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June 2019 Juvenile Queen Scallop Survey Analysis

Bangor University and MFPO Combined Report

August 2019

Sustainable Fisheries and Aquaculture Group, School of Ocean Sciences

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Executive Summary:

Survey and methods:

A juvenile queen scallop survey was undertaken onboard two industry vessels (F.V. Benolas and F.V. Sarah Lena) from 19th – 27th June 2019. The survey was undertaken at three of the main queen scallop fishing grounds (Targets – 3 vessel days; Chickens – 3 vessel days and Douglas – 6 vessel days). 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 ~ 50 kings and 50 queens were measured.

Key results:

Targets: The highest density of queen scallops from both the juvenile and standard dredges was recorded within the current closed area (2018/2019) within this fishing ground (Figure ES1).

Chickens: The highest density of queen scallops from juvenile and standard dredges was recorded at an area along the 3 nm line that was identified in the April spring scallop survey onboard the R.V. Prince Madog, and the extent was further delineated as part of the survey work undertaken in June (targeted sampling of juveniles). In addition high densities were also found in juvenile dredges on the west of the survey area just on the edge of the traditional fishing grounds and south of the survey area near 12 nm (Figure ES1).

Douglas: The highest density of queen scallops from both the juvenile and standard dredges was recorded at three survey cells in the middle of the fishing ground. This 'hotspot' recorded densities of up to 250 queen scallops per 100 m^2 in the juvenile dredges and 186 queen scallops per 100 m^2 in the standard dredges (Figure ES1). It should be noted that the high density area identified in the June 2019 survey is located in an area that was closed as part of the overall queen scallop management plan both in 2014/2015 and 2015/2016 queen scallop fishing seasons and remained closed during the king scallop fishing seasons in those years as well. The current size range of these queen scallops (width ~60 mm average) equates to 3-5 year old queen scallops. This was verified with age analysis from the April 2019 survey. Queen scallops settling as spat in the summer of 2016, 2015 and 2014 would be 3, 4 or 5 years old respectively in the summer of 2019.

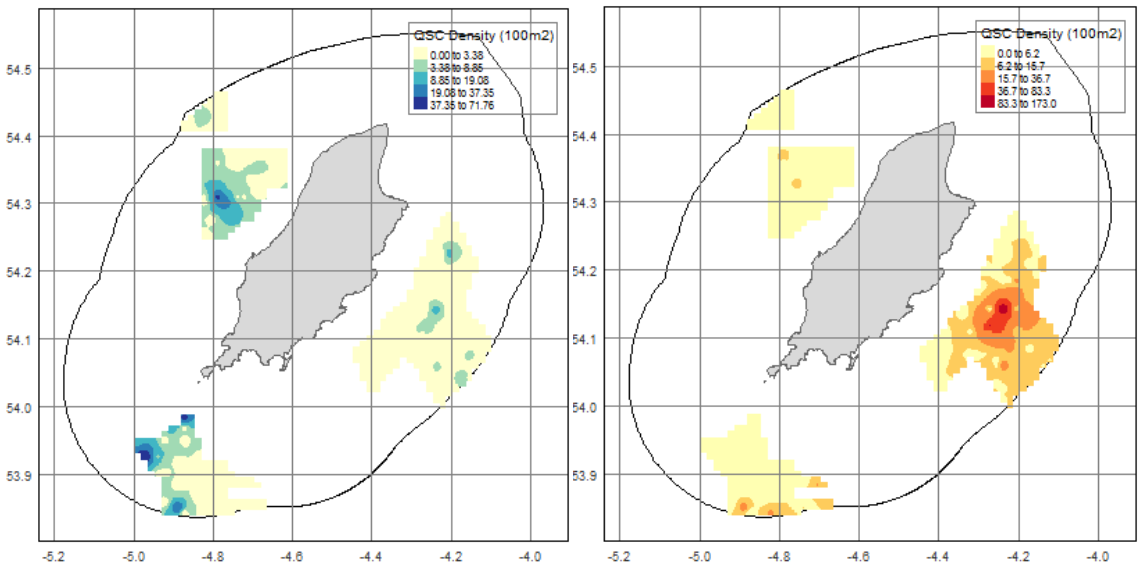

Figure ES1: An IDW interpolation of queen scallop abundances showing spatial abundance trends from the June survey for queen scallops across all three surveyed fished grounds. Under MLS from Juvenile QSC Dredges only (left) and over MLS from Standard QSC Dredges only (right).

Key discussion points:

The first year of the June 2019 Industry survey produced useful results on both queen scallops over and under MLS which corroborate and supplement the April 2019 survey data. A high density patch of queen scallops over MLS was identified in the Douglas ground. High densities of queen scallops under MLS were identified in the current closed area at Targets and the extent of another patch, first identified in the April survey, was mapped by the survey vessels at Chickens. This area of dense juveniles was then closed for the current 2019 season to protect the queen scallops for next year's fishery. Additional areas of high density juveniles were observed in both surveys on the edges of the survey area at Chickens which indicates the importance of expanding the survey extent in future years to better encompass these areas of juvenile settlement. The relative densities among the June survey sites indicates that both Chickens and Targets had substantially lower densities of queen scallops over MLS compared to the hotspot located at Douglas. However it should be noted that lower densities were identified across the wider area of the Douglas fishing ground.

The survey cells which were sampled by both the April and June surveys were comparable in density estimates which indicates that both the research and fishing vessels fish in a similar and defined way.

The data from both the long-term April survey and the new finer-scale June surveys combined with commercial catch data provide a level of data that may now support spatial management of this fishery for the first time (i.e. management at the level of fishing ground rather than overall Territorial Sea level).

Introduction:

At the May 2019 meeting of the Scallop Management Board (SMB) it was decided, in line with scientific advice, that a juvenile queen scallop survey should be undertaken in June onboard Industry vessels. The aim of the survey was to better assess densities of queen scallops under MLS (0 – 35 mm) that would recruit to the fishery in ~ 2 years. In addition the fine-scale resolution of survey sites would enable the demarcation of closed areas to protect queen scallops under MLS during the 2019 fishing season.

Methods:

A juvenile queen scallop survey was undertaken onboard two industry vessels (F.V. Benolas and F.V. Sarah Lena) from 19th – 27th June 2019. The survey was undertaken at three of the main queen scallop fishing grounds (Targets – 3 vessel days; Chickens – 3 vessel days and Douglas – 6 vessel days).

At each fishing ground the outer survey extent was delineated using vessel monitoring system data (VMS) amalgamated from 2007 – 2018. 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. 1.5-3.5 knots). These survey areas were then split into a fixed grid with a resolution of 1 min (longitude) x 0.5 min (latitude). Survey cells were sampled randomly within each sub-area 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 ~ 50 kings and 50 queens were measured.

In addition to the random Survey Cells described above additional cells (5 sites at CHI [Survey Cells: 5057, 5058, 5129, 5130 and 5203] and 1 site at TAR [Survey Cell: 2067) were surveyed in those areas targeted for juvenile closed area placement. These were excluded from the analysis below because these areas were chosen specifically because they were known high density areas of queen scallops (i.e. they were not a random selection of the identified fishing ground).

Results:

June survey analysis:

The overall densities of queen scallops (of all sizes) are displayed below for each of the three main fished grounds surveyed (Targets, Chickens and Douglas) by dredge type (i.e. SQD = standard queen scallop dredges and JQD = juvenile queen scallop dredges) (Figures 1 – 6).

Targets: The highest density of queen scallops from both the juvenile and standard dredges was recorded within the current closed area (2018/2019) within this fishing ground.

Chickens: The highest density of queen scallops from juvenile and standard dredges was recorded at an area along the 3 nm line that was identified in the April survey and the extent was further delineated as part of the survey work undertaken in June (targeted sampling of juveniles). In addition high densities were also found in juvenile dredges within survey cells 5561 (west of the survey area just on the edge of the traditional fishing grounds) and 6223 (south of the survey area near 12 nm).

Douglas: The highest density of queen scallops from both the juvenile and standard dredges was recorded at three survey cells in the middle of the fishing ground (3707, 3924, 3925). This 'hotspot'

recorded densities of up to 250 queen scallops per 100 m^2 in the juvenile dredges and 186 queen scallops per 100 m^2 in the standard dredges. It should be noted that the high density area identified in the June 2019 survey is located in an area that was closed as part of the overall queen scallop management plan both in 2014/2015 and 2015/2016 queen scallop fishing seasons and remained closed during the king scallop fishing seasons in those years as well (Figure 7). The current size range of these queen scallops (width ~60 mm average) equates to 3-5 year old queen scallops. This was verified with age analysis from the April 2019 survey. Queen scallops settling as spat in the summer of 2016, 2015 and 2014 would be 3, 4 or 5 years old respectively in the summer of 2019. There is similar observational evidence in both of the other two main fished grounds surveyed (Targets and Chickens) with high density patches of queen scallops (juveniles or adults) occurring where closed areas have been in place for multiple years and fishing activity has been minimal. The conditions within any given closure (i.e. suitability of habitat for queen scallops, fishing intensity before and after closure, tidal conditions, environmental conditions etc.) will impact how well individual closures react in terms of increases in queen scallops density. More work is therefore needed to monitor and assess the effectiveness of closed areas in relation to queen scallop spawning and recruitment success which will be aided by the ongoing data collection as part of this annual juvenile queen scallop survey.

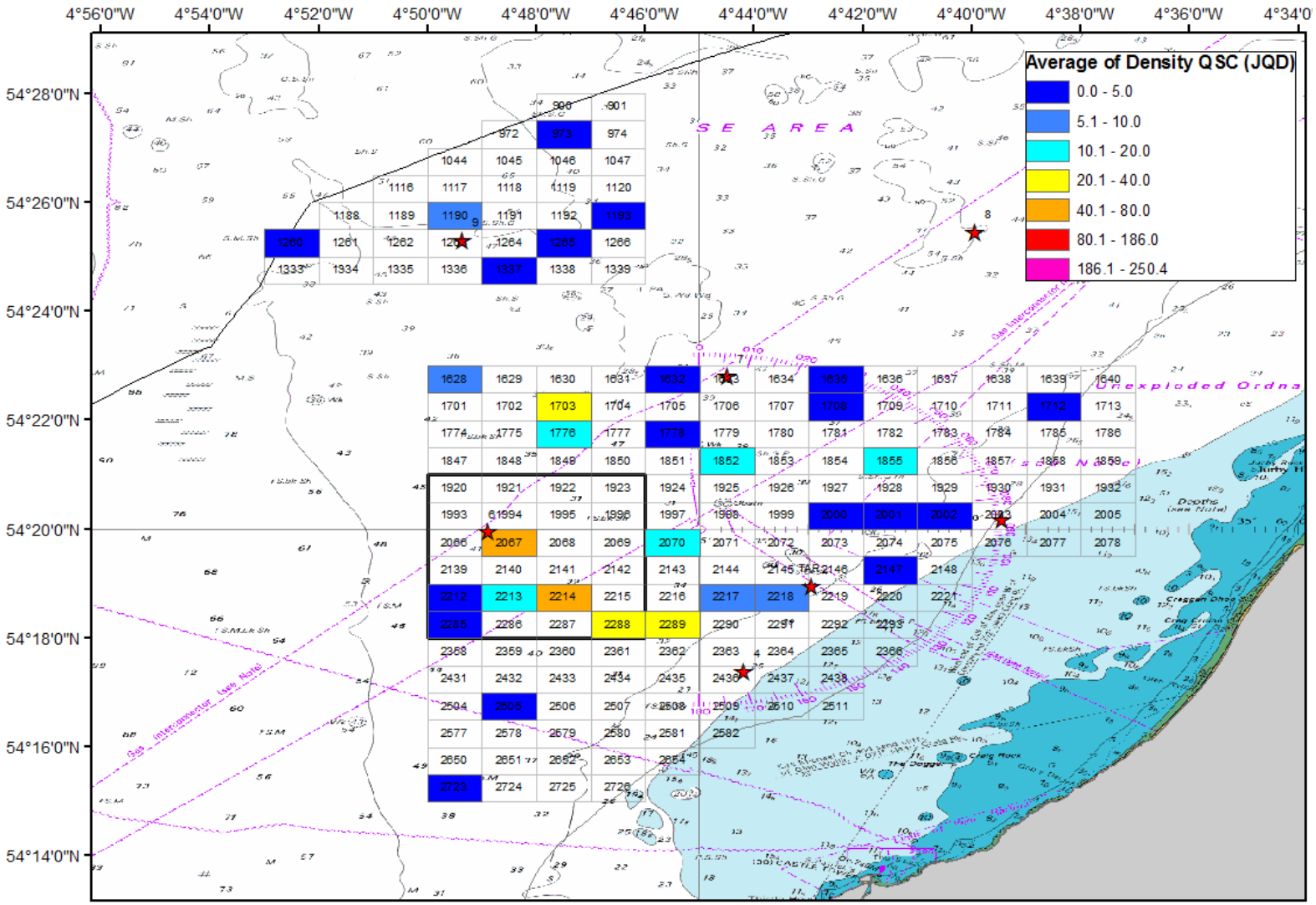

Figure 1: June survey results from Targets displaying density of queen scallops (all sizes) from juvenile (17 teeth) queen scallop dredges. The black box indicates the current closed area (closed for 2017/2018 and 2018/2019 king and queen scallop fishing seasons and currently still closed during the 2019/2020 queen scallop fishing season). Red stars indicate April survey stations.

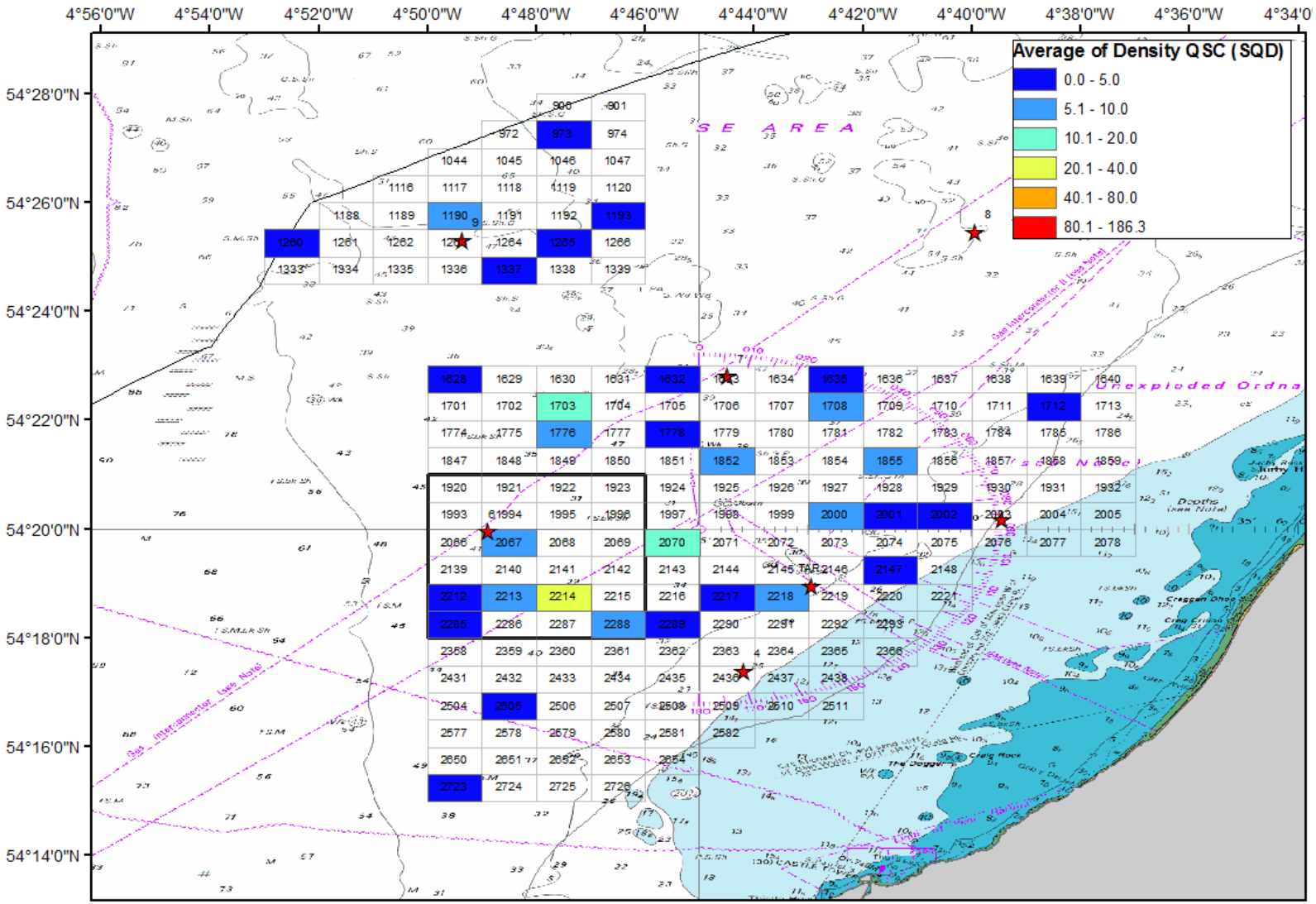

Figure 2: June survey results from Targets displaying density of queen scallops (all sizes) from standard (10 teeth) queen scallop dredges. The black box indicates the current closed area (closed for 2017/2018 and 2018/2019 king and queen scallop fishing seasons and currently still closed during the 2019/2020 queen scallop fishing season). Red stars indicate April survey stations.

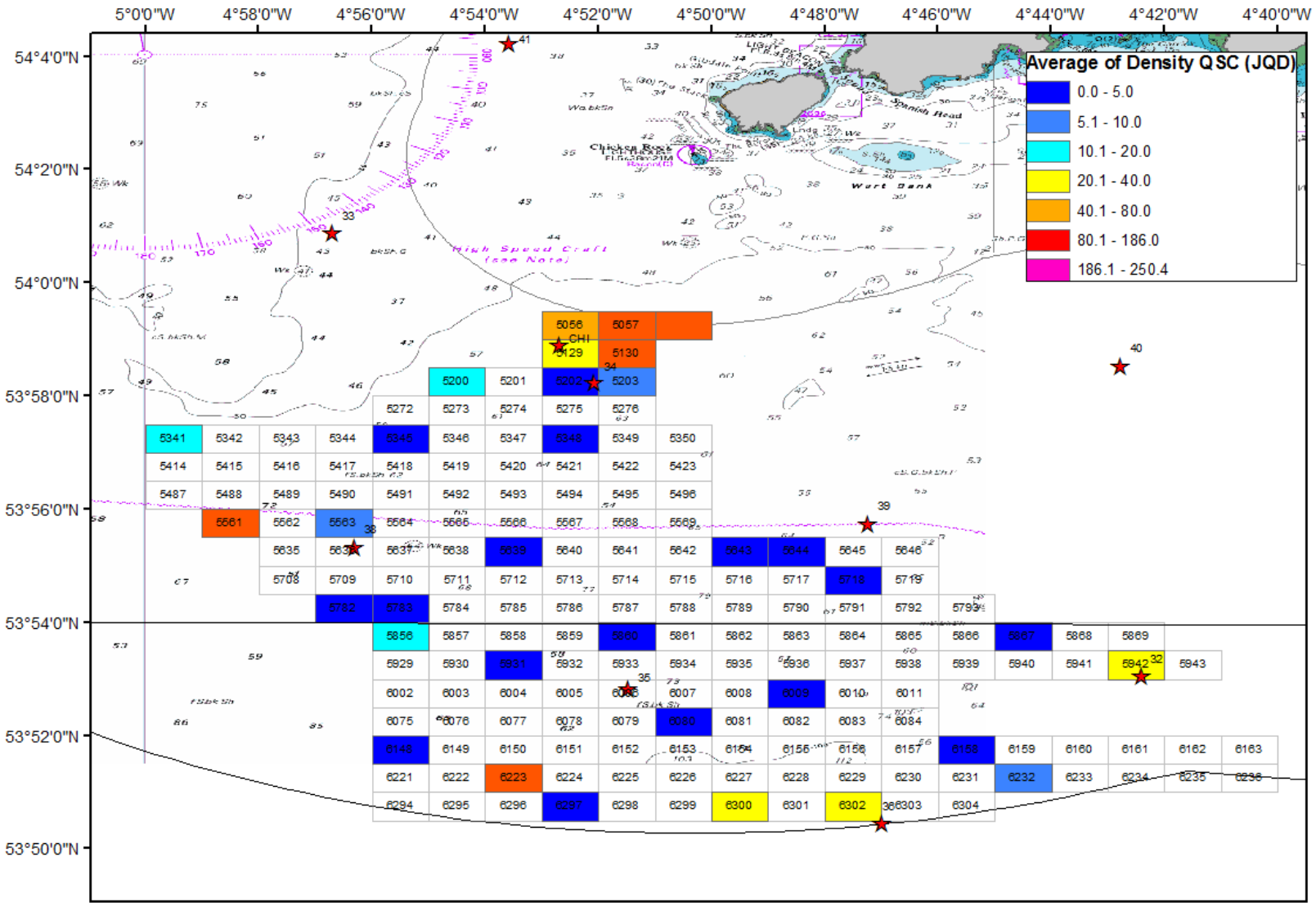

Figure 3: June survey results from Chickens displaying density of queen scallops (all sizes) from juvenile (17 teeth) queen scallop dredges. Red stars indicate April survey stations.

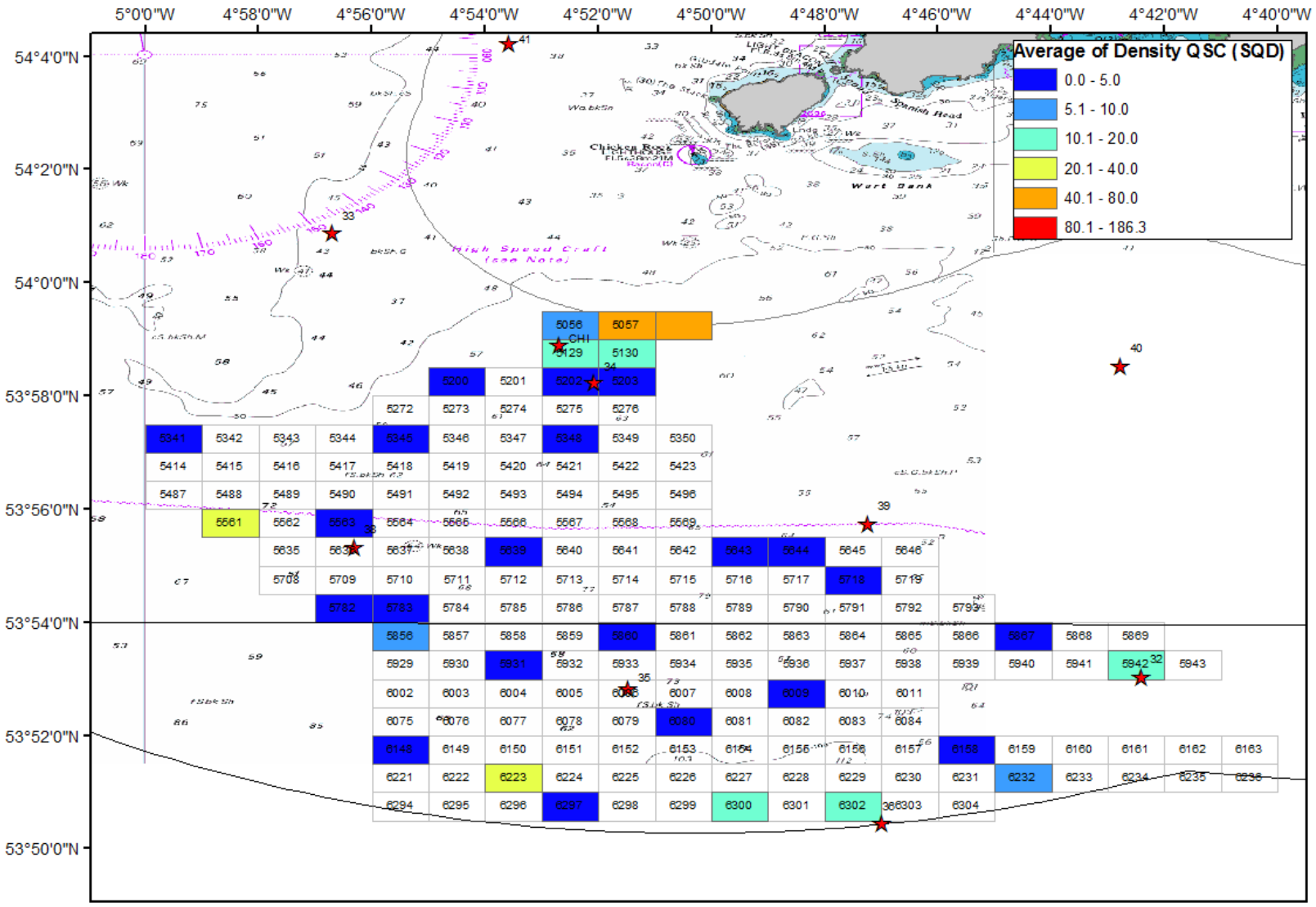

Figure 4: June survey results from Chickens displaying density of queen scallops (all sizes) from standard (10 teeth) queen scallop dredges. Red stars indicate April survey stations.

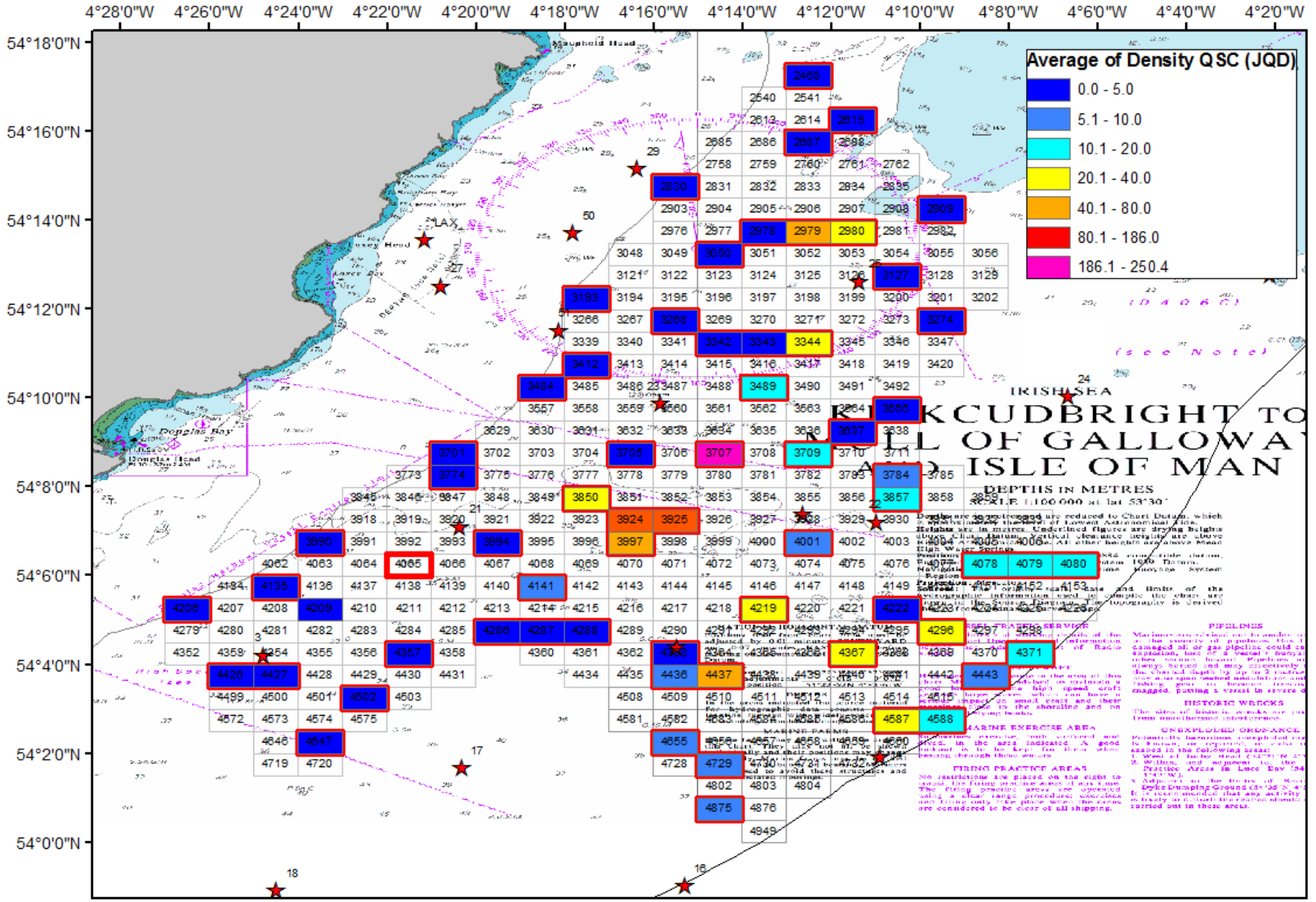

Figure 5: June survey results from Douglas displaying density of queen scallops (all sizes) from juvenile (17 teeth) queen scallop dredges. Red stars indicate April survey stations.

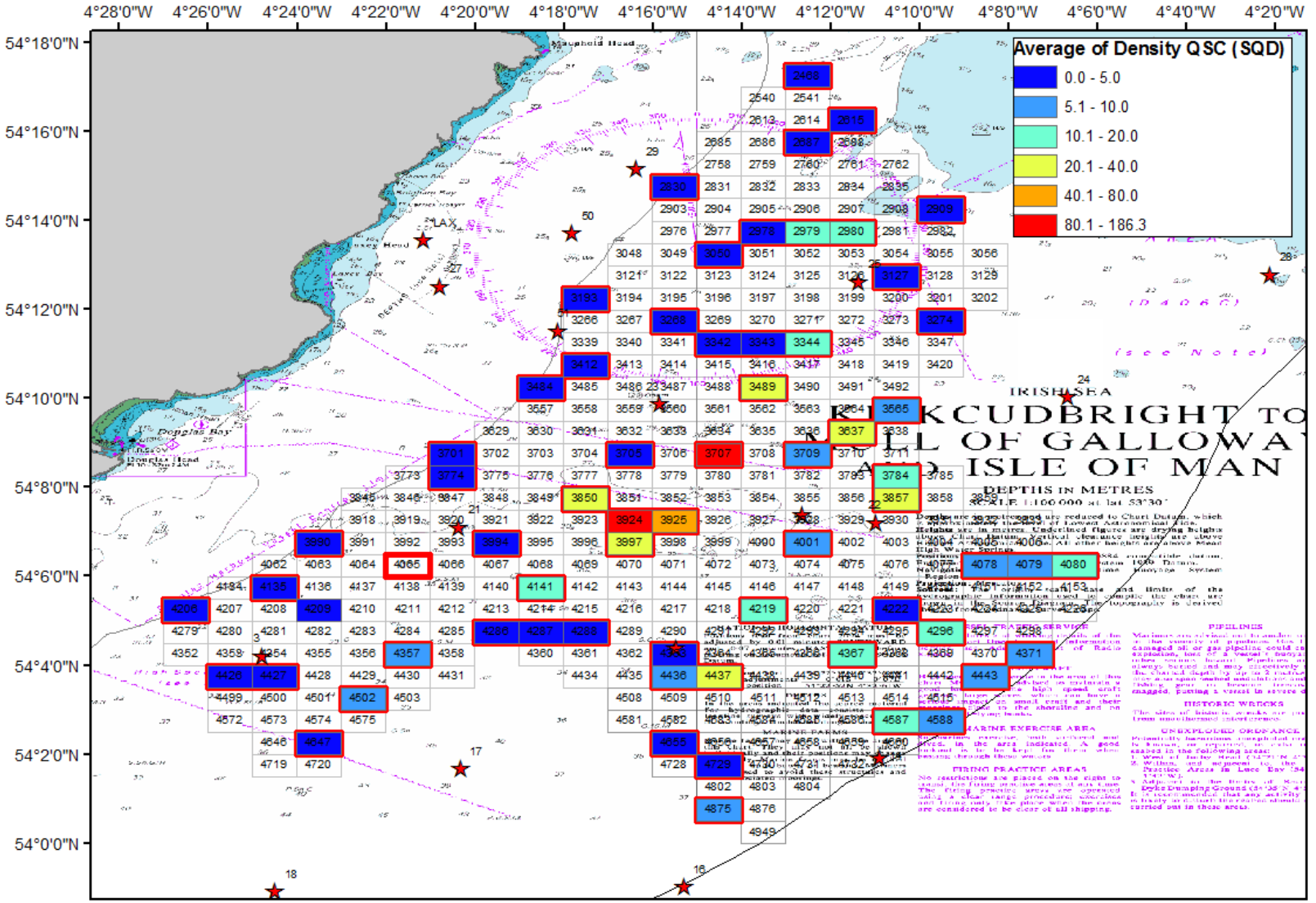

Figure 6: June survey results from Douglas displaying density of queen scallops (all sizes) from standard (10 teeth) queen scallop dredges. Red stars indicate April survey stations.

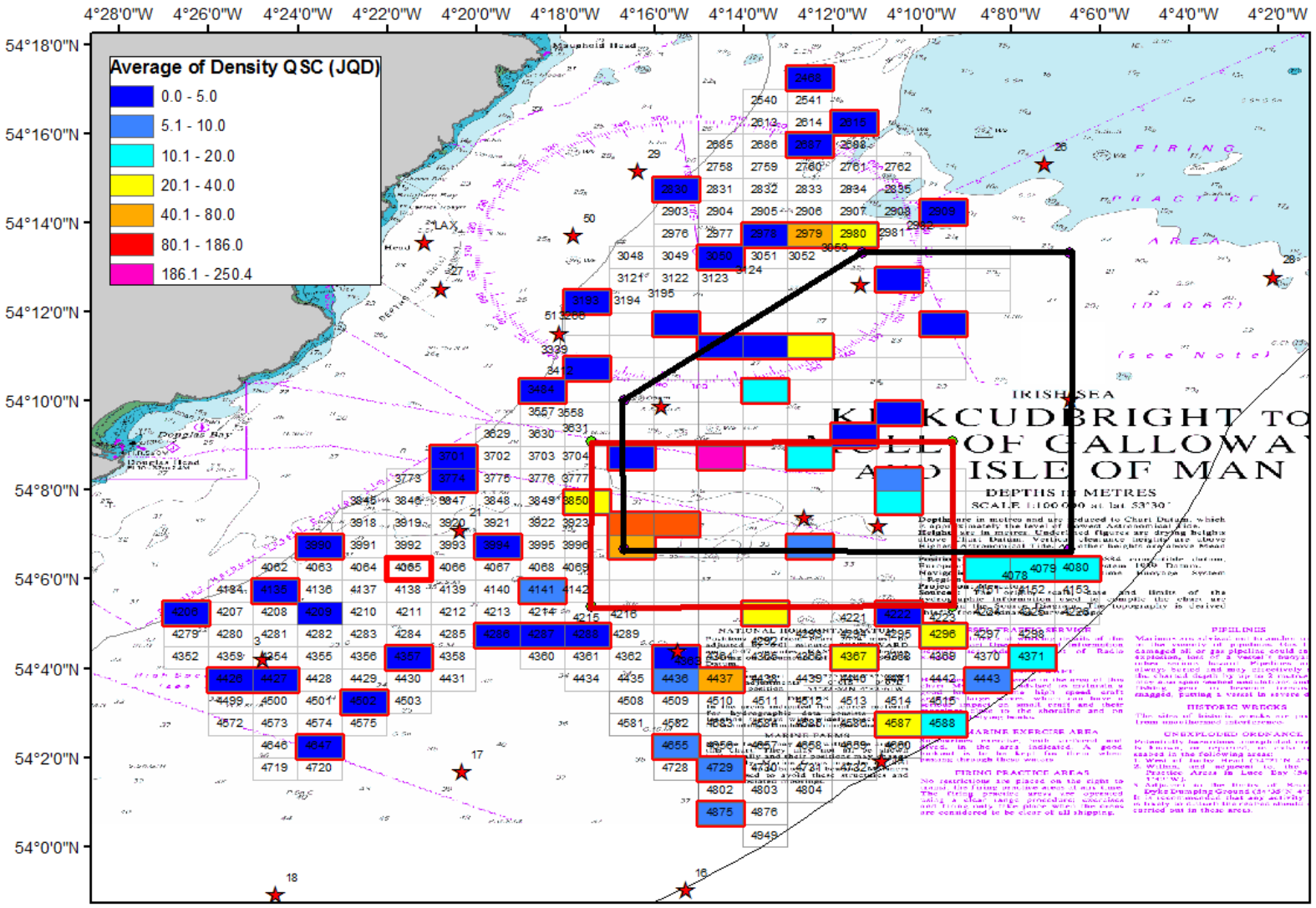

Figure 7: June survey results from Douglas displaying density of queen scallops (all sizes) from juvenile (17 teeth) queen scallop dredges. Red stars indicate April survey stations. Closed areas for 2014/2015 (Black box) and 2015/2016 (Red box) king and queen scallop fisheries.

In the following analysis we have made a distinction between queen scallops under the Minimum Landing Size (MLS) of 55 mm and those above it. We purposefully avoid the term 'recruit' owing to the ambiguous way in which this term can be interpreted and instead refer to under and over MLS.

The proportion of queen scallops above MLS varied among the three fishing grounds (Figure 1). Both Targets and Chickens had a high proportion of catch under MLS whilst the Douglas fishing ground catches were dominated by queen scallops over MLS. This pattern was reflected in both dredge types (juvenile and standard dredges) (Figure 8).

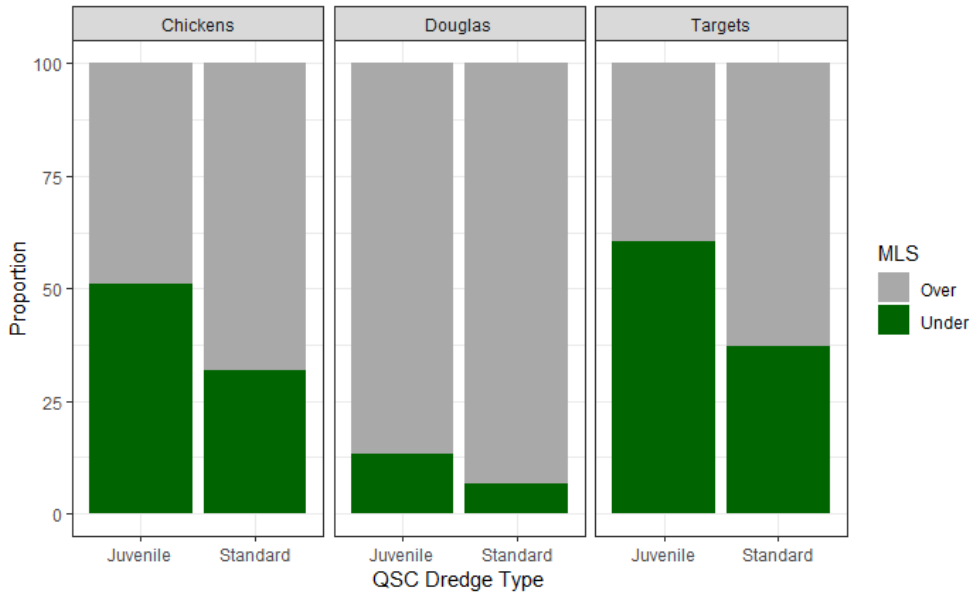

Figure 8: Proportion of under (<55 mm) and over (≥55 mm) MLS queen scallops subsampled during the survey and averaged across the main fished grounds (Juvenile and Standard QSC survey dredges displayed separately).

This difference among the grounds can be seen clearly from the size distribution of individuals. At Douglas the size range of the sampled catch was predominately over MLS whilst the catch at Chickens and Targets showed two distinct cohorts (Cohort 1: ≈25-50 mm and Cohort 2: ≈50-80 mm) (Figure 9).

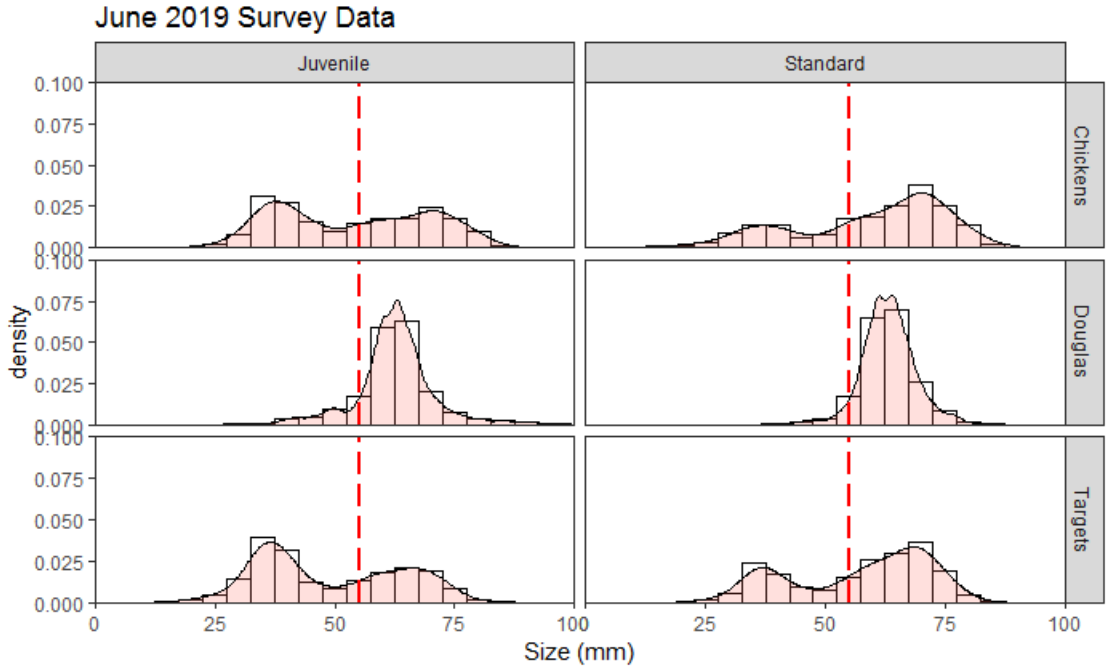

Figure 9: Density plots of size ranges of queen scallops sampled during the survey and displayed by Main Fished Ground. The red dotted line indicates MLS (55 mm).

Estimated mean densities varied among the three grounds. Average density of queen scallops over MLS was highest at Douglas in both dredge types. The average density of queen scallops under MLS was highest at Targets and Chickens in both dredge types (Figure 10 and Figure 11).

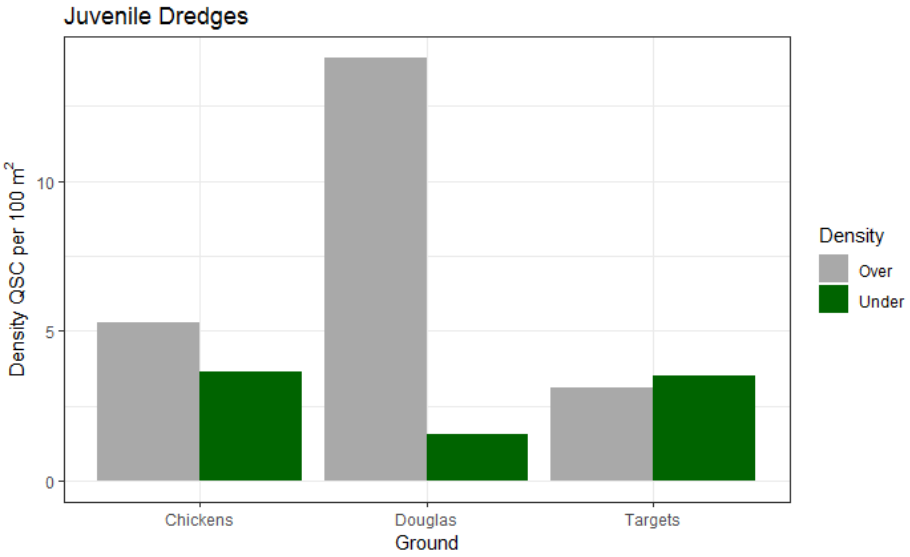

Figure 10: Density of queen scallops from queen scallop dredges split into over and under MLS and displayed by Main Fished Ground (Juvenile Dredges Only)

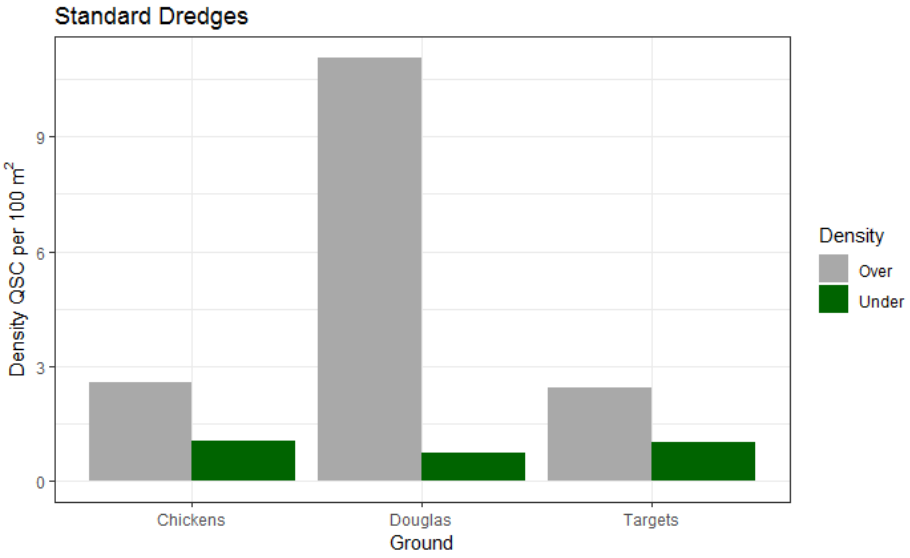

Figure 11: Density of queen scallops from queen scallop dredges split into over and under MLS and displayed by Main Fished Ground (Standard Dredges Only)

It is clear from the data that standard dredges catch larger scallops (over MLS) more efficiently and juvenile dredges catch smaller scallops (under MLS) more efficiently. For this reason the additional analysis presented below focuses on using juvenile (under MLS) density data from juvenile dredges and adult density data (over MLS) from standard dredges.

In Figure 12, Figure 13, Figure 14 and Figure 15 an inverse distance weighted (IDW) interpolation has been created using the data from the randomly surveyed cells to interpolate densities across the whole survey extent. Figure 12 shows the survey results for all three fished grounds and indicates hotspots of over MLS queen scallops at Douglas and under MLS queen scallops at both Chickens and Targets (within the current closed area). Close up maps of each of the three grounds (for both over and under MLS queen scallops) are provided in Figure 13, Figure 14 and Figure 15.

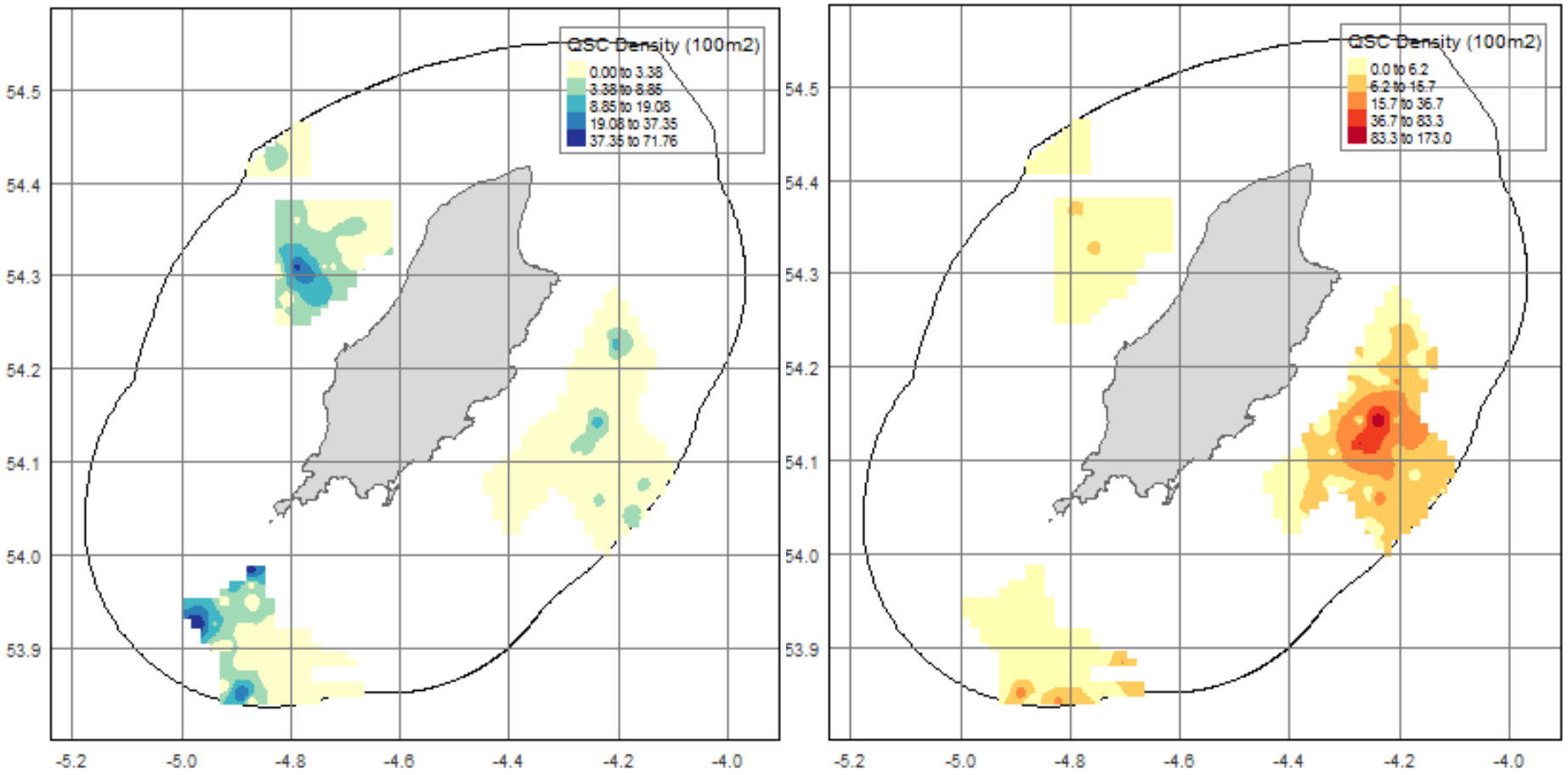

Figure 12: An IDW interpolation of queen scallop abundances showing spatial abundance trends from the June survey for queen scallops across all three surveyed fished grounds. Under MLS from Juvenile QSC Dredges only (left) and over MLS from Standard QSC Dredges only (right).

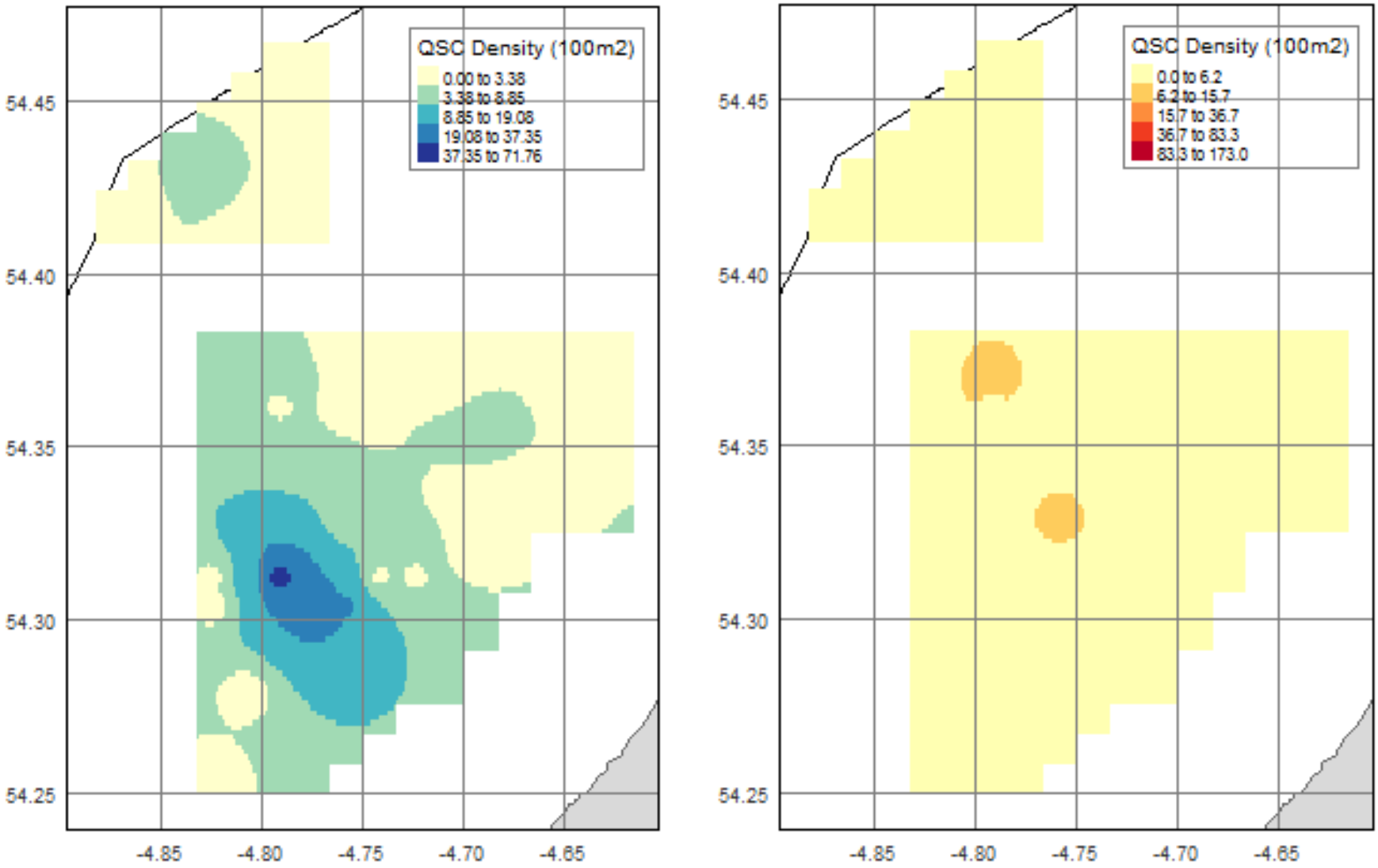

Figure 13: An IDW interpolation of queen scallop abundances showing spatial abundance trends from the June survey for queen scallops at Targets fishing ground. Under MLS from Juvenile QSC Dredges only (left) and over MLS from Standard QSC Dredges only (right).

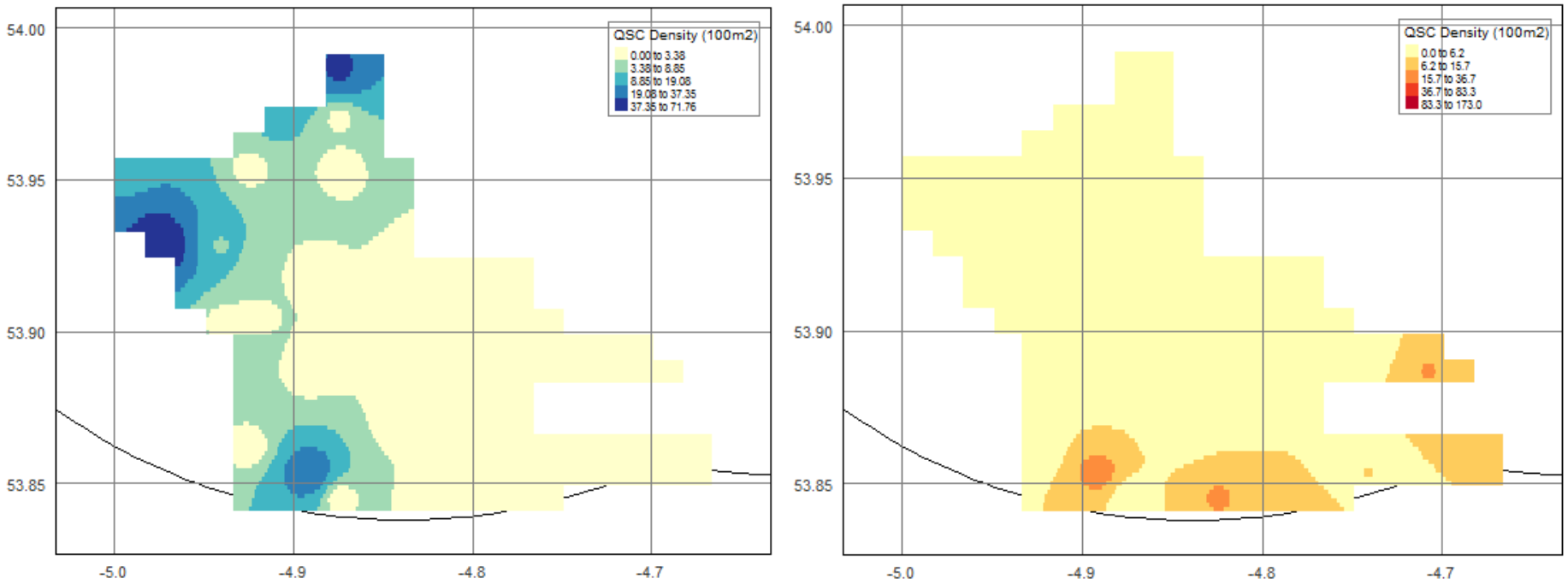

Figure 14: An IDW interpolation of queen scallop abundances showing spatial abundance trends from the June survey for queen scallops at Chickens fishing ground. Under MLS from Juvenile QSC Dredges only (left) and over MLS from Standard QSC Dredges only (right).

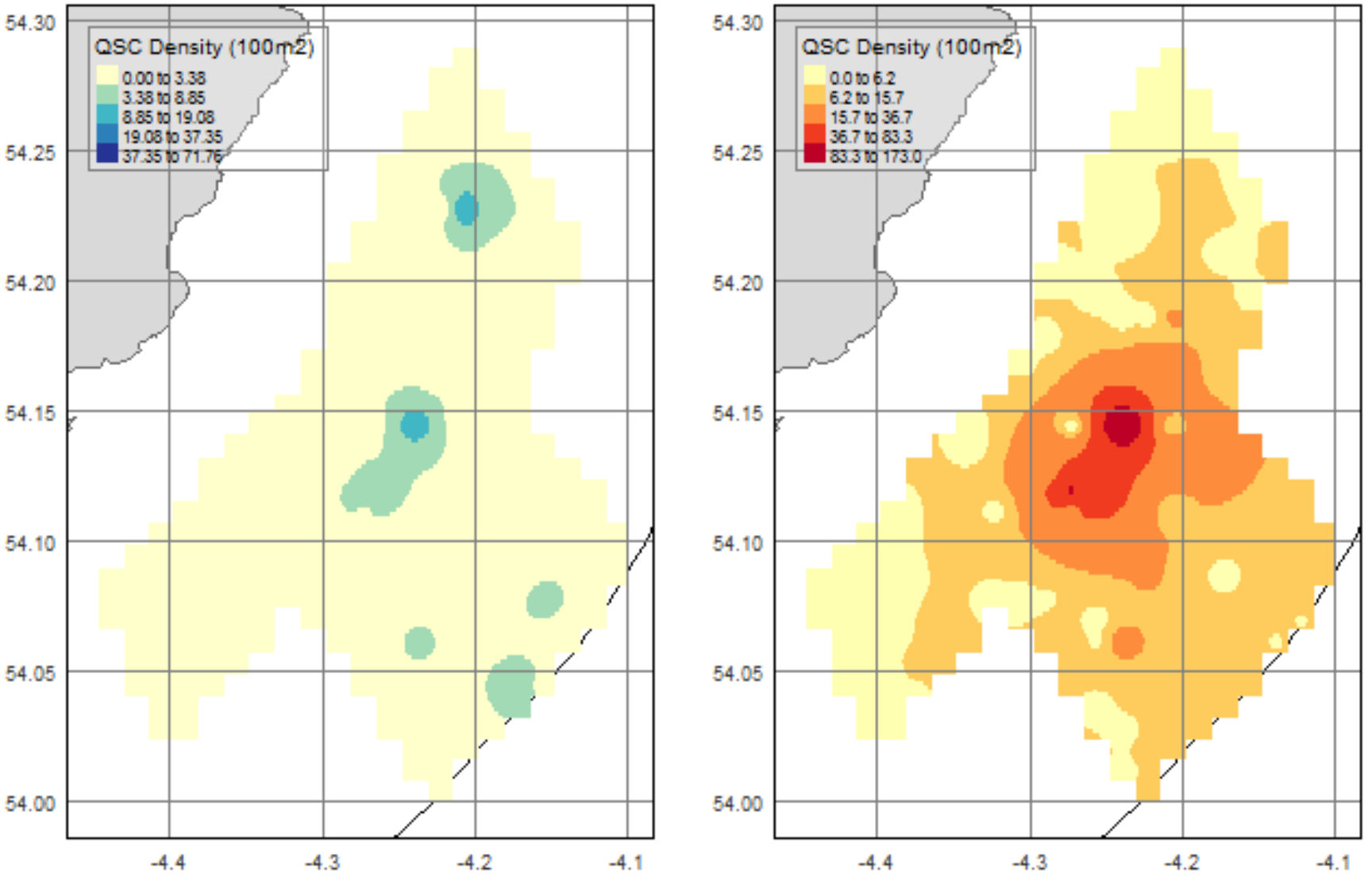

Figure 15: An IDW interpolation of queen scallop abundances showing spatial abundance trends from the June survey for queen scallops at East Douglas fishing ground. Under MLS from Juvenile QSC Dredges only (left) and over MLS from Standard QSC Dredges only (right).

Survey comparison June v April:

A comparison of the survey data from April 2019 (Prince Madog) and June 2019 (F.V. Benolas and F.V. Sarah Lena) is presented below. Average densities at each of the three surveyed grounds for the April and June surveys are displayed in Table 1.

Table 1: Average densities (queen scallops per 100 m^2) for sites surveyed in both the April 2019 and June 2019 survey for each of the main fished grounds (standard dredges only).

Ground	QSC 100 m^2 (April Survey)	QSC 100 m^2 (June Survey)
Chickens	4.17	5.37
Douglas	4.12	12.37
Targets	1.71	4.45

There were only five comparative survey stations/cells that were surveyed in both June 2019 and April 2019 (i.e. the April survey station fell within the June survey cell). At each of these survey locations the density of queen scallops per 100 m^2 (from standard queen scallop dredges only) was similar (Table 2). A regression analysis using data from these survey stations indicates a close relationship between the catches in April and in June (Figure 16 -R^2 value of 0.97 and a slope of 0.8).

Table 2: Comparison of densities from April (R.V. Prince Madog) and June (F.V. Benolas and F.V. Sarah Lena) at survey station located within the same survey cell (i.e. the Prince Madog survey station was within the industry survey cell).

April Survey Station	Comparative June Survey Cell	QSC 100 m^2 (April Survey)	QSC 100 m^2 (June Survey)	Ground
6	2067	8.52	5.05	Targets
34	5202	0.09	0.65	Chickens
CHI	5129	10.4	8.31	Chickens
32	5942	16.11	12.93	Chickens
20	4363	0.767	0.26	Douglas

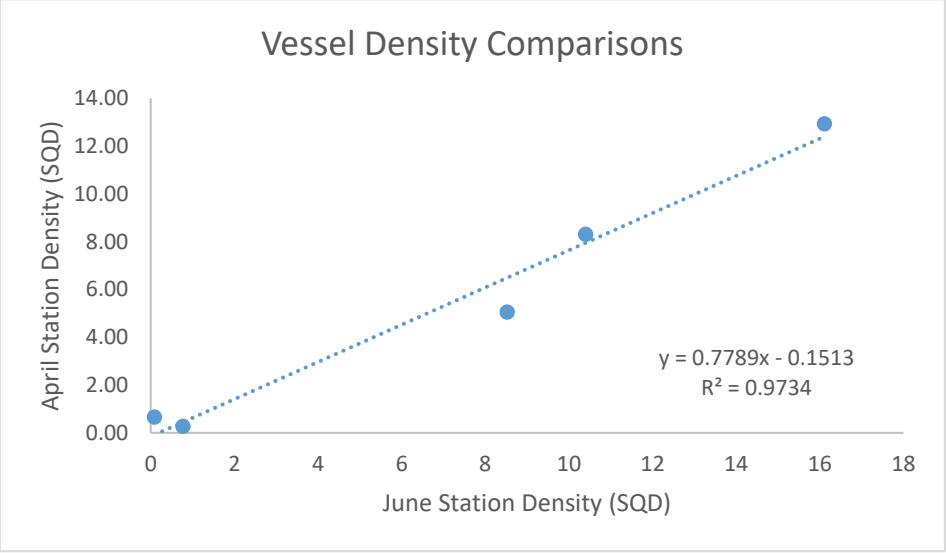

Figure 16: Regression analysis showing the relationship between the density of queen scallops per 100 m^2 caught in April (R.V. Prince Madog) and June (F.V. Benolas and F.V. Sarah Lena) at each of the five comparative stations sampled in both surveys (i.e. April survey stations that were located within June survey cells).A trend line has been fitted to the data which has an R^2 value of 0.97 indicating a good fit between the two data sets

Spatial trends in abundance between the April (lower scale resolution of survey stations) and June (higher scale resolution of survey stations) surveys are displayed in Figure 17 (Over MLS) and Figure 18 (Under MLS). Although the surveys were undertaken at different resolutions the abundance patterns are very similar for both under and over MLS and any significant difference in scales between the two surveys is driven by the three high density stations at Douglas surveyed in June.

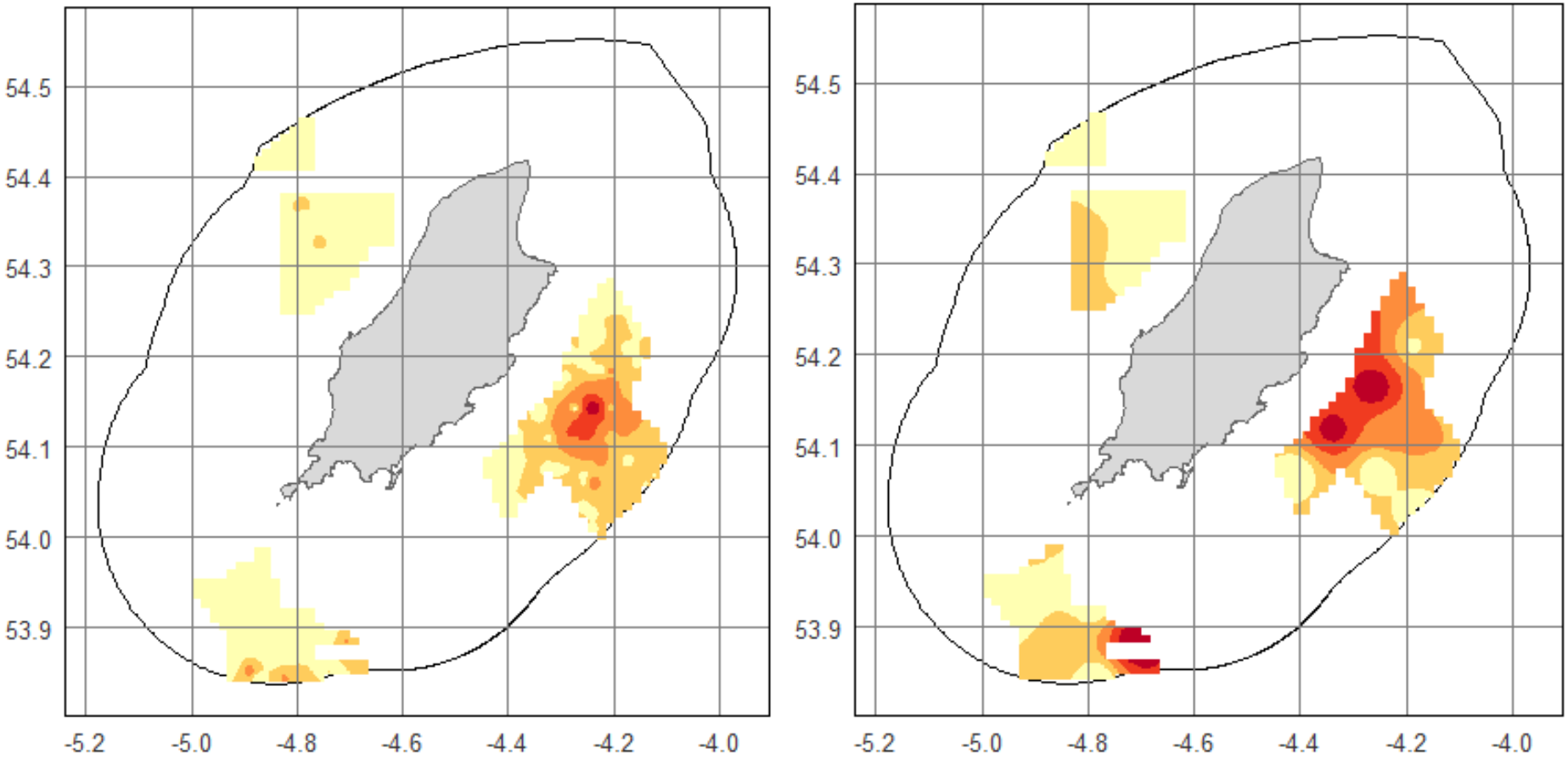

Figure 17: An IDW interpolation of queen scallop abundances showing spatial abundance trends from all three surveyed main fishing grounds from the June survey (left) for queen scallops Over MLS from Standard QSC Dredges and the April survey (right) for queen scallops Over MLS from Standard QSC Dredges. Darker areas represent higher density areas and lighter areas represent lower density areas. ***Please note: that these maps present data from different sampling regimes and use different scales but are presented here to show the overarching similarities in spatial patterns.***

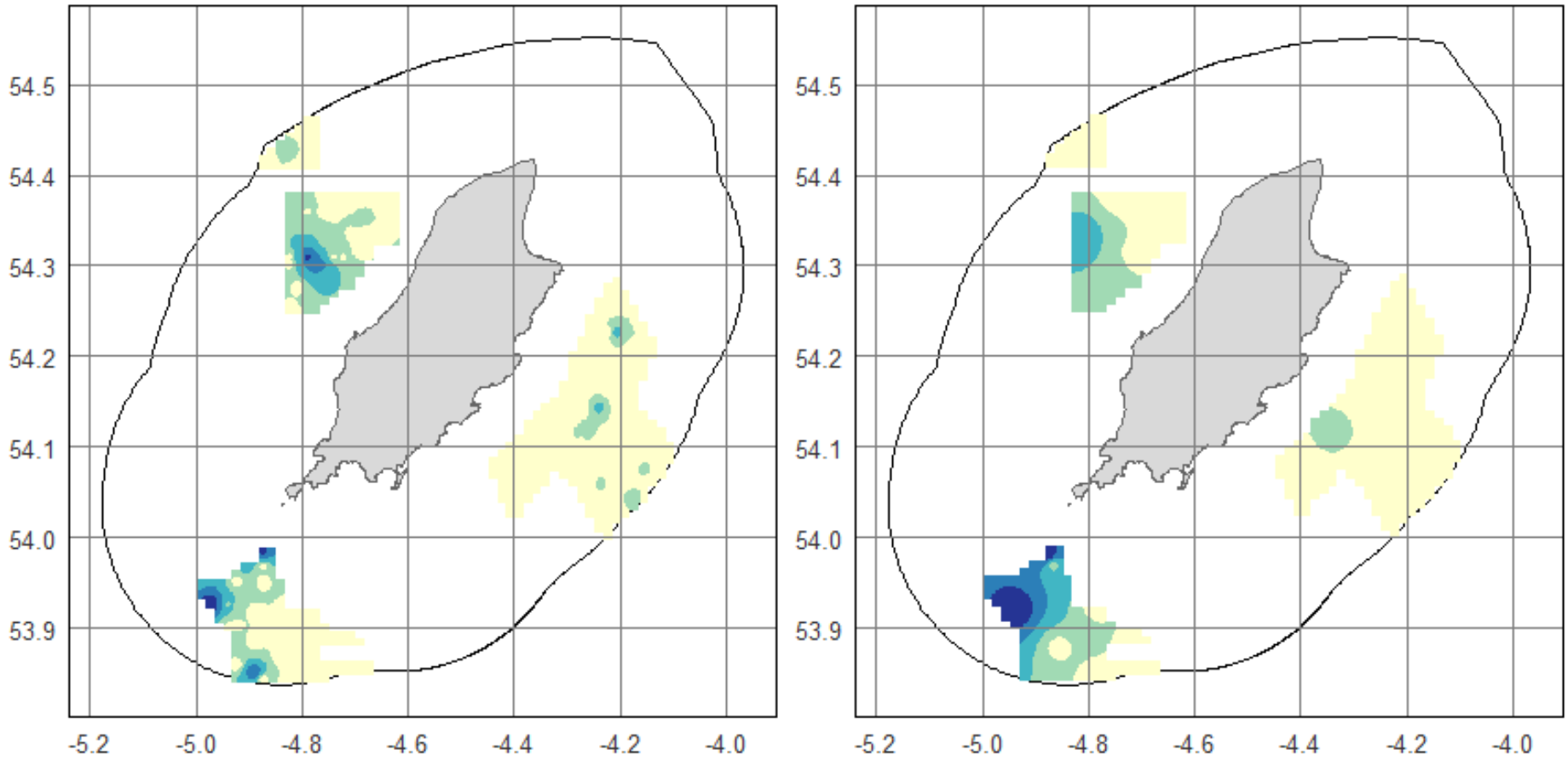

Figure 18: An IDW interpolation of queen scallop abundances showing spatial abundance trends from all three surveyed main fishing grounds from the June survey (left) for queen scallops under MLS from Juvenile QSC Dredges and the April survey (right) for queen scallops under MLS from Standard QSC Dredge Darker areas represent higher density areas and lighter areas represent lower density area. ***Please note: that these maps present data from different sampling regimes and use different scales but are presented here to show the overarching similarities in spatial patterns.***

Discussion:

The first year of the June 2019 Industry survey produced useful results on both queen scallops over and under MLS which corroborate and supplement the April 2019 survey data. A high density patch of queen scallops over MLS was identified in the Douglas ground. High densities of queen scallops under MLS were identified in the current closed area at Targets and the extent of another patch, first identified in the April survey, was mapped by the survey vessels at Chickens. This area of dense juveniles was then closed for the current 2019 season to protect the queen scallops for next year's fishery. Additional areas of high density juveniles were observed in both surveys on the edges of the survey area at Chickens which indicates the importance of expanding the survey extent in future years to better encompass these areas of juvenile settlement.

The survey cells which were sampled by both the April and June surveys were comparable in density estimates which indicates that both the research and fishing vessels fish in a similar and defined way. The relative densities among sites indicates that both Chickens and Targets had substantially lower densities of queen scallops over MLS compared to the hotspot located at Douglas. However it should be noted that lower densities were identified across the wider area of the Douglas fishing ground. Conversely lower densities of under MLS queen scallops were identified at Douglas compared to Targets and Chickens indicating that recruitment of queen scallops into the fishery in this area may be relatively low next year compared to the other two fishing grounds. Once a time series of data has been established from this survey then both temporal and spatial variations in recruitment can be examined. In the meantime the data from the June survey can identify areas where juveniles or adults are present in very high proportions (i.e. survey cells at Chickens: 5057, 5057, 5129, 5130, 5200, 5341, 5561 amd 5563 all had greater than 75% of queen scallops under MLS whilst survey cells 6300, 6302 and 5842 all had greater than 97% of queen scallops over MLS) which may help direct areas where fishing effort should be minimised or directed towards conversely.

The current survey data identifies higher density areas of queen scallop juveniles (under MLS) at Targets and Chickens which may support good fishable densities next year. If the hotspot at Douglas can be managed in a sustainable way this ground too could support good densities next year meaning potentially all three fishing grounds *may* support healthy stocks. In considering the management of the Douglas ground this year it is important, based on experience at Targets, to limit fishing (i.e. based on LPUE limits) to maintain sufficient mature stock to support successful spawning of future year classes and to minimise excessive damage to the habitat thus facilitating effective recruitment.

The June survey has revealed an important finding which indicates the potential benefits of closed areas to queen scallop recruitment. The hot spot of queen scallops identified by the June 2019 survey is in an area which has had overlapping closures in both the 2014/2015 and 2015/2016 fishing seasons. There is similar observational evidence in both the other two main fished grounds surveyed (Targets and Chickens) with high density patches of queen scallops (juveniles or adults) occurring where closed areas have been in place for multiple years and fishing activity has been minimal. More work is needed to look at this is further detail.

The data from both the long-term April survey and the new finer-scale June surveys combined with commercial catch data provide a level of data that may now support spatial management of this fishery for the first time (i.e. management at the level of fishing ground rather than overall Territorial Sea level).

Future work:

Refinement of survey extent and methods: Prior to the 2020 survey the survey area within each of the main fishing grounds will be refined with knowledge from the survey skippers to remove unsuitable habitats etc. from within the current survey extent. The fourth main fished ground at Point of Ayre should also be included in any future surveys (Ramsey is already surveyed independently by the MFPO). Additionally, the survey methods and analysis will be reviewed for optimisation going forward.

Experimental fishing: In addition to the core survey area within each of the main fishing grounds a proportion of additional survey time should be allocated to each ground to a) allow refinement of the extent of hotspots of adults and juveniles; b) explore additional survey cells in traditionally unfished areas.

Funding: A reliable funding source needs to be secured for this survey work to be undertaken on an annual basis going forward. To support spatial management it will be essential to obtain the data at the same time each year using the same or similar vessels and gear.

Survey timing: In order for the Scallop Management Board to receive the analysis from this survey in time to inform management for the upcoming queen scallop fishing season the survey work will need to be undertaken in April. If funding is available, areas of high density juveniles that were detected on the edges of the current survey area at Chickens could also be re-surveyed prior to the king scallop season to assess the full spatial extent of these juvenile settlements in order to assess whether additional small scale closures should be implemented to protect these small queen scallops during the next king scallop season.

Spatial management: A literature review and meta-analysis will be undertaken to review spatial management examples from both scallop fisheries and other sessile aggregating species to look at potential options, data analysis and management methods for spatial management in the 2020 fishery based on all available data. This will include ascertaining options for managing high densities of either juvenile (“protected areas”) or adults (“Fishery Hotspot areas”). This review will be produced by Bangor University staff by January 2020.

King scallops: The survey also collected data on king scallops which will be analysed in due course but it is of note to mention that substantial numbers of king scallops under MLS were also found at several survey cells at Douglas (i.e. 4437 and 3344). A separate report will be produced on king scallop survey densities in due course.