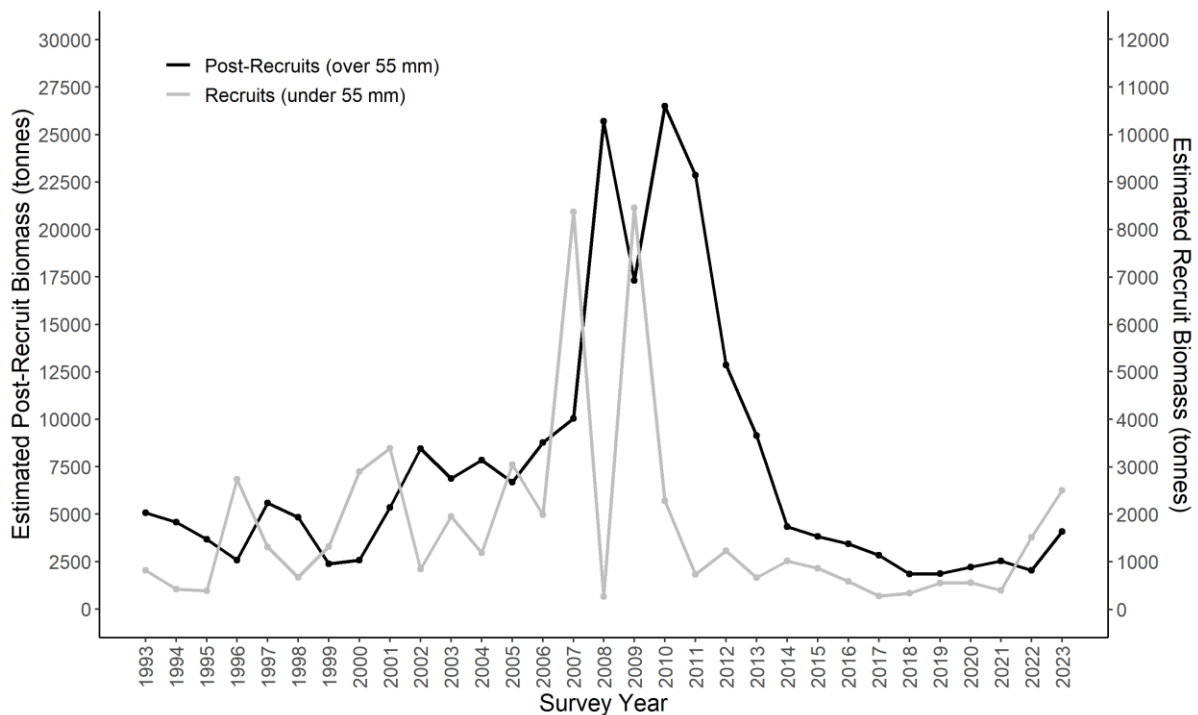
Figure 18: Estimated biomass for the stock assessment unit (Isle of Man territorial waters) MCMC results from CSA Version 4.3. The black line is for post-recruit (≥ 55 mm) biomass (left y-axis) and the grey line is for recruit (< 55 mm) biomass (right y-axis), please note different axes scales.

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 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 around the ICES Category three stock assessment methods (ICES 2012). This approach requires an index of abundance or biomass to be available usually derived from a research vessel survey. For the purposes of providing management advice, the recent trend in biomass is assessed by calculating the mean biomass index in the last two survey years (index A) compared with the previous three years (index B). Given the uncertainty that the stock survey index is representative of true stock status, large inter-annual changes in TAC are avoided. This is achieved by capping any annual advised changes in the TAC by + 20 %, known as the uncertainty cap.

In 2020 there was no survey due to covid restrictions and so there is a missing data point for that year in the five year time series. As we have data from each year after 2020, and it is known that the industry survey abundance index increased in 2020, then 2020 has been estimated as a mean value between 2019 and 2021 for the purpose of the TAC calculation.

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

Table 3: Queen scallops in Isle of Man territorial waters, TAC calculation for the trawl fishery based on ICES Category 3 stock approach for 2023 advice (total abundance index i.e. scallops of all sizes).

		Landings 2022
Index A (2023 & 2022)		321
Index B (2021-2019; no data for 2020)		134
Index ratio (A/B)		2.4
Uncertainty cap	Applied|	0.8
Landings from 2022 (trawl)		889 tonnes
Precautionary buffer	Not applied|	NA
Catch advice for 2023 (trawl)		1067 tonnes
% advice change relative to prior season		+ 20 %

In considering the output of the ICES Category 3 approach, which would give a recommended TAC of 1067 t (equating to an uplift of 20% on 2022 landings), 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 ICES protocol uses actual landings (as above) rather than proposed TAC as the metric for adjustment for setting the next seasons TAC.
- The highest density of post-recruits identified in the 2023 survey are spatially restricted to the west coast. Setting a TAC at the territorial sea level does not take into account the spatial variability in fishing opportunities.

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 22nd May - 6th June 2023. Four main queen scallop fishing grounds, one transient bed and an Experimental Area at East Douglas (EDGERA) were surveyed (Table 4):

Table 4: Grounds surveyed during the 2023 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.

Ground	Survey Tows	Type
Targets (TAR)	42	Permanent
Chickens (CHI)	39	Permanent
East of Douglas (EDG)	61	Permanent
Point of Ayre (POA)	10	Permanent
Bradda (BRA)	54	Transient
EDGERA	6	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 (Figure 19) 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' survey comments.

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 were surveyed in some 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 and 2022 surveys were undertaken in April, the 2021 survey in May and the 2023 survey in May/June. 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.
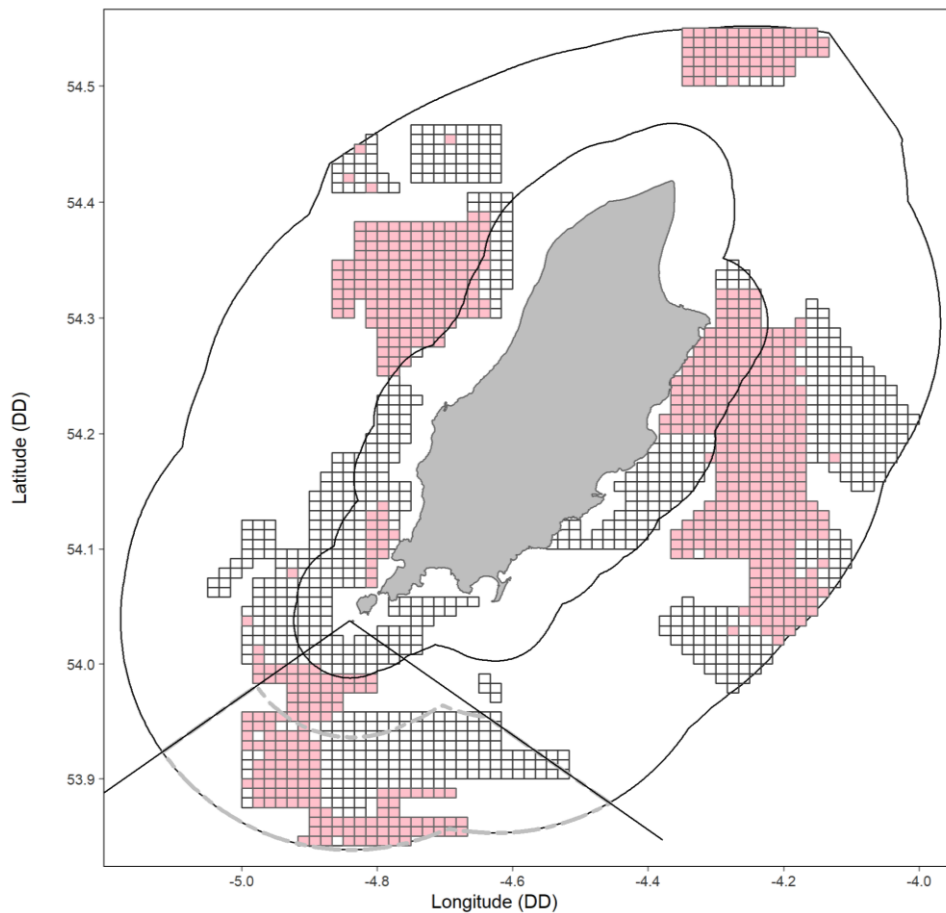

Figure 19: Current extent of the industry scallop survey grid with survey cells defined as queen scallop area highlighted in pink

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 20 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 (i.e. <45 mm).
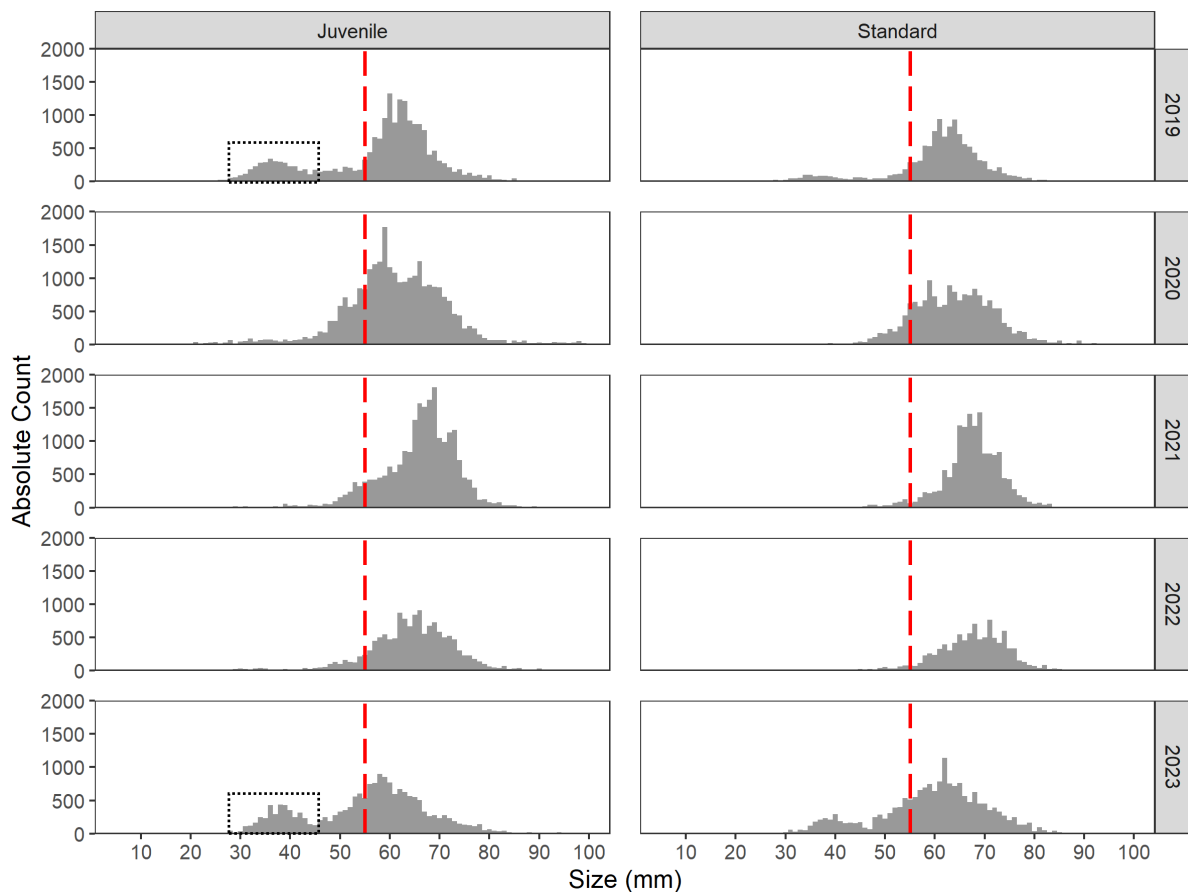
Figure 20: Size frequency distribution (by 1 mm size bin) of absolute counts of queen scallops displayed by year and dredge type (red dotted line indicates the MLS of 55 mm) for survey cells at East of Douglas, Targets and Chickens combined (targeted survey cells excluded). The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions. The black dotted boxes in 2019 and 2023 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.

Both 2019 and 2023 indicate a well-defined peak in recruiting queen scallops in the juvenile dredge data. In 2019, this peak was focused in two key areas at Chickens and Targets whilst in 2023 the peak is focused predominately at Targets (Figure 20, Figure 21 and **Error! Reference source not found.**). These recruitment peaks are an important consideration when looking at sustainable management over a > 1 year period.

Figure 21 and Figure 22 shows the spatial distribution of recruitment (i.e. under 55 mm) and harvestable (i.e. over 55 mm) scallops respectively around Isle of Man territorial waters for 2023. For both recruits and harvestable scallops the majority of higher densities are focused on the west coast in the Targets fishing ground.
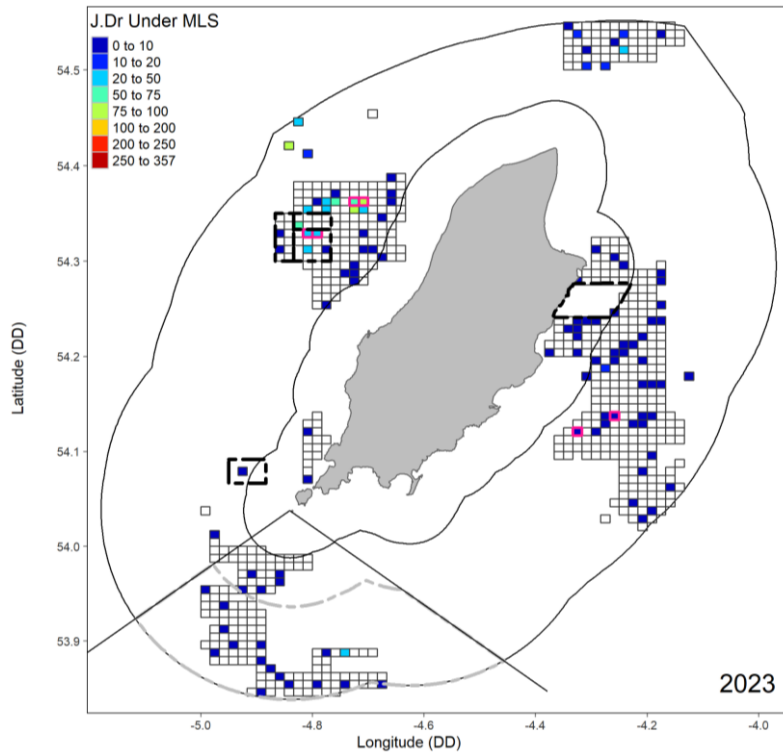
*Figure 21: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2023. The pink cell borders indicate cells that were part of an additional targeted survey. The black dashed boxes indicate closed or managed areas for the 2022 queen scallop fishery and the 2022/2023 king scallop fishery. The grey dashed line and solid black lines indicate the queen scallop dredge zone.*
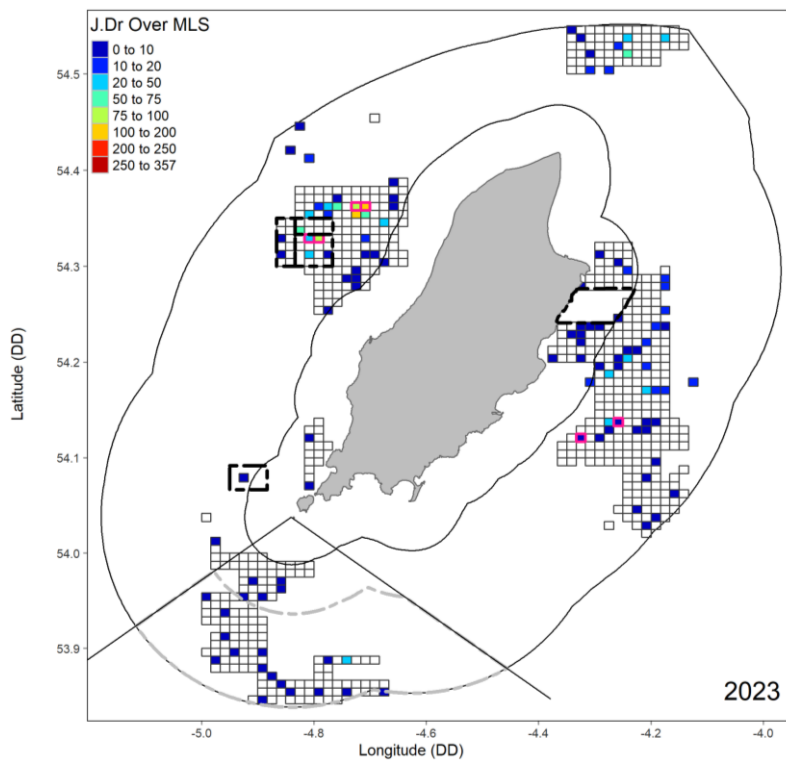

*Figure 22: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2023. The pink cell borders indicate cells that were part of an additional targeted survey. The black dashed boxes indicate closed or managed areas for the 2022 queen scallop fishery and the 2022/2023 king scallop fishery. The grey dashed line and solid black lines indicate the queen scallop dredge zone.*

4.3.2.2 Fishing Grounds:

4.3.3.2.1 Targets:

Targets supported the highest quantity of landings from the 2022 fishing season (799.6 t; ~90% of total landings). The size frequency distribution of scallops at Targets indicates that 2023 is the first year, since the survey began in 2019, with high levels of both recruits (i.e. under 55 mm) and harvestable scallops (i.e. over 55 mm) (Figure 23). For recruits (under 55 mm) the 2023 data indicates good levels of recruitment across a relatively wide area when compared to the data from previous years (2019 to 2023; Figure 24). For post-recruits (over 55 mm) the 2023 data also indicates that there are high densities across a relatively wide area of the commercial fishing ground (Figure 25).
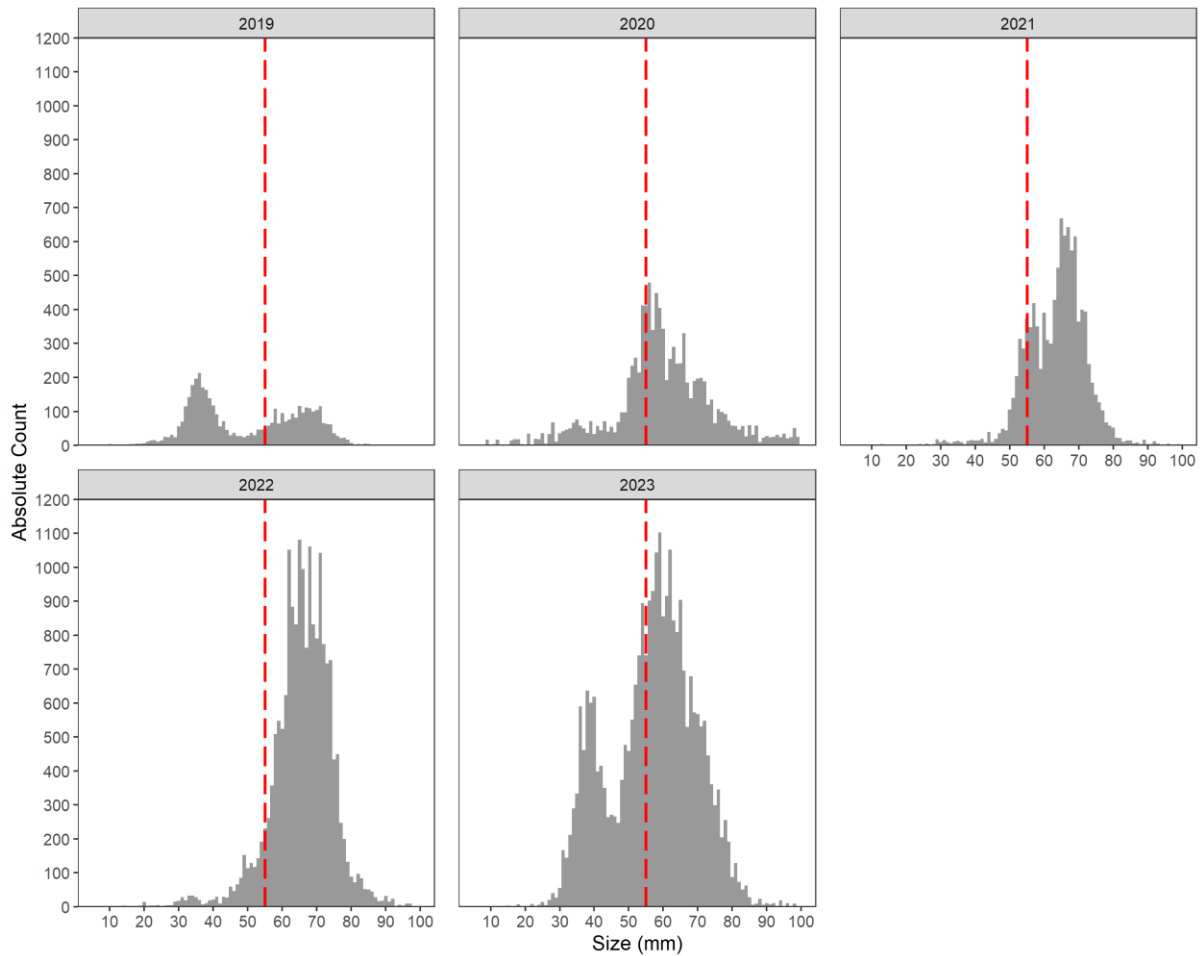

Figure 23: Size density histogram of absolute counts of queen scallops displayed by survey year for Targets (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.
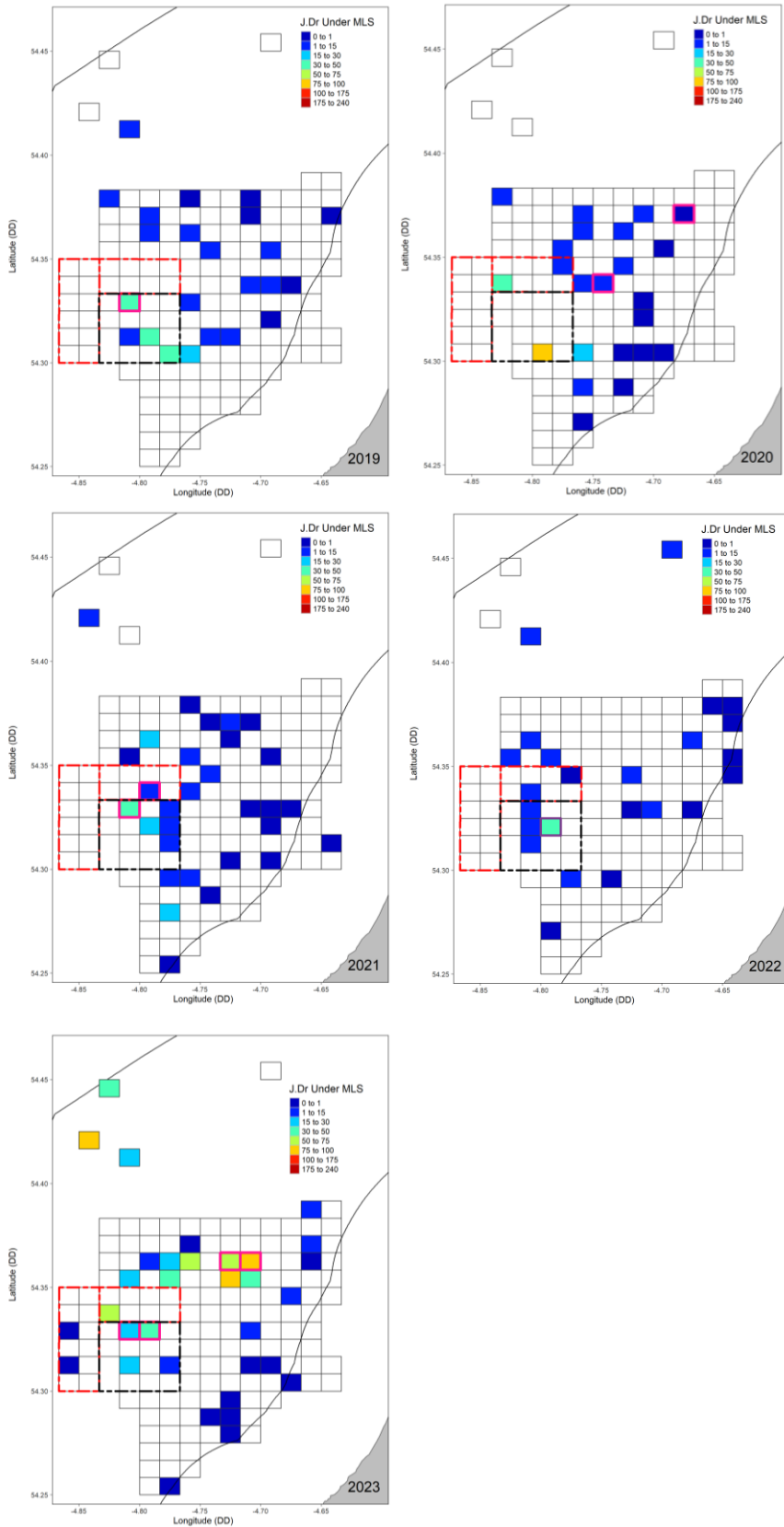
Figure 24: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2019 to 2023 at Targets (West coast). The red box indicates the areas closed and black box indicates areas with restricted access to scallop fishing in 2022. Pink borders indicate cells that were 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).
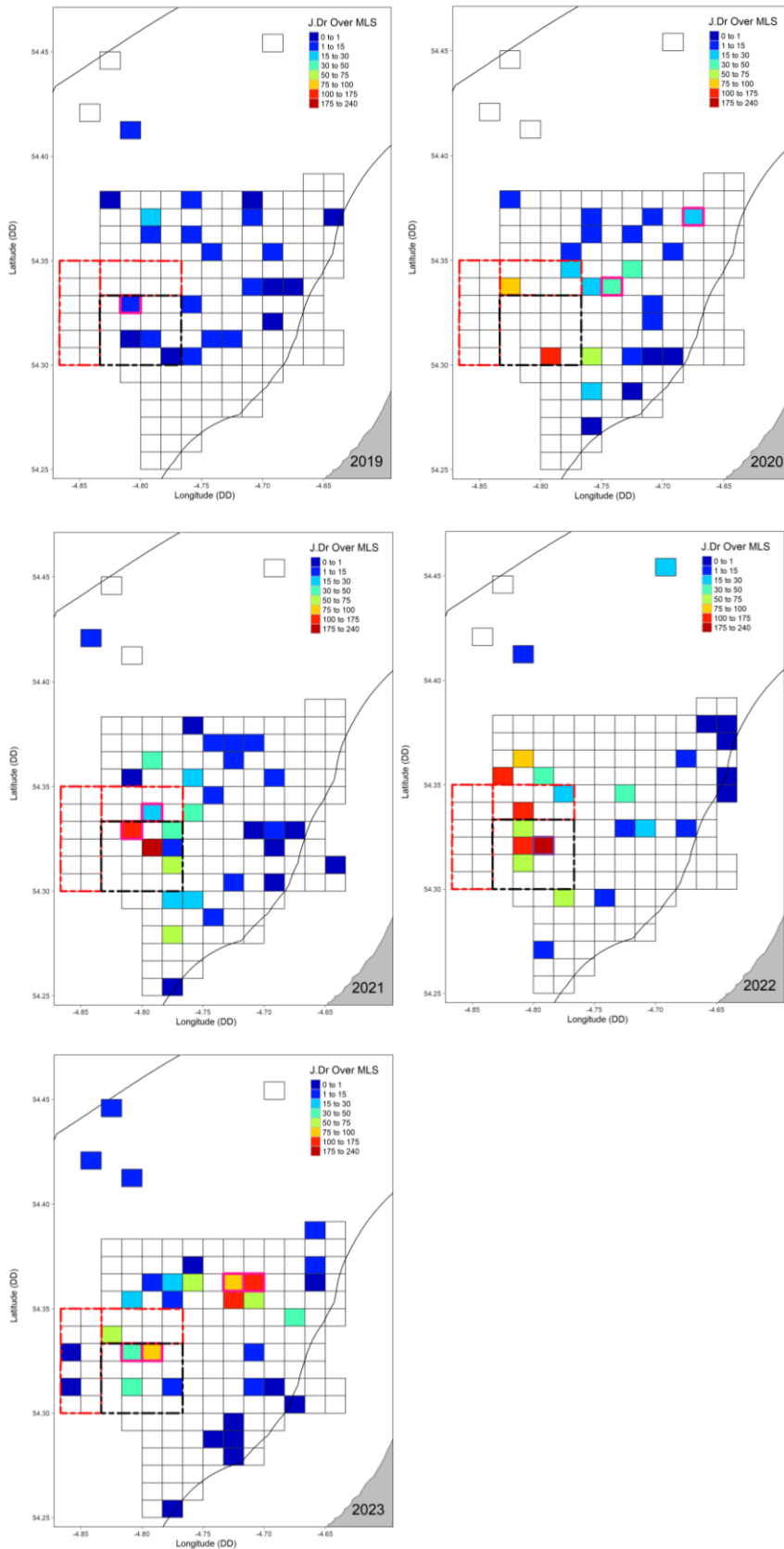
*Figure 25: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2019 to 2023 at Targets (West coast). The red box indicates the areas closed and black box indicates areas with restricted access to scallop fishing in 2022. Pink borders indicate cells that were 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).*

The locations of potential closed areas for the 2023 fishing season to protect recruits from fishing activity are indicated by solid black boxes in Figure 26. By focusing on queen scallops under 45 mm (i.e. scallops unlikely to recruit to the fishery until the 2024 fishing season) two potential locations can be identified for closure during the 2023 fishing season to protect these pre-recruit (i.e. scallops under 45 mm) scallops (solid black line boxes in Figure 26). The 2022 western closed area is in muddy ground and the intention from the SMB is that this area should continue to remain closed as it is an area where recruitment of queen scallops is common but the sizes and yield are typically low and therefore not of commercial value.
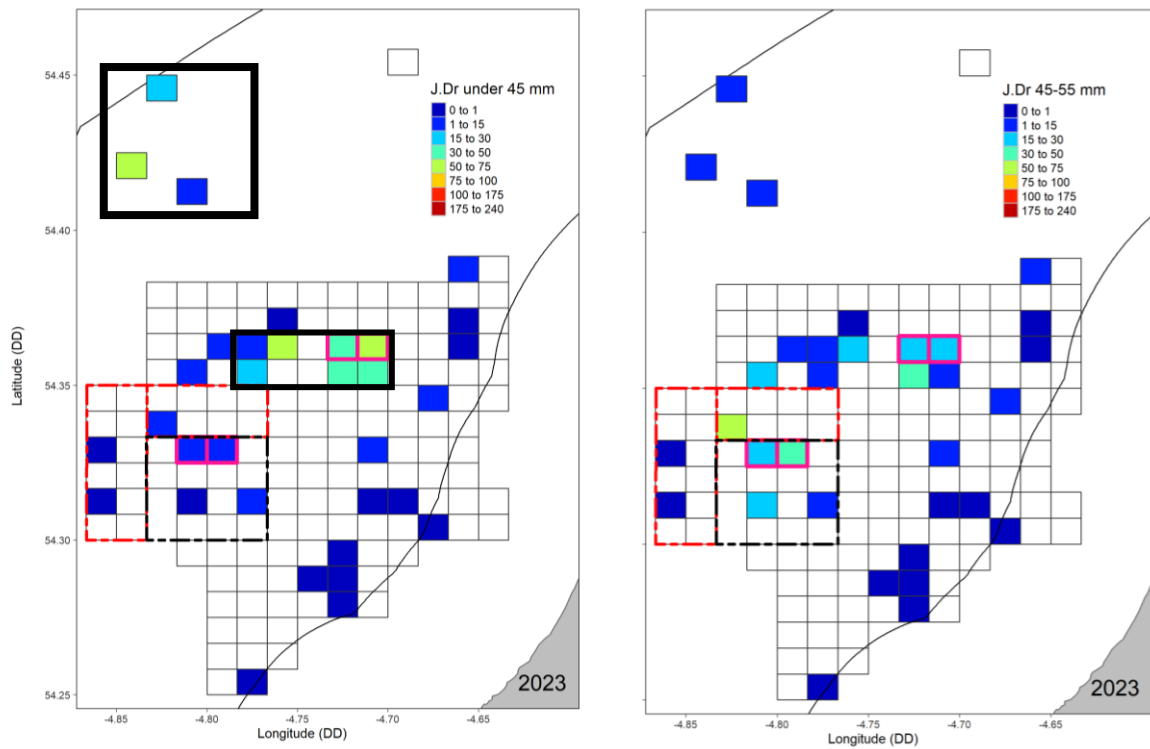

Figure 26: Maps indicating the split of queen scallops at TAR in 2023 which are under 45 mm (Left) and between 45 and 55 mm (Right). Queen scallops under 45 mm are not likely to be harvestable until the 2024 queen scallop fishing season. Black boxes (solid lines) indicate suggested closures to protect queen scallops under 45 mm during the 2023 fishing season. Black box (dashed line) indicates restricted area for 2022 fishing season and red boxes (dashed lines) indicate closed areas for 2022 fishing season.

4.3.3.2.2 Chickens:

Chickens supported a very low quantity of landings during the 2022 fishing season (10.8 t; ~1% of total landings). The size frequency distribution of scallops at Chickens indicates that 2023 had relatively low levels of both recruits (i.e. under 55 mm) and harvestable scallops (i.e. over 55 mm) compared to previous survey years (i.e. 2019 to 2022; Figure 27). For recruits (under 55 mm) and post-recruits (over 55 mm) the 2023 data indicates very low levels of densities across the entire fishing area (Figure 28 and Figure 29).

Given the low densities of queen scallops within the Chickens fishing ground there are no recommendations for discrete closed areas to protect high densities of recruit or post recruit queen scallops. Given the lack of any substantial fishing at Chickens in 2022 (no dredge fishing and limited trawl fishing) and continued low densities, the advice would be to consider whether the ground is commercially viable at present for either the trawl or dredge fishery. In addition, a discussion on both short and long-term management measures for this ground which could help promote future recruitment is required.
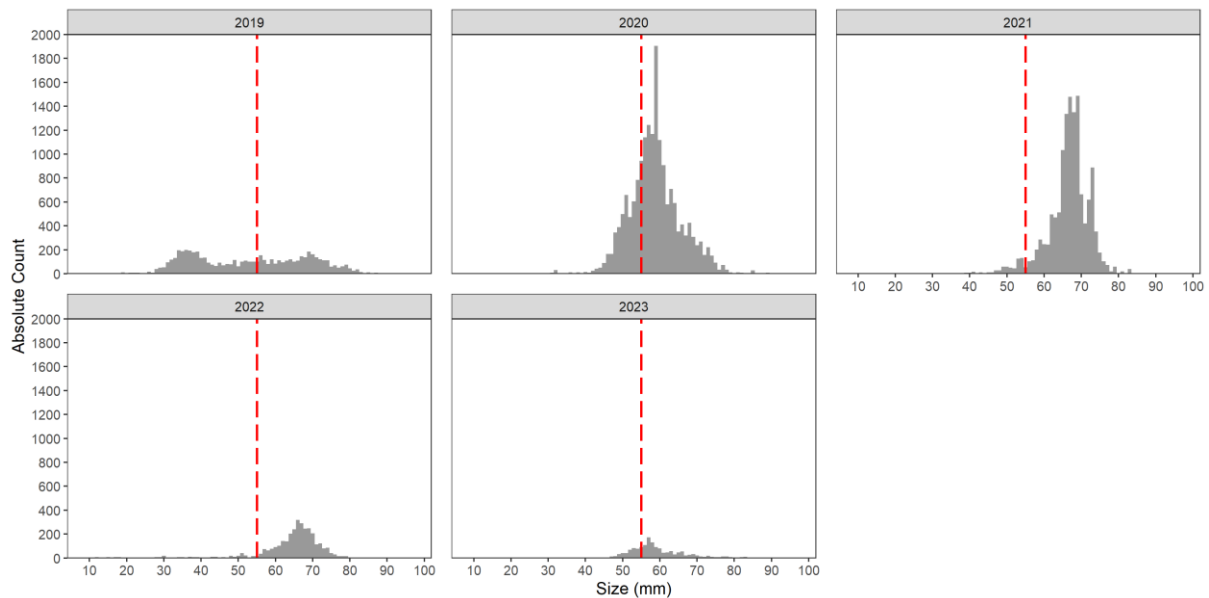

Figure 27: Size density histogram of absolute counts of queen scallops displayed by survey year for Chickens (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.
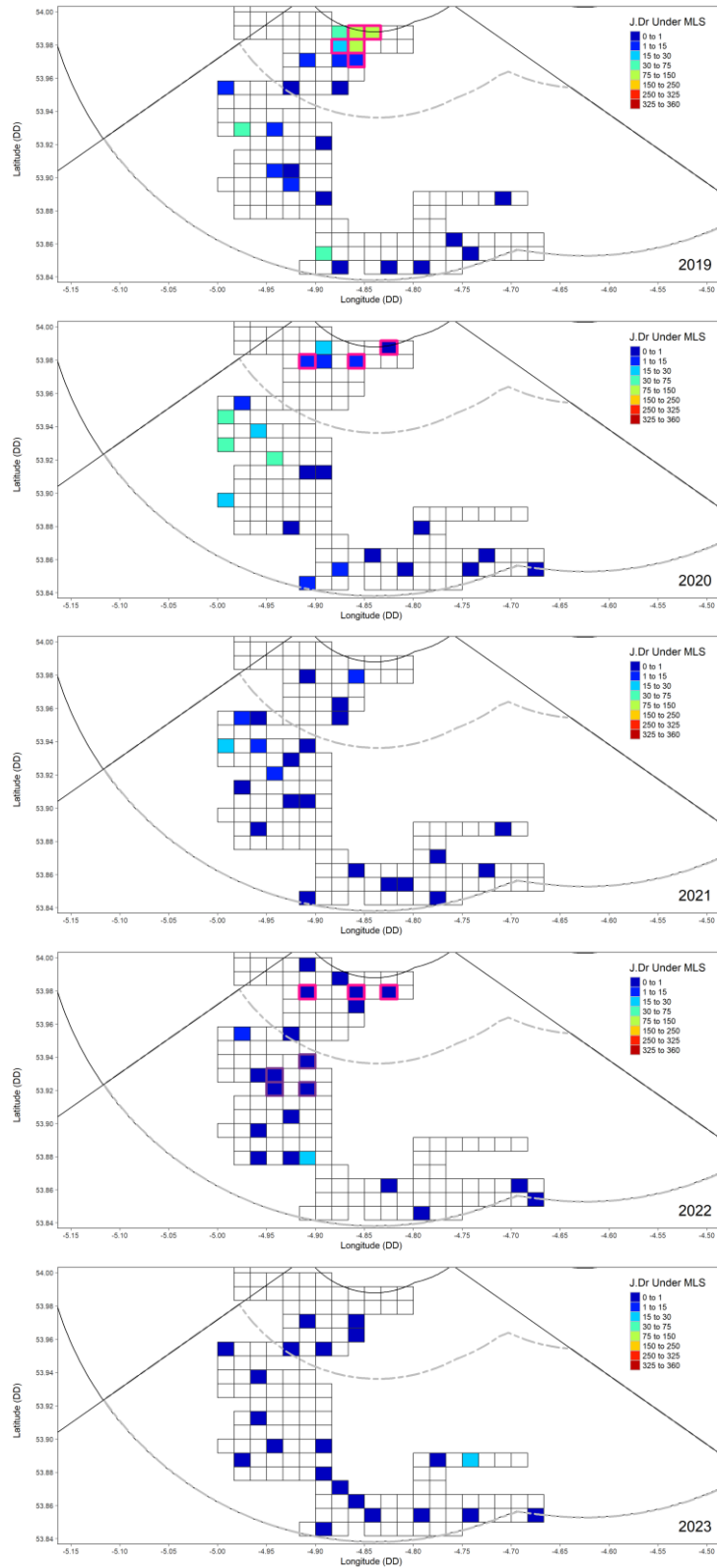
*Figure 28: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2019 to 2023 at Chickens (South coast). Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis). Purple borders indicate cells missing size data. The grey dashed lines indicate the area within which queen scallop dredging can occur.*

*Figure 29: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2019 to 2023 at Chickens (South 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). Purple borders indicate cells missing size data. The grey dashed lines indicate the area within which queen scallop dredging can occur.*
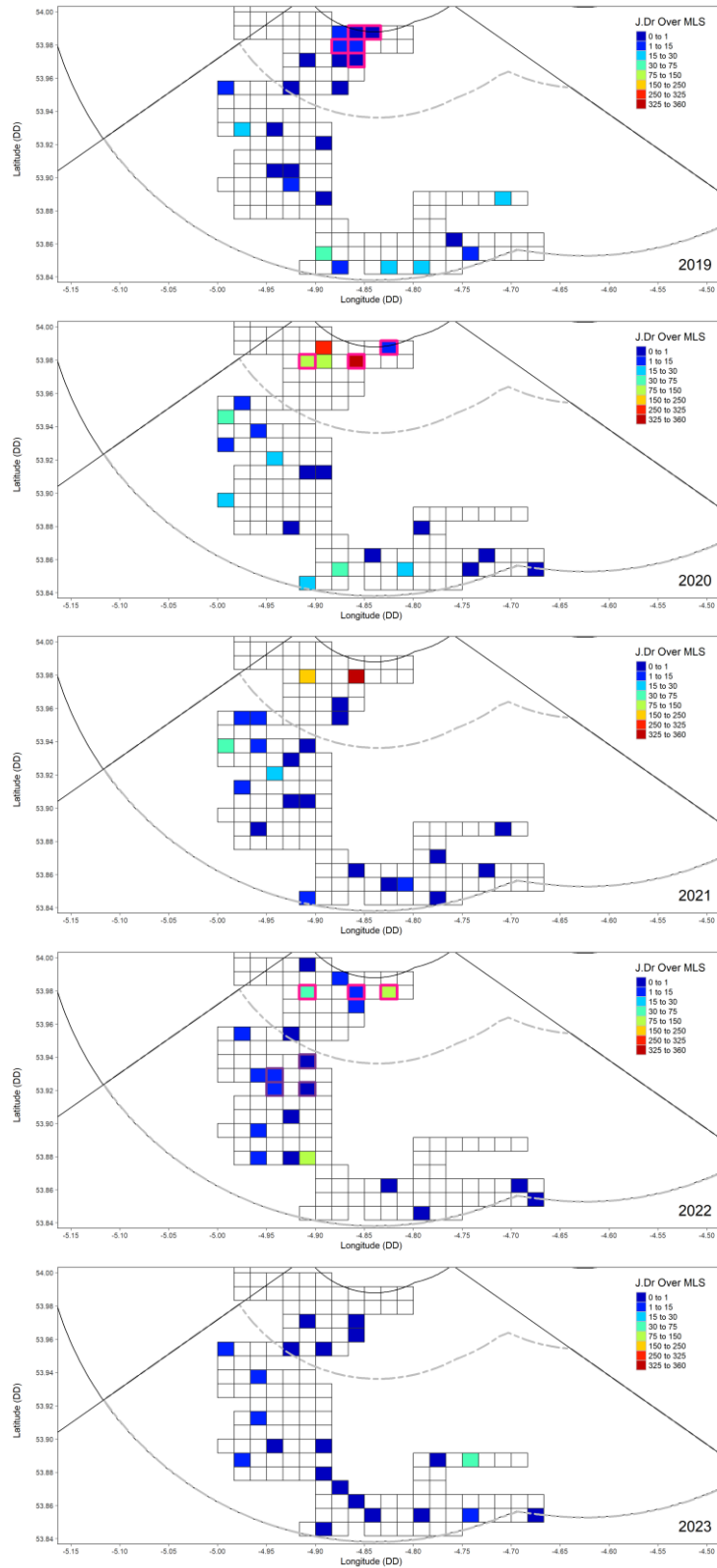
4.3.3.2.3 East of Douglas:

East of Douglas supported a very low quantity of landings during the 2022 fishing season (13.3 t; ~1.5 % of total landings). The size frequency distribution of scallops at East of Douglas indicates that 2023 had a higher level of post-recruits (i.e. over 55 mm) than 2022 and 2021 (Figure 30), and with a wider coverage, that densities were still lower and more spatially restricted than previous survey years (i.e. 2019 to 2020; Figure 32). For recruits (i.e. under 55 mm), although the levels are still low (and lower than recorded in 2019) there was evidence of better recruitment than in 2020 to 2022 (Figure 31). The last good recruitment at East of Douglas must have been before the start of the survey in 2019 given the high level of post-recruits recorded in that first survey year) (Figure 30).

Given the low densities of queen scallop recruitment evident within the East of Douglas fishing ground there are no recommendations for discrete closed areas to protect high densities of recruit queen scallops.
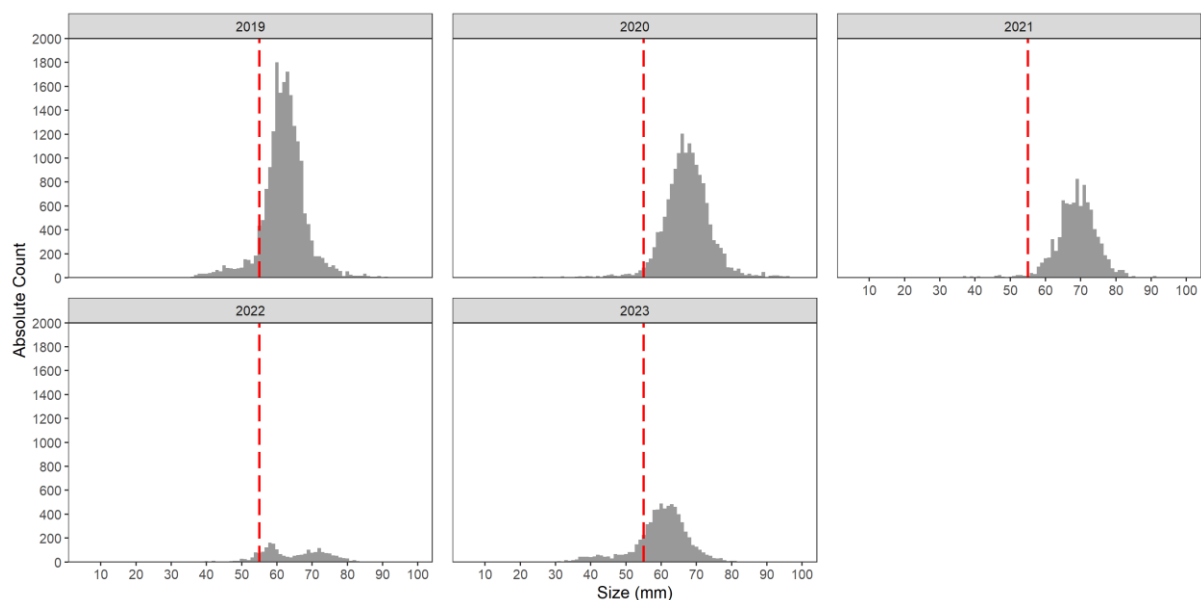

Figure 30: Size density histogram of absolute counts of queen scallops displayed by survey year for East Douglas (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.
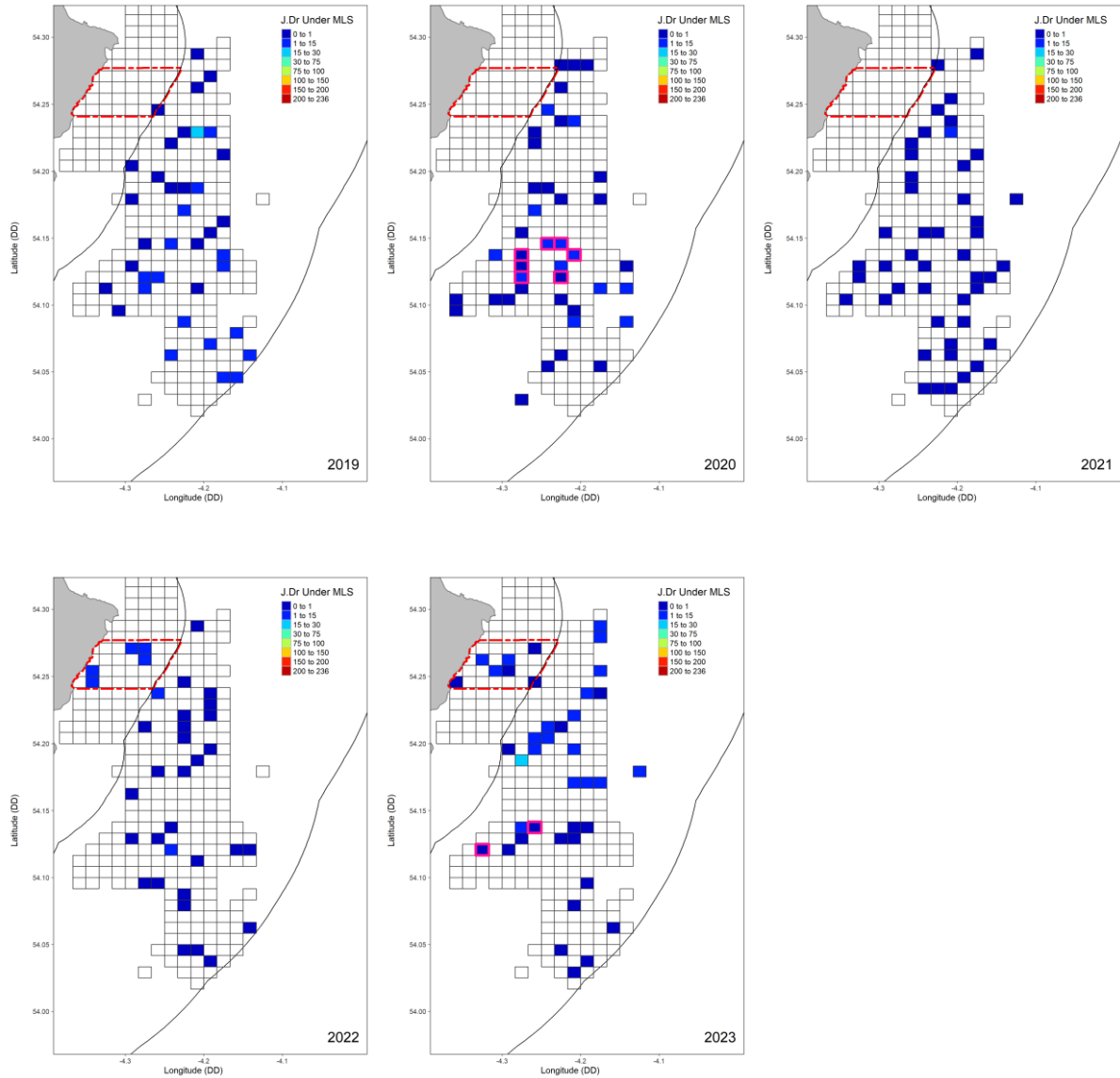
*Figure 31: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2019 to 2023 at East Douglas (East coast). Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis. The red dashed box indicates the East Douglas Experimental Research Area.*
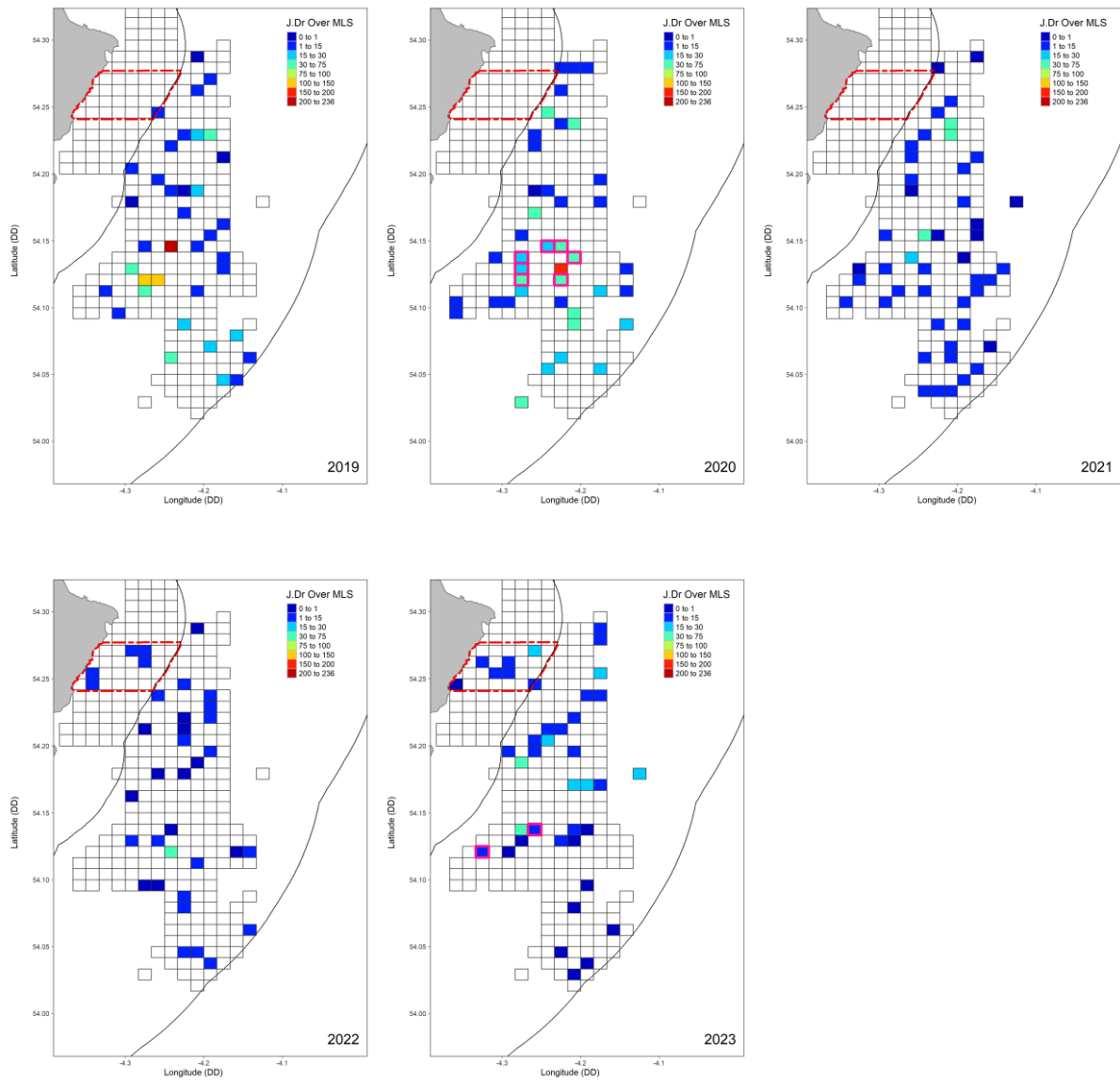
*Figure 32: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2019 to 2023 at East Douglas (East coast). Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis. The red dashed box indicates the East Douglas Experimental Research Area.*

4.3.3.2.4 Point of Ayre:

Point of Ayre had a separate 'exploratory' weekly catch limit of 2100 kg per vessel during the 2022 fishing season and supported the second highest quantity of landings for the season (53.1 t; ~6 % of total landings). The size frequency distribution of scallops at Point of Ayre indicates that 2023 is the first year, since the survey for this ground began in 2020, with high levels of both recruits (i.e. under 55 mm) and harvestable scallops (i.e. over 55 mm) (Figure 33). For both recruits (i.e. under 55 mm) and post-recruits (i.e. over 55 mm), the 2023 data indicates good levels of recruitment across a relatively wide area compared to previous survey years (Figure 34 and Figure 35).

Given the small area of the fishing ground at Point of Ayre there are no recommendations for discrete closed areas to protect high densities of recruit queen scallops.
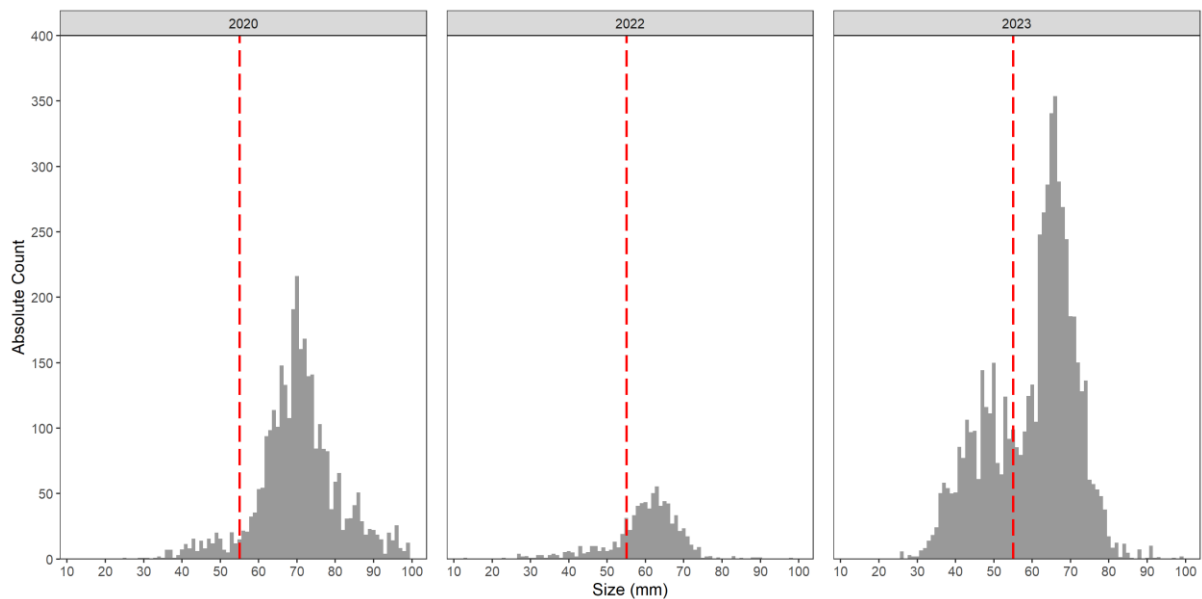

Figure 33: Size density histogram of absolute counts of queen scallops displayed by survey year for Point of Ayre (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

*Figure 34: Maps illustrating the survey densities for queen scallops **under** MLS from juvenile dredges for 2020 and 2023 (bottom) at Point of Ayre (North coast).*
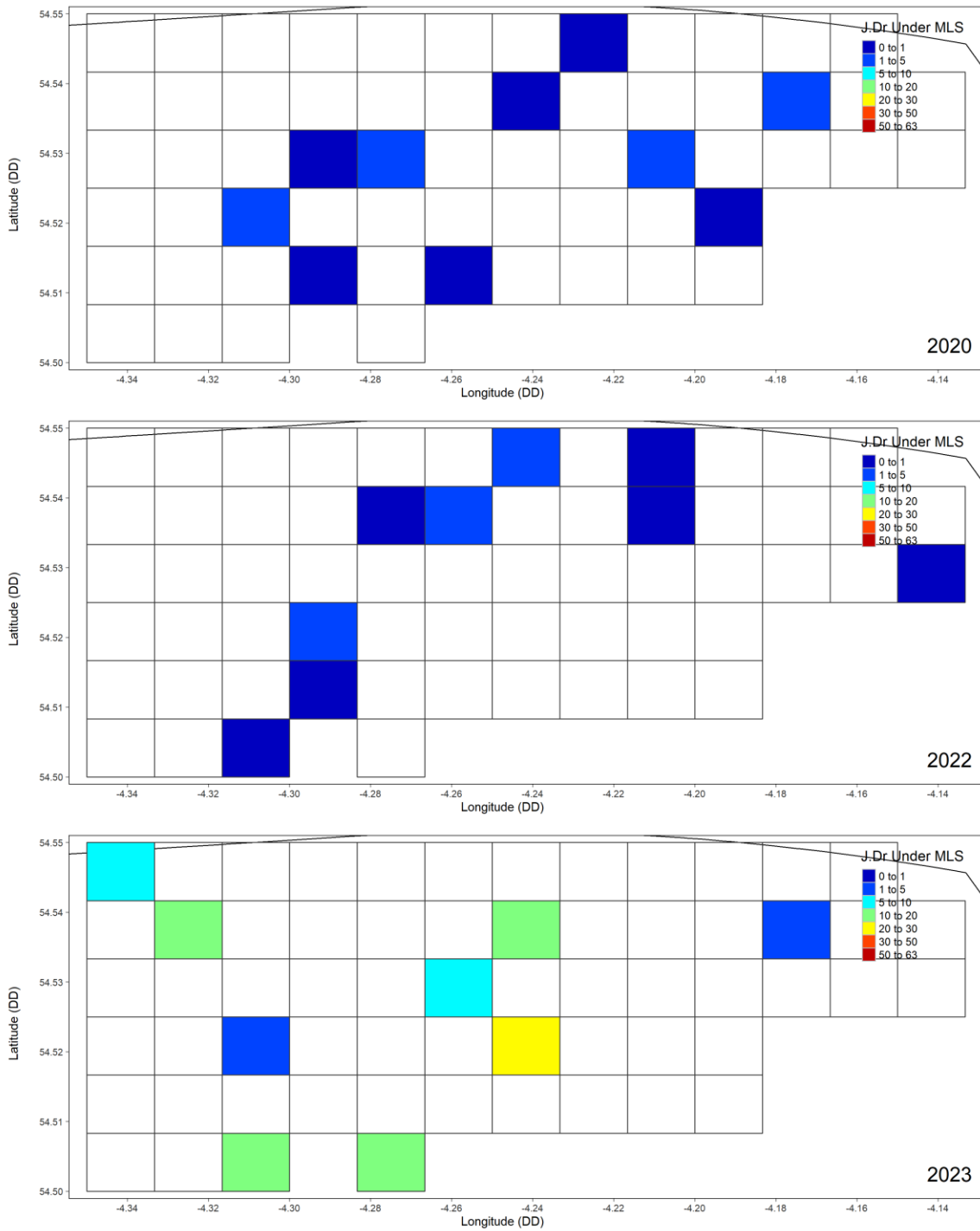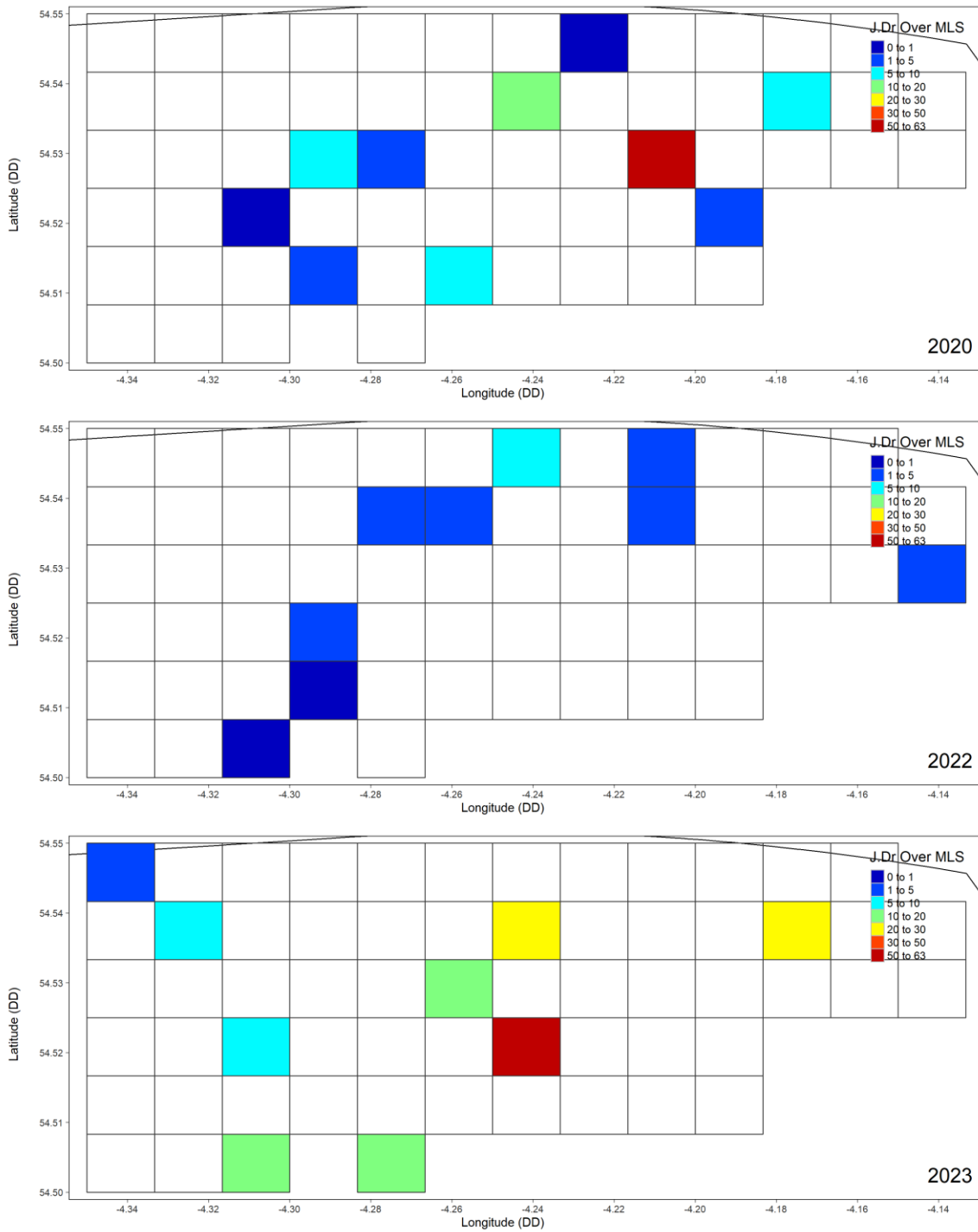
*Figure 35: Maps illustrating the survey densities for queen scallops **over** MLS from juvenile dredges for 2020 and 2023 (bottom) at Point of Ayre (North coast).*

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. In terms of recruits both surveys detected the highest densities of recruits at Targets. The industry survey also detected good recruitment at Point of Ayre. 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 are high densities of both recruits and post-recruits. Both surveys also indicated that the Chickens (CHI) fishing ground in the south of the island had low densities in both the recruit and post-recruit indices with the exception of one survey site/cell in the south-east of the fishing ground. Both surveys also indicated good densities of post-recruits at stations in the North of the Island (Point of Ayre; POA) whilst the industry survey also detected high densities of recruits in this area. At East of Douglas (EDG), which is on the east coast of the Island, both surveys also indicate relatively low recruit and post-recruit values for the 2023 surveys within this ground (although reasonable densities were detected at Station 23, 51 and EDG in the scientific survey).

Recommendations

A harvesting reference point (TAC) of 1067 t has been calculated for the 2023 fishing season using the ICES Category 3 data limited approach which calculates a 20% increase in the TAC based on actual landings from the season prior. Using the harvest rule proposed for sustainable fishing mortality as part of the MSC certification in 2011 (20% of the estimated post-recruit biomass) would give a biomass linked TAC for the 2023 fishing season of 818 t, much lower than the ICES Category 3 approach. It should be noted when setting a territorial sea level TAC that the highest densities of post-recruits from the 2023 surveys are spatially restricted to the west coast. Setting a TAC at the territorial sea level does not take into account of the spatial variability in fishing opportunities.

Recommendations for the management approach for the 2023 queen scallop fishing season are as follows:

- TAC of a between 818 – 1049 t
- Separate management for high-density hotspots should be considered (i.e. closure of two high density areas of pre-recruits at Targets for the 2023 fishing season).
- Discussion of short and long-term management measures to promote recovery and recruitment within the Chickens fishing ground where densities have been low for consecutive years.
- Regular monitoring and triggered reviews of all fishing areas throughout the fishing season in terms of LPUE thresholds and total catch.
- Development of a long-term management plan for queen scallops within the Isle of Man and wider Irish Sea (including development of future Harvest Control Rules and TAC calculations and the future of the dredge fishery).

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