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Queen Scallop: 2020 Industry Survey Analysis

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

June 2020

Sustainable Fisheries and Aquaculture Group, School of Ocean Sciences

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1. Introduction:

1.1: Background:

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

1. **Long-term, medium resolution, fixed site survey:** This survey has been undertaken since 1992 and is currently completed on the R.V. Prince Madog. It is a medium resolution survey (~ 3nm between survey sites), conducted at fixed survey stations. There is a long-term data set associated with this survey which enables stock assessment to be undertaken along with provision of a time series for calculation of the ICES Category 3 data limited approach to TAC calculation (i.e. survey based methods approach). Unfortunately, due to the Coronavirus restrictions in place in both the IoM and the UK this survey could not be completed in April 2020 (survey postponed until September 2020).
2. **Short-term, fine resolution, random stratified survey:** This is a new survey that was undertaken for the first time in June 2019. It is currently completed on two industry fishing vessels and sampling is coordinated by the MFPO with scientific support from Bangor University. It is a fine resolution survey (survey cells: 1 min (longitude) x 0.5 min (latitude)). The 2020 survey included the three main fishing grounds surveyed in 2019 (EDG, CHI and TAR) whilst also extending to include the fourth main queen scallop fishing ground (POA) and a transient bed at BRA. This survey was able to be completed by local industry in April 2020 in line with the Coronavirus restrictions and social distancing regulations.

The long-term survey data is used annually to undertake a quantitative stock assessment to estimate biomass and to support the calculation of the 'ICES Category 3 data limited' approach to estimating annual total allowable catch (TAC). This approach requires a minimum time series of data of five years with the survey indices of the two most recent survey years summed and then divided by the sum of the survey indices from the three years prior. This ratio is then used to adjust the previous year's TAC up or down by a maximum of 20%. The five year time series of data is important in this calculation as stocks can be variable in any year and comparing one year against another doesn't incorporate trends in the data (e.g. 2018/2019 were years of low stock biomass so taking data from 2020 & 2019 and comparing it with data from 2017, 2016 and 2015 gives a more accurate representation of stock trends than simply comparing 2020 and 2019 data).

With no long-term time series available for April 2020 the management advice for the 2020 queen scallop (QSC) fishery will need to be based largely on the data analysis and results from the short-term survey, whilst continuing to acknowledge the context of longer-terms survey outputs from previous quantitative stock assessments and fishery dependent data from the fishery. As stated above the short-term survey has comparative data from 2019 and 2020 for EDG, CHI and TAR but there is only data for 2020 from POA and BRA.

1.2: Fishery 2019

A fishery for queen scallops (QSC), *Aequipecten opercularis*, has been prosecuted in and around the Isle of Man's territorial sea since the 1960s. Inside the territorial sea Manx vessels now fish exclusively for QSC with otter trawls, while UK vessels continue to use both otter trawls and toothless dredges. The fishery within the territorial sea is regulated by several management measures. For the 2019 fishing season these included:

- Three closed areas where fishing for king and queen scallops was prohibited
- Queenie conservation zones where dredging for queen scallops was prohibited.

- Spawning protection closure (1st April to 31st May)
- Statutory Irish Sea closure (1st April to 30th June)
- Weekend ban
- Daily curfew (fishing only between 06:00 – 18:00)
- Weekly catch limits for trawl fishery (maximum of 2695 kg per vessel)
- Individual quotas for dredge fishery (10500 kg per vessel)
- Minimum landing size (55 mm)
- Limited TAC of 615.29 t (split: 557 t trawl fishery and 58.29 t dredge fishery)
- Spatial management trial with the closure of the main TS fishery and continued fishing at an isolated hotspot at EDG with a fisheries-dependent LPUE threshold utilised as a proxy biological reference point (BRP).

These management measures were covered by the Fisheries Act 2012 and applied via licencing conditions.

Following a decline in the 2019 long-term survey abundance index (Bloor et al., 2019), the 2019 Isle of Man queen scallop fishery had a total allowable catch (TAC) of 615.29 t which was subdivided into 557 t trawl TAC and a 58.29 t dredge TAC. This represented ~ 20 % reduction in the trawl quota and a 40% reduction in the dredge quota compared to 2018.

Total reported landings for the trawl fishery during the 2019 fishing season were ~ 550 t with 30 unique vessels reporting landings. The majority of trawl landings came from East Douglas, with much smaller amounts landed from Chickens and Maughold. An additional 39 t was landed from the Ramsey Bay permit only fishery which has its own TAC and a further 18.5 t was landed from Chickens as part of the dredge fishery in October 2019.

Table 1: Landings by ground for the 2019 queen scallop fishery (trawl and dredge)

Area	Landings (t)
IS15: East Douglas	542.8
IS10: Ramsey Bay (Permit)	38.6
IS21: Chickens	23.7
IS10: Maughold	0.9

Average weekly landings per unit effort, standardised to 35 kg bags per 10 fathom net per hour fished (bags per 10 FTM per HrF), are displayed for each of the fished grounds (Figure 1). LPUE at East Douglas, which was the predominant ground fished in 2019, saw a steady decrease over the season but with average LPUE maintained above 4 bags per 10 FTM per HrF. LPUE decreased across the limited fishing season for IS10: Ramsey Bay (which is limited access permit only fishery with an independent TAC) with a drop from an average of 11 to 6 bags per 10 FTM per HrF during the three weeks of the fishery. There was relatively little fishing at Chickens where LPUE was around 6-7 bags per 10 FTM per HrF whilst Maughold is around 3 bags per 10 FTM per HrF (displayed as IS10: Other in Figure 1).

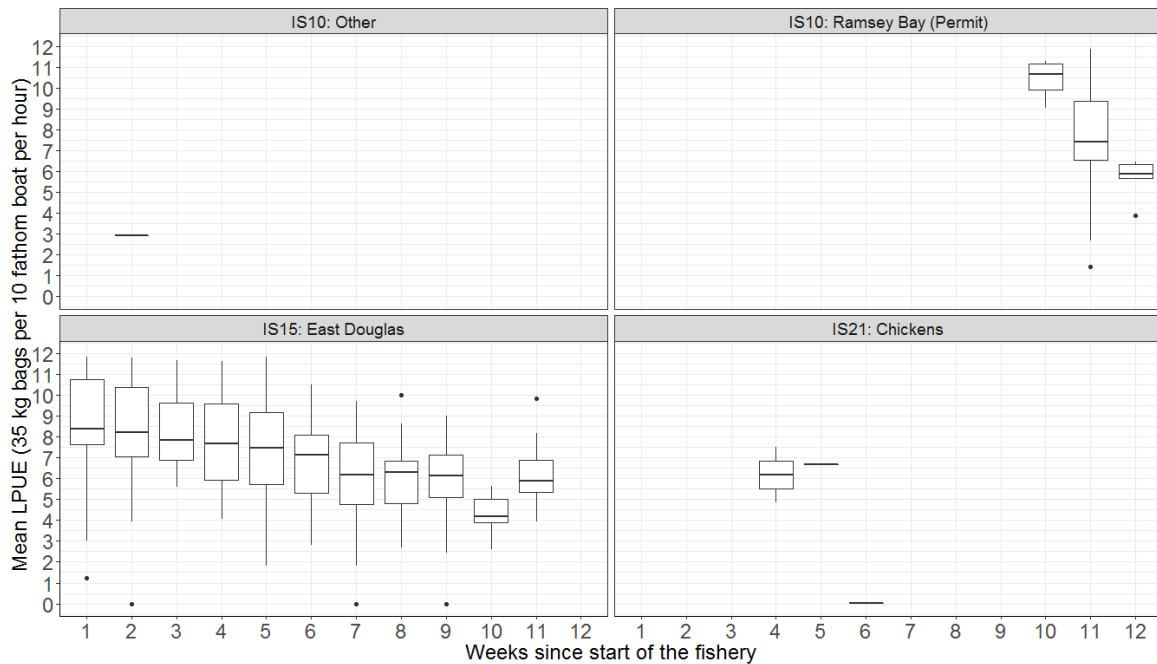


Figure 1: Landings per unit effort standardised to 35 kg bags per 10 fathom net per hour fished for the 2019 queen scallop trawl fishery displayed by main fished ground.

The dredge fishery had a sub TAC of ~58 t and opened on 1st October 2019 and remained open until 31st March 2020. For the dredge fishery each eligible vessel was allocated an individual quota of 10500 kg which could be fished as and when suited by the vessel (before 31st March 2019). Total reported landings for the dredge fishery during the 2019/2020 season were ~ 18.5 t with 2 unique vessels reporting landings.

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. Industry have however implemented voluntary closures in 2016 (May) and 2017 (April, May & June) in ICES areas VIa and VIIa during one of the spawning periods. Since 2018, the 3 month closure (April, May and June) has become statutory, via licence condition, for ICES areas VIa and VIIa. As the queen scallop stock is considered to span across both the Isle of Man TS and the wider Irish Sea it is likely that management outside of the TS can impact the portion of the stock within the TS as well (i.e. through recruitment effects).

2. Methods:

Methods: A survey for queen scallops was undertaken onboard two industry vessels (F.V. Benolas and F.V. Sarah Lena) from 18th – 28th April 2020. The survey was undertaken at the four main queen scallop fishing grounds and one transient bed (Targets (TAR) – 3 vessel days; Chickens (CHI) – 3 vessel days; Douglas (EDG) – 6 vessel days and, for the first time, at Point of Ayre (POA) – 1 vessel day and Bradda Offshore (BRA) – 0.5 vessel day). These survey areas were split into a fixed grid with a resolution of 1 min (longitude) x 0.5 min (latitude). Survey cells were sampled randomly within each ground strata (strata were defined predominately by depth) with approximately equal effort to ensure relatively even distribution of survey effort across the entire fished ground. Within each survey cell a 10 minute tow was undertaken at ~ 2.5 knots. Each vessel towed a ‘standard survey dredge bar’ with four dredges, two King and two Queen dredges interspersed along the bar (Queen dredges had 10 teeth) and a ‘juvenile survey dredge bar’ of the same design but using Queen dredges with 17 teeth with a mesh (60 mm) attached internally that when stretched into a fixed position resulted in a maximum

mesh size of 38 mm. The catch from each dredge was counted and a subsample of up to ~ 90 kings and 90 queens were measured.

Data cleaning: During 'data cleaning' any scallops in the subsample that were recorded as queen scallops over 100 mm were assumed to be king scallop recorded as the wrong species and the data adjusted accordingly. Discrepancies between the number reported on the tow sheet and the number sampled (where the whole dredge catch were measured) were altered to reflect the number measured.

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

Ground inclusion: POA and the transient bed at BRA were only surveyed for first time in 2020 so to keep the data constant only EDG, CHI and TAR are included in the main territorial sea analysis section. Each ground will be analysed individually later in the report.

Targeted Cells: In addition to the random Survey Cells described above, additional selected cells (3 sites at CHI [Survey Cells: 5059, 5127 and 5130], 2 sites at TAR [Survey Cells: 1710 and 1998 and 7 sites at EDG [Survey Cells: 3707, 3708, 3778, 3782, 3851, 3924 and 3927) were surveyed in those areas on the basis of suitability for closed area or hotspot placement or exploratory fishing. These were excluded from the main analysis because these areas were chosen specifically because they were typically areas of known high queen scallop density (i.e. they were not a random selection of the particular fishing ground).

Data analysis: The geometric mean was used for data analysis due to the skewed (non-normal) distribution of the density data. In addition, the juvenile dredges appear to be more efficient for catching both post recruits (i.e. ≥ 55 mm) and recruits (i.e. < 55 mm) and so the analysis within this report focuses on that data set.

Survey timing: It should be noted that the 2019 survey was undertaken in June whilst the 2020 survey was undertaken in April. 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.

2.1 Results:

2.2 Territorial Sea

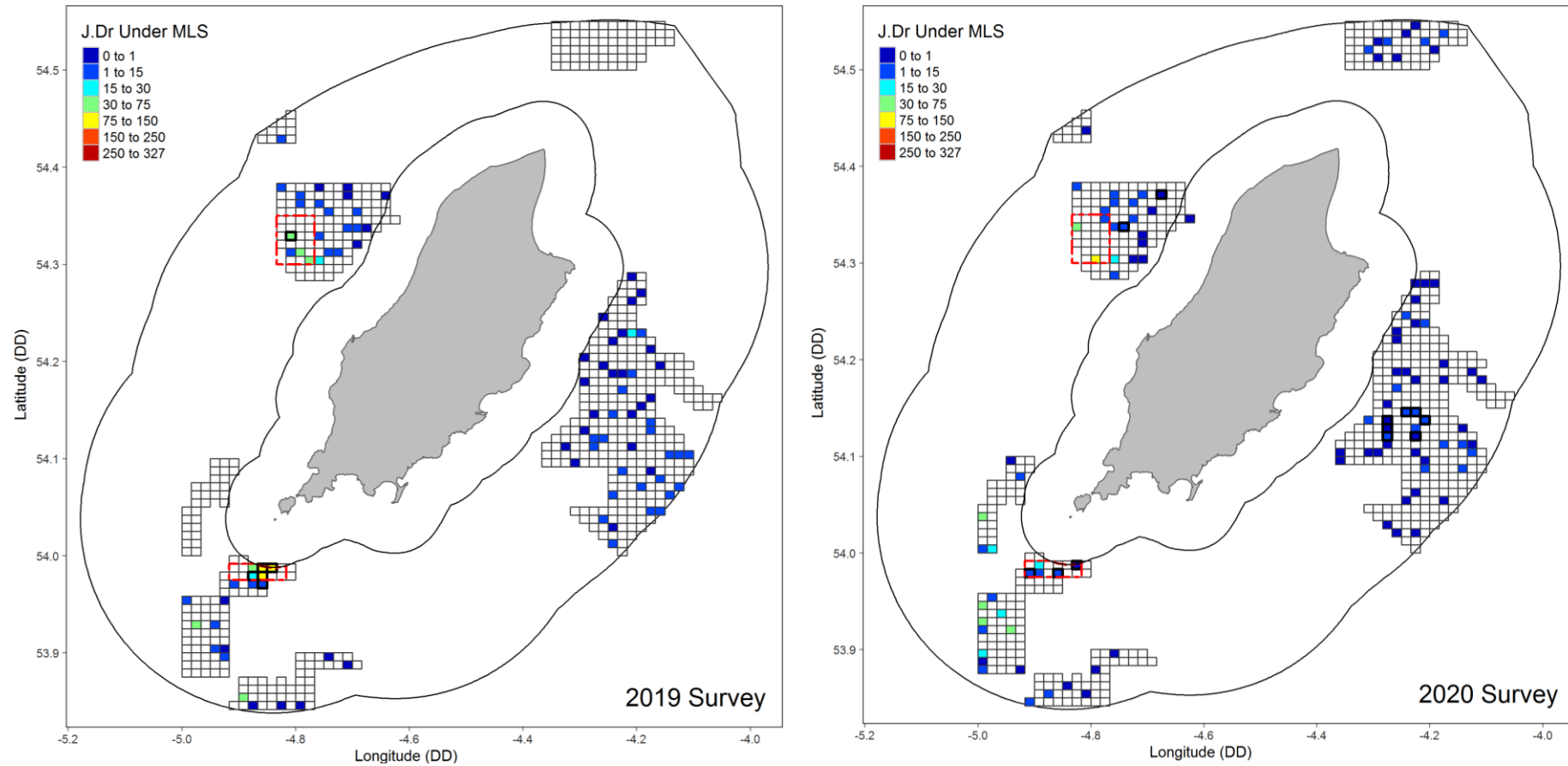


Figure 2: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (left) and 2020 (right), Point of Ayre in the north of the TS and Bradda offshore to the west of the TS were only surveyed for the first time in 2020. The red boxes indicate areas closed to scallop fishing in 2019. Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis).

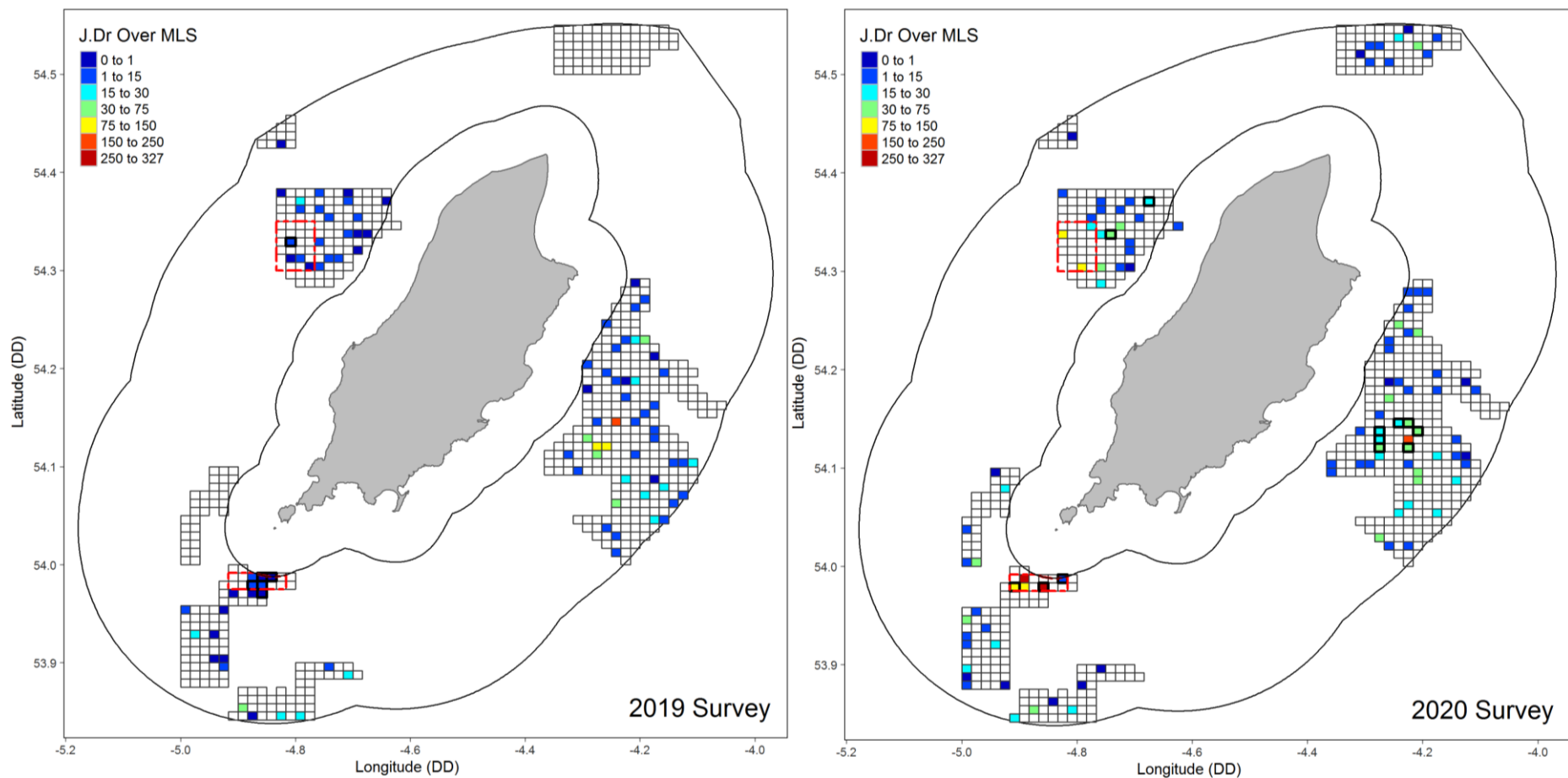


Figure 3: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left) and 2020 (right), Point of Ayre in the north of the TS and Bradda offshore to the west of the TS were only surveyed for the first time in 2020. The Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis).

Table 2: Juvenile dredge density of QSC per 100 m² split by over and under MLS for the territorial sea (EDG, CHI, TAR); note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Targeted survey cells excluded.

	2019 < 55 mm	2020 < 55 mm	2019 > 55 mm	2020 > 55 mm
Cells Surveyed	85	78	85	78
Min	0.00	0.00	0.00	0.00
Median	1.19	0.60	4.26	8.01
Mean	5.22	6.38	14.03	22.93
Geometric Mean	1.09	0.82	3.40	6.42
Max	72.03	96.78	235.51	272.99

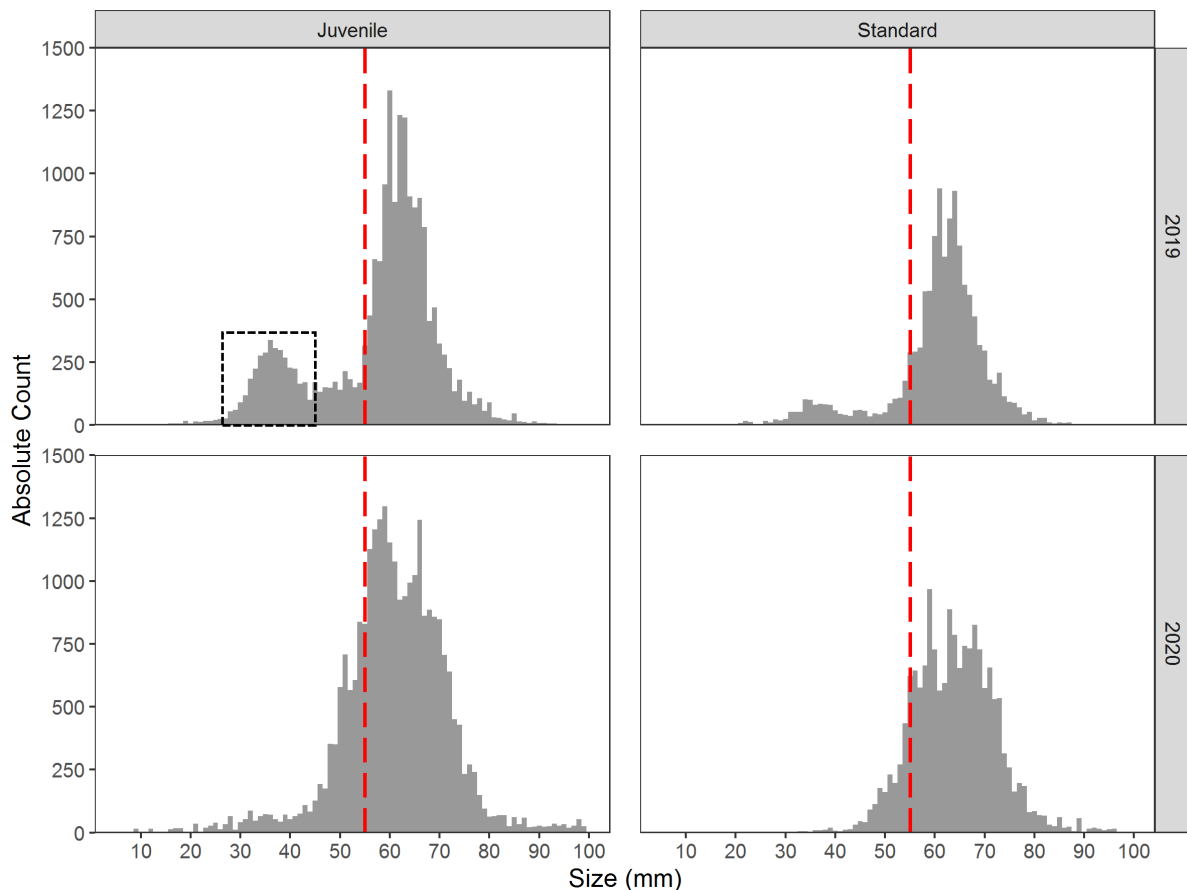


Figure 4: Size: density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type (red dotted line indicates the MLS of 55 mm). Targeted survey cells excluded. The absolute count is calculated by using a scalar (i.e. the ratio of total observed to subsampled counts) to scale the size frequency distributions. The black dotted box highlights a new recruitment peak (i.e. queenies of ~ 25 – 45 mm) indicating new recruitment coming through from that year (i.e. these queen scallops are 1 year old). Note recruitment peak absence in 2020.

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. The overall data for the TS indicates that the survey index has increased for post-recruits (over 55 mm) from **3.40 in 2019 to 6.42 in 2020** and decreased for recruits (under 55 mm) **from 1.09 in 2019 to 0.82 in 2020**. A recruitment peak (i.e. new recruits ~ 25-45 mm or 1 year olds) can be seen in the 2019 survey data, this peak was focused in two key areas at Chickens and Targets which were protected by closures and by 2020 this peak had grown into the fishery (Figure 2, Figure 3 and Figure 4). However, **no new recruitment peak is present in 2020** (Figure 4), this is an important consideration when looking at sustainable management over a > 1 year period.

2.3 Fishing Grounds

2.3.1 Targets:

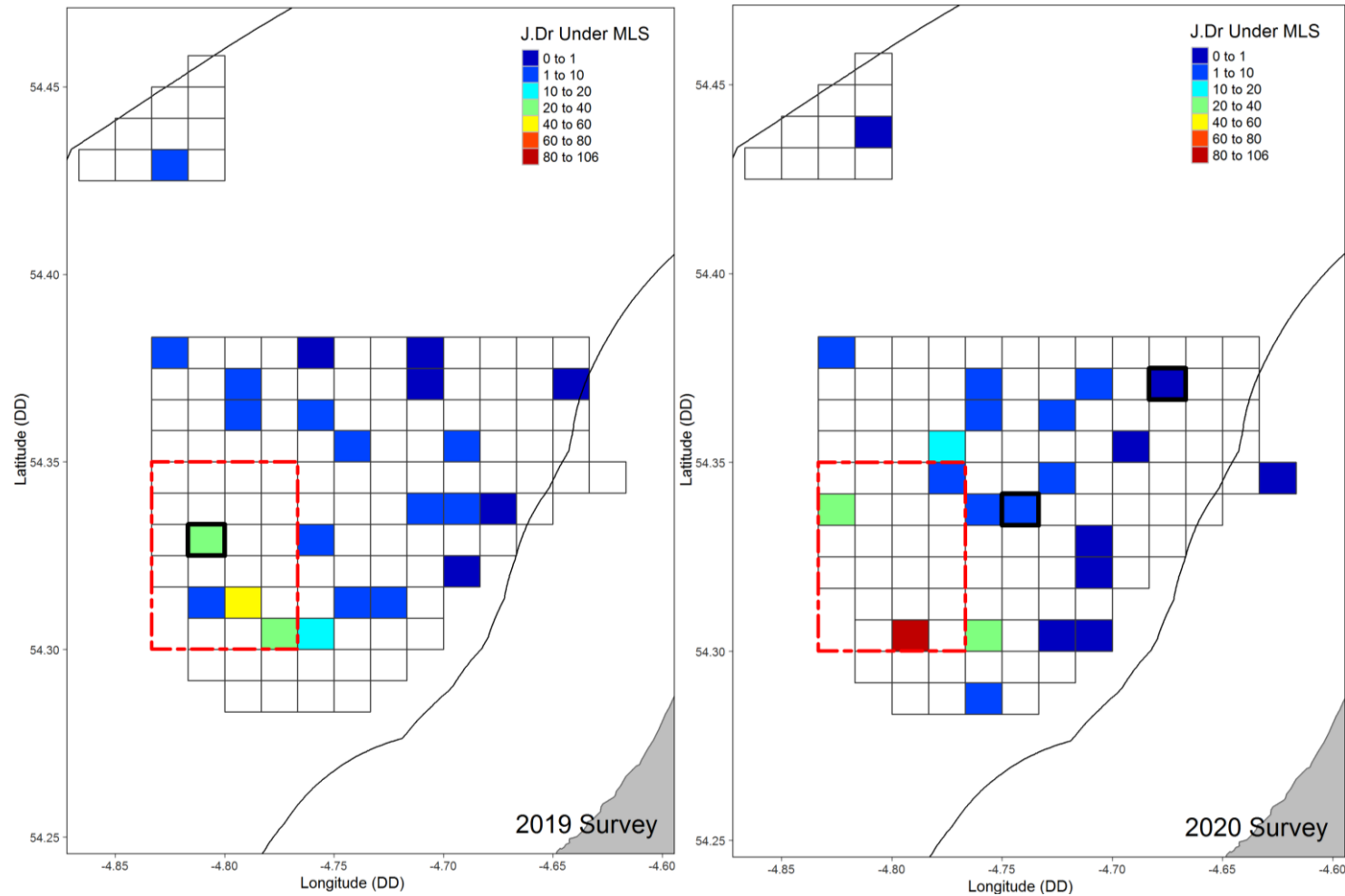


Figure 5: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (left) and 2020 (right) at Targets (West coast). The red box indicates the area closed to scallop fishing in 2019. Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis).

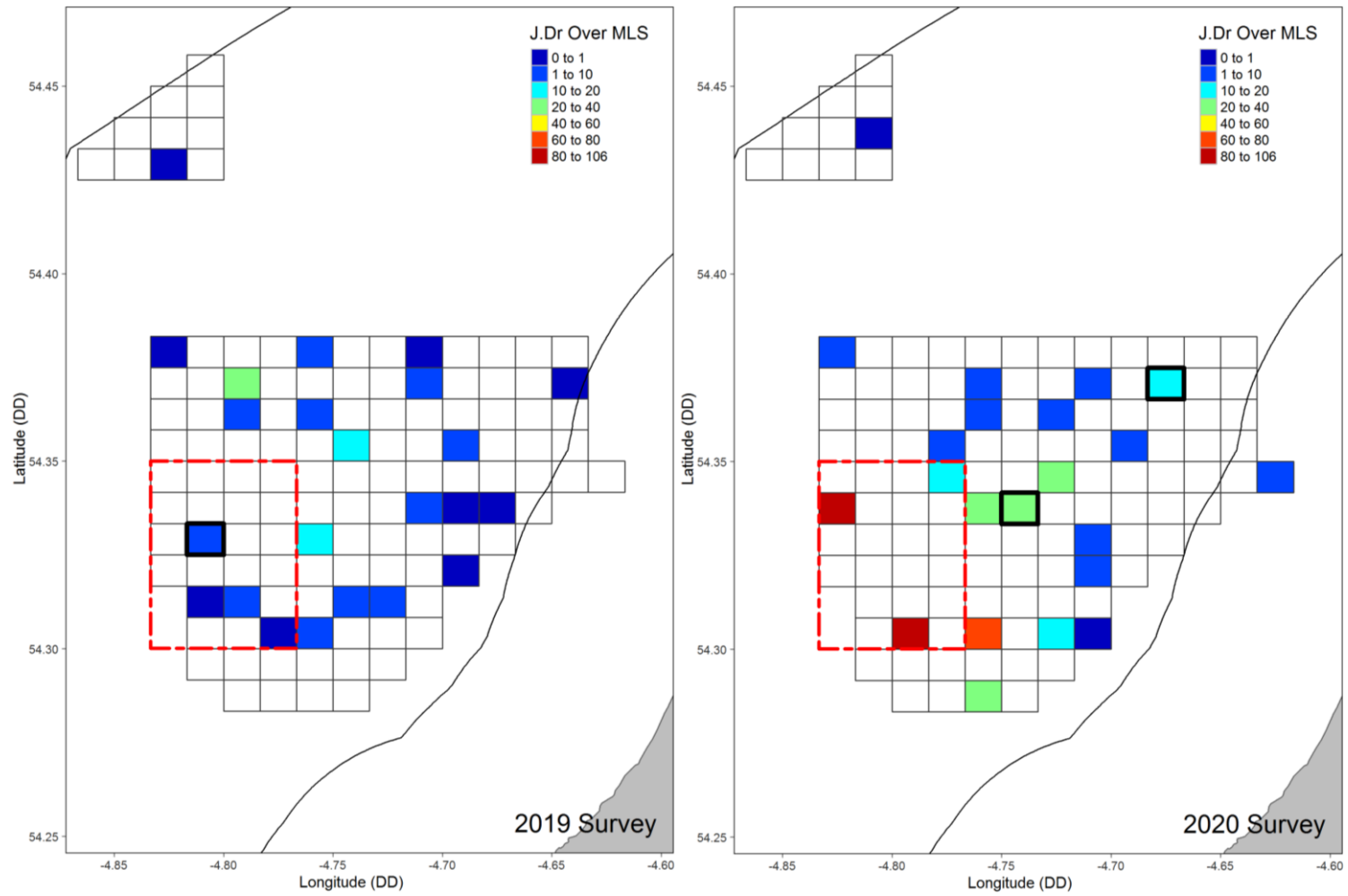


Figure 6: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left) and 2020 (right) at Targets (West coast). The red box indicates the area closed to scallop fishing in 2019. Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis)

Table 3: Juvenile dredge density of QSC per 100 m² split by over and under MLS for Targets; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Excludes targeted survey cells.

	2019 < 55 mm	2020 < 55 mm	2019 > 55 mm	2020 > 55 mm
Cells Surveyed	22	20	22	20
Min	0.00	0.00	0.09	0.26
Median	2.52	3.29	1.21	5.29
Mean	6.86	10.15	3.94	20.70
Geometric Mean	2.16	1.98	1.50	7.09
Max	43.02	96.78	23.19	105.27

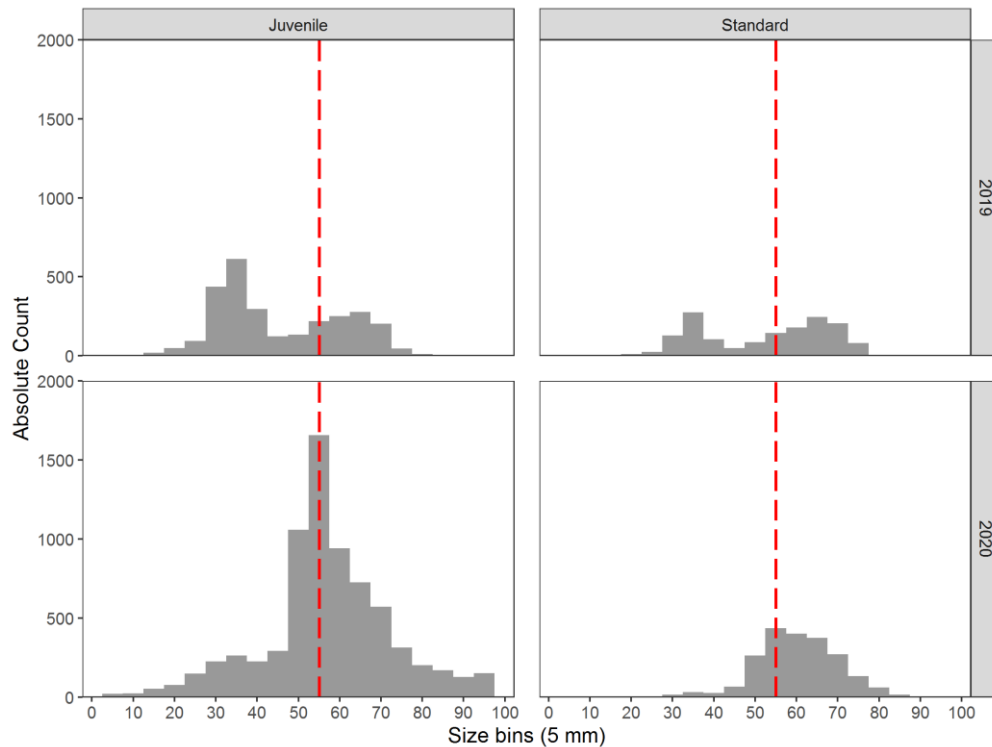


Figure 7: Size density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type for Targets (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

TAR Closed Area

Table 4: Juvenile dredge density of QSC per 100 m² split by over and under MLS for TAR Closed Area; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's)

	2019 < 55 mm	2020 < 55 mm	2019 > 55 mm	2020 > 55 mm
n	4	3	4	3
Min	9.63	4.09	0.09	19.01
Median	34.74	33.14	0.78	81.18
Mean	30.53	44.67	2.52	68.50
GeoMean	26.6	23.7	0.88	54.60
Max	43.02	96.78	8.44	105.27

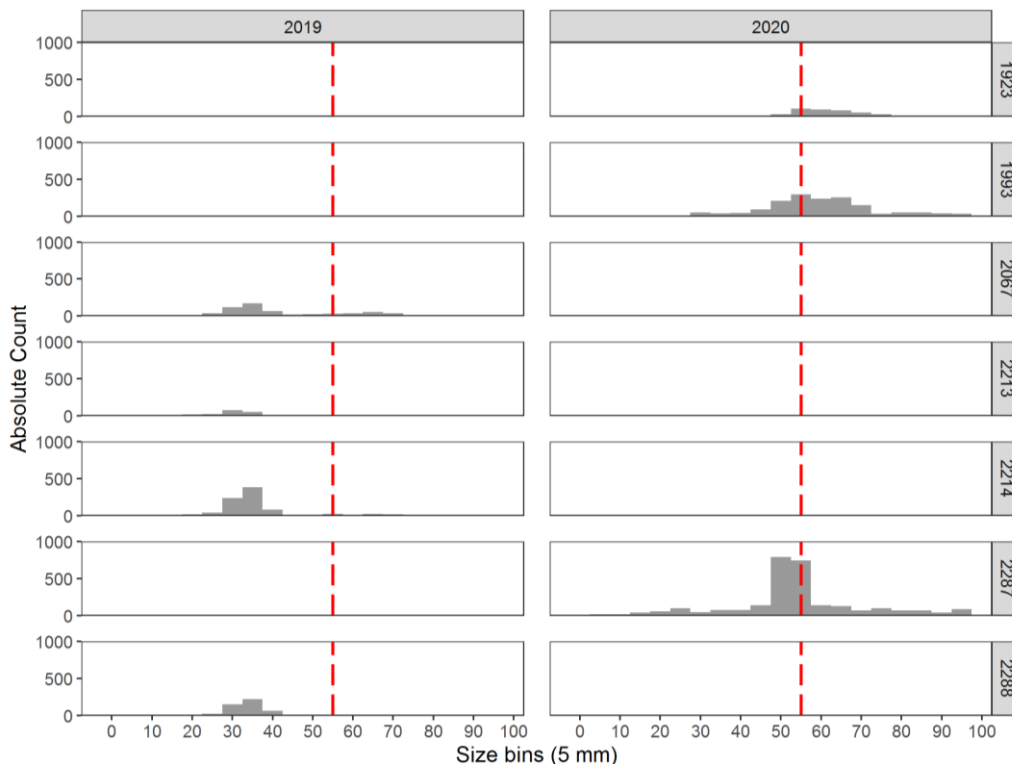


Figure 8: TAR Closed area size frequency of absolute counts of queen scallops by cell for 2019 and 2020 using data from all random and targeted survey cells.

For TAR, which had no fishing effort during the 2019 queen scallop fishery, the post-recruit index increased (1.50 for 2019 and 7.09 for 2020) whilst the recruit index remained relatively stable (2.16 for 2019 and 1.98 for 2020). The survey index for the closed area at TAR, which was closed in 2018 and 2019 to protect high densities of recruit scallops (king and queen), increased significantly for post-recruits (0.88 in 2019 to 54.60 in 2020) and was relatively stable for recruits (26.6 in 2019 to 23.7 in 2020).

The northern and southern sections of the closed area have recorded different shifts in the size-frequency distribution with survey cells in the northern section recording a large proportion of post-recruit queen scallops whilst the survey cell in the southern section recorded high densities of both recruits and post-recruits (*note: the highest recorded densities for queen scallop recruits for 2020 were recorded in the southern area of the Targets Closed Area: 97 queenies per 100 m²*).

The data indicate that a split in the management of the Targets Closed Area would therefore be appropriate for the 2020 fishing season with the northern section open to fishing and the southern section remaining closed to protect the high densities of recruits. It is noted again that some form of managed opening (voluntary or statutory) for the northern section should be considered to avoid over fishing within the area. *In addition, there is a high density patch of juvenile king scallops to the south-east of the closed area which should be considered for inclusion in the closed area box for the 2020 fishing season (see Appendix).*

2.3.2 Chickens

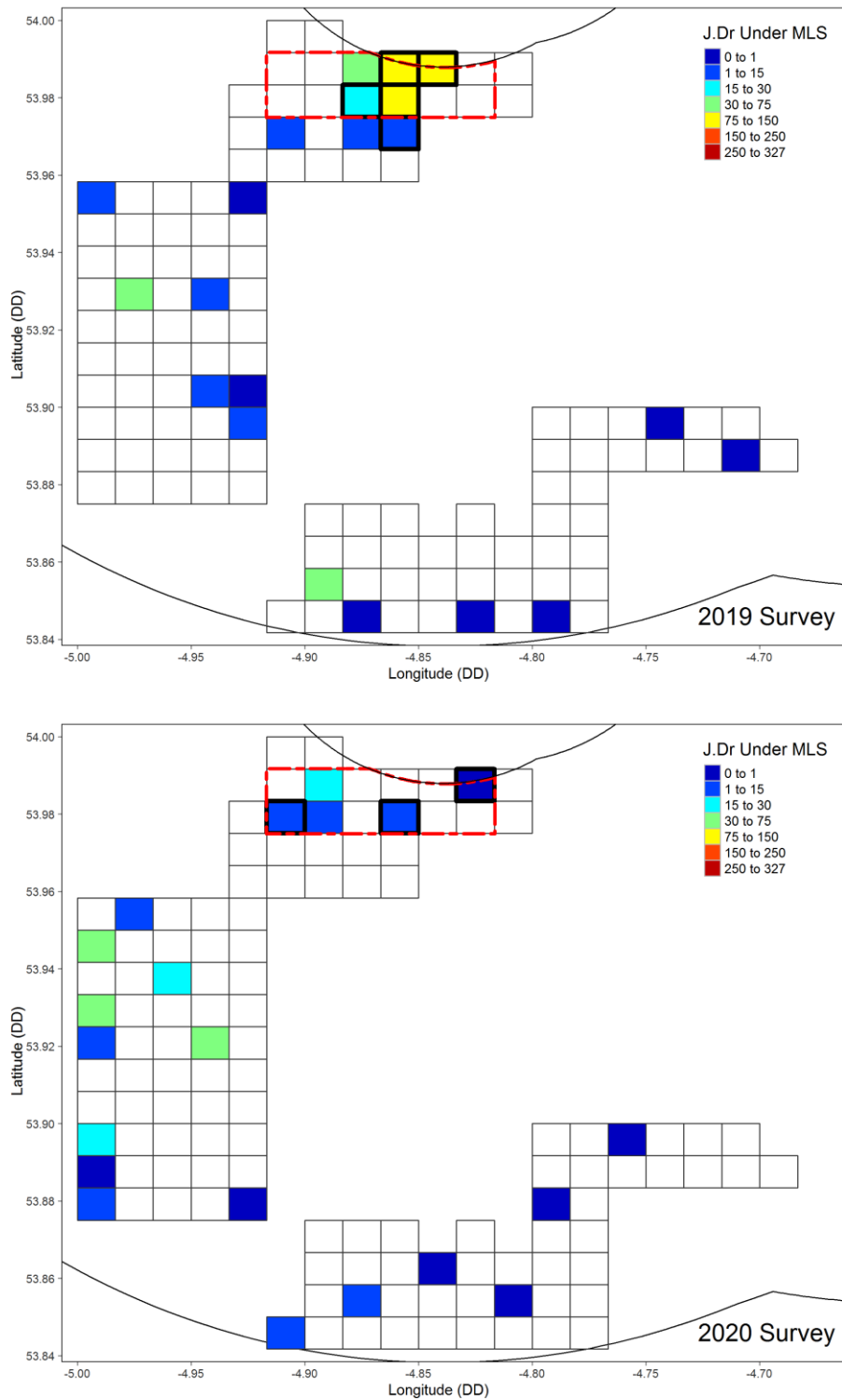


Figure 9: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (left) and 2020 (right) at Chickens (South coast). The red box indicates the area closed to scallop fishing in 2019. Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although, they are used in the closed area or hotspot analysis).

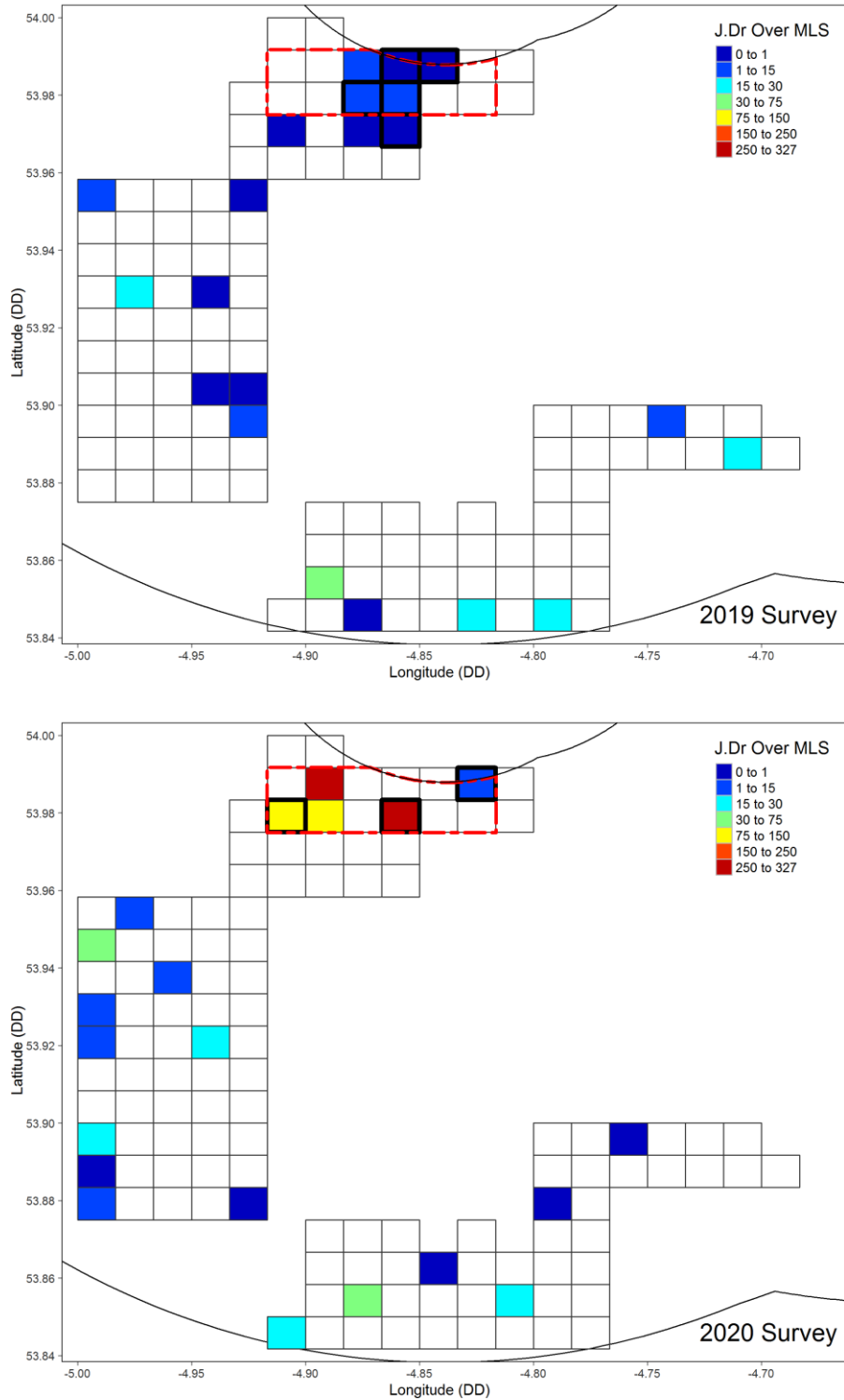


Figure 10: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left) and 2020 (right) at Chickens (South coast). The red box indicates the area closed to scallop fishing in 2019. Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS, or for individual fishing areas (although they are used in the closed area or hotspot analysis).

Table 5: Juvenile dredge density of QSC per 100 m² split by over and under MLS for Chickens; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Excludes targeted survey cells.

	2019 < 55 mm	2020 < 55 mm	2019 > 55 mm	2020 > 55 mm
Cells Surveyed	16	18	16	18
Min	0.00	0.00	0.00	0.00
Median	1.40	5.95	2.63	12.39
Mean	12.10	14.71	10.11	36.78
Geometric Mean	1.66	2.43	1.71	4.61
Max	72.03	72.20	51.88	272.99

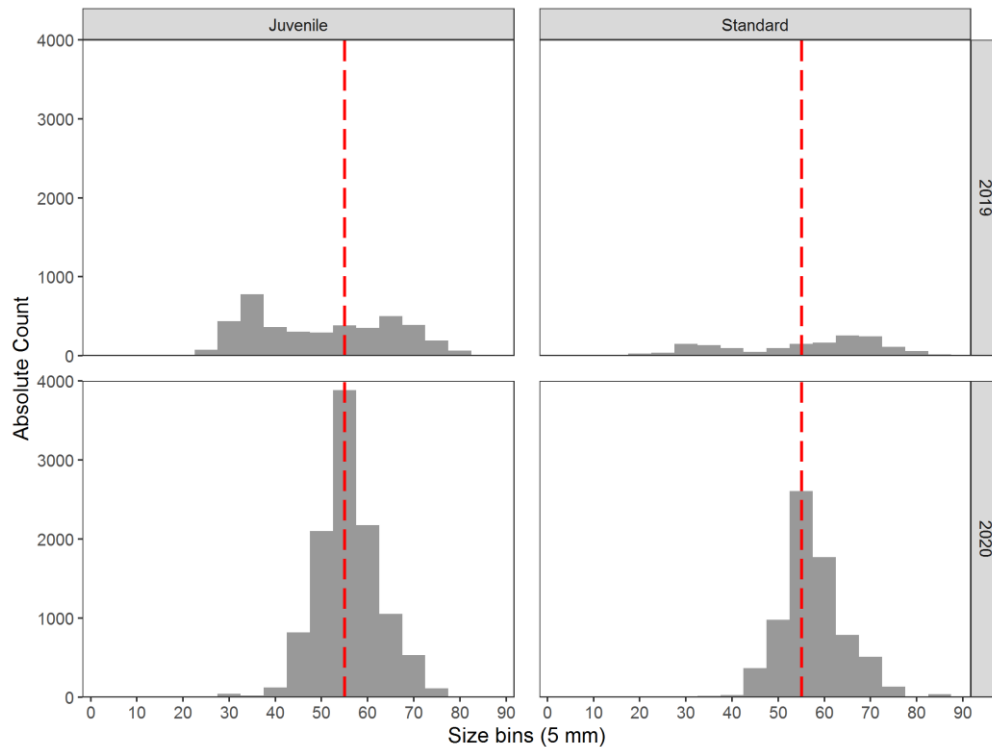


Figure 11: Size density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type for Chickens (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

CHI Closed Area

Table 6: Juvenile dredge density of QSC per 100 m² split by over and under MLS for CHI Closed Area; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's).

	2019 < 55 mm	2020 < 55 mm	2019 > 55 mm	2020 > 55 mm
Cells Surveyed	5	5	5	5
Min	27.08	0.43	0.00	1.71
Median	78.15	10.63	3.78	147.26
Mean	70.07	10.31	5.91	165.98
Geometric Mean	62.1	6.37	1.10	71.6
Max	103.24	20.61	13.83	326.90

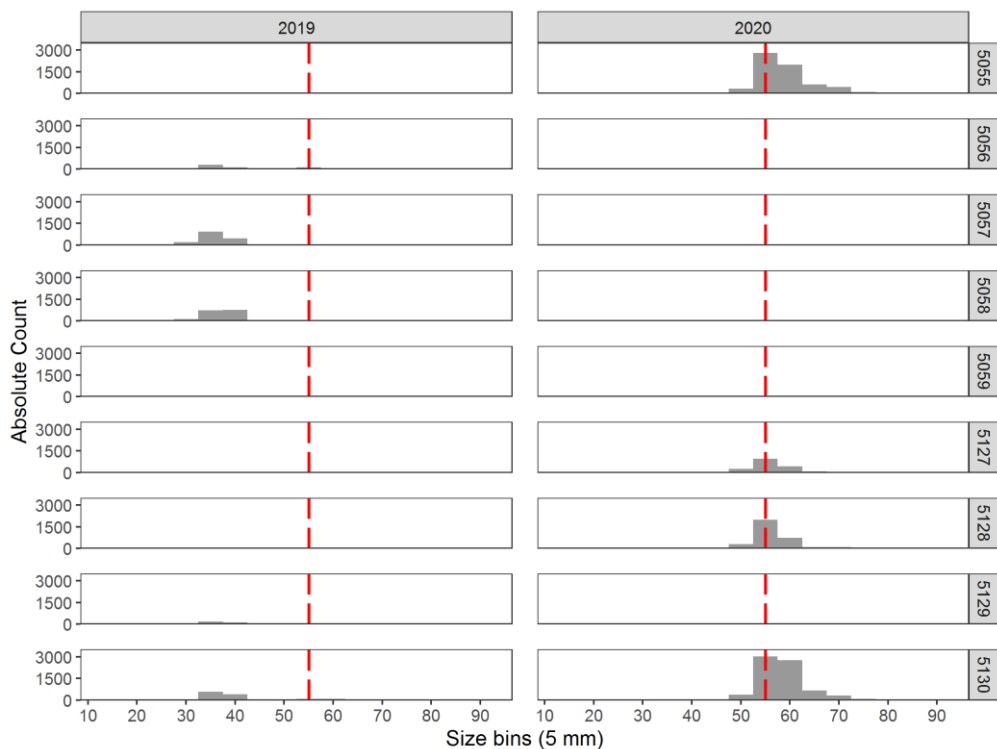


Figure 12: CHI Closed area size frequency of absolute counts of queen scallops by cell for 2019 and 2020 using data from all random and targeted survey cells.

For CHI, which had a small amount of fishing effort during the 2019 queen scallop fishery (~24 t dredge and ~ 5 t trawl) the post-recruit index (1.71 for 2019 and 4.61 for 2020) and the recruit index (1.66 for 2019 and 2.43 for 2020) both increased. The survey index for within the 2019 closed area, closed to protect high densities of recruit scallops (king and queen), saw an increase for post-recruits (1.10 in 2019 to 71.6 in 2020) and a large decrease for recruits (62.1 in 2019 to 6.37 in 2020). The shift in abundance indices for recruits and post-recruits is a result of growth within the cohort identified in the 2019 survey, which was protected during the 2019 season by a closed area (*note: the highest recorded densities for from the industry survey were recorded for post-recruits in a closed area targeted tow: 327 queenies per 100 m²*).

The large increase in post-recruit density in this area would indicate that for queen scallops the area could be opened for fishing during the 2020 fishing season, though some form of managed opening (voluntary or statutory) should be considered to avoid over fishing within the area. *In addition the area should also be considered for closure again during the 2020/2021 king scallop fishing season as it contains high densities of king scallop recruits (see Appendix).*

The increase in the recruit index overall for this fishing ground would indicate that other areas within the fishing ground have increased in recruit density. The highest recruit density for this ground is in the western area of the CHI ground, an area of muddy habitat, and this would be an area suitable for consideration for closure during the 2020 queen scallop fishery.

2.3.3 East of Douglas:

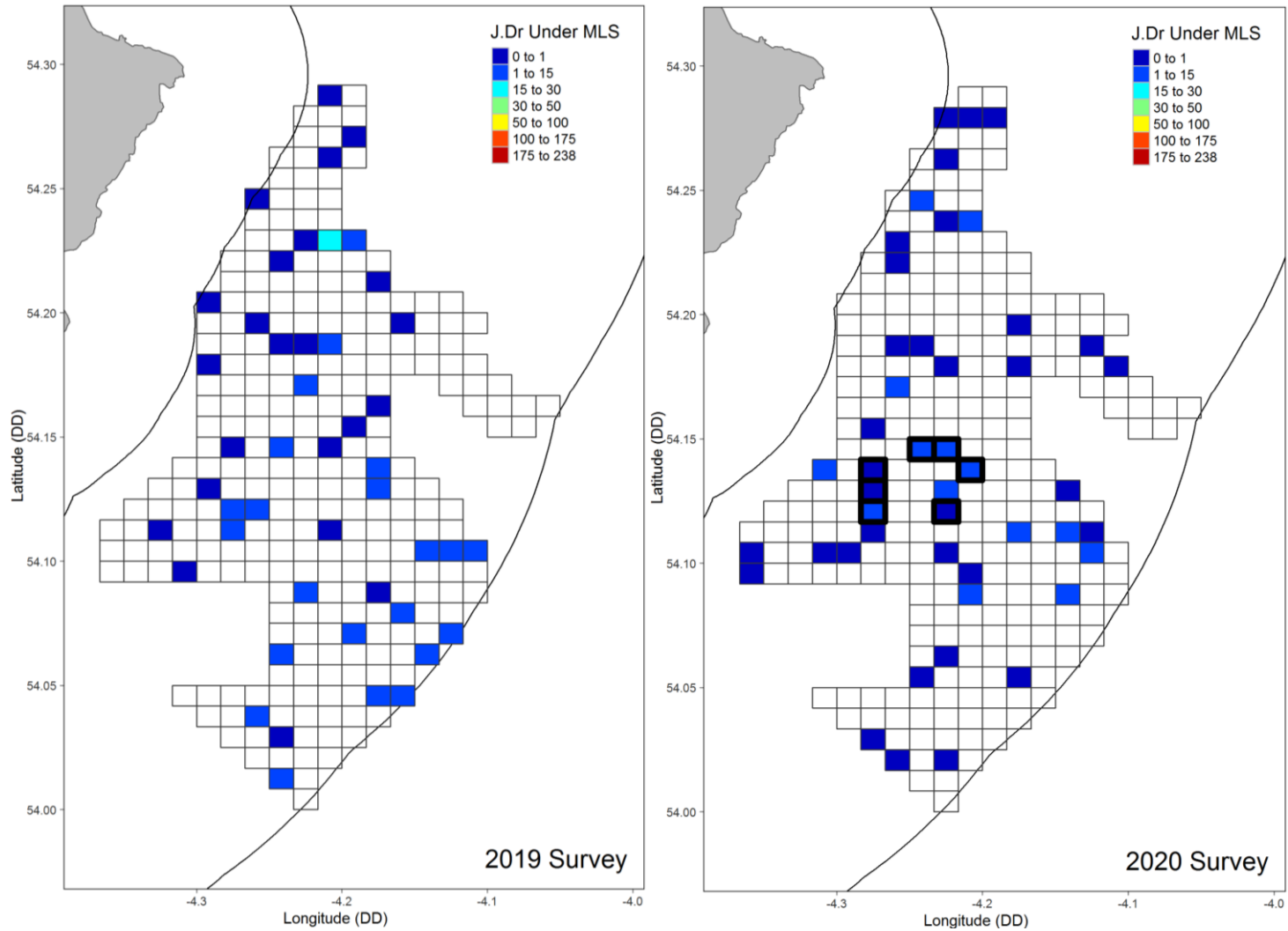


Figure 13: Maps illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2019 (left) and 2020 (right) at East of Douglas (East coast). Black borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS or for individual fishing areas (they are used in the closed area or hotspot analysis).

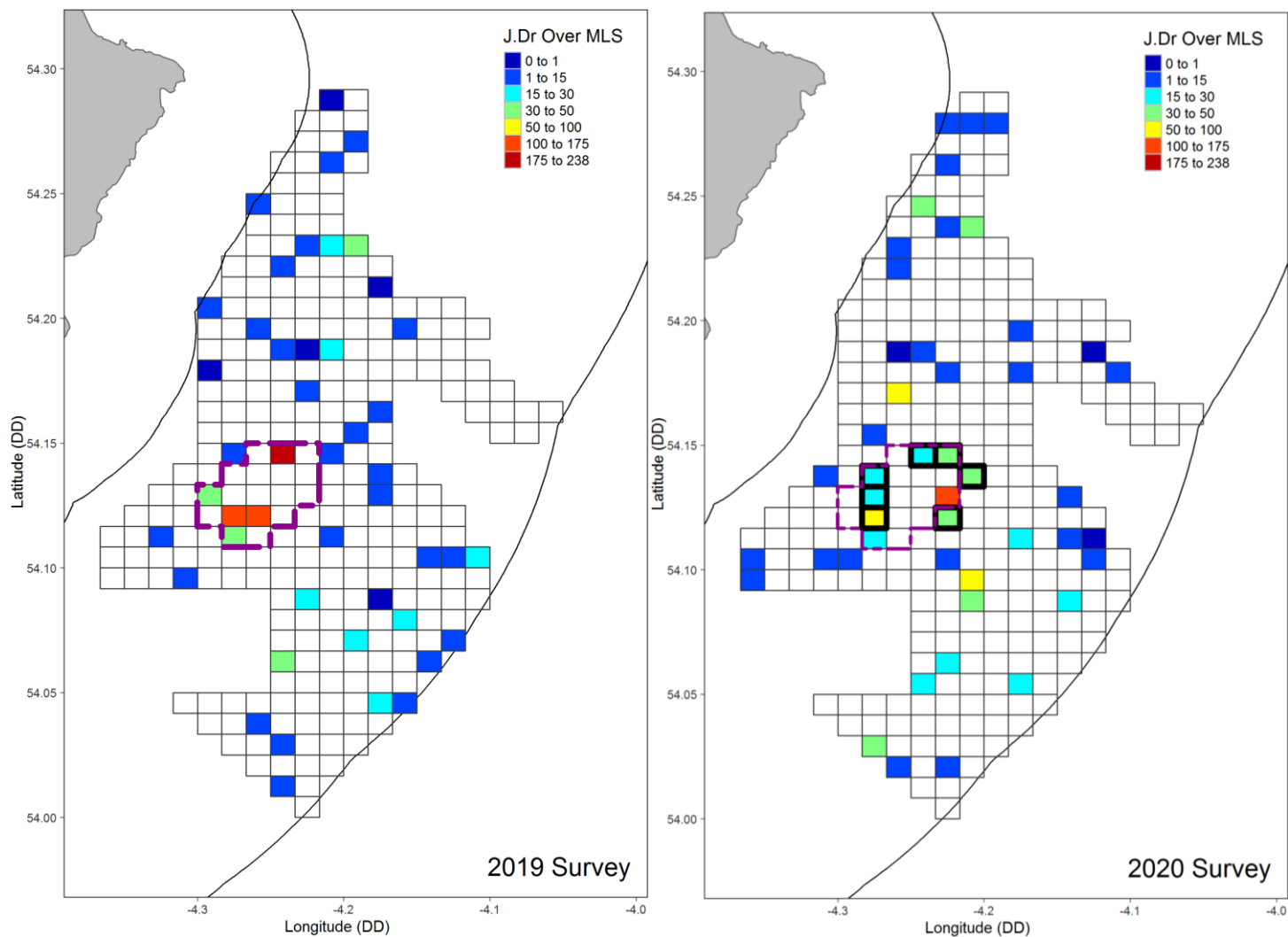


Figure 14: Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2019 (left) and 2020 (right) at East of Douglas (East coast). The purple dashed box indicates a hotspot of post-recruits identified in the 2019 survey within which the majority of fishing effort was focused 2019. Pink borders indicate cells that were part of an additional targeted survey and are not included in the main analysis for the TS or for individual fishing areas (they are used in the closed area or hotspot analysis).

Table 7: Juvenile dredge density of QSC per 100 m² split by over and under MLS for East of Douglas; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Excludes targeted survey cells.

	2019 < 55 mm	2020 < 55 mm	2019 > 55 mm	2020 > 55 mm
Cells Surveyed	47	40	47	40
Min	0.00	0.00	0.09	0.00
Median	0.85	0.32	6.40	7.87
Mean	2.11	0.74	20.09	17.82
Geometric Mean	0.68	0.32	6.28	7.10
Max	15.65	4.18	235.51	165.99

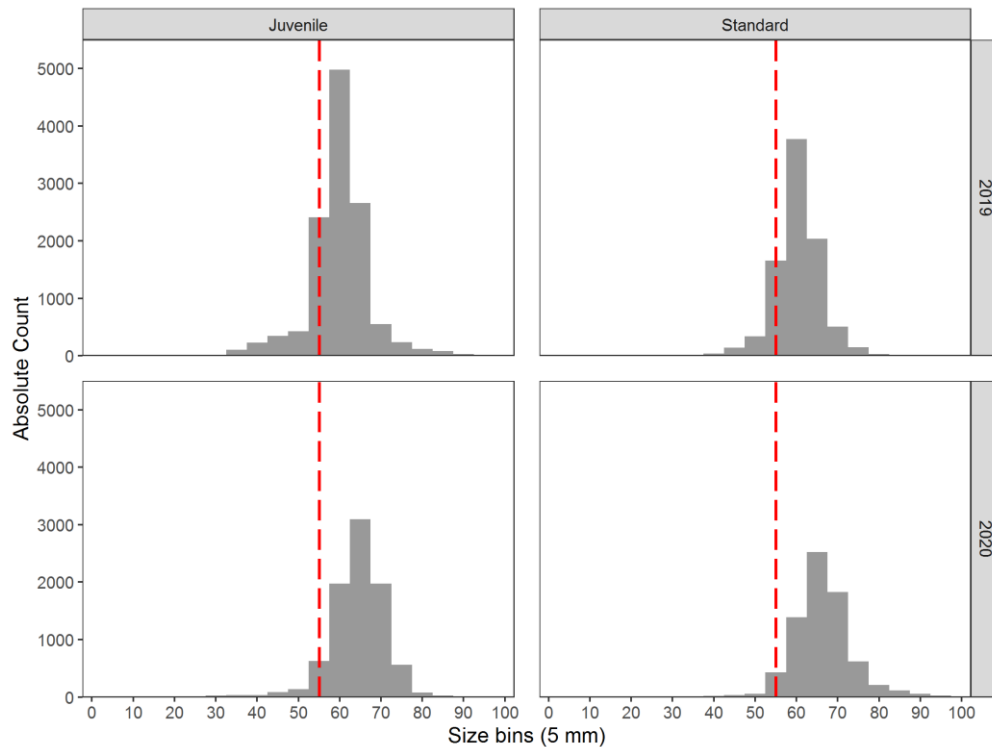


Figure 15: Size density histogram of absolute counts of queen scallops displayed by survey year and survey dredge type for East of Douglas (red dotted line indicates the MLS of 55 mm). Excludes targeted survey cells.

Hotspot:

Table 8: Juvenile dredge density of QSC per 100 m² split by over and under MLS for East of Douglas Hotspot; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's)

	2019 < 55 mm	2020 < 55 mm	2019 > 55 mm	2020 > 55 mm
Cells Surveyed	5	9	5	9
Min	0.79	0.45	31.69	20.21
Median	3.73	2.13	115.71	41.84
Mean	6.72	2.23	114.60	49.64
Geometric Mean	4.22	1.65	90.50	38.50
Max	14.87	5.37	235.51	165.99

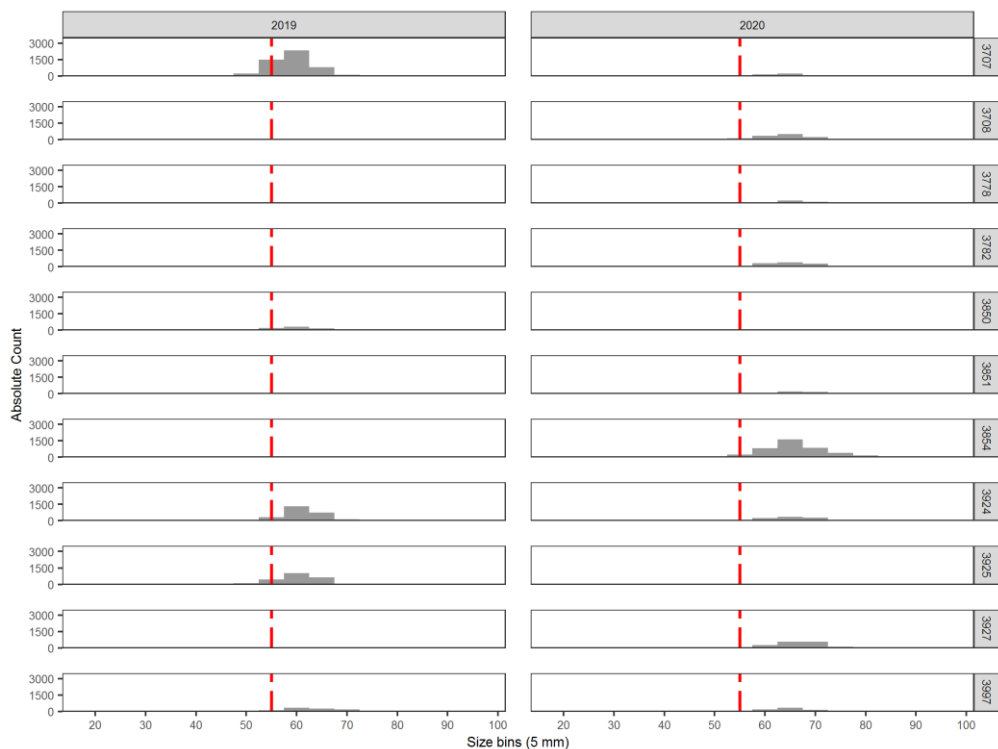


Figure 16: EDG Hotspot area size frequency of absolute counts of queen scallops by cell for 2019 and 2020 using data from all random and targeted survey cells.

For EDG which was the fishing ground with the majority of fishing effort and landings from the 2019 fishery (~543 t) the post-recruit index increased (6.28 for 2019 and 7.10 for 2020) whilst the recruit index decreased (0.68 for 2019 and 0.32 for 2020).

The survey index for the hotspot area at EDG, which had the highest post-recruit densities in the TS in 2019 and where the majority of the season's fishing effort occurred, decreased for both post-recruits (90.50 in 2019 to 38.50 in 2020) and recruits (4.22 in 2019 to 1.65 in 2020). These localised decreases within the hotspot area equate to > 50% decline of both indices, indicating that there has been a significant decrease in queen scallop densities within this localised hotspot. A spatial management trial was undertaken at this hotspot area towards the end of the 2019 fishing season with implementation of an LPUE threshold which was monitored in parallel with the TAC. The purpose of this LPUE threshold was to ensure that any decrease in density within this area was managed to ensure sufficient densities of queen scallops persisted for the 2020 fishing season.

The slight increase in the overall post-recruit index for EDG, despite the significant decline observed within the localised hotspot area, would indicate that other areas within the fishing ground have increased in density.

Given the significant reduction in post-recruit densities within the hotspot area following removal of ~ 543 t in 2019 it is recommended that a lower amount is harvested from this fishing ground during the 2020 fishing season to limit any further significant decline across the entire fishing ground.

2.3.4 Point of Ayre

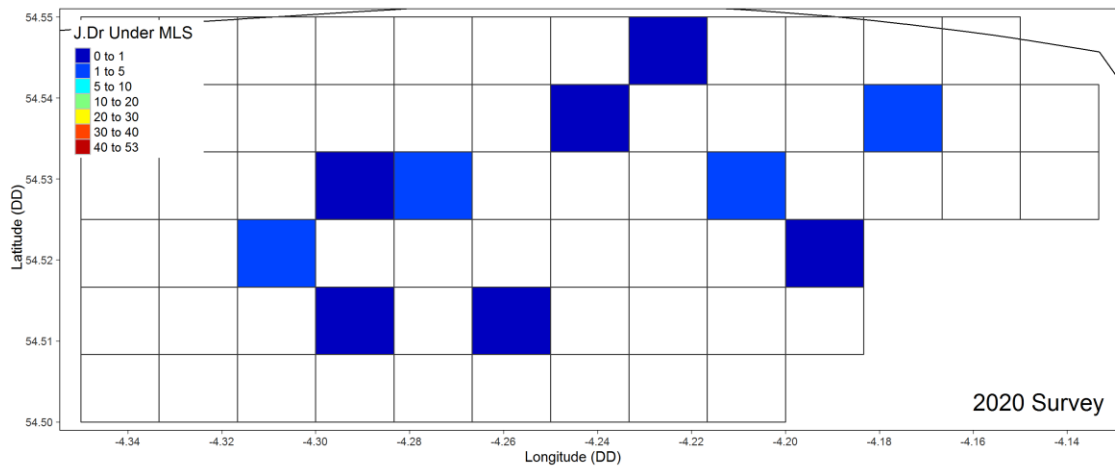


Figure 17: Map illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2020 at Point of Ayre (North coast).

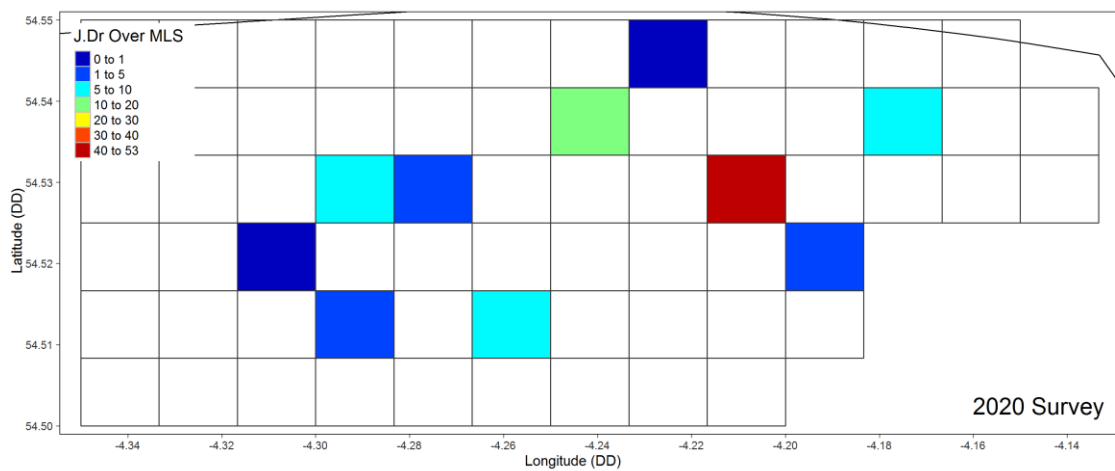


Figure 18: Map illustrating the survey densities for queen scallops over MLS from juvenile dredges for 2020 at Point of Ayre (North coast).

Table 9: Juvenile dredge density of QSC per 100 m² split by over and under MLS for Point of Ayre; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Excludes targeted survey cells.

	2020 < 55 mm	2020 > 55 mm
Cells Surveyed	10	10
Min	0.17	0.43
Median	0.69	5.33
Mean	0.95	10.23
Geometric Mean	0.80	4.51
Max	2.95	52.13

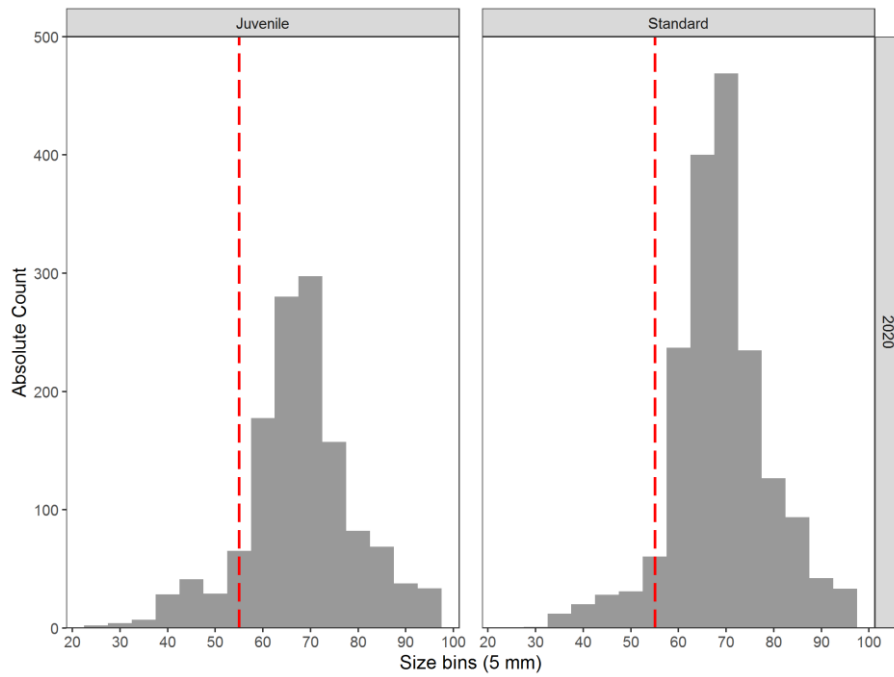


Figure 19: Size density histogram of absolute count of queen scallops displayed by survey dredge type for Point of Ayre (red dotted line indicates the MLS of 55 mm).

For POA, which had no fishing effort during the 2019 queen scallop fishery and no 2019 survey data, the post-recruit index for 2020 was 4.51 and the recruit index for 2020 was 0.80.

2.3.5 Bradda offshore

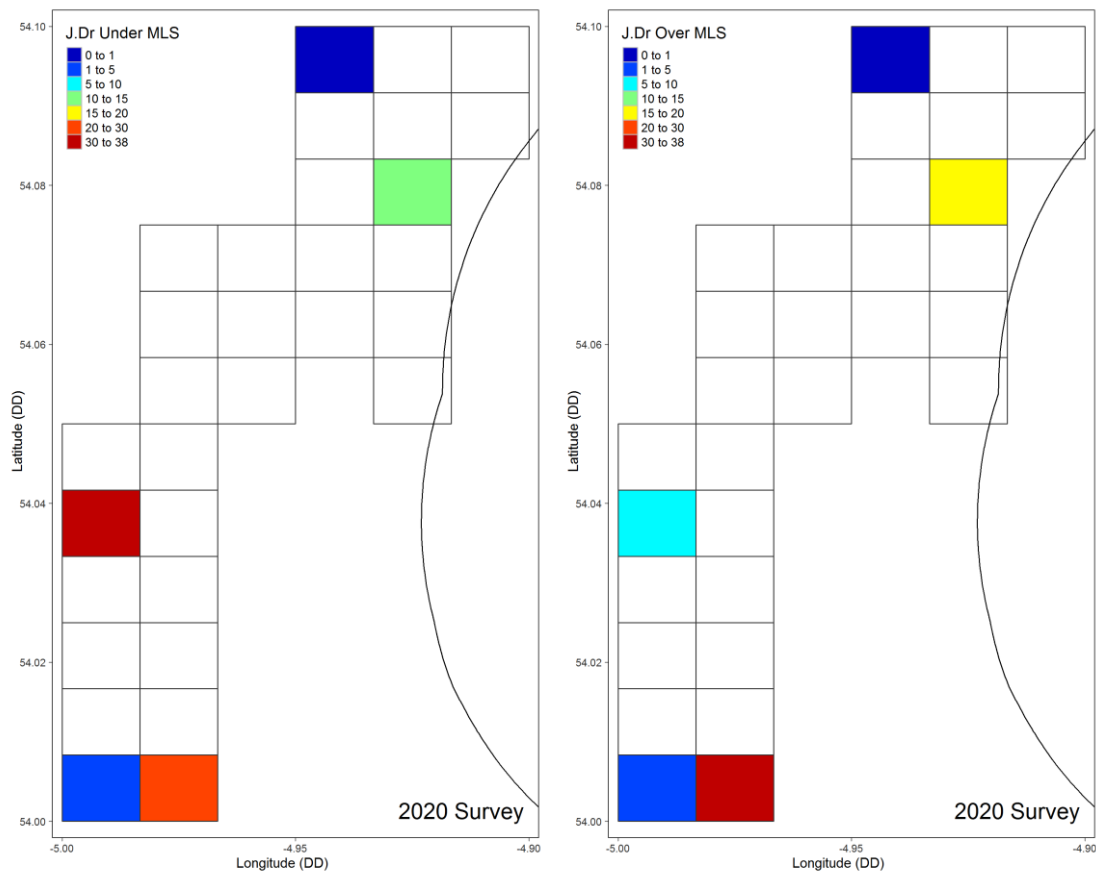


Figure 20: Map illustrating the survey densities for queen scallops under MLS (left) and over MLS (right) from juvenile dredges for 2020 at Bradda offshore.

Table 10: Juvenile dredge density of QSC per 100 m² split by over and under MLS for Bradda offshore; note that a constant of 0.05 was added prior to calculation of the geometric mean (to eliminate 0's). Excludes targeted survey cells.

	2020 < 55 mm	2020 > 55 mm
Cells Surveyed	5	5
Min	0.00	0.00
Median	13.81	6.69
Mean	15.79	11.28
Geometric Mean	4.88	3.05
Max	37.38	32.22

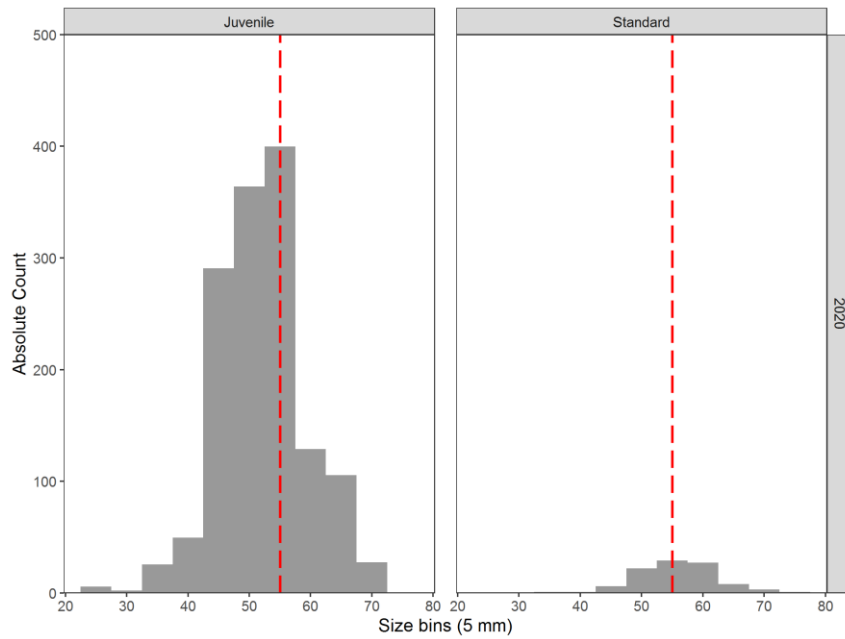


Figure 21: Size density histogram of absolute count of queen scallops displayed by survey dredge type for Bradda offshore (red dotted line indicates the MLS of 55 mm).

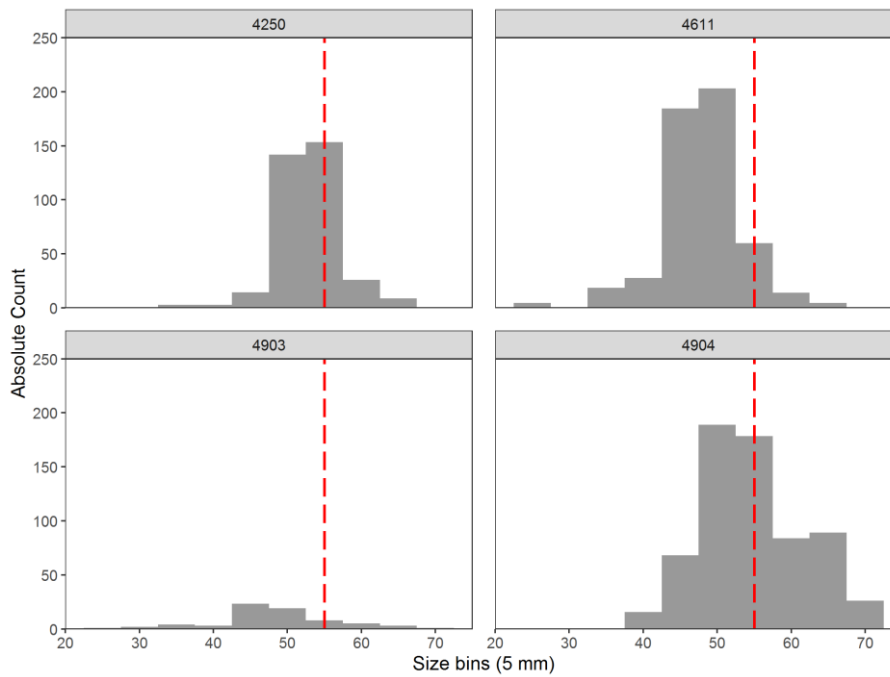


Figure 22: Size density histogram of absolute count of queen scallops displayed by survey dredge type for Bradda offshore (red dotted line indicates the MLS of 55 mm) displayed by survey cell for Juvenile dredges (No QSC recorded in juvenile dredges at Survey Cell 4103).

For BRA, which has not had any quantity of recent fishing activity for queen scallops (though historically there has been activity and densities recorded in the longer term survey) and no 2019 survey data, the post-recruit index for 2020 was 3.05 and the recruit index for 2020 was 4.88. There are good densities specifically of recruits at this site which may require consideration of a partial closed area. 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.

3.2.5 Overall Spatial and Temporal Comparison

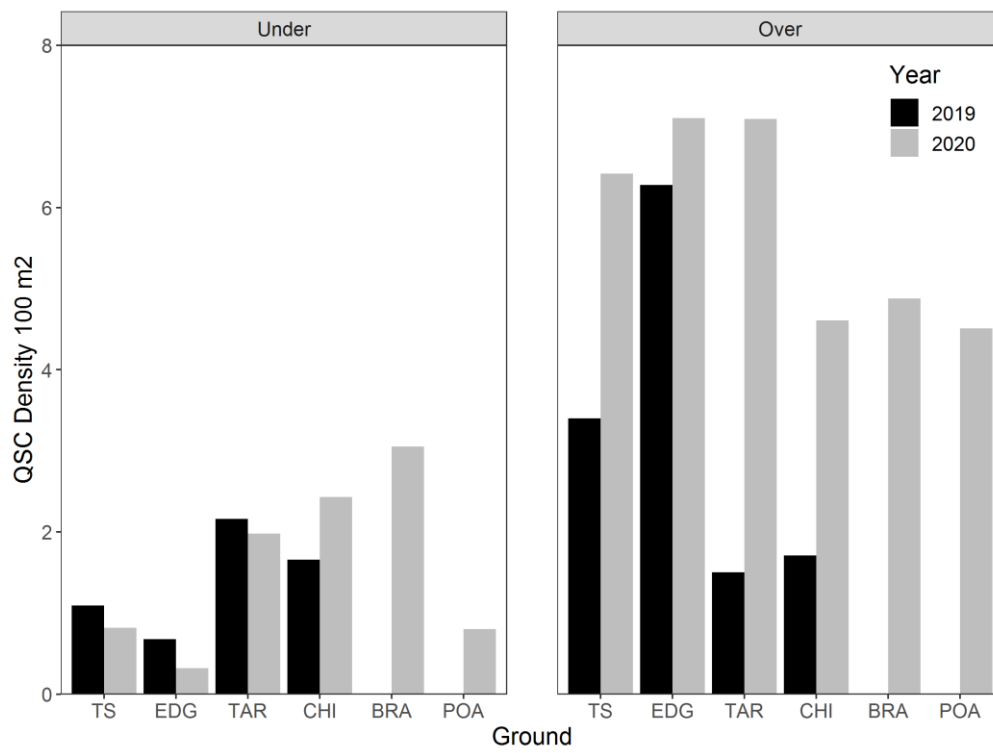


Figure 23: Comparison of queen scallop densities (over and under MLS) by year and by ground

3. Recommendations:

Scallop stocks are well known for their spatial and temporal variability with the main causes for this variation thought to be recruitment variability and species longevity (i.e. short-lived species like queen scallops have no buffer capacity if there is a period of poor recruitment) (Vause et al., 2005). The annual success of the queen scallop fishery around the Isle of Man in the northern Irish Sea has already been shown to be dependent on the strength of recruitment following the establishment of a significant relationship between the densities of 1-year-olds (i.e. ~20- 45 mm caught on surveys and commercial catch rates the following year (Vause et al., 2007). Monitoring of queen scallop recruit density therefore allows a reasonable prediction of recruitment and fisheries variations at least 1 year in advance (Vause et al., 2007). For management to be sustainable and effective it is therefore important to assess not only fluctuations in the current fishable portion of the stock (i.e. post-recruits or over 55 mm queen scallops) but also fluctuations in the newly recruiting portion of the stock that will support the fishery next year (i.e. recruits or under 55 mm queen scallops; specifically queen scallops between 20 – 45 mm). Assessing and managing both components of the stock should help reduce the fluctuations in the fishery and aid with long-term sustainability of both the stock and fishery.

The TS survey indices for 2020 recorded an increase for post-recruits and a decrease for recruits compared to 2019. The survey data from 2019 indicates a good recruitment peak (~ 25 – 45 mm queen scallops) (Figure 4) which was suitably protected and managed during the 2019 fishing season to enable these queen scallops to grow into the fishery in 2020, as reflected in the 2020 survey data and the increase in post-recruit abundance. A similar recruitment peak is not present in the 2020 survey data (Figure 4) and as such management should be considered within a two-year window, i.e. assessing the fishable stock this year (post-recruits) and the potential fishable stock for next year (recruits) together, rather than focusing on the post-recruit densities alone.

With only 2 years of survey data the industry survey dataset lacks the longevity to enable calculation of the 'ICES Category 3 data limited approach' to adjust the previous seasons TAC (capped at +/- 20%), with five years of survey data required. Given the lack of data to use this approach directly, and the known decrease in the recruit density for 2020 (together with the observed lack of a new 'recruitment peak'), a precautionary approach is recommended as below:

Start the 2020 queen scallop trawl fishing season at the same seasonal TAC for the trawl fishery as 2019 (i.e. 557 t); which is a 0% change. This leaves scope to look at adjusting the TAC by a maximum of 20% during the fishing season based on fishery dependent data (i.e. Daily Catch Return Forms) which is collected in near real-time during the season combined with feedback on scallop prices and market demand, the latter may be variable due to both competition from other small scallop species on the market and supply and market issues resulting from corona virus restrictions).

It is recommended that this precautionary management approach for 2020 should incorporate all of the following three elements:

- **Spatial management:** A spatial divide of the TAC to avoid the entire TAC being harvested from a single area, i.e. a "soft" TAC for each ground. This approach, as per the trial in EDG in 2019, can also allow flexible spatial management (i.e. individual grounds to be opened or closed).
- **Closed area management:** Managed opening of current closed areas and new closed areas to be put in place to protect high density areas of recruits (king and queen scallops).
- **In-season reviews:**

- **Monthly reviews:** Monthly reviews of the fishery have become commonplace during previous seasons and these should continue (i.e. SMB review of the entire TS fishery should be scheduled as standard for the end of July and August).
- **Triggered Reviews:** As per the trial at EDG in 2019, near real-time monitoring of “soft” TACs and “soft” LPUE thresholds for individual grounds could be used to trigger an immediate review by the SMB of an individual fishing ground (i.e. if the “soft” TAC for a ground is met then the LPUE and fishing activity in the area would be assessed to see if the ground should be closed or the “soft” TAC extended to enable the ground to remain open).

General recommendations for the 2020 queen scallop fishery based on the survey data analysis produced here therefore include:

Trawl TAC:

- An initial precautionary starting trawl TAC for 2020 of 557 t (i.e. a 0% change from 2019 trawl TAC).
- Scope to adjust the starting trawl TAC by a maximum of 20% based on monitoring of fishery dependent data in-season (i.e. arising from monthly or triggered reviews).
- A split of the TAC between the main four fishing grounds (e.g. based on survey density and the area of each fishing ground) using “soft” TACs.

In-season reviews:

- Consideration of “soft” LPUE thresholds for each ground (based on previous seasons data)
- Monthly reviews of the TAC and fishery (i.e. end of July and end of August)
- Triggered immediate reviews in response to either “soft” TACs or “soft” LPUE thresholds being reached for an individual fishing ground.

Closed Area management:

- A managed opening of the current CHI Closed Area (& discussion about closure for SCE season)
- A closure to protect high density of recruits in the western area of the CHI fishing ground (muddy habitat)
- A managed opening of the northern section of the TAR Closed Area
- A continued closure of the southern section of the TAR Closed Area (potentially spatially extended for SCE recruits)
- A continued closure of the East Douglas Experimental Research Area (EDGERA) to enable continued monitoring of the recovery of this area as well as scientific trials to better understand recruitment and habitat recovery in this fishery.

Transient scallop beds:

- Management of the queen scallop bed identified in the 2020 survey at Bradda offshore which appears to be a transient rather than permanent queen scallop bed should be considered. There are good densities of recruits within this area which may require management or protection during the 2020 fishing season.

Dredge TAC:

- Any dredge TAC, which has been restricted to the CHI dredge zone, would also need to be considered (total dredge landings from 2019/2020 were only 18.5t of the 58.29 t TAC)

Future work on recruitment:

The differences in general oceanography and frontal systems across the territorial sea might lead to long-term recruitment patterns varying considerably among individual fishing grounds. At present we only have two years of data for the three main queen scallop fishing grounds. As the time series continues to extend then the survey data will provide a better insight into what is average, good and poor in terms of recruitment densities for individual grounds. Historical analysis of the scientific survey data would for example indicate that larger recruitment events typically occur at CHI and TAR compared to EDG or POA. A longer term data set will therefore provide more information on what is normal in terms of recruitment at the fishing ground level. This in turn will assist with a longer-term management approach and knowing when to expect above average fisheries within each ground in the coming year(s).

4. References:

Bloor, I.S.M, Emmerson, J. and Jenkins, S.R. (2019). Assessment of Queen Scallop stock status for the Isle of Man territorial sea 2019/2020. SFAG Report No.1, pp18.

Vause, B.J., Beukers-Stewart, B.D. and Brand, A.R. (2006). Age composition and growth rates of queen scallops *Aequipecten opercularis* (L.) around the Isle of Man. *Journal of Shellfish Research*, 25: 310-312.

Vause, B.J., Beukers-Stewart, B.D. and Brand, A.R. (2007). Fluctuations and forecasts in the fishery for queen scallops (*Aequipecten opercularis*) around the Isle of Man. *ICES Journal of Marine Science*, 64: 1124-1135.

5. Appendix:

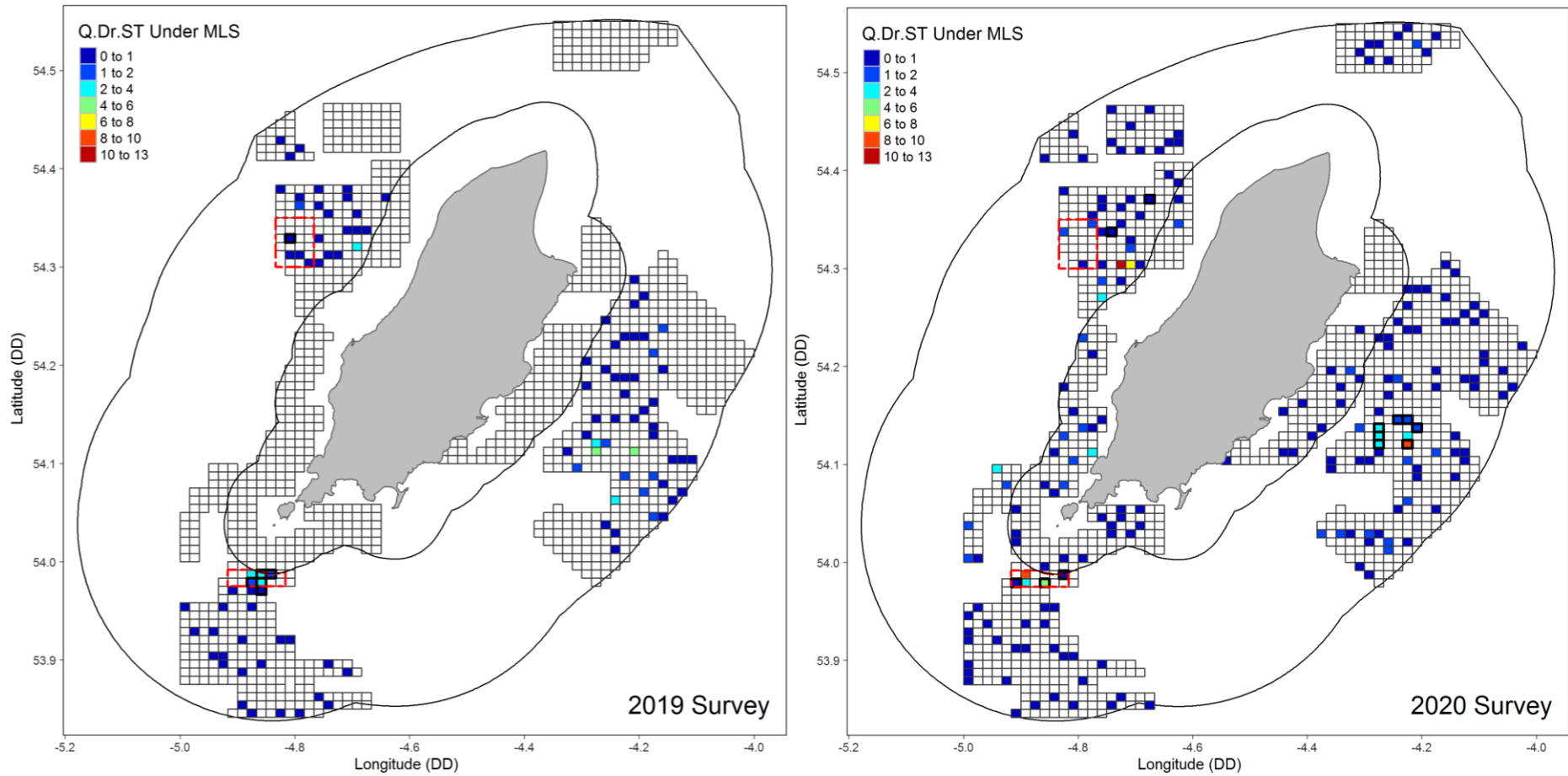


Figure 24: Juvenile king scallops (under MLS) from standard QSC dredges. Please note: this data has not been cleaned and so the results here are based on raw data before cleaning and processing. In addition, only the three main fishing grounds (EDG, TAR and CHI) were surveyed in 2019. The proportions for the three high density squares: Cell 5055 (CHI) = 80%; Cell 3927 (EDG) = 83% and Cell 2291 (TAR) = 90% under MLS.

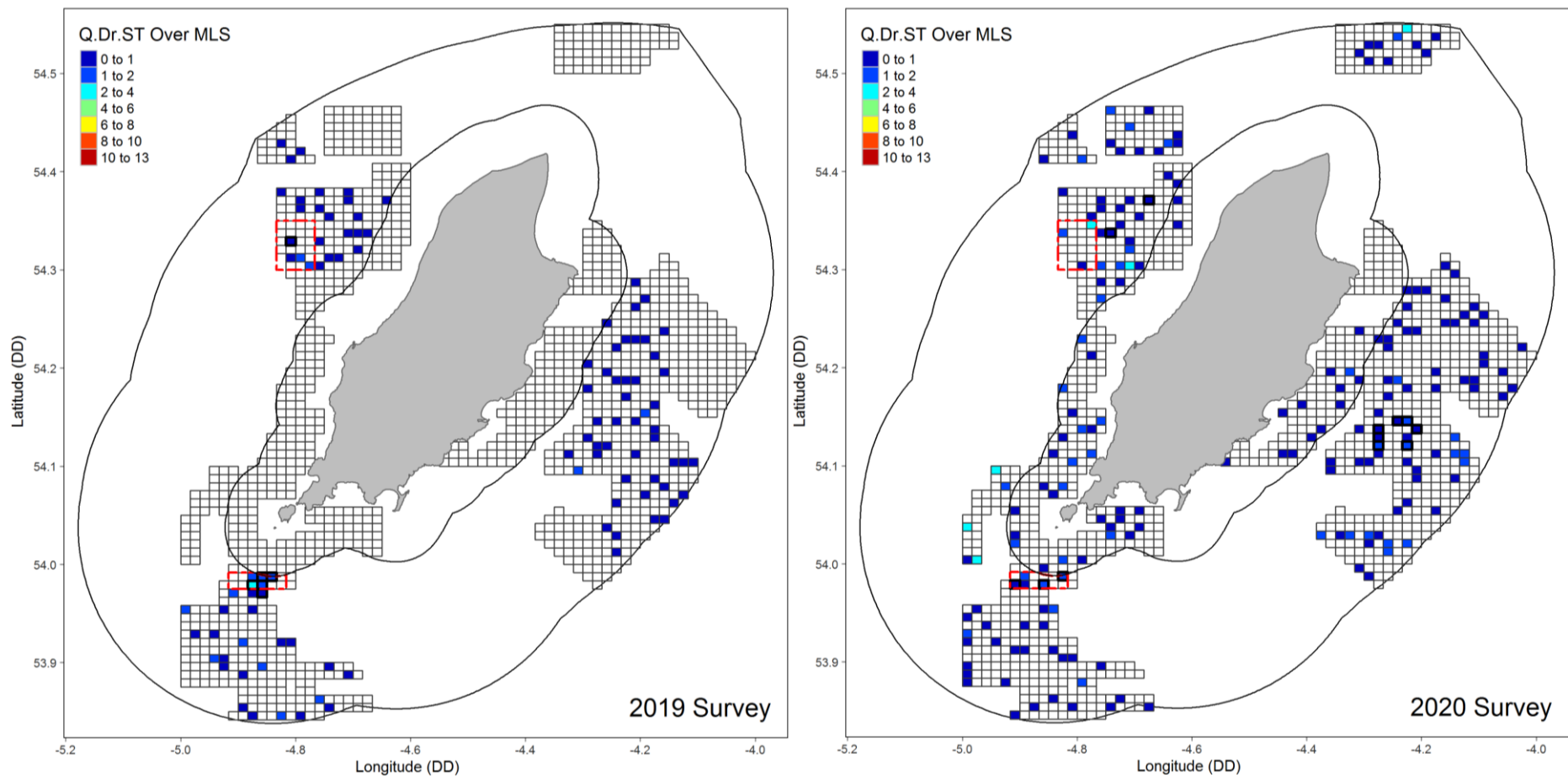


Figure 25: Adult King Scallops (Over MLS) from Standard Queen Scallop Dredges. *Please note: this data has not been cleaned and so the results here are based on raw data before cleaning and processing. In addition, only the three main fishing grounds (EDG, TAR and CHI) were surveyed in 2019.*