Annual Fisheries Science Report
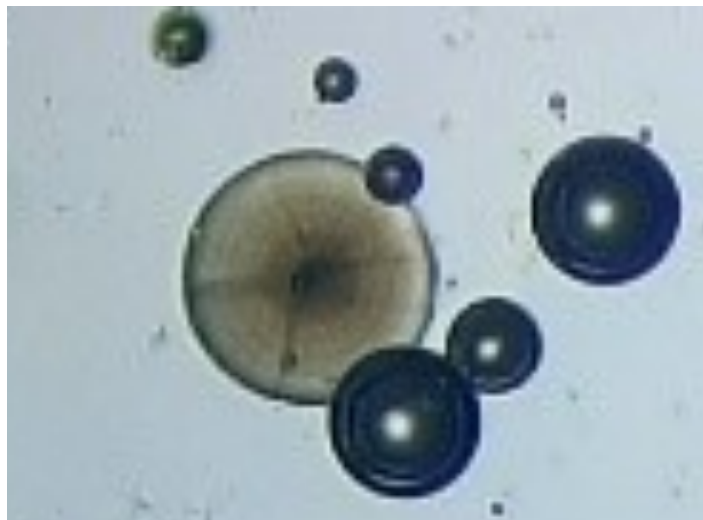
2023

Sustainable Fisheries and Aquaculture Group

School of Ocean Sciences

Annual Report for 2023
(Report No. 9)

Isle of Man Fisheries Science

Sustainable Fisheries and Aquaculture Group
Bangor University

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Review of 2023 by Professor Stuart Jenkins

Stuart Jenkins is a Professor of Marine Ecology at the School of Ocean Sciences, Bangor University and is the academic and scientific lead for the Isle of Man.

Bangor University has now been providing scientific advice and research on commercial fisheries to the Isle of Man Government for 16 years. Over this period we have seen significant changes in the principle Manx fisheries of king scallop, queen scallop, whelk, crab and lobster.   This 2023 report, as well as describing a number of avenues through which we are developing novel methods of collection and analysis of fisheries data in the Isle of Man, also reports on the long term trends of all these fisheries. For both king and queen scallops I believe we can be cautiously optimistic that careful management, achieved through a close working relationship between industry, government and scientists, is having positive outcomes. Our stock assessment model for queen scallops indicates a modest year-on-year increase in queen scallop biomass for the Territorial Sea over the past five years. King scallop stocks equally show positive signs. There has been a general increasing trend in both recruits and post-recruits over the past four to five years. These generally positive signs of stock status, though not reaching levels of some boom years in the past, are reflected in the current catches recorded per unit effort. The median Landings per Unit Effort (LPUE) for queen scallops in 2023 was the 3rd highest in the last 10 years. For king scallops the LPUE for most grounds were within the top range for these grounds over the last five fishing seasons. These indicators are critically important to ensure Manx scallopers continue to work in a productive and sustainable fishery.

For static gear fisheries (crab, lobster and whelk), trends from fisheries-dependent data (i.e. landings and LPUE) in Manx waters show patterns consistent with many other parts of the British Isles, with landings being maintained but generally through greater fishing effort. Data acquisition in the static gear sector has lagged behind the scallop fisheries and stock status for these data poor fisheries is not currently well determined. A lack of high resolution spatial data and fisheries independent/ dependent surveys has limited the progress with quantitative stock assessment for these species. The smaller vessel size within static gear pot fisheries has previously limited access for these vessels to traditional VMS (Vessel Monitoring System) units. However, the introduction of inshore vessel monitoring systems (iVMS) in April 2023, which is specifically designed for inshore fleets of smaller vessels, has provided a step change in the spatial data collection for these metiers.

In this report Dr Matt Coleman details how iVMS data is now being used to significantly increase our understanding of the spatial distribution of effort and landings in Manx static gear fisheries for whelk, crab and lobster. As the time series of high resolution spatial data acquisition for this sector extends over the next few years, this data set will become increasingly important for the assessment and management of these fisheries. Research on fisheries-independent stock monitoring methods for static gear fisheries, undertaken by Bangor scientists based on both the Isle of Man and in Wales, are also presented in this report. This includes novel means of estimating stock density for species targeted by pots. It is anticipated that these changes in both data collection and development of methods for determining stock status will present greater opportunities for scientists, management and the static gear fishing industry to work together to ensure effort is targeted optimally.

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Annual scallop surveys (2023)

Within Isle of Man territorial waters King and Queen scallops stocks are assessed via two annual surveys:

- A long-term, coarse-scale fixed station survey (1992 onwards) undertaken by Bangor University's research vessel.

- A short-term, fine-scale stratified-random survey (2019 onwards) undertaken by two commercial fishing vessels.

The long-term data enables quantitative stock assessment models to be used, whilst the fine-scale nature of the shorter-term survey data means inter and intra seasonal spatial patterns can be visualised and managed at the resolution of individual fishing grounds, which is of importance when managing high density areas of recruitment ('hotspots') which can vary annually.

The R.V. Prince Madog surveyed 55 stations (fixed locations) between 31st March and 8th April 2023 (Figure 1). The standard survey gear comprises of a set of four Newhaven dredges: two with 80 mm ring diameter and 9 teeth of 110 mm [king dredges] and two with 55 mm ring diameter and 10 teeth of 60 mm [queen dredges]. At each station the dredges are towed at 2.6 knots for 20 minutes with the direction of the tow dependent on tidal state and current condition. For each tow the total biomass of king and queen scallops is recorded by dredge and a subsample of 90 queen scallops and 90 king scallops from each dredge are then weighed and measured (king scallops are also aged).
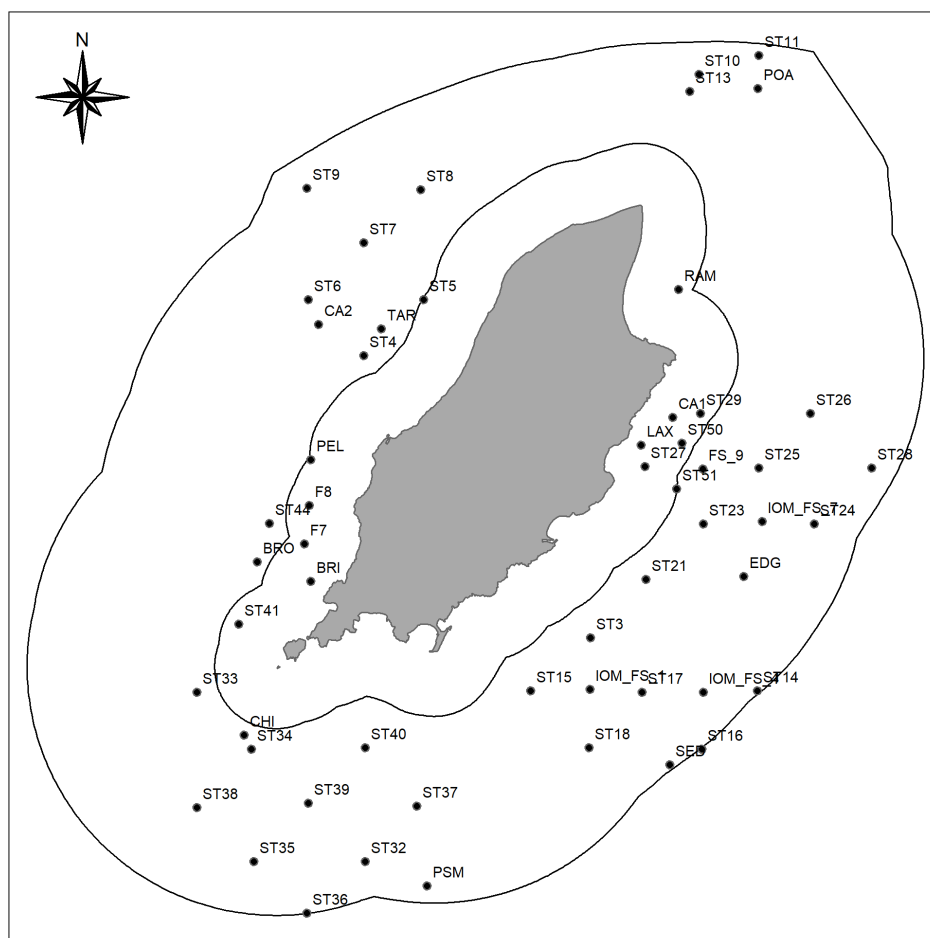
Figure 1: A map showing the location of fixed stations surveyed by the R.V. Prince Madog in 2023.

The F.V. Benolas and F.V. Sarah Lena surveyed 234 stratified random survey cells between 22nd May and 3rd June 2023 [≈ 19 survey days] with sampling coordinated by the MFPO with scientific support from Bangor University. 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 (Figure 2). Within each survey cell a 10-minute tow was undertaken at ~ 2.5 knots. Each vessel towed two dredge bars, a 'standard survey dredge bar' (two King and two Queen dredges interspersed along the bar) and a 'juvenile survey dredge bar'. This is of the same design but uses Queen dredges with 17 teeth with a mesh (60 mm) attached internally that when stretched into a fixed position results in a maximum mesh size of 38 mm. These 'juvenile' dredges are designed to enable smaller queen scallops to be sampled. The catch from each dredge was counted and a subsample of up to ~ 90 kings and 90 queens were measured.

Further details of the standardised methodology used by each survey are provided within the annual survey reports, which are available on request.

Figure 2: A map showing the survey grid for the fine-scale random stratified scallop survey undertaken by industry vessels. Green cells show the locations of randomly selected cells for surveying in 2023.

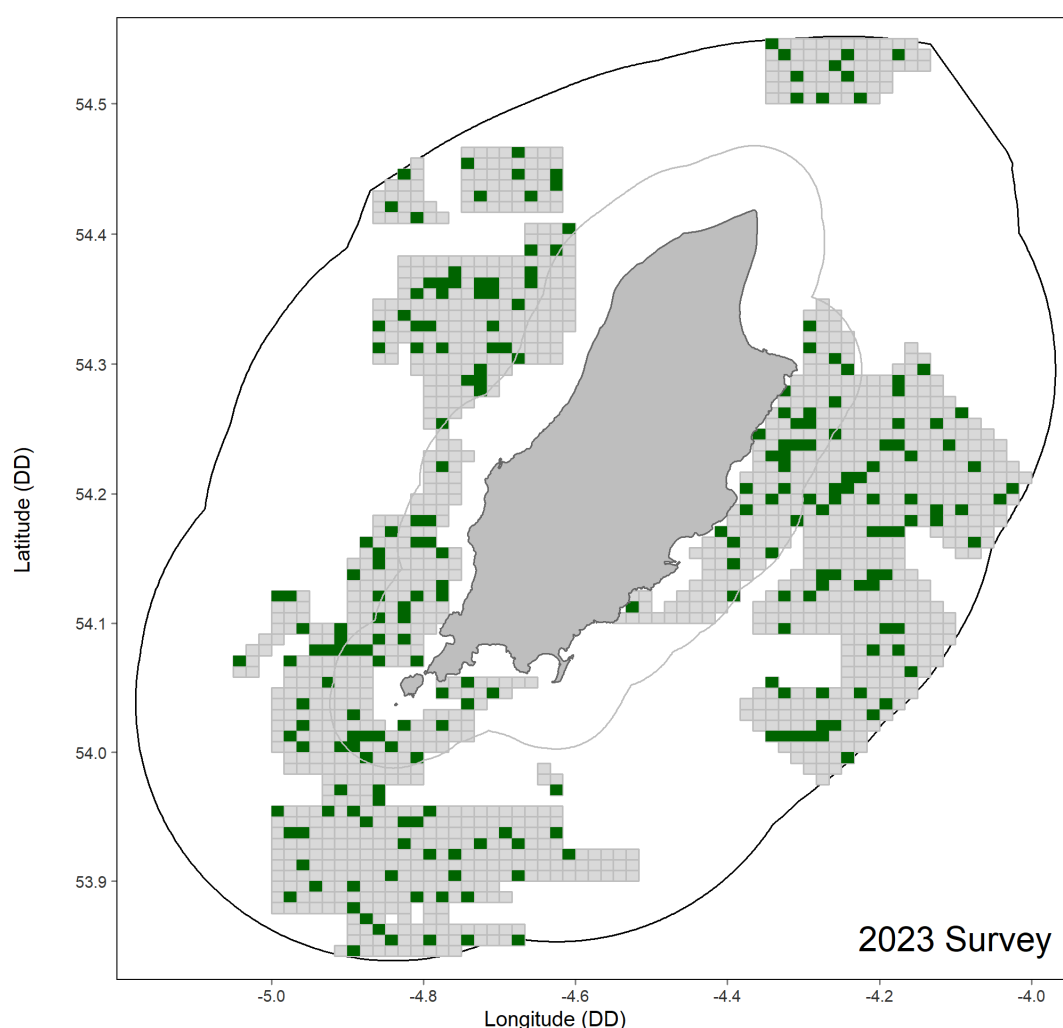# Long-term, Coarse-Scale Survey 2023: Queen scallops

The long-term nature of this dataset enables quantitative stock assessment to be undertaken whilst the coarse-scale of the survey is suited to the assessment of trends at the scale of the whole territorial sea. The key results and analysis from this survey are presented below.

The mean density (scallops per 100 m^2) of queen scallops from queen scallop dredges for all stations where queen scallops were present (i.e. over 0.45 scallops per 100m^2) is displayed in Figure 3. 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.
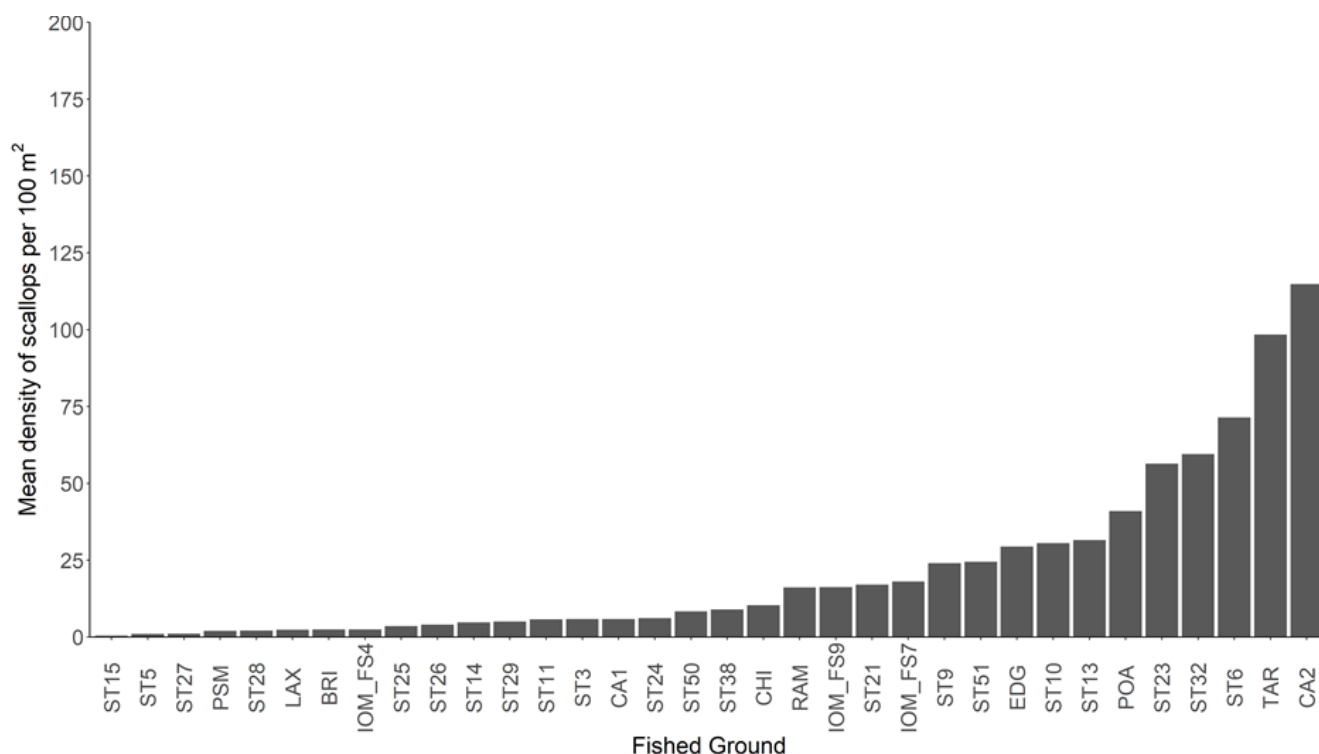
Figure 3: Average survey density (scallops per 100m^2) of queen Scallops from queen scallop dredges from all sites surveyed during the 2023 Prince Madog survey. For plotting purposes sites where QSC density was > 0.45 scallops per 100 m^2 are not displayed.

Stations that have been sampled over at least two years and at which queen scallops are present (3, 4, 5, 9, 10, 14, 17, 20, 21, 22, 23, 24, 25, 32, 35, 36, 38, 39 and 45), in addition to the standard historical queen scallop survey stations (CHI, EDG, LAX, POA, PSM, RAM, SED and TAR), were included in the 2023 stock assessment for Isle of Man territorial waters (Figure 4 and 5).

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 (Figure 4) and is above the long-term mean of 81. There are several sites with relatively high recruit densities around the island (i.e. TAR, ST32, S96, CA2 and ST9)

The abundance index for post-recruits (scallops ≥ 55 mm) had an increasing trend from 2007 to 2010, reaching the highest levels on record in 2010. From 2012 to 2019 there has been a declining trend in post-recruit abundance (slight increase observed in 2016). The data for 2023 (285), although still below the long-term mean (~386), is the highest recorded for post-recruits since 2017 (Figure 5).

Figure 4 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.
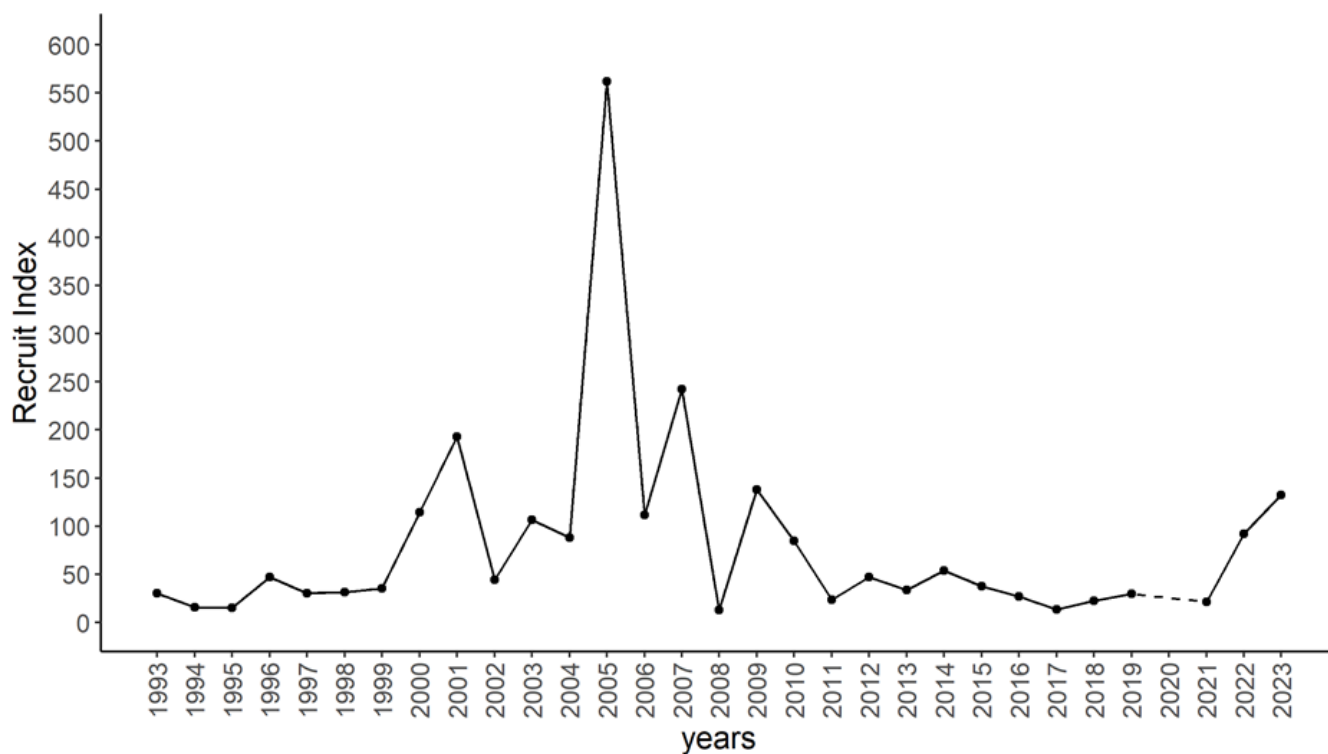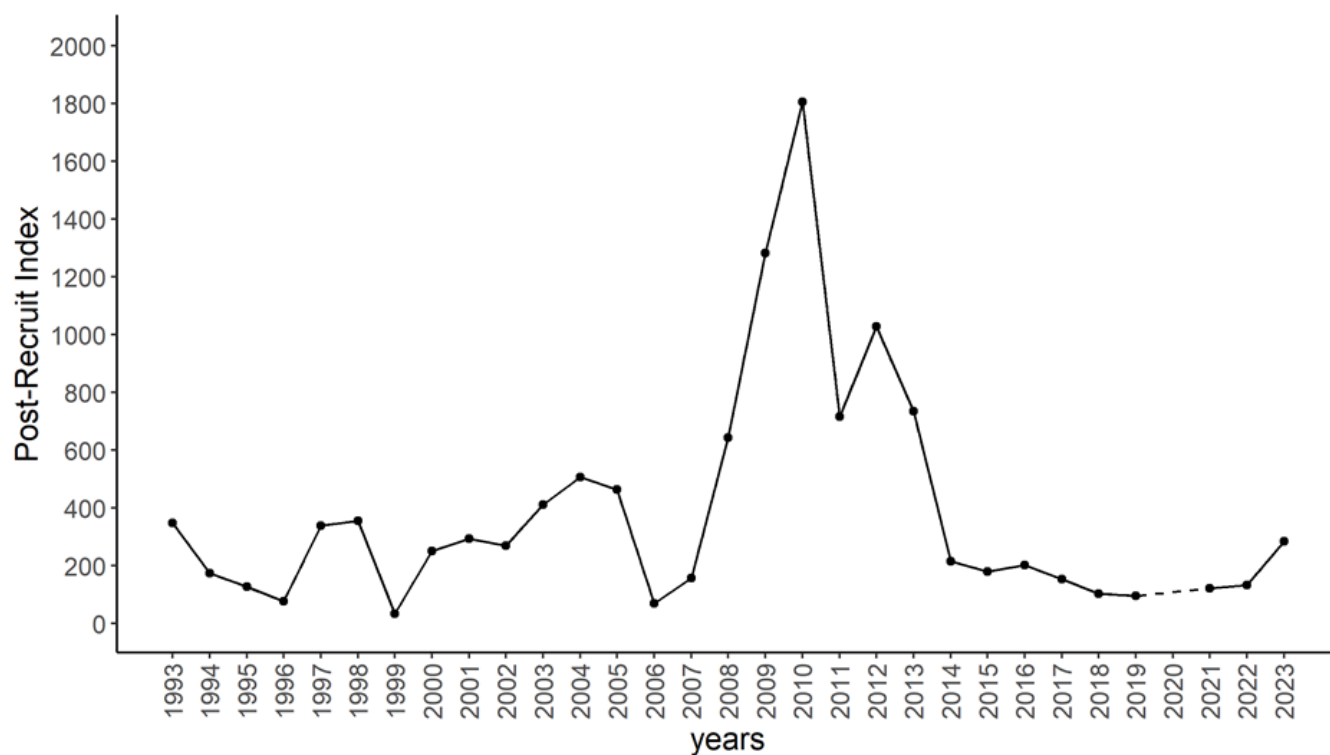

Figure 5 Abundance index (based on geometric mean) for post-recruits (over 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account for zero data values. Dashed line represents missing values.

Long-term, coarse-scale Survey 2023: QSC Cont.

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). Within the stock assessment unit (Isle of Man's territorial waters), the trend from the model output (Figure 6) 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 6417 t) *Note, that there is a missing year of survey data for 2020 in the input data.*

The management currently in place for queen scallops within the Isle of Man's territorial waters has included closing areas of high density juvenile scallops for on-growing which has created spatially discrete high density areas within several fishing grounds. The methods used for the stock assessment down-weights high density isolated patches of queen scallops when calculating the overall stock biomass. As such, assessing the stock at the territorial sea level may be less applicable for the current fine scale spatial management that is in place for queen scallops. Whilst the densities among general fishing grounds remains low and the model indicates only a slight increase in biomass, there are spatially discrete areas within grounds with exceptionally high densities of post-recruits. In this scenario data assessment and management at a fishing ground level may provide a better basis for on-going spatial management than assessment of the overall stock biomass.
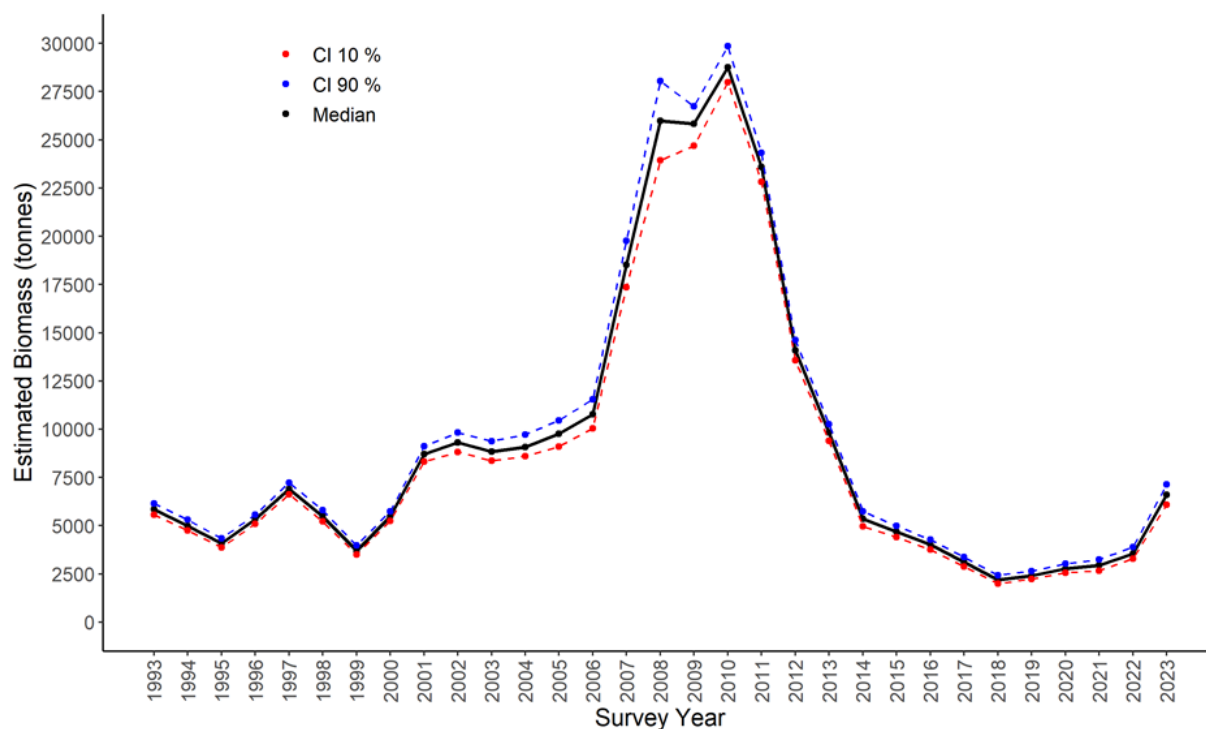
Figure 6. Estimated biomass for the stock assessment unit (Isle of Man territorial waters) MCMC results

The full report is also available on request from **i.bloor@bangor.ac.uk**

Bloor, I.S.M., Coleman, M.J. and Jenkins, S.R. (2023). Isle of Man Queen Scallop: 2023 Stock Survey Report . Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report. pp. 40.

Short-term, fine-scale survey 2023: Queen scallops

The short-term nature of this dataset limits its use in quantitative stock assessment models at present. However, the fine-scale nature of the survey is suited to the assessment of trends at the scale of individual fishing grounds which is important given the sedentary and aggregating nature of queen scallops, which also have variable spatial and temporal recruitment patterns (i.e. high densities occurring in spatially discrete areas which vary in location and size temporally). The key results and analysis from this survey are presented below.

For recruits, the overall data for the TS (Figure 7) indicates that the majority of high densities are focused on the west coast in the Targets fishing ground.
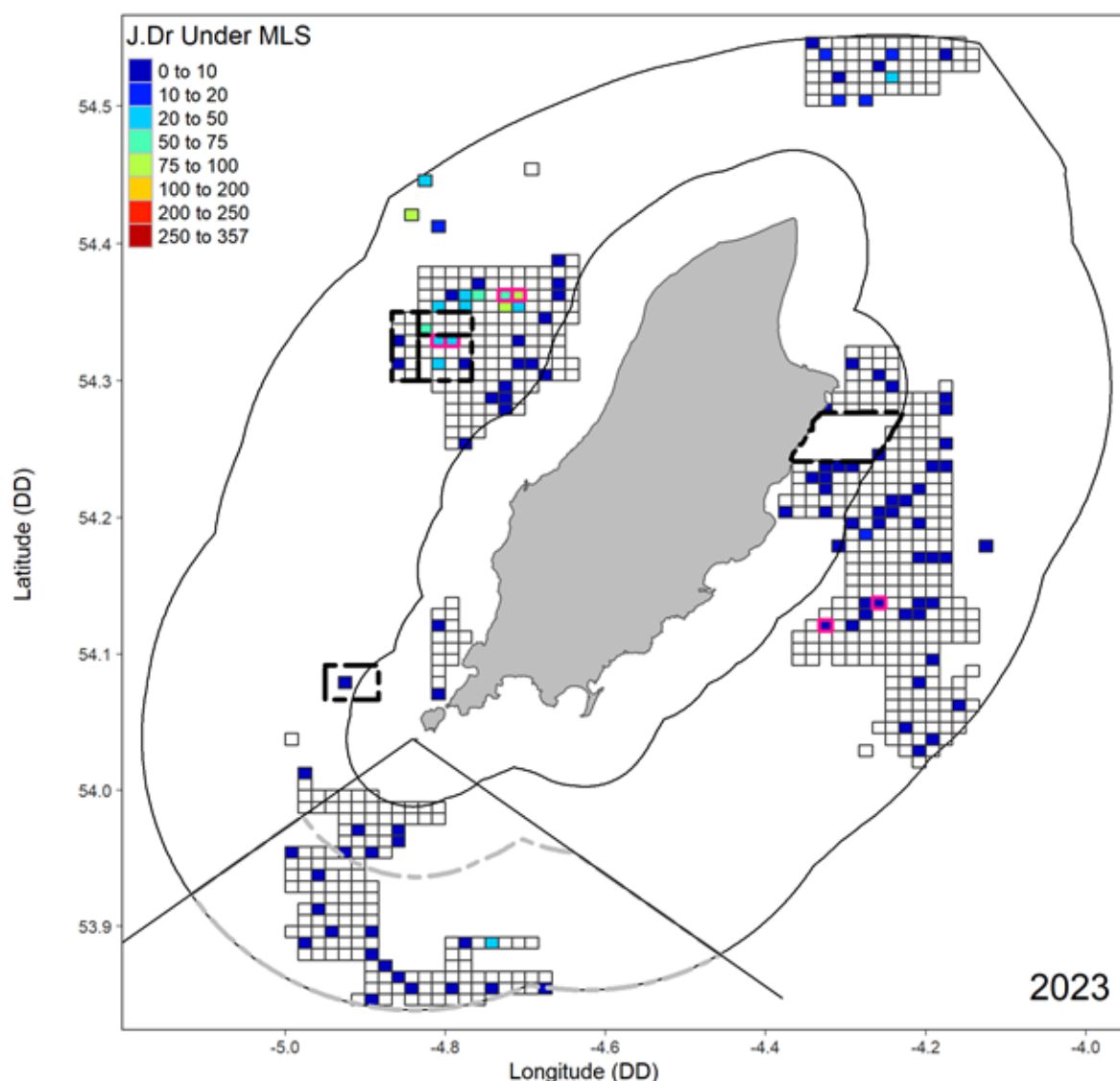
Figure 7. Map illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2023. The pink cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis. The black dashed boxes indicate closed or managed areas for the 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.

Short-term, fine-scale survey 2023: Queen scallops Cont...

For post-recruit scallops, the overall data for the TS (Figure 8) also indicates that the majority of higher densities are focused on the west coast in the Targets fishing ground.
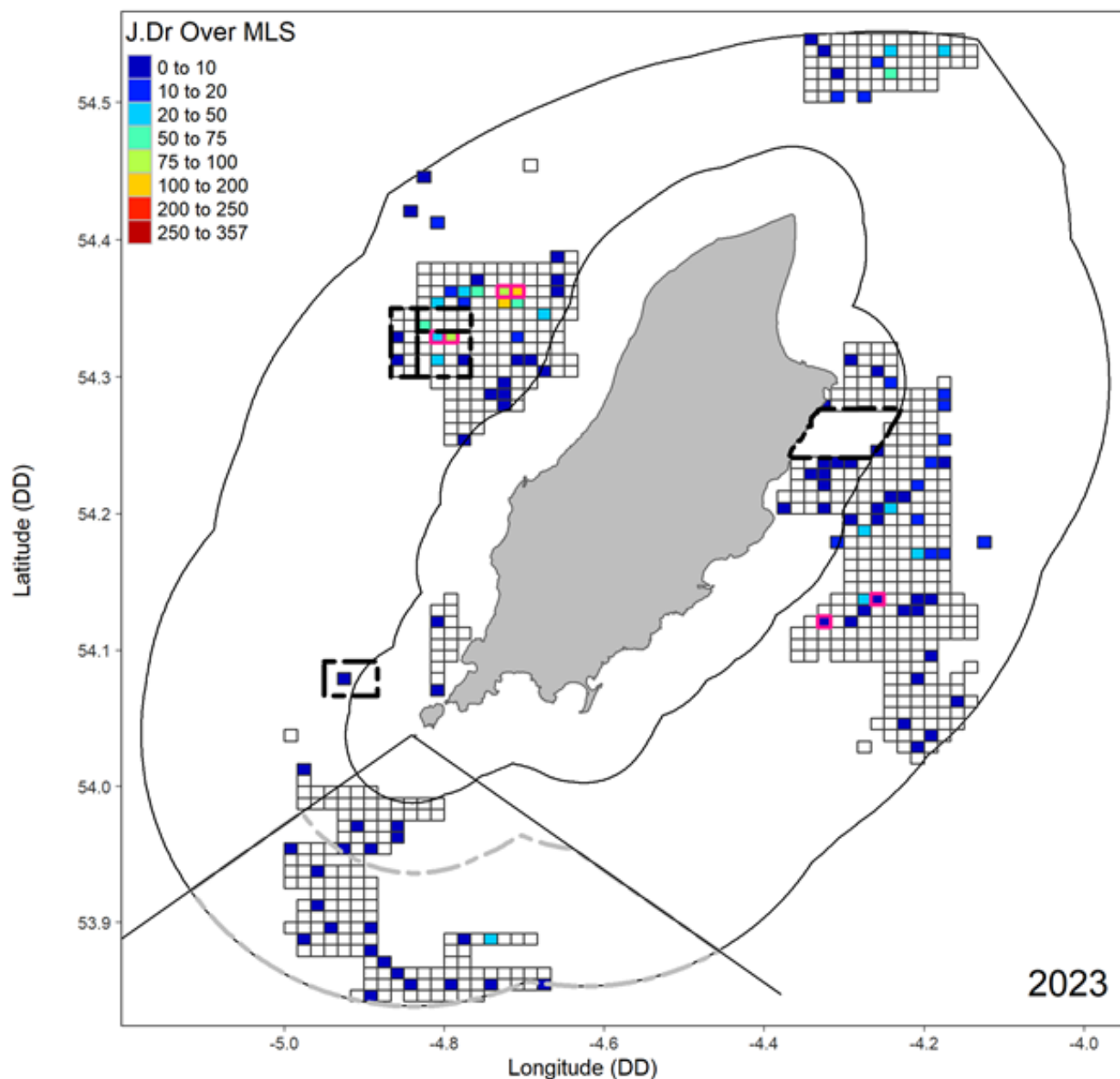
Figure 8 Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges 2023. The pink cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis. The black dashed boxes indicate closed or managed areas for the 2022 queen scallop fishery and the 2022/2023 king scallop fishery. The grey dashed line and solid black lines indicate the queen scallop dredge zone.

Queen Scallop Survey Summary 2023

Summary of survey 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.

TAR: 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.

CHI: 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.

POA: 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

EDG: 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).

BRA: The fine-scale survey also indicates relatively low densities at Bradda (BRA) on the SW of the island which is typically a transient bed for queen scallops (i.e. it does not consistently recruit).

Queen Scallop Stock Advice Summary 2023

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 were as follows:

- TAC of a between 818 – 1067 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).

Queen Scallop Trawl Fishery Update (2023)

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]) and the ability to modify management at a fine spatial resolution within the fishing season.

The 2023 trawl fishery had an initial starting TAC of 1142 t (20% increase on the 2022 initial starting TAC) with a review at 818 t (20 % of estimated median stock biomass). The fishery opened on Monday 3rd July 2023 and closed on Tuesday 31st October 2023. In contrast to the previous season fishing was prohibited on both Saturday and Sunday during the 2023 fishery (i.e. fishing is allowed 06:00 to 18:00 Monday to Friday). For the trawl fishery, a weekly catch limit (WCL) of 5460 kg per vessel was implemented for the general territorial sea with an additional "exploratory" opportunity at Point of Ayre of 2100 kg per vessel per week. Total reported landings for the trawl fishery during the 2022 fishing season were ~ 605 t with only 14 unique vessels (out of 35 licenced QSC trawl vessels) reporting landings from 252 fishing trips. The majority of landings came from Targets (409 t; Table 1) with East of Douglas supporting the second highest landings (126 t) and Point of Ayre supporting the third highest landings (69.55 t) following the implementation of an additional "exploratory" fishing WCL. For 2023 there were no additional trawl landings from Chickens, Maughold in the main fishery or from Ramsey Bay which is a permit only fishery which operates under a separate TAC (i.e. 0 t landed) .

The SMB recommended that the Weekly Catch limit for both the main TS and for the additional "exploratory" opportunity at POA be increased by 30 % in Week 8 (equating to 7098 kg and 2730 kg respectively).

Table 1: Landings by ground for the 2023 queen scallop fishery (trawl and dredge)

Area	Landings (t)
IS9: Targets	409.16
IS15: East Douglas	126.03
IS6: Point of Ayre	69.55

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 9. Targets (IS 9) had the highest LPUE across the season (median weekly LPUE values of ~ 9 – 15 for TAR). The mean weekly LPUE for the remaining two fished grounds (POA and EDG) was typically below 9 bags (35 kg) per hour fished per 10 fathom of net (Figure 9).

Seasonal landings per unit effort, standardised to 35 kg bags per hour fished per 10 fathoms of net, is displayed for each fishing season from 2014 to 2023 in Figure 10. The boxplot indicates that the median LPUE for the 2023 fishery was the third highest in the ten year time series with 2015 and 2021 the first and second highest respectively (Figure 10).

Queen Scallop Trawl Fishery Update (2023) (Cont…)
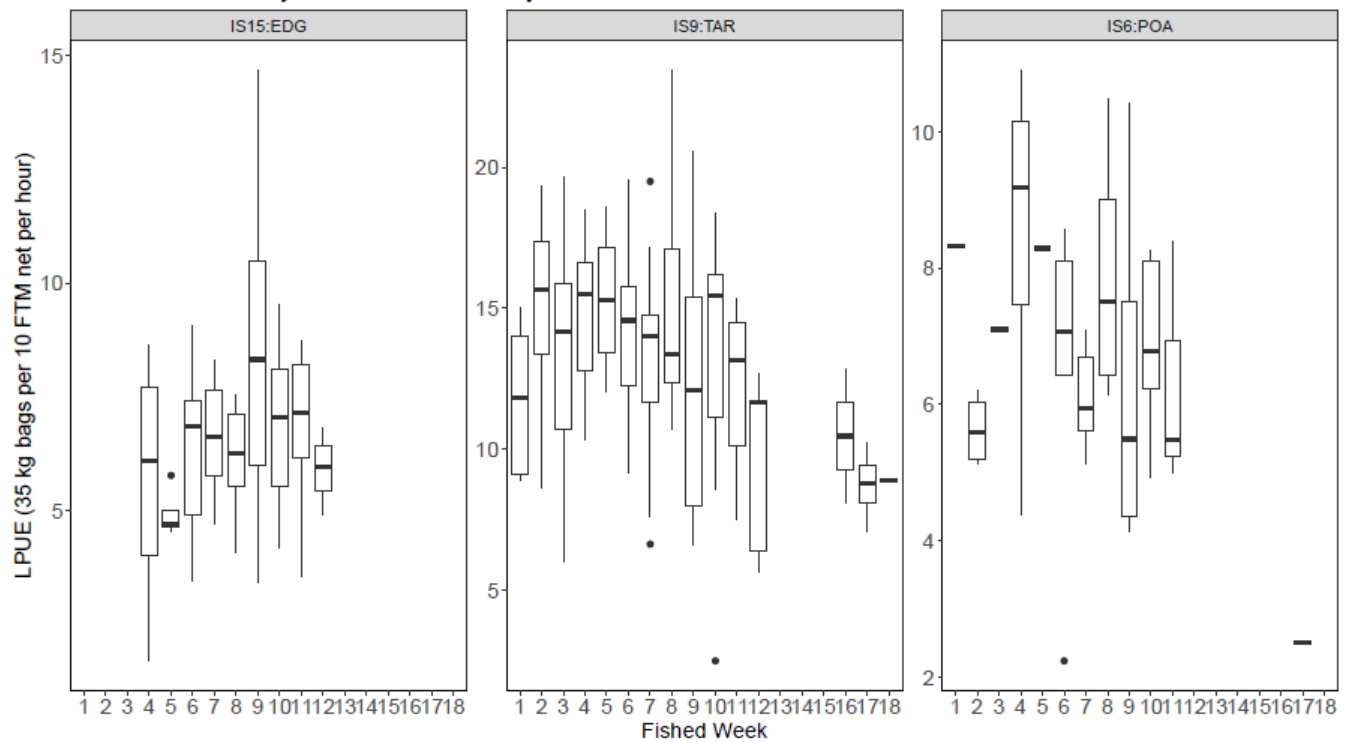

Figure 9 A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for the 2023 queen scallop trawl fishing season displayed by week and main fished ground. Note: Different scales on Y-axes.
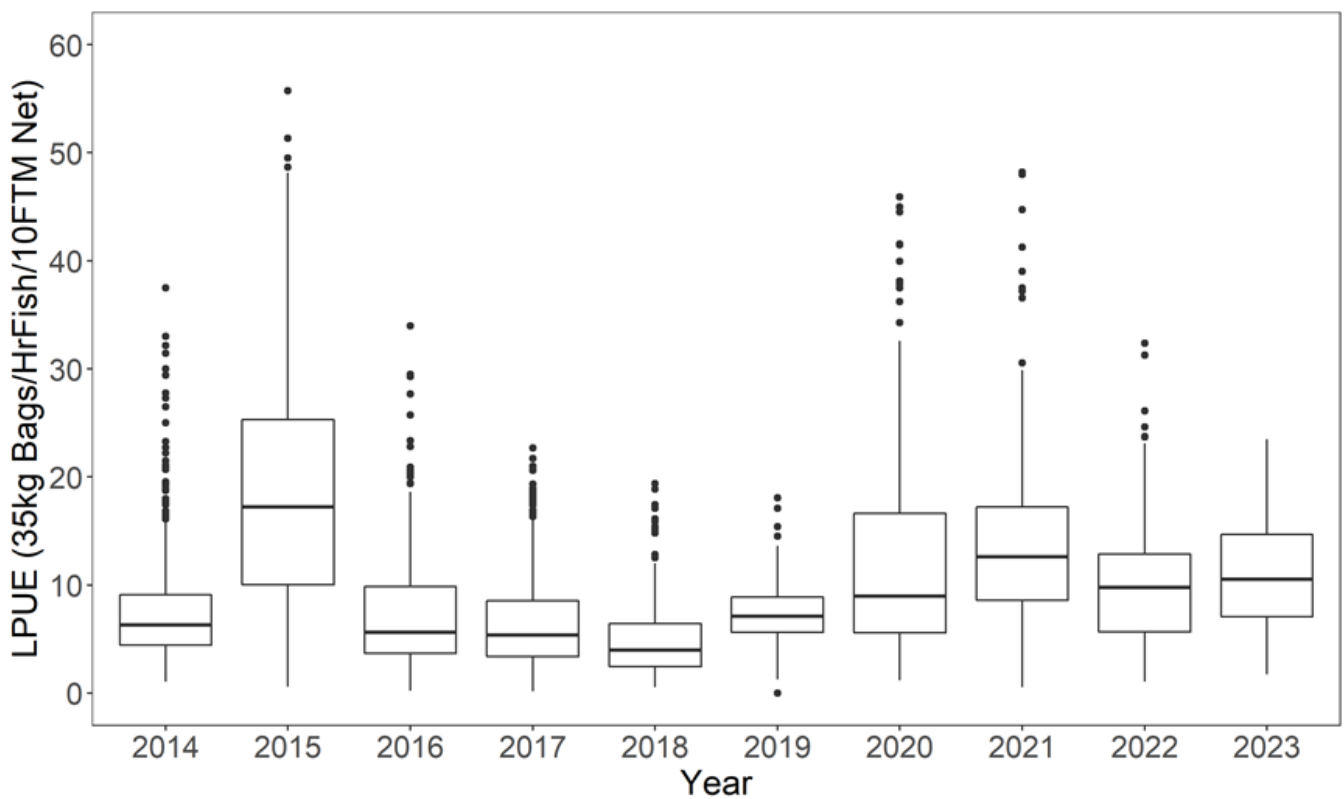

Figure 10 A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for all vessel trips by fishing season from 2014 to 2023.

Queen Scallop Dredge Fishery Update (2023)

A precautionary approach to the dredge fishery was advised as the annual scallop surveys found little evidence of stock improvement within the dedicated dredge zone at the south of the Island. It is also noted that LPUE declined in each of the past five active years of the dredge fishery (2015 to 2020; Figure 11).

The SMB allocated a TAC to the dredge fishery of ~58 t but as neither of the two licenced dredge vessels expressed an interest in fishing, this metier did not operate in 2023. Total reported landings for the dredge fishery during the 2021, 2022 and 2023 seasons have therefore all been 0 t. Letters of comfort were issued by DEFA to both trawl and dredge vessels that may otherwise target the queen scallop fishery in 2023 to enable them to maintain a track record.
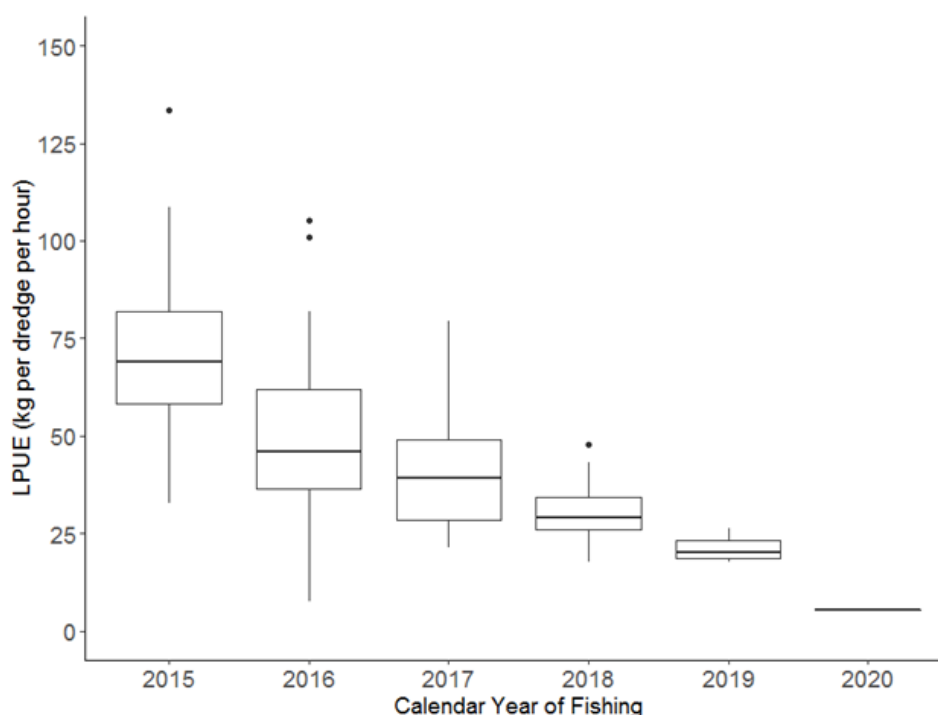
Figure 11 LPUE standardised to kg per dredge per hour for dredge vessels participating in the Isle of Man queen scallop dredge fishery which occurs within the dredge box located within the CHI fishing ground from 2015 to 2020 (note no landings reported in 2021, 2022 or 2023).

Queen Scallop Research Priorities for 2024:

- The priority for queen scallops for 2024 will be to establish and consult on a long term fisheries management (LTFMP) for queen scallops within Isle of Man territorial waters. This LTFMP will be established in collaboration with industry and government and will provide the key foundations and aims for economic and biological sustainability of this fishery for the long term.

- Develop ageing methods for using the resilia and hinge of queen scallops to ascertain age

- Validation of 1st ring using stable Isotope Analysis

- Draft manuscript on ageing and growth analysis of queen scallops within ICES areas and the development of a standardised ageing protocol for queen scallops.

Review: King Scallop Fishery (2022/2023)

Electronic monitoring via the Nestforms App continues to be used in the king scallop fishery providing high resolution data. This allows monitoring and analysis of commercial data for this fishery to be produced in near real-time. These analyses, which are provided on a weekly basis, enable the SMB and DEFA to respond rapidly to conditions in the fishery as they occur.

The fishery opened on Tuesday 1st November 2022 and closed on Wednesday 31st May 2023. The total allowable catch (TAC) for the 2022/2023 Isle of Man king scallop fishery was 2049t. This was equal to the TAC set for the 2021/2022 fishing season. Total reported landings for the Isle of Man king scallop fishery during the 2022/2023 season were 1816t with 47 unique vessels [7 fewer than in the 2021/2022 season] reporting landings from 2770 fishing trips.

Landings are reported below by IS Box which represents the Main Fished Ground (Figure 12). The main fishing grounds are Targets in IS9, Chickens in IS21, Bradda/Port St Mary in IS14, East Douglas in IS15, Maghould in IS10 and Point of Ayre in IS6. For the 2022/2023 fishing season East of Douglas (IS15: EDG) had the most landings. The fill colour of each bar shows landings by month, enabling temporal changes in the spatial distribution of landings through the season to be detected.
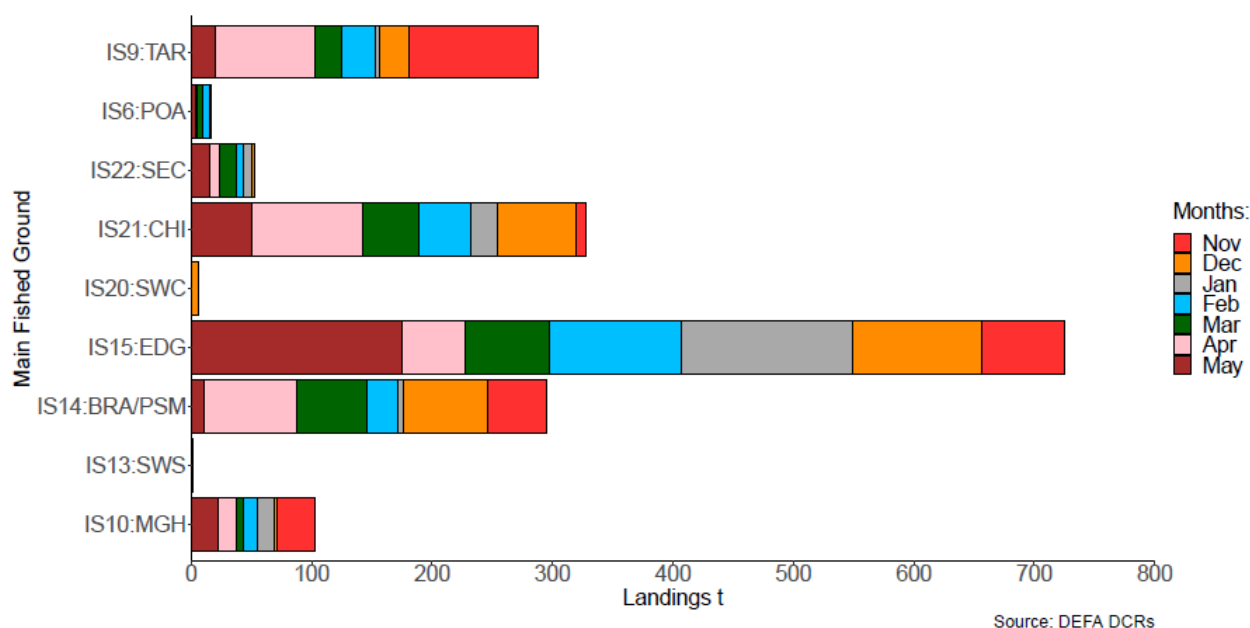
Figure 12 King scallop landings (t) from Isle of Man territorial waters displayed by main fished ground and month for the 2022/2023 fishing season.

The area with the highest fishing effort was the fishing ground at Maughold just south of the current East Douglas Experimental Research Area (EDGERA). The highest effort survey cells within this ground equated to around 120-214 fishing hours per survey cell.

The Daily catch limit for the 2021/2022 Isle of Man king scallop dredge fishing season within the 0- 12 nm limit was **700 kg** per vessel (increasing to 900 k from 1st—21st December 2022 and from 1st February to 31st May 2023). At the start of the fishing season (November 2022) ~ 74 % of vessel trips were meeting the DCL (i.e. landing around 700 kg) whilst at the end of the fishing season (May 2023) this had reduced to ~ 55 % of vessel trips (but note the DCL had increased to **800 kg**).

The 2022/23 average LPUE (**kg per hour fished per dredge**) at each of the main fished grounds is displayed in Figure 13 (green line) with comparisons for 2017/18, 2018/19, 2019/20, 2020/21 and 2021/22 (grey lines) by fished week. For 2022/2023 LPUE was highest at the limited permit only fishery that occurs in December within the Fisheries Management Zone of Ramsey Bay (~ 20-40kg/Dr/HrF) (*N.B. A commercial survey also took place in Ramsey Bay towards the end of the season*). For 2022/2023 the LPUE at all other grounds ranged between ~2 and 20 kg/Dr/HrF. The LPUE for most grounds were within the top range of LPUE for these grounds over the last five fishing seasons.
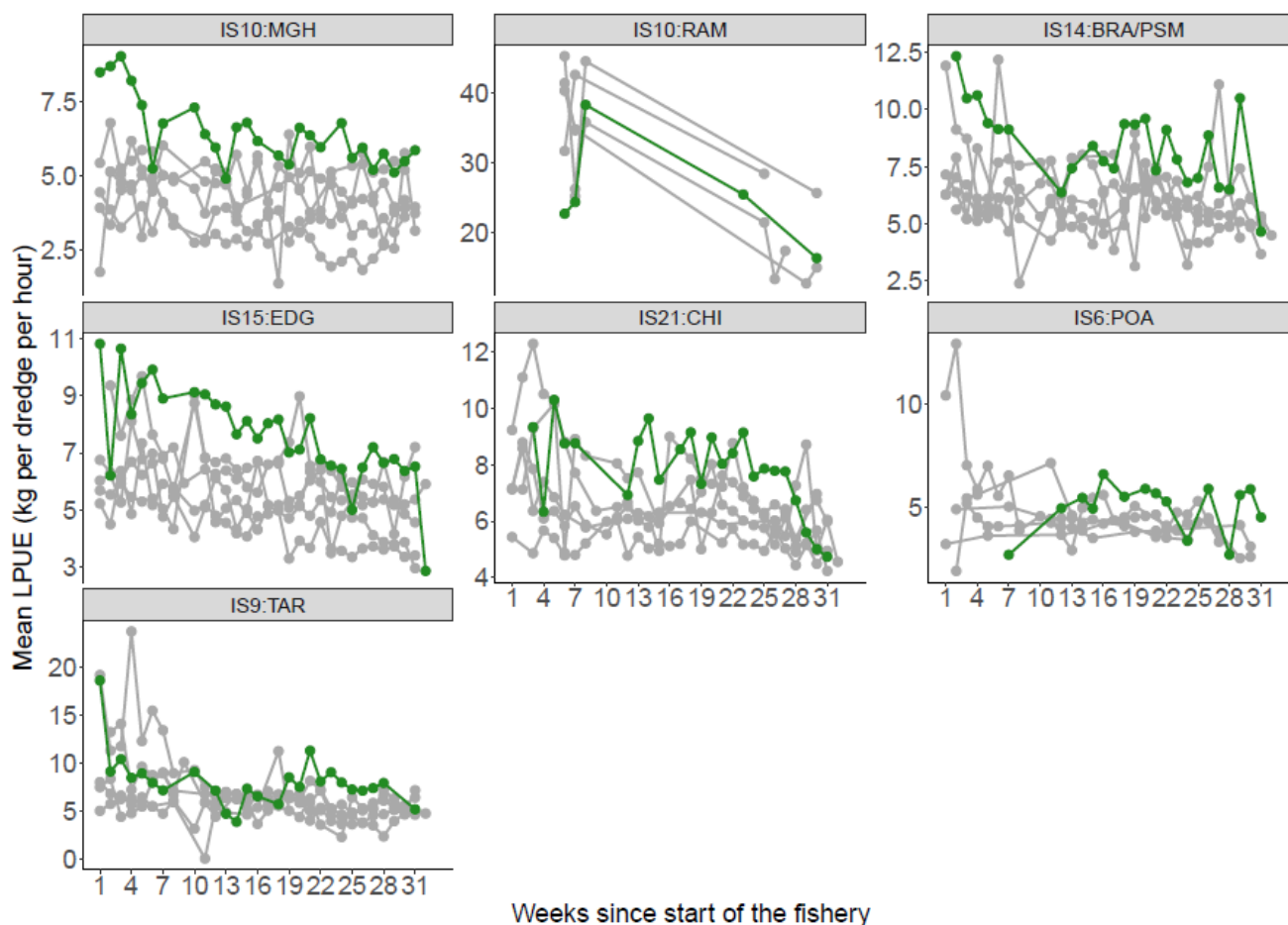
Figure 13 King scallop LPUE (kg per dredge per hour) for the 2022/2023 (green) and historic (grey) fishing seasons.

Research set aside scheme:

In 2022 the Department enacted a pilot scheme that allowed industry to establish a Research Fund using 'excess scallops'. The industry research fund is generated by the sale of excess scallops that vessels were previously required to discard in order to remain under the DCL. Processors receiving excess scallops from participating vessels pay the landed value of excess scallops into the industry survey fund. Landings of excess scallops count against the fishery TAC and are capped at 30 t. For 2022/2023 the scheme was open to all licenced vessels (vessels and processors must sign-up together and have a permit issued by the Department). The Scheme will initially be used to support the MFPOs high-resolution scallop surveys. During the 2022/23 fishing season the scheme landed ~ 10 t of king scallops to contribute to the research set aside scheme fund.

Long-term, Coarse-Scale Survey 2023: King scallops

As for queen scallops, the results for king scallops from the long-term, coarse-scale survey enable territorial sea trends to be assessed and the long term nature of the data means that they are sufficient for undertaking stock assessments. The average survey density of king scallops (of all sizes caught) per 100 m^2 around the Isle of Man for the 2023 survey is displayed in Figure 14 for all survey stations where the density is greater than 0.25 scallops per 100 m^2. In 2023 the three highest density stations TAR, ST51 and ST33 (all above 5 king scallops per 100 m^2) are on the West, East and South coats respectively, indicating a good spread among fishing grounds. (Figure 14).
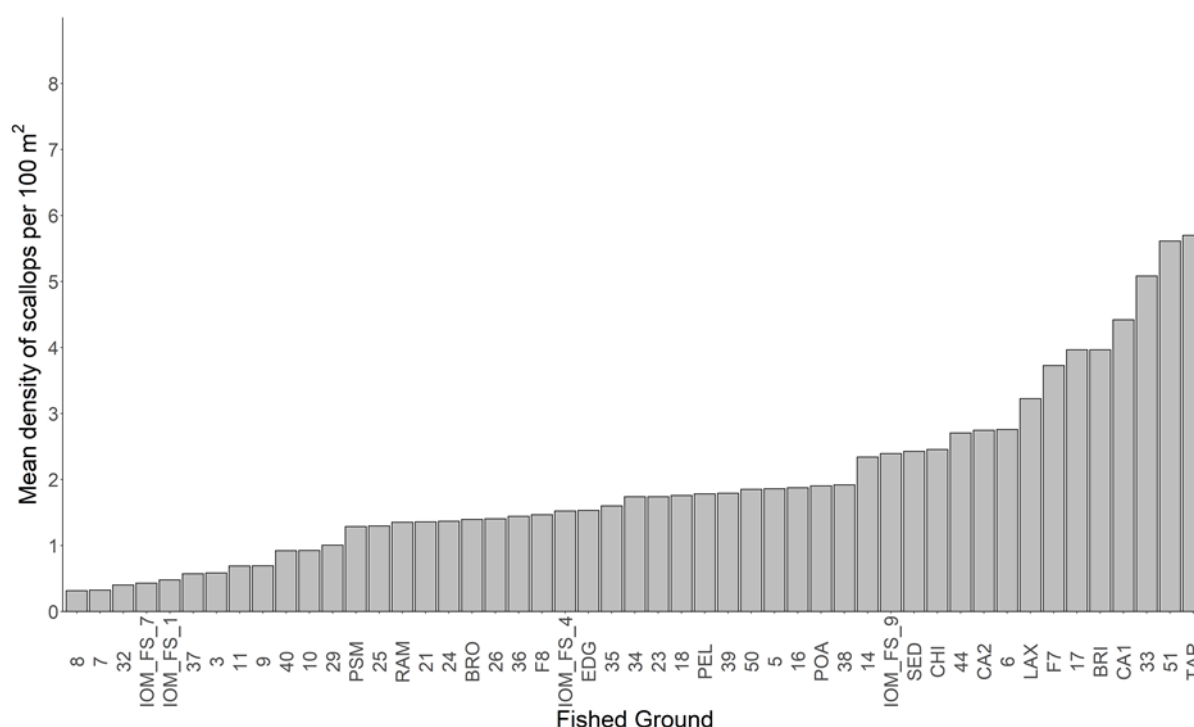

Figure 14 Survey densities (king scallops per 100 m^2) displayed by survey station for spring 2023 survey (average of queen scallop dredge data). Only sites with densities ≥ 0.25 king scallops per 100 m^2 are displayed.

Overall stock trends for recruits can be observed using the recruit abundance index calculated using the geometric mean (solid line; Figure 15). The recruit index (geometric mean) peaked in 2014 with subsequent year on year reductions until 2018, when the lowest estimate since surveys began was recorded. However, the data for 2019, 2021 and 2022 all show increases in the abundance of recruits for the first time since 2014, with 2022 having one of the highest values in the time series (solid line; Figure 16). Whilst there has been a slight decline in 2023 relative to 2022 the value is still at the high end of the time series. This is a positive sign for the fishery over the next 1 or 2 years as these small scallops will hopefully grow and recruit into the fishery increasing the harvestable quantity of stock.

The recruit abundance index calculated using the arithmetic mean (dashed line; Figure 15), which does not down-weight isolated high-density patches of scallops, can be useful to identify cyclical spatially specific recruitment events. Whilst the use of this index for stock assessment would cause an over-estimation of stock abundance it is useful for observing spatially specific recruitment events which may need to be managed independent of the remaining stock. This index shows peaks in 2007/2008 and in 2015 which tally with large recruitment events at both Chickens (south coast) and Targets (west coast). Both of these recruitment events supported high density fisheries of post-recruits on the west coast of the Island in the subsequent year (i.e. November 2009 and November 2016).
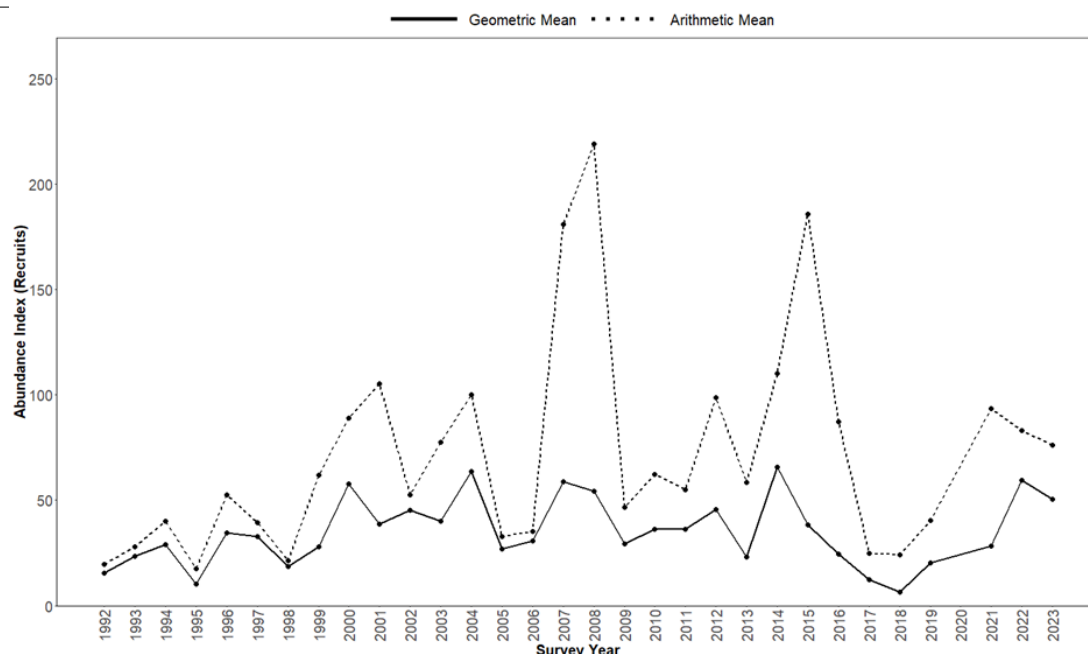
Figure 15 Recruit abundance index (scallops < 95 mm). Calculated based on length-based data where recruits were categorised as scallops under 95 mm at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. final day of the following season). The index is displayed using calculation of both the Geometric mean (solid line) for general stock trends and the Arithmetic mean (dashed line) for spatially specific cyclical recruitment events.

Overall stock trends for post recruits (scallops ≥ 95 mm) using the abundance index calculated using the geometric mean (solid line; Figure 9) shows a general increasing trend from 1992 to 2015 (reaching the highest level on record in 2015). This was followed by three years of decreasing values before an increase in 2021, a slight decrease in 2022 and then a slight increase again in 2023. The post recruit abundance index calculated using the arithmetic mean (dashed line; Figure 9) which does not down-weight isolated high-density patches of scallops shows peaks in 2009 and 2016 which tally with large recruitment events observed in the recruit index the year before.
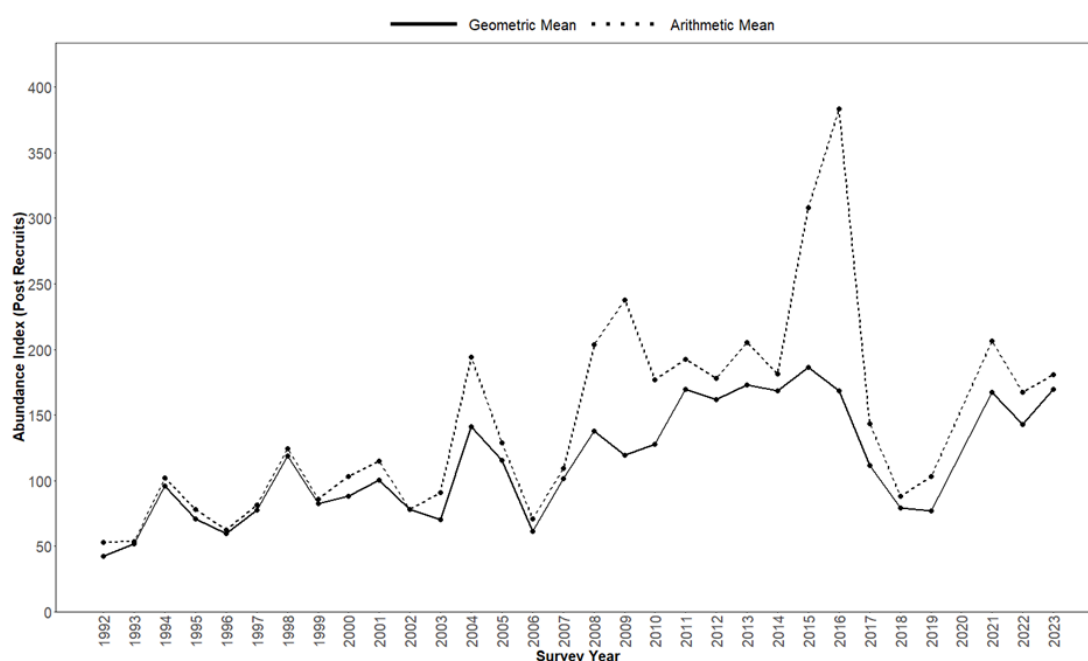
Figure 16 Post recruit abundance index (scallops ≥ 95 mm). Calculated based on length-based data where post recruits were categorised as scallops 95 mm or above at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. final day of the current season). The index is displayed using calculation of both the Geometric mean (solid line) for general stock trends and the Arithmetic mean (dashed line) for spatially specific cyclical recruitment events.

Short-term, fine-scale survey 2023: King scallops

Within the territorial sea (0-12 nm) there has been an overall increase in the abundance index (geometric mean) of all scallop sizes from 2022 to 2023 (Figure 17; Top).

Within the 0-3 nm limit the industry survey has shown increases in the recruit abundance index at ECO, MGH and ERA (Figure 17; Bottom). For post-recruit abundance the index from the industry survey showed increases at all grounds (i.e. ECO, BRA, MGH and ERA) (Figure 17; Bottom).

Within the 3-12 nm limit the industry survey has shown increases in the recruit abundance index at all grounds (i.e. EDG, CHI, TAR and POA) compared to 2022 (Figure 17; Bottom). For post-recruit abundance, the index from the industry survey showed increases at two grounds (EDG and POA) compared to 2022.
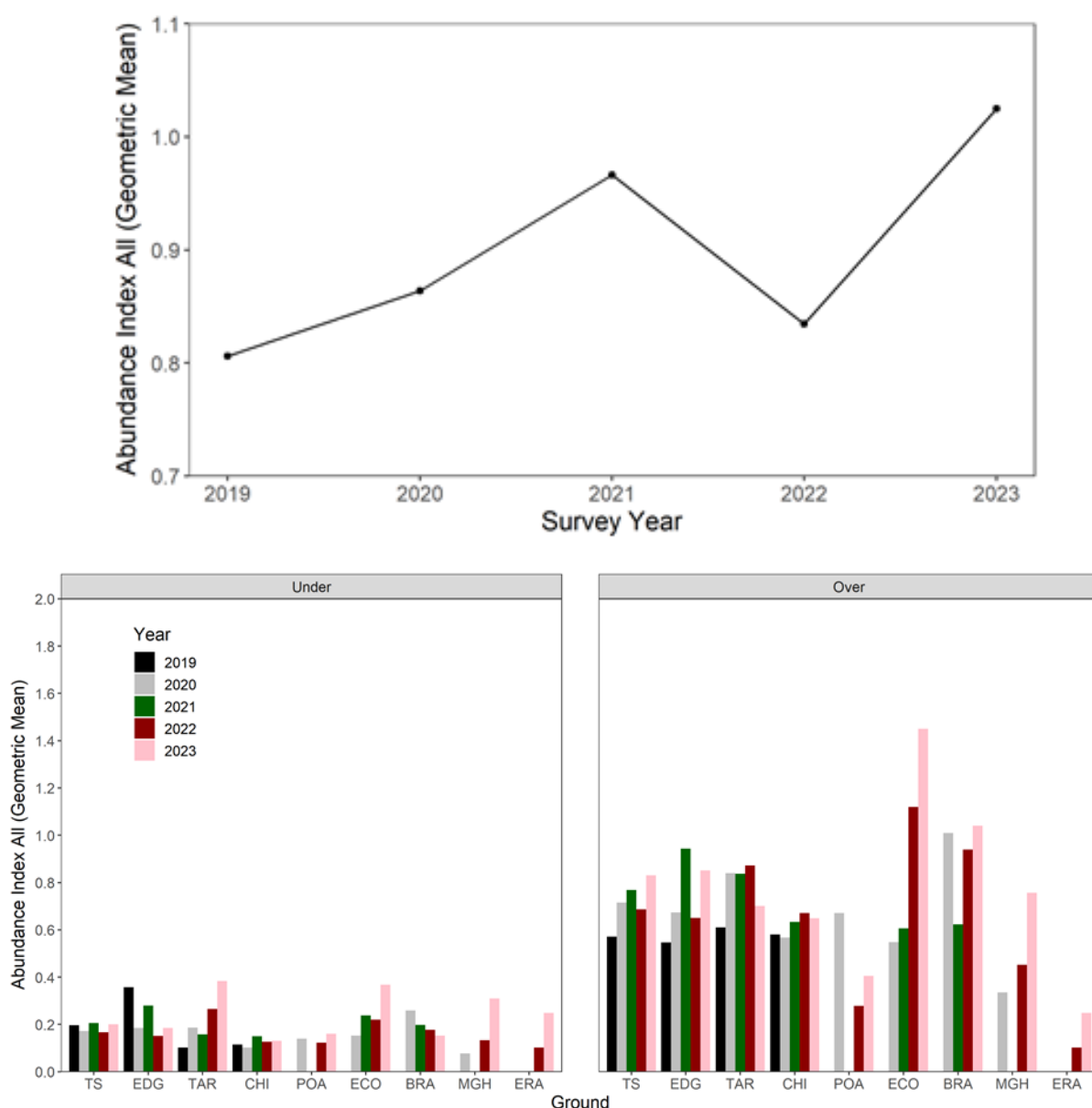
Figure 17 Top: King scallop abundance index (geometric mean) for all sizes of scallops, Bottom: Comparison of king scallop abundance indices (geometric mean) (over and under 95 mm) by year and by ground for the fine-scale survey
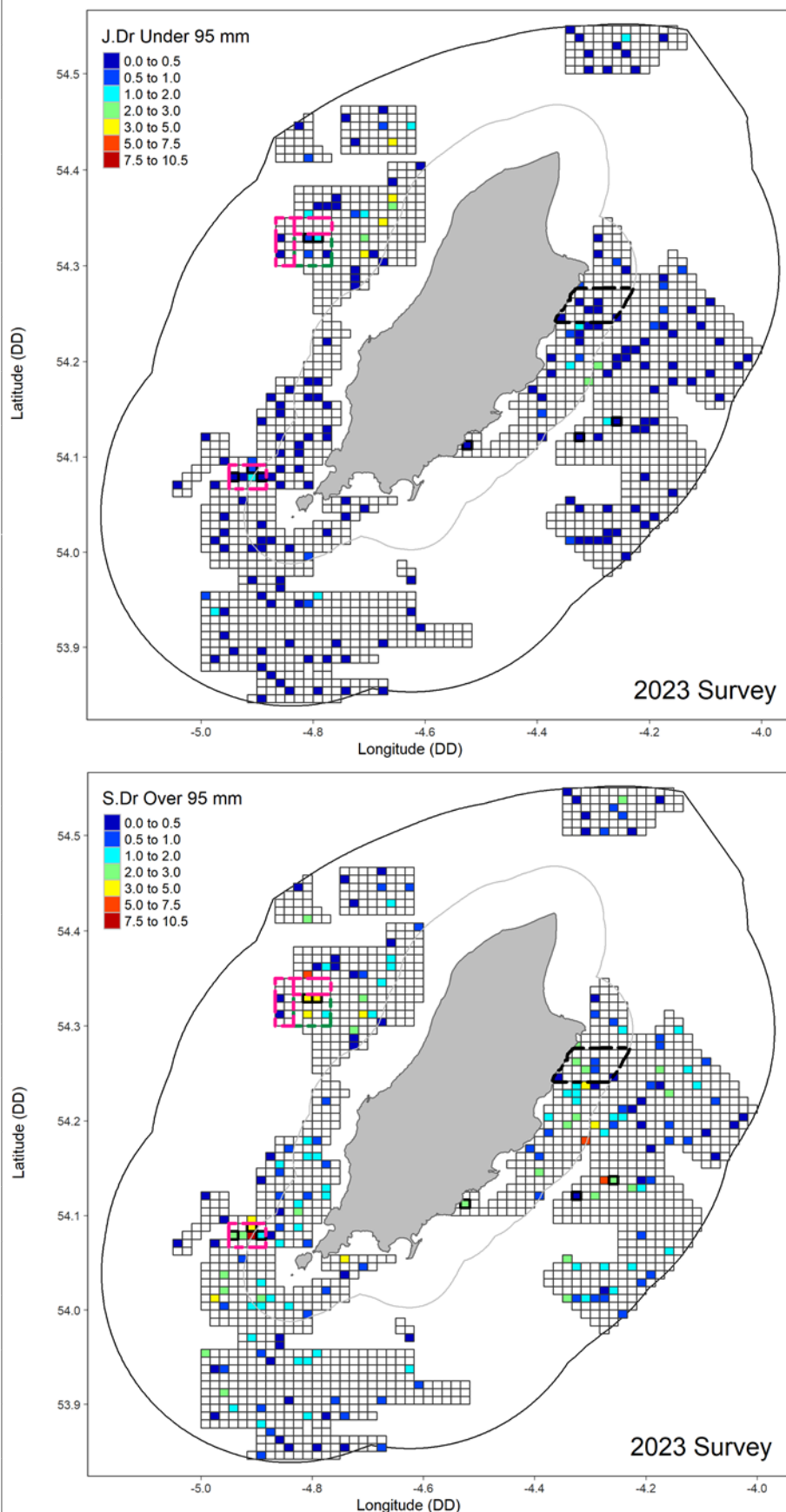
Figure 18 Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm (top) and over 95 mm (bottom) from standard king and standard scallop dredges for 2023. The green boxes indicate restricted access areas during the 2023 queen scallop fishing season and the pink boxes indicate areas closed for queen scallop fishing in 2023.The black box indicates the East of Douglas Experimental Research Area. (decisions for closed areas in the 2022/2023 fishing season were based on the survey data presented here).

The full report is available on request from **i.bloor@bangor.ac.uk**

Bloor, I.S.M., Coleman, M. and Jenkins, S.R. (2023). Isle of Man King Scallop 2023 Stock Survey Report. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 50.

King Scallop Stock Advice (2023/2024)

The advice below was provided by Bangor University to the Scallop Management Board for consideration for management of the 2023/2024 king scallop fishing season.

Summary of survey findings

Within the territorial sea (0 - 12 nm) there has been an overall increase in the abundance index (geometric mean) of all scallop sizes from 2022 to 2023 for both the Prince Madog and industry surveys. The top four highest densities recorded in each survey occurred across a range of fishing grounds with the industry survey recording densities of 8.2-9.5 scallops per 100 m^2 at four survey cells within BRA, TAR, EDG and ECO. Similarly, the Prince Madog survey recorded densities of 4.4-5.7 scallops per 100 m^2 at four survey stations within BRA, TAR, ECO and EDGERA.

When split into post-recruit and recruit abundance the Industry survey showed increases in both indices in 2023 relative to 2022. The post-recruit index from the Prince Madog survey also increased in 2023 relative to 2022 and remains above the long-term mean for this stock (3rd highest value in the 32 year time series). Whilst the Prince Madog survey showed a slight decrease in the recruit abundance index in 2023 relative to 2022, it is still relatively high and remains above the long-term mean for this stock (7th highest value recorded in the 32 year time series).

Recommendations

It was recommended that the management approach for 2023/2024 king scallop fishery continued to be precautionary and that it should incorporate all of the following three elements:

- **In-season reviews:** Monthly reviews of the fishery by the SMB or a subgroup for the entire TS fishery should be scheduled as standard.

- **Spatial monitoring and management:** Spatial monitoring for each individual ground should be undertaken as part of the in-season review to allow flexible spatial management (i.e. individual grounds to be opened or closed) based on the real-time data collected by the fishery. High density areas within a ground (i.e. Bradda) may require additional fine scale management to avoid high fishing intensities leading to excessive fishing mortality and habitat damage.

- **Closed area management:** The continued management of restricted areas and current/new closed areas is required to protect high density areas of post-recruits and recruits (king and queen scallops).

Total allowable catch:

- The ICES Category 3 approach indicates a potential to increase the TAC by 20%.
- Catch rates, various management measures, including the use of a DCL to ensure the TAC lasts throughout the season, and various logistical issues as a result of BREXIT and Coronavirus may have contributed to the under achievement of the TAC in recent seasons (2020, 2021, 2022 and 2023).
- A precautionary management approach should be considered in line with the long-term management plan for this fishery and to promote continued stock improvements.
- An initial starting TAC based on a 20% increase of actual landings (TAC = 2179 t) is advised, but with the flexibility to decrease or increase the TAC during the fishing season based on fisheries-dependent data (i.e. Daily Catch Return Forms), which is collected in near real-time during the season, combined with industry feedback on market conditions.

General:

- Consideration of restricted access and additional management measures within the high-density fishing area at Bradda., Targets and East of Douglas.
- Consideration of temporary closed areas implemented to protect any high densities of recruits identified in the survey. For 2023 survey cells within TAR and EDG had the highest densities of recruits in the industry surveys
- Monitoring of LPUE and fishing intensity (swept area) should also be undertaken in managed areas to try and ensure overfishing of these spatially discrete areas does not occur.
- Monthly reviews of the TAC and fishery with consideration of LPUE and fishing intensity within each fishing ground

King Scallop Research Priorities for 2024:

- Development of an R Shiny Dashboard for real time fisheries management data interaction and viewing.

- Progress stock assessment model development for the Isle of Man and the wider Irish Sea with collaboration with ICES colleagues as part of WGScallop.

- Development of a stock synthesis (SS3) stock assessment for Isle of Man king scallops.

- Progress towards short-term objectives for the long-term management plan

ICES Working Group on Scallop Stock Assessment
10th – 12th October 2023, Hybrid, Tromsø, Norway

The ICES Scallop Assessment Working Group (WGScallop) was attended in person by Dr Isobel Bloor. The Working Group discusses scallop surveys, stock assessment methodologies, advances in technology, scallop aging procedures, and recent studies on scallop species to develop and improve stock assessment methods. A summary of the work from the 2023 meeting is below:

Collated data from the 4th annual data call were reviewed and compared to data from the Regional Database Estimation System (RDBES). Further intersessional comparison work will be undertaken and if the two datasets match, then RDBES data can be used routinely.

Fisheries independent surveys are critical for many stock assessment methods. The WG held an intersessional meeting on survey design and will continue further discussions during 2024. The first staff exchanges on scallop surveys occurred during 2023 and a list of surveys with available spaces for staff exchange have been compiled for 2024.

Scallop larval dispersal models have progressed in Scotland and Northern Ireland. Connectivity work among locations in the Irish Sea found that no significant spatial genetic differentiation among populations at the scale of ~ 400 km. There was however a significant genetic differentiation within samples that may be temporally linked to spring and autumn spawning. This hypothesis will be investigated using stable isotope analysis of king scallop shells.

WGScallop decided to combine two existing terms of reference,ToR B and ToR C, which are closely related and focus on developing stock assessment methods for scallops. A table was produced to highlight the international range of scallop stocks, current data and methods utilised, and a "road map" of best practice was suggested. An intersessional subgroup will meet to further discuss and consider options for a workshop.

New research on modifications to traditional dredge gear,i.e. skid dredges and n-viro dredges, to increase harvesting efficiency and decrease environmental impacts was presented. In addition, invited guests presented novel alternative harvesting methods involving pot fishing and suction methods.

Chairs: Dr Lynda Blackadder and Dr Isobel Bloor

The 2023 Report of the Scallop Assessment Working Group (WGScallop), which covers all terms of reference and a summary of all progress from the meeting, is now available on the WGScallop community page.

The citation for this report is:

ICES. 2024. Scallop Assessment Working Group (WGSCALLOP; outputs from 2023 meeting).

ICES Scientific Reports. 6:17. 88 pp. https://doi.org/10.17895/ices.pub.25249255

The next meeting will be hosted by the French national institute for ocean science and technology (IFREMER) in Bayeux, France from 8th – 10th October 2024 (this will be a hybrid meeting virtual and in person as per ICES current advice).

ICES WKSA II
7th - 8th March 2023, CEFAS, Lowestoft

lCES Workshop on Scallop Aging (WKSA I & II) provided a forum to progress scallop age determination by member institutes across diverse scallop fisheries, stocks and geographies. Age determination methods and their reliability are vital for stock assessors to develop appropriate stock assessment parameters and for informing ecosystem-based fisheries management.

The ICES Workshop on Scallop Aging II (WKSA2) sought to collaborate on current age determination methodologies and protocols, to identify consensus and to improve accuracy across institutes. The aims of the workshop were to review current age reading methodologies, undertake method training and develop standardised processes and quality assurance to promote best practices.

The two-part workshop evaluated methodologies, quality assurance aims and piloted online age determination (SmartDots) events. As requested at WKSA 2020, a microscope age training session was undertaken and the release of a second SmartDots online aging event took place.

Participant institutes discussed techniques in age determination and parameters for improving consensus, defined standard principles across institutes and promoted knowledge sharing. Training in the technique of microscope aging for shells and resilium was delivered. SmartDots was trialled with new images to further examine its potential use for virtual scallop shell aging in future exchanges.

Future work for WKSA includes links to WGScallop with respect to the development of confidence parameters for scallop age quality assurance, promoting partnerships for reference collection consensus aging and training, information sharing and the development of a scallop aging methodology manual.

In addition to king scallops determining ages in other species such as queen scallops were also discussed and the hinge plate (Figure 19) was suggested as a good alternative to ageing via shell growth rings and this will be investigated further in 2024.

A full report is available:

ICES. 2023. Workshop on Scallop Aging 2 (WKSA2). ICES Scientific Reports. 5:91. 42 pp. https://doi.org/10.17895/ices.pub.24198975

Figure 19: Growth lines on a hinge plate of a queen scallop

Potting Sector fisheries: Crab, Lobster & Whelk

The potting sector of the Isle of Man fishery is dominated by three primary target species; Brown Crab (*Cancer pagurus*), European Lobster (*Homarus gammarus*) and Common whelk (*Buccinum undatum*). These three species face separate challenges and gaps in scientific knowledge to progress towards the level of management advice currently being achieved for the scallop fishery sector. Bangor University continues to work collaboratively with both industry and DEFA to address a number of these knowledge gaps over the course of the current contract.

The necessity of addressing these knowledge gaps is evident in the price of first sale, with static gear target species in 2021 individually at a higher value to Queen Scallops (QSC) (2021 sales : QSC—£0.3million; Whelk—£0.6million; Crab £0.9million; European lobster £0.6million). A summary of the current status of these three static gear fisheries is presented along with complementary research undertaken in 2023.

Common Whelk (*Buccinum* undatum) Fishery update

Management of the whelk fishery in the Isle of Man territorial sea is not yet informed by stock assessments or fisheries-independent surveys of stock biomass. Trends in fisheries-dependent data are therefore presented at a whole territorial sea level.

In 2023, the landings of whelk into the Isle of Man was 346 tonnes, an increase of ~15% compared to 2022 (Figure 20). The total effort by Isle of Man registered vessels was c.285,000 pot-lifts in 2023, an increase equal to ~36% compared to 2022 (Figure 20). The lowest mean LPUE for the fishery was however recorded in 2023 at ~1.4kg/pot a decrease of 15% compared to 2022 (Figure 20). The explanation for continued low LPUE in 2023 compared to previous years can be attributed to a number of factors. This could include overfishing or changes in targeting behaviour due to market forces and or low catch rates.

One of the primary issues surrounding whelk management currently is the delineation of stock boundaries and spatial variation in targeting behaviour and LPUE, with such information not routinely reported via logbooks. However, following the implementation of inshore vessel monitoring systems (iVMS) in April 2023 more precise spatial and temporal information can be added to logbook data, increasing our understanding and interpretation of long term trends. Its implementation will allow us to better understand stock delineation around the island and inform the scale at which such stocks should be managed (see iVMS section for further details).

In addition Bangor University is in the process of developing methodologies to assess whelk stock status using baited underwater video (BRUV's) alongside conventional mark recapture techniques ,whilst also investigating stock assessment techniques that can be used to further analytically assess whelk stocks in the Isle of Man territorial sea.
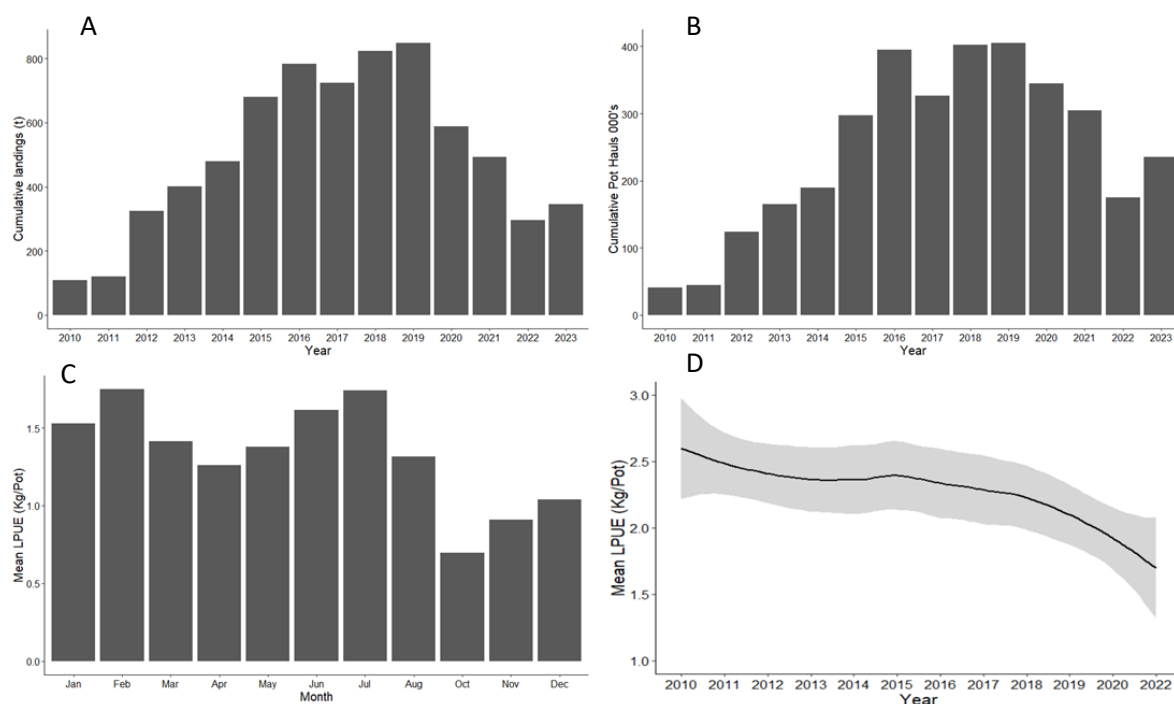
Figure 20. Common Whelk Fishery A) cumulative landings in the Isle of Man Territorial Sea per year from 2010 to 2023 B) Cumulative pot hauls per year in the Isle of Man Territorial Sea C) Monthly mean landing per unit effort (LPUE—Kg/pot haul) D) Whelk LPUE trend for the whole Isle of Man.

Common Whelk Size-Based Indicators

In 2023 we set up a whelk sampling scheme with commercial fishers on the Isle of Man with the aim of assessing size-based indicators of stock health. In data-limited fisheries such as whelk, the International Council for the Exploration of the Sea (ICES) recommends monitoring such stocks in the first instance using indices calculated from length data and life history parameters as proxies for key parameters typically derived from traditional stock assessment models (e.g. maximum sustainable yield) (Table 2). Whelk pots of a standardised design were provided to each fisher participating in the scheme to avoid potential variation in the size-selectivity of commercial gear and ensure indicators are comparable across areas.

Table 2. Length-based indicators developed by ICES. Reference points are calculated from size-at-maturity and size-at-age models

Indicator	Description	Reference point	Category
$L_{max5\%}$	Mean length of largest 5%	$L_{max5\%} / L_{inf} > 0.8$	Conservation of large individuals
P_{mega}	Proportion of individuals above L_{opt} + 10%	$P_{mega} > 0.3$	
$L_{25\%}$	25th percentile of length distribution	$L_{25\%} / L_{mat} > 1$	Conservation of immatures
L_c	Length at 50% of modal abundance	$L_c / L_{mat} > 1$	
L_{mean}	Mean length of individuals above L_c	$L_{mean} / L_{opt} \approx 1$	Optimal yield
L_{mean}	Mean length of individuals above L_c	$L_{mean} / L_{F=M} \geq 1$	MSY

L_{opt} –optimum size for capture

Common Whelk Size-Based Indicators - Continued

During the main whelk fishing season in 2023 (February to June) a total of 86 pot samples were fished by three commercial vessels which incorporated the full size distribution of catch (permits were granted by DEFA to land undersized whelks). Samples were predominately from the southeast and northwest territorial sea (Figure 1), with the total shell length of all individuals measured (~4000 whelks in total).
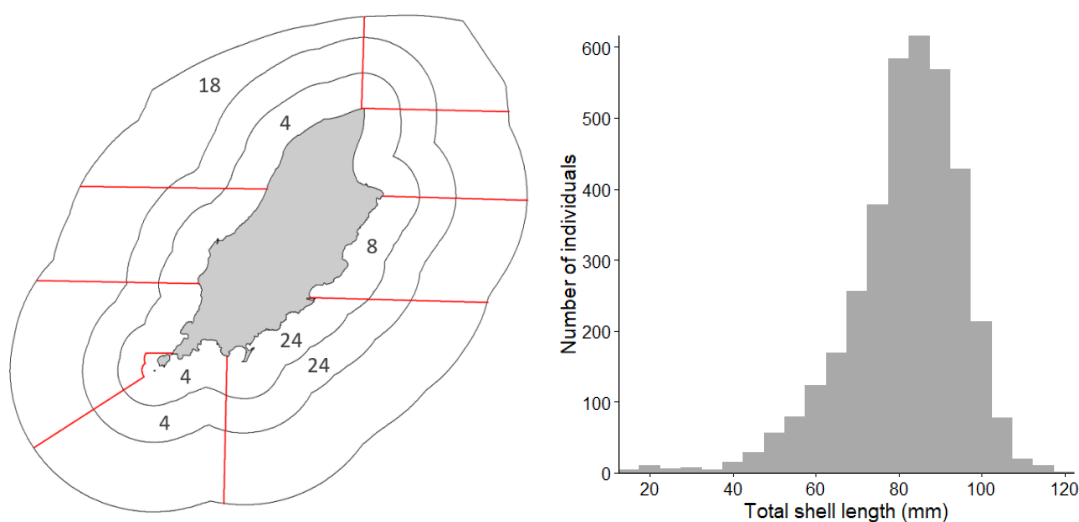
Figure 21. Number of pot samples by area (left) and the overall size distribution of catch (right) in 2023.

In order to assess biological parameters (size-at-maturity and size-at-age) required as reference points for the length-based indicators, size-stratified subsamples were retained from each area and dissection work is currently underway (Figure 2). The pot sampling scheme will also continue in 2024 to collect more length data and a full report will be made available with the results.

Figure 22. Dissection methods for size-at-maturity (left) and size-at-age (right). Maturity is assessed based on the level of development of the gonads, and age is determined by the number of growth rings on the statoliths (microscopic calcareous spheres which are found in the head of each whelk).

Common Whelk Pot Spacing Survey

In 2023 we conducted a survey to estimate the area of seabed fished by commercial whelk pots, known as the trapping area. Trapping areas are a poorly understood, yet crucial, component of stock assessment for species targeted by static gear fisheries, and are needed in order to estimate true population density from catch information. This was achieved by recording whelk catches at a range of different pot spacings, under the assumption that pots which are close together on a string are competing, owing to the overlap of trapping areas. Such competition between pots will invariably lead to lower catch rates, as has been demonstrated for a number of crustaceans.

The survey took place over a 7-day period (16-22 June 2023) in a whelk fishing area off the North Wales coast. This included 10 strings of commercial pots of a similar length, with 7 different spacings selected and spatially replicated across the strings (Table 3). The strings were fished 100m apart in a randomised grid and hauled three times during the survey (48 hours between each haul), with the catch recorded on a pot-by-pot basis. The size of the trapping area and density of whelks were estimated using a Bayesian statistical model which assumes a circular attraction area and a linear decline in the probability of capture with distance from the pot. We developed this model further to allow for varying abundances between fishing strings, thereby accounting for the heterogeneous nature of whelk stocks.

String	Spacings	Pots	Length
1	4m, 6m & 50m	21	510m
2	4m, 6m & 50m	21	510m
3	25m & 50m	14	525m
4	25m & 50m	14	525m
5	10m, 15m & 35m	21	510m
6	10m, 15m & 35m	21	510m
7	4m, 15m & 25m	21	414m
8	4m, 15m & 25m	21	414m
9	6m, 10m & 35m	21	456m
10	6m, 10m & 35m	21	456m

Table 3. Summary of whelk pot strings fished during the survey. Each spacing replicate consisted of 7 pots (5 middle pots and 2 end pots), with 75m of rope between different spacings.

Based on our data the model estimated the radius of the trapping area to be 6.1m (5.1-7.5m 95% confidence) (Figure 23), indicating whelk catches originated from an area of 82-178m^2 around each pot over a typical 48-hour soak time. CPUE (catch per unit effort) varied spatially across the 10 strings, with estimated densities between 0.5 and 1.4 whelks m^{-2}. These values are similar to densities reported from other methods (e.g. mark-recapture, dive surveys). Our results also suggest, based on the size of the trapping area (12.2m diameter), that the pot spacing used by commercial whelk fishers (13-20m in Wales and Isle of Man) is generally
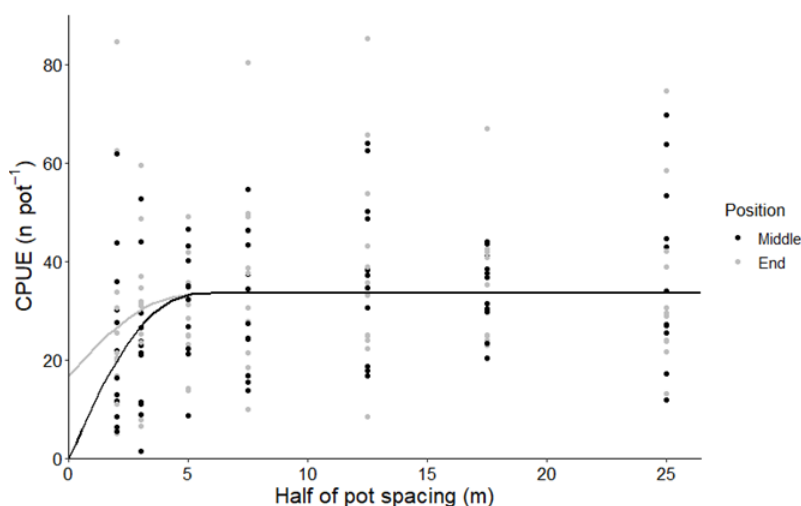

Figure 23. Fitted relationship between pot spacing and CPUE (catch per unit effort) for middle pots (interacting with two adjacent pots) and end pots (interacting with one adjacent pot). The asymptote in the relationship, occurring at a catch rate of 33.5 whelks pot^{-1}, indicates the radius of the trapping area estimated by the model (6m).

Brown Crab (*Cancer pagurus)* Fishery Update

The edible crab fishery in the Isle of Man territorial sea has typically produced between c.400 and c.550 tonnes each year over the past decade. 2018 was an exceptional year for the fishery, producing over 575 tonnes, whilst 2019 saw harvest levels return to previous levels (~475 tonnes). In 2023, total landings 549t and ~431,000 pot-lifts, equal to a decreases of ~1% and an decrease of 6% relative to 2022 respectively (Figure 24). The fishery is historically an autumn fishery, a pattern which continued in 2023, when the highest landing per unit effort (Kg/Pot) was recorded in October (Figure 24).

The fishery is also monitored using LPUE. Mean LPUE remained similar to 2022 at a value of 1.06kg/pot. The 'mixed' crab and lobster fishery means there are challenges with reporting effort although the fisheries are becoming increasingly distinct (seasonally and temporally). Following the implementation of inshore vessel monitoring systems (iVMS) from April 2023, more precise spatial and temporal information can be added to logbook data and incorporated in the analysis, increasing our understanding and interpretation of long term trends. In addition Bangor University is investigating stock assessment techniques that can be used to further analytically assess brown crab stocks in the Isle of Man territorial sea.
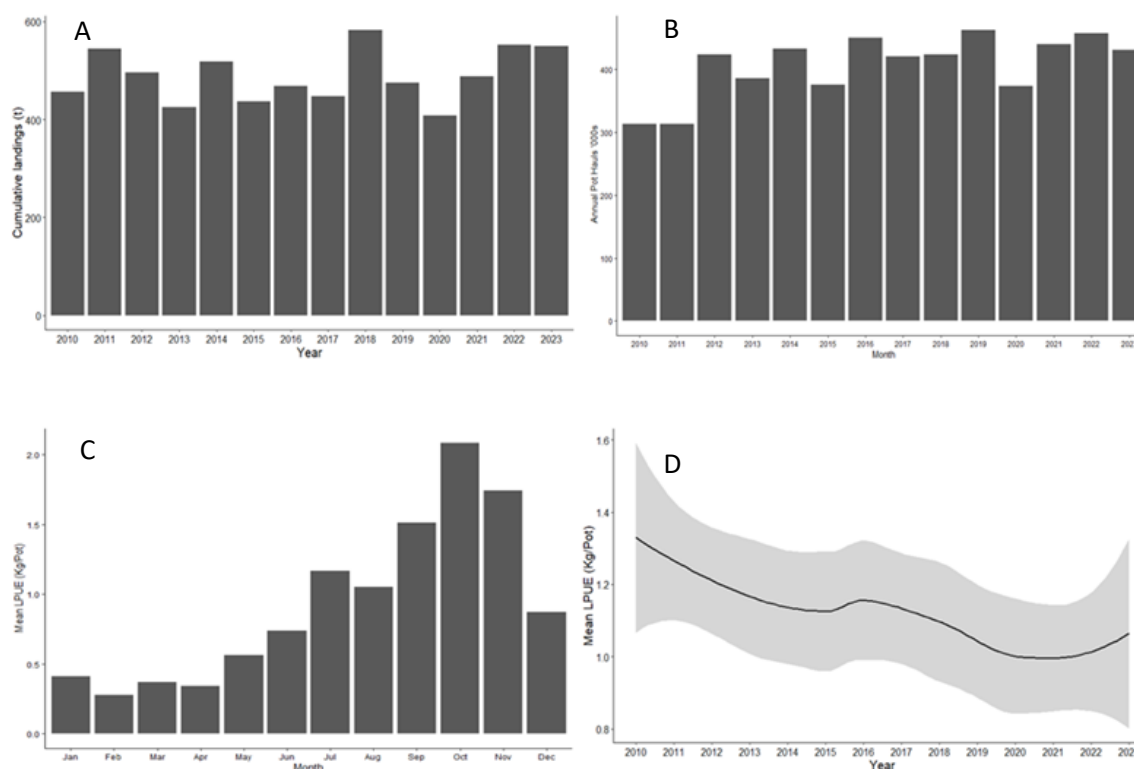

Figure 24. Brown Crab A) annual declared landings in the Isle of Man Territorial Sea throughout from 2010—2023. B) Annual pot hauls in Man Territorial Sea from 2010 –2023 C) Mean monthly LPUE in 2023 D) Long term LPUE trend (2012 –2022) for the Isle of Man territorial sea.

European Lobster (*Homarus gammarus*) Fishery Update

The European lobster fishery in the Isle of Man territorial sea has produced between 40 and 60 tonnes of lobster annually from 2007-present (Figure 25). Landings in 2023 were 47 tonnes, an increase of 8% compared to 2022. Effort in the fishery decreased from 273,000 to 262,000 pot lifts, a decrease of 4% compared to 2022.

The fishery is also monitored using landing per unit effort LPUE. Compared to brown crab LPUE values for lobsters are markedly lower. This in part is due to the differences in catchability and potentially their lower density. Monthly LPUE is seen to remain consistent throughout the year ~0.15kg/pot, with peak LPUE and fishery occurring in July – August coinciding with increasing water temperatures. A peak in LPUE was also recorded in February, with fishers remarking on a late winter/early spring fishery.

Annual LPUE for 2023 was recorded as 0.185/kg per pot, continuing the overall decreasing trend in annual LPUE since the peak of 2016 (0.245kg/pot). These declines are difficult to verify from logbook data alone, considering that the lobster and edible crab fishery are reported as a 'mixed' fishery.   As for crab, we expect greater clarity in 2024 as the implementation of inshore vessel monitoring systems (iVMS) enhances our ability to tease apart these two fisheries.
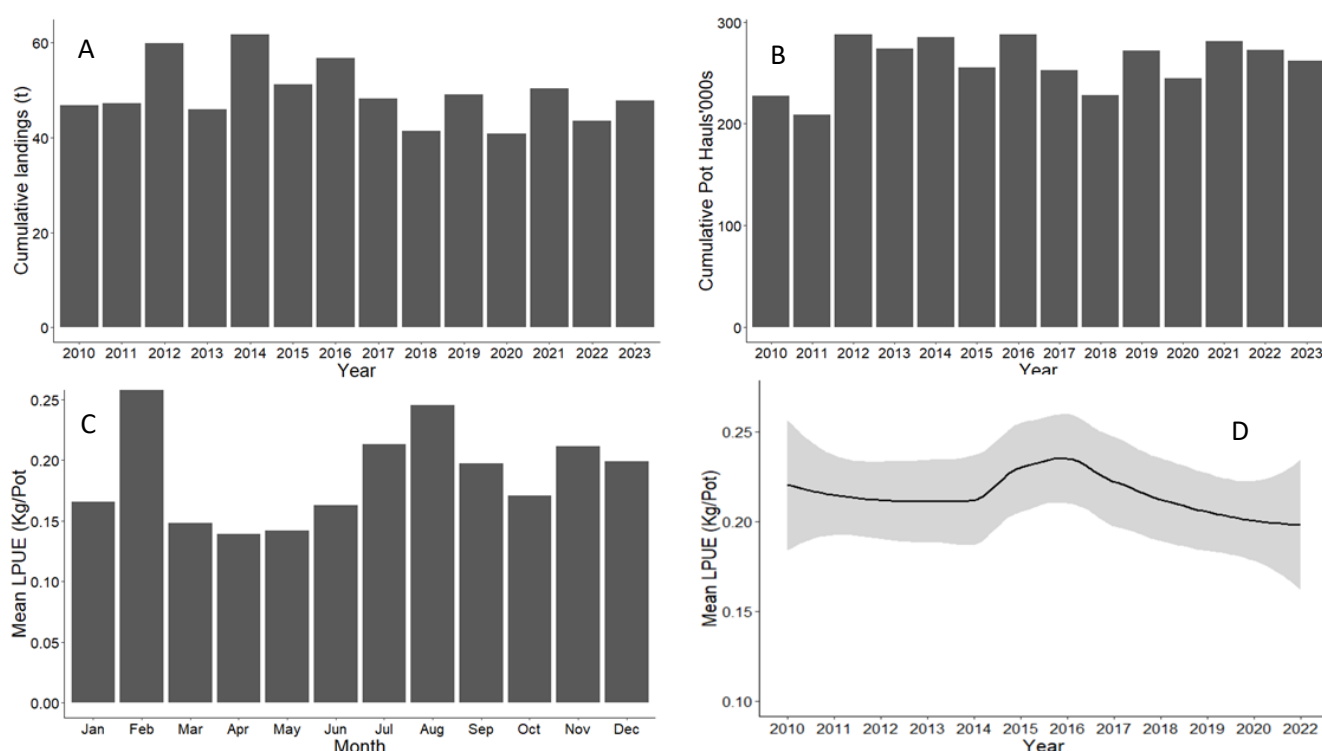

Figure 25. European Lobster A) Annual landings declared in the Isle of Man Territorial Sea from 2010 –2023 B) annual pot lifts declared in the Isle of Man Territorial Sea from 2010—2023 C) Monthly variation in LPUE (Kg./per pot lift) throughout 2023 D) long term LPUE trend (2012 –2022) for the Isle of Man territorial sea.

Use of Inshore Vessel Monitoring in the Isle of Man Static Gear Fishery

April 2023 saw the roll out of inshore vessel monitors systems (iVMS) for vessels engaged in static gear fishing activities. This marks an important step in the management of Manx fisheries. With 99% of fishing vessels now required under statutory licence conditions to be fitted with a working tracking unit.

Prior to the introduction of iVMS, static gear vessels reported spatial location of fishing activities via monthly shellfish returns. The spatial scale of reporting has varied; from 1997 – 2011 fishing activities were reported to Port Erin Marine Lab Squares (PEML), while from 2011-2023 Monthly Shellfish Activity Log (MSAL) squares (a series of 62 rectangles for IoM territorial waters) were used. A high proportion of shellfish returns prior to 2023 lacked any spatial information with this varying from 1 – 87% of returns annually for crab/lobster landings. The roll out of iVMS has effectively eliminated this significant data gap.

Figure 26. Proposed Brown Crab management zones

Following the roll out, Bangor scientist's have used the information to better understand the spatial and temporal usage of the territorial sea and apply this to how best static gear fisheries could be managed in the future. This has resulted in the creation of species specific zones in which static gear fisheries can be assessed, creating the potential for area-specific management. These have been designed through both the usage of new iVMS data, historical records and habitat maps, culminating in management zones that best encompasses species specific fishing activities .

Two examples presented here are for Brown crab and the Common Whelk. Dedicated brown crab fishing activity primarily occurs on the West and South West coast, with a small amount of fishing activity occurring South of Port St. Mary. Using this information a dedicated Brown crab assessment area has been devised (Figure 26). Currently this is broad and will require further refinement through both conversations with fishers and the continued analysis of iVMS data. In the case of Common Whelk, the benthic nature and life history traits (direct development as opposed to planktonic larvae) of this species creates the potential for more localised management. In this instance 5 management zones (MGZ) have been devised (Figure 27), with this based on historic records of fishing activity, iVMS data and previous work investigating size at maturity around the Isle of Man. A Lobster fishery specific assessment area has also been devised, but due to this assessment area containing commercially sensitive information it is not presented.

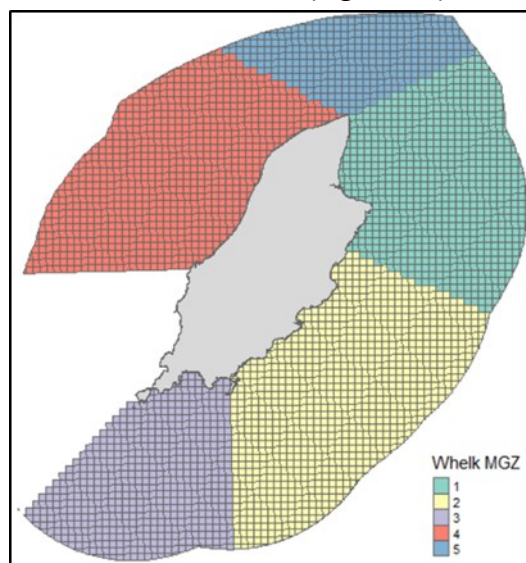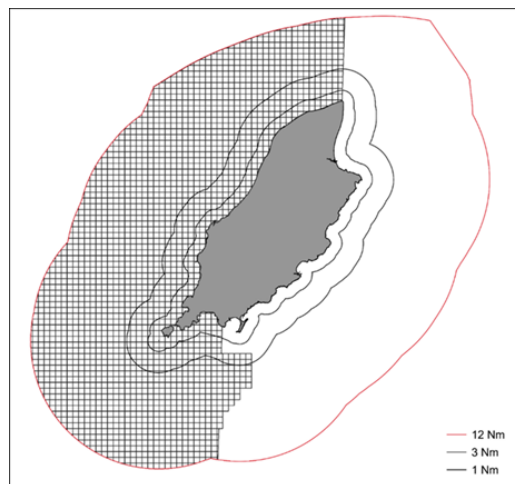Figure 27. Proposed Whelk Management Zones

The management areas presented indicate the first attempt to utilise iVMS as a tool in which to manage IoM static gear fisheries. Data collation and analysis to inform this work will continue into 2024

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ICWL: 12th International Conference and Workshop on Lobster (and Crab) Biology and Management 2023

October 2023 saw the 12th international conference and workshop on lobster biology and management (ICWL) held in Fremantle Western Australia. The conference was attended by over 200 delegates from 20 countries, with attendees from universities, government institutions, fishermen organisations and indigenous people. Of those delegates present, only 4 were from European institutions, highlighting the importance of attending such conferences to provide a holistic overview of lobster and crab management and research from a European perspective.

The ICWL agenda encompassed a broad spectrum of topics including the use of novel stock assessment methods, industry sampling schemes, indigenous harvesting strategies and the impact and co-existence of renewable energy on historical marine users. This was also the first year that crab fisheries and associated research has been included in the conference and marked an important change in attendees and discussion topics. Notable presentations included the use of historic spiny lobster settlement indices that are used to inform future lobster biomass in Western Australia and the effect of environmental drivers on annual changes. There were many notable presentations which have provided the basis for future research to be undertaken in the Isle of Man.

Dr Matthew Coleman presented two pieces of work from the Bangor University Isle of Man Team. The first was work undertaken to standardise size at maturity estimates in European lobster populations across the North-East Atlantic, collecting samples and working collaboratively with researchers from universities and government agencies across the United Kingdom and Ireland. The second was a presentation on the novel research looking at the use of historical beam trawl data for the North West Irish sea to monitor brown crab abundance in conjunction with historic and current logbook data collected by the Isle of Man Government. This work also included the exploratory work into the role of the North Atlantic Oscillation on crab abundance.

A summary of the conference will be available in the Lobster Newsletter along with a special conference edition of the academic journal Fisheries Research. The work presented on the role of the North Atlantic Oscillation has been submitted to be included in this special edition.

The next ICWL conference will be held in Mallorca, in October 2026 with the hope a lager continent of Europeans will be able to attend given its proximity.

ICES: WGCRAB
Bangor Hybrid Meeting 2023

The International Council for the Exploration of the Sea crab and lobster working group met in North Wales at Bangor University, School of Ocean Sciences 7th—9th November 2023

The group brings together crustacean researchers from Universities and government institutions, providing a platform to share ideas, encourage collaborative working and provide time to investigate holistic trends in catch rates and fluctuations in biomass across jurisdictions. Each member typically presents ongoing work ranging from crustacean biology, fisheries management and stock assessment techniques. Notably this year saw Marine Scotland present work on compiling unassigned landings in the southern North Sea by Scottish Vessels and the importance of accounting for this data in stock assessments. A new member from the Netherlands presented work from on-board machine learning to obtain data from lobster fisheries

Bangor University Isle of Man presented 4 key pieces of work at the meeting: 1) an overall update on current crustacean stocks in the Isle of Man enabling comparison with other fisheries; 2) The role of the North Atlantic Oscillation on brown crab abundance; 3) estimating key life history parameters in European lobster from tagging work and 4) Preliminary results from the baited underwater cameras to estimate crustacean abundance to inform stock assessment.

As part of the meeting the group discussed the ongoing project to produce a status of stocks document for brown crab. This is being led by Marine Scotland, with the aim to summarise the broad scale decline in brown crab being recorded and reported by the group. This is still in development and will be progressed over the coming year.

A hybrid in person/virtual meeting will be held at in Weymouth, England by CEFAS in November 2024.

Title: Stock assessment for whelk fisheries; evaluation of survey and statistical approaches

PhD Degree (Year 2 progress update)

Student: Matthew Garratt

Supervisors: Stuart Jenkins, Isobel Bloor and Natalie Hold

This PhD is aiming to address key knowledge gaps in relation to whelk (*Buccinum undatum*) stock assessment, with a focus on identifying reliable methods for fishery-independent surveys and obtaining abundance estimates. Significant progress was made in the second year of the project, including the development of baited remote underwater video (BRUV) units, which were then subsequently trialled alongside commercial pots in multiple locations around North Wales. The design proved to be an efficient survey method for whelk, with few other species attending the bait, and spatial patterns in abundance were detected with notable consistency across a spring-neap tidal cycle. Abundance indices from BRUVs displayed significant linear relationships with pot catch per unit effort (CPUE), and a novel method for estimating the density on the ground based on arrival times was also formulated and successfully applied.

In addition, a whelk pot sampling scheme was established on the Isle of Man with the goal of assessing the health of the fishery using length-based indicators. Commercial pots of a standardised design were sourced and provided to three different fishing vessels, with a subsample of the pots modified to try and retain smaller whelks (this involved replacing the netting on top and covering the drainage holes with plastic mesh). Sampling then began on a monthly basis, with the catch measured to determine length distributions and subsamples dissected for key biological parameters (size-at-maturity and size-at-age).
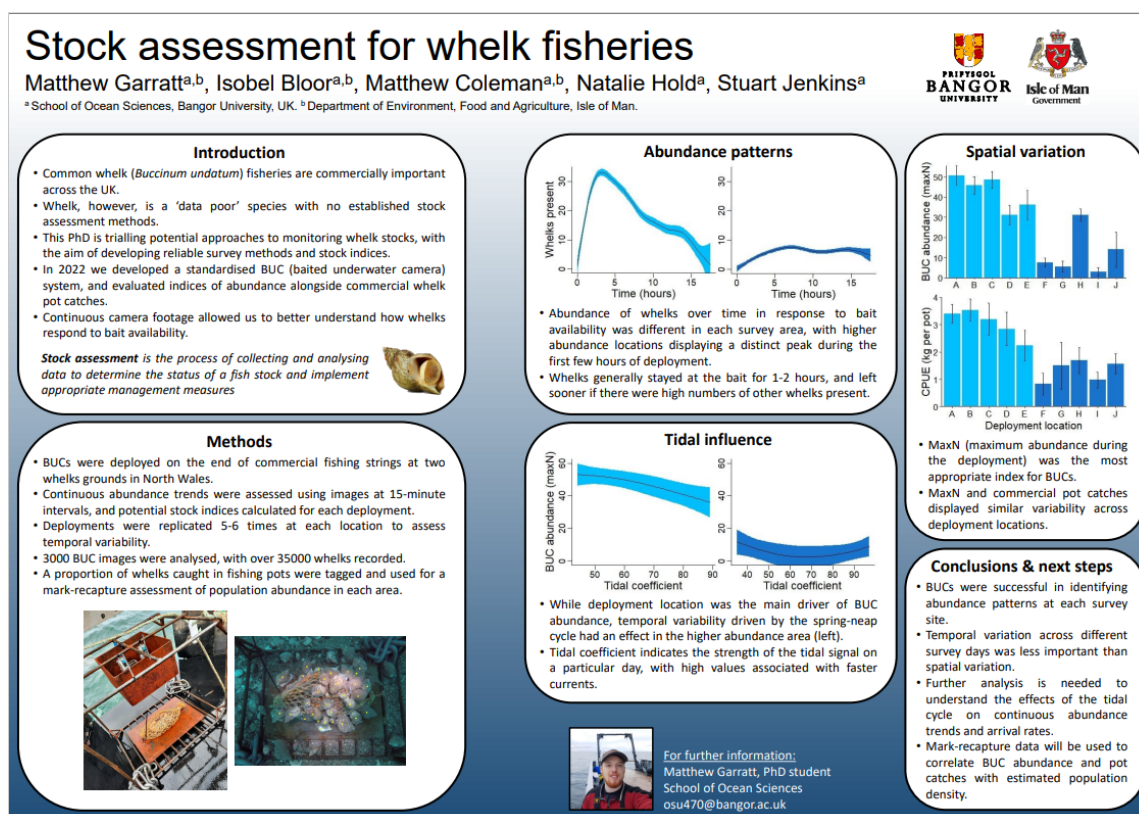

Fig 28. Year 2 PhD poster presentation presented at Bangor University (virtual presentation).

Nephrops and Blue Carbon Consultation Evidence base:

A Blue Carbon research project is investigating the importance of the area of mud habitat on the west coast of the Isle of Man for carbon uptake and storage and the impacts of any interactions with fisheries. In order to facilitate this research the Department of Environment, Food and Agriculture launched a stakeholder consultation to seek views on the introduction of new spatial management measures in part of the territorial waters of the Isle of Man within an area known as the Western Irish Sea Mud-belt (WISMB). These spatial management measures aimed to deliver co-benefits in sustainable fisheries, marine conservation and blue carbon research. The Western Irish Sea Mud-belt is of known importance for commercial shellfish species (i.e. *Nephrops norvegicus* and *Cancer pagurus)*, Vulnerable Marine Ecosystems (VMEs) (e.g. Sea pens, *Virgularia mirabilis*), burrowing megafauna and is considered at risk from fishing activity (particularly from subsurface abrasion caused by bottom-towed gear).

In the Irish Sea, *Nephrops* are mainly exploited in the waters to the west of the Isle of Man in the west Irish Sea mud-belt (WISMB) (Fig 29) which encompasses "Functional Unit 15" (FU15) which is officially delineated by ICES Statistical Rectangles 36E3, 35E4, 36E4, 37E4, 38E4 and 35E5, 36E5 and 37E5. The fishery occurs throughout the year with no major seasonality and most landings are made by vessels from Northern Ireland (5000 t per annum; 2017-2021) and the Republic of Ireland (ROI) (1500 t per annum ; 2017-2021). These landings gave a combined first-sale annual value of about £14.2 million for UK vessels in 2022.

The aims and objectives of the Department's proposal to introduce spatial management measures in the Western Irish Sea Mud Belt (Fig 30) were set out in the consultation as follows:

Objective 1: To enable Phase 1b research of the Manx Blue Carbon Project, as part of the Island's Climate Change Plan, to inform future policy and Blue Carbon Management.

Objective 2: To enable further research into the sustainable fisheries and marine conservation benefits of spatial management measures, in particular for commercial fish stocks and conservation features that are assessed as being highly depleted or in a critical status, as well as other species that are known to rely upon the WISMB for nursery grounds.

Objective 3: Encourage the establishment and development of an environmentally sustainable prawn creel fishery, to allow for the Isle of Man's additional quota to be utilised in line with the Memorandum of Understanding between the Fisheries Administrations of the United Kingdom and the Isle of Man.

To support the consultation Bangor University put together an evidence based document to look at the current fishing levels for *Nephrops* in the proposed closed areas relative to the wider fishing ground for *Nephrops* both within the Isle of Man's territorial waters and in the larger functional unit (FU15). The fishing effort exerted by the *Nephrops*-directed UK bottom-towed gear fleet inside and outside the proposed areas of interest was evaluated using data from Vessel Monitoring Systems (VMS) combined with Logbook data for the period 2012-2022. Full Analysis and results are presented within the evidence based document.
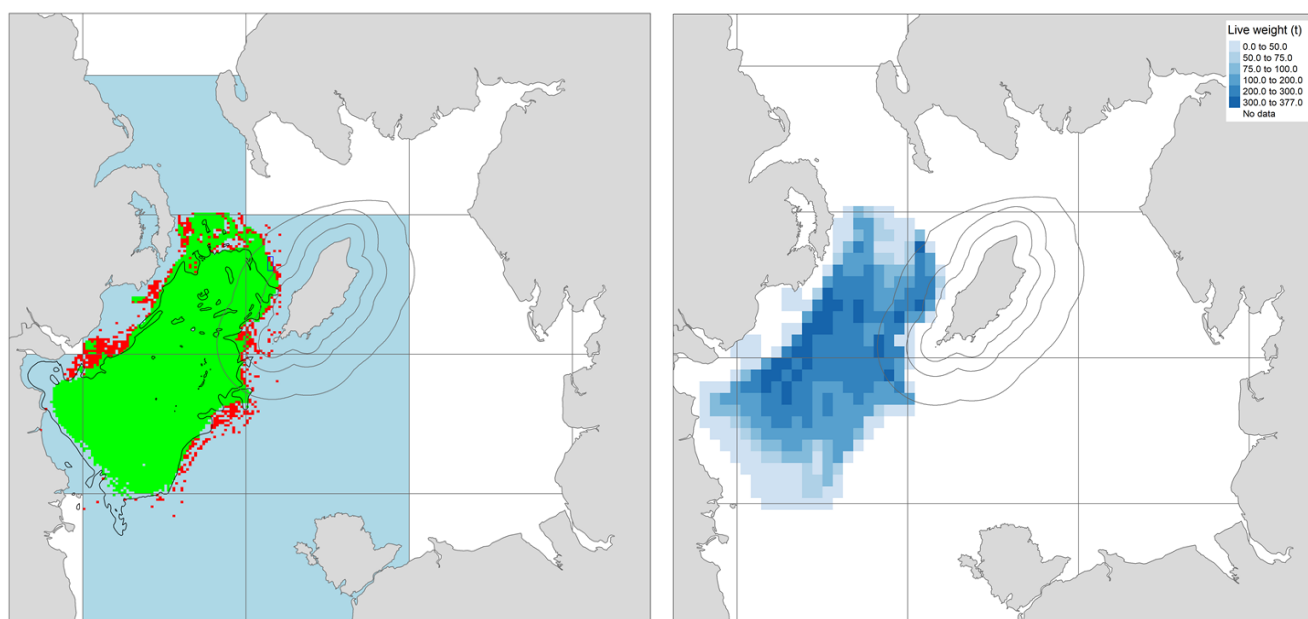
Fig 29. Maps showing: Left: Raster layer with 1km^2 cells indicating the fishery footprint (green cells) for *Nephrops* within FU15. Red cells indicate cells outside of the known *Nephrops* habitat (polygon with black outline; source: Marine Scotland 2019) with less than 6 VMS fishing pings over the period 2012-2022; Right: Raster layer showing Live Weight (t) of *Nephrops* over the period 2012-2022. The catch-and-effort data displayed here were aggregated to a grid of 0.06 longitude by 0.04 latitude (~2.2 x 2.4 nautical miles).
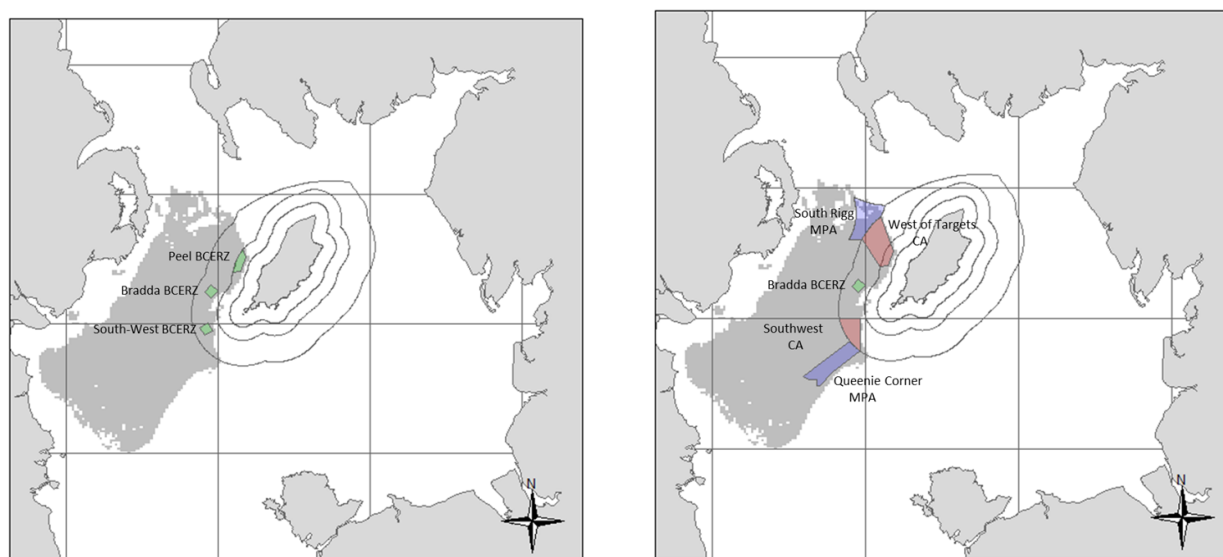

Fig 30. Maps showing: Left: Minimum spatial management measures to facilitate Blue Carbon research—three temporary Blue Carbon Experimental Research Zones; Right: Extended spatial management measures for co-benefits of Blue Carbon, *Nephrops* creel fishing and marine conservation. One temporary Experimental research zone (green) and two temporary closed areas (red). UK existing adjacent MCZs in purple.

The full report with analysis, results and discussion is available on request from **i.bloor@bangor.ac.uk** or for download at www.consult.gov.im

Bloor, I.S.M., Coleman, M. and Jenkins, S.R. (2023). Nephrops and Blue Carbon consultation evidence document. Assessment of current Norway lobster (*Nephrops norvegicus*) fishing activity within the Isle of Man territorial sea. Analysis to support the *Nephrops* and Blue Carbon consultation (2023). Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report.

Title: Risso's dolphins (*Grampus griseus)* in Isle of Man waters: Spatial and temporal distribution with links to cephalopod prey availability

Student: Leanne Rosser

Supervisors: Stuart Jenkins and Isobel Bloor

Understanding the temporal and spatial patterns of highly mobile animals, such as cetaceans, is vital for conservation and management of populations. Cetaceans lead long lives, with 39 complex behaviour, social structure, and ecology that combined with environmental variables and intrinsic factors, such as reproductive status or foraging strategies impact their distribution. Determining key areas of cetacean range and spatiotemporal behaviours can be achieved through long-term monitoring of cetacean populations and their habitat use, helping to establish the areas of critical habitat that are crucial to specific demographic processes, such as breeding, raising calves or feeding. Identifying critical habitat is not only an opportunity to further understand cetacean ecology but also key in providing evidence to ensure their protection by the establishment or better management of marine protected areas.

This study presents an overview of the spatial and temporal distribution of Risso's dolphins (*Grampus griseus*) in the Isle of Man's territorial waters, assessing the potential factors driving their distribution. Cetacean sightings data have been collected from 2006-2022 by Manx Whale and Dolphin Watch, through boat and land-based surveys as well as sightings submitted by the public (Fig 31).

Sightings predominantly occurred from March to September, beginning on the eastern side of the island (March-June) then shifting mainly to the southern part (July-Sep). As well as a shift in distribution, the summer months saw increased group sizes and higher individuals per unit of observer effort (IPUE) . Groups containing juveniles/calves were involved in resting behaviours significantly more than adult only groups.

Maxent habitat suitability models (Fig 32) and fishers' questionnaire responses for potential prey species, the long-finned squid (Loligo forbesii) and the curled octopus (*Eledone cirrhosa*), showed that better overlap existed between *E. cirrhosa* and Risso's dolphin feeding behaviours. Furthermore, preliminary identification from stomach content analyses on stranded individuals found in IoM waters confirmed octopus to be the predominant food source. Both cephalopod distribution knowledge and Risso's dolphin dietary information acquired suggests octopus, rather than squid, to be a contributing driving factor behind Risso's dolphin distribution in IoM waters.

The additional examination of marine nature reserves provides up-to-date information on how the species are using protected areas, indicating key zones. The results of both Risso's dolphin feeding and nursery groups support the hypothesis that Isle of Man waters are critical habitat for the species.
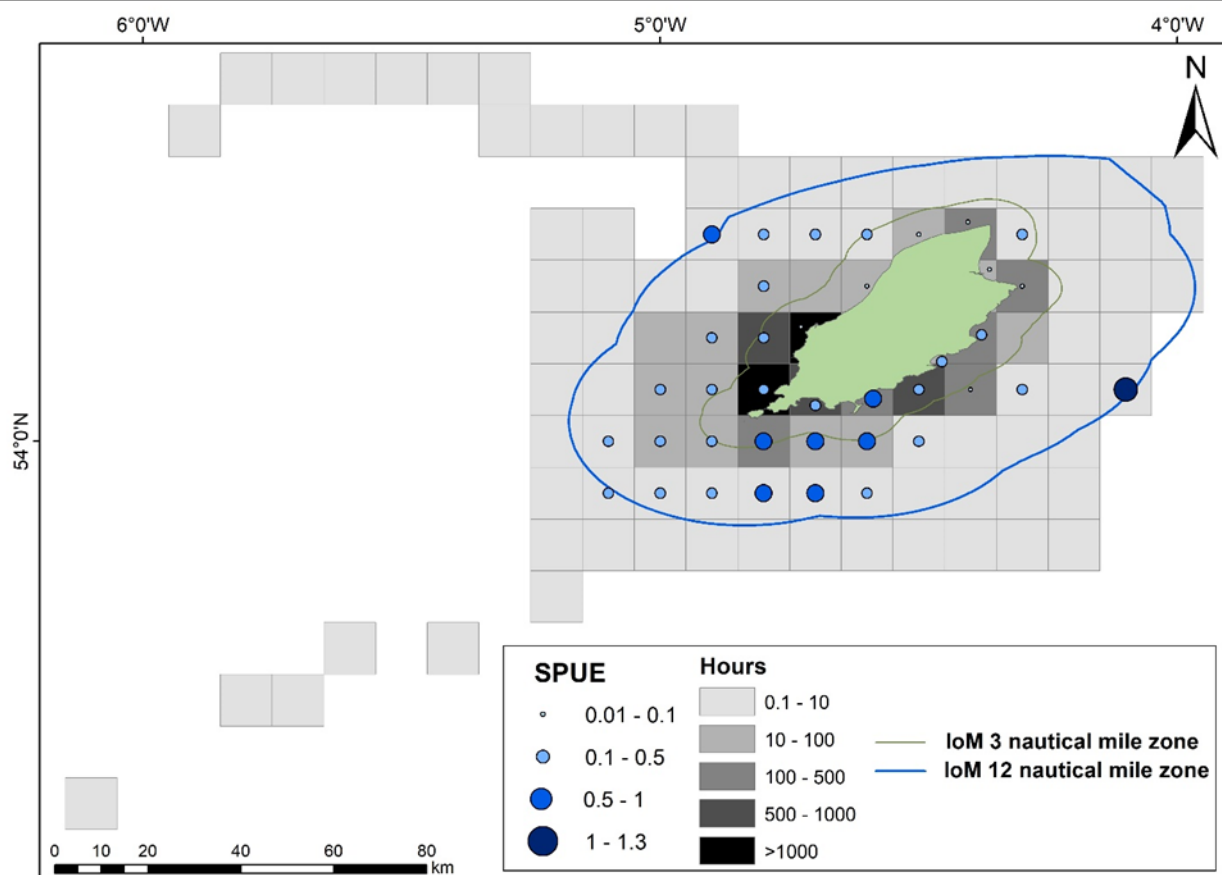
Fig 31. Map showing total effort (hours) from all boat, land and public data with sightings standardised by hour of total effort (SPUE) around the Isle of Man.

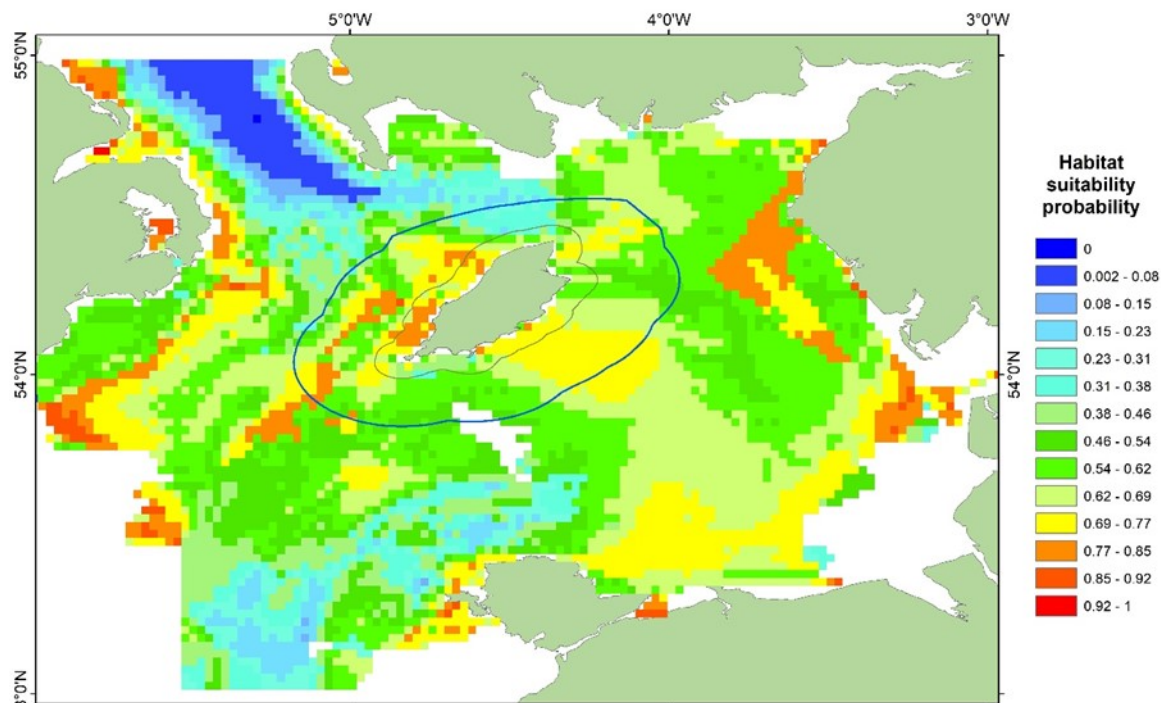Fig 32. Cloglog output maxent habitat suitability model for *E. cirrhosa*. Colours indicate modelled suitability of habitat

The full MSc thesis is also available on request from **i.bloor@bangor.ac.uk**

Rosser, L. (2023). Risso's dolphin (Grampus griseus) in Isle of Man waters: Spatial and temporal distribution with links to cephalopod prey availability. Bangor University School of Ocean Sciences, MSc Thesis. pp. 50.

Title: Assessing the Relative Benthic Status of the Isle of Man King and Queen scallop fisheries to inform ecosystem-based management.

Student: Catherine M. Wright

Supervisors: Jennifer Shepperson and Isobel Bloor

The Marine Stewardship Council (MSC) has developed a benthic impacts tool in partnership with Bangor University to assess and quantify the impact of bottom-towed fishing gear on sedimentary ecosystems (Evans *et al.,* 2020). Using data on the spatial distribution of fishing activity, and benthic habitats, this tool is able to predict and quantify the relative benthic status (RBS) and recovery trajectories of fished habitats. The tool uses the parameters: impact rate (depletion by gear), recovery rate (of species within habitat) and exposure to trawling to quantify the RBS of impacted habitats relative to an unimpacted habitat baseline. The RBS scores are then ranked from 0-1, with 0 indicating a habitat/area is totally depleted and a score of 1 not depleted. As well as RBS scores, MSC recovery scores are based on the probability that an environment will recover to 80% of its unfished value within 20 years.

The King/Queen scallop fishery in the Isle of Man is one of the largest and most commercially valuable of its kind in Europe. Both fisheries use bottom-towed fishing gear methods (trawls and dredges), which can cause environmental impacts such as physical disturbance of the seabed and the capture of non-target species .

We used the recently developed Benthic Impacts tool to quantify the impact of bottom towed scallop fishing gear on benthic habitats using quantitative RBS scores to guide management decisions (Fig 33).

The objectives were:

1) To identify the overall damage/differences caused to sediment and benthic habitats by the King and Queen scallop fishery,

2) To assess whether yearly fluctuations in the severity and spatial distribution of fishing effort have altered the RBS of habitats on a yearly basis,

3) Quantification of King and Queen fishing thresholds for individual habitats to prevent areas from falling below healthy RBS levels.

In coarse sand and very coarse sand, the King and Queen scallop fisheries were the most active, along with biotopes 6/10 (Circalittoral coarse sediment & Laminaria on gravel and pebbles) for the King fishery, 18/19 (brittlestar beds on sublittoral mixed sediments & sublittoral sands and muddy sands) for the Queen scallop fishery, and 16 (hydroids in circalittoral muddy mixed sediments) for both fisheries. Biotopes 8 and 18 (Neopentadactyla mixta in circalittoral shell gravel or coarse sand & brittlestar beds on sublittoral mixed sediments) had the lowest mean RBS scores, followed by coarse and very coarse sand. The RBS scores in biotope habitats were significantly lower, emphasizing careful consideration when choosing habitat data. All habitats passed the MSC scoring accreditation, recovering to 80% unaffected after 20 years of no fishing.

Annual variability in RBS scores showed no trend for the Queen fishery, however a general increasing trend was observed for the King fishery (2017 and 2022; Fig 34). According to the weekly average King/Queen fishing effort, most sedimentary habitats did not fall below an RBS of 0.8, but the weekly cumulative average fishing effort showed that all sedimentary habitats fell below 0.8 RBS in weeks 2- 3 of the King fishery, and in week 9 of the Queen fishery only for mud and gravel.
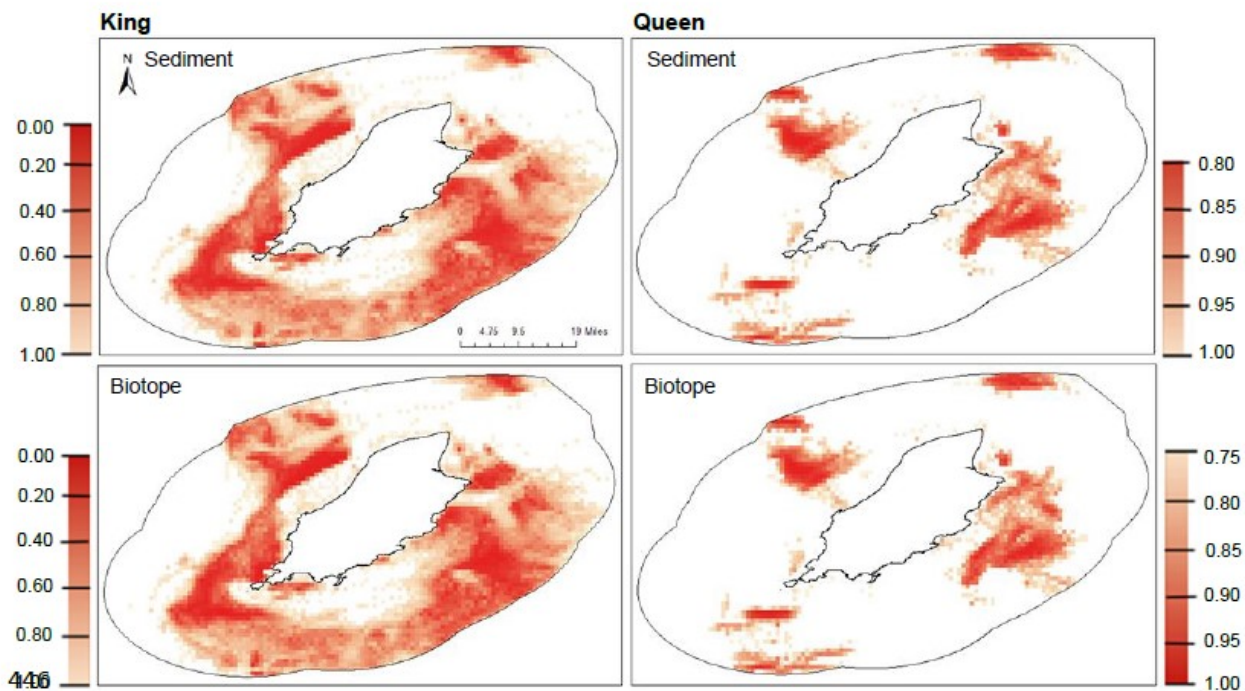
Fig 33. Map of relative benthic status (RBS) of habitats in the Isle of Man King Scallop fishery. Top Left: Sediment RBS scores from the King Fishery; Bottom Left: Biotope RBS scores from the King fishery. Top Right: Sediment RBS scores from the Queen scallop fishery; Bottom Right: Biotope RBS scores form the Queen fishery.
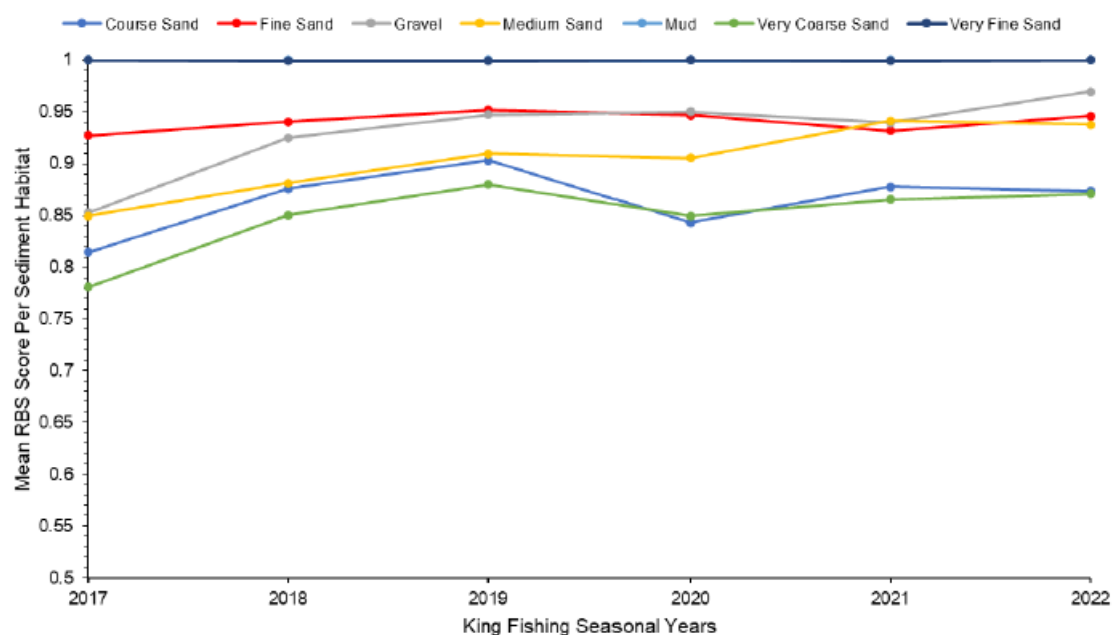

Fig 34. Annual mean sediment habitat RBS differences for the king scallop fishery

The full MSc thesis is also available on request from **i.bloor@bangor.ac.uk**

Wright, C.M. (2023). Assessing the relative benthic status of the Isle of Man king and queen scallop fisheries to inform ecosystem-based management. Bangor University School of Ocean Sciences, MSc Thesis. pp. 37.

During 2023 the Isle of Man research team (staff and students) have communicated the findings of the scientific work undertaken to interested stakeholders. These communications include advisory reports to the Isle of Man Government and during attendance at national and international committees, working groups and meetings.

Publications:

- Coleman, M.T., Garratt, M., Hold, N., Bloor, I.S., Jenkins, S.R., Porter, J.S., Tully, O. and Bell, M.C., 2023. A standardized assessment of geographic variation in size at maturity of European lobster (Homarus gammarus L.) in the North East Atlantic. ICES Journal of Marine Science, 80(4), pp.911-922.

- Hiddink, J.G., Coleman, M.T., Brouwer, S., Bloor, I.S. and Jenkins, S.R., 2024. Estimating the abundance of benthic invertebrates from trap-catch data. ICES Journal of Marine Science, 81(1), pp.86-96.

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Government Reports:

- Bloor, I.S.M., Coleman, M. and Jenkins, S.R. (2023). Isle of Man Queen Scallop: 2023 Stock Survey Report . Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report.

- Bloor, I.S.M., Coleman, M. and Jenkins, S.R. (2023). Isle of Man King Scallop 2023 Stock Survey Report. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report.

- Bloor, I.S.M., Coleman, M. and Jenkins, S.R. (2023). Nephrops and Blue Carbon consultation evidence document. Assessment of current Norway lobster (*Nephrops norvegicus*) fishing activity within the Isle of Man territorial sea. Analysis to support the *Nephrops* and Blue Carbon consultation (2023). Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report.

- Coleman, M., Bloor, I.S.M, Hiddink, J. & Jenkins, S.R. (2023). Estimating are of attraction in a Brown crab fishery using experimental potting. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report.

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Conferences & Outreach:

- ICWL: 12th International Conference and Workshop on Lobster (and Crab) Biology and Management 2023. Freemantle, Perth, Australia.

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Meetings and Committees:

- International Council for Exploration of the Seas (ICES) Working Group on Scallop Stock Assessment. Hybrid Meeting, 10th—12th October 2023, Hybrid, Norway.

- International Council for Exploration of the Seas (ICES) Workshop on Scallop Aging II (WKSA2). 7th—8th March 2023, CEFAS, Lowestoft.

- Scallop Management Board meeting, Queen Scallop Management for 2023, Thursday 15th June 2023, (King Scallop Management for 2023/2024, Thursday 28th September 2023

- Blue Carbon Steering Group Meetings 2023 attended by Dr Isobel Bloor or Dr Matthew Coleman

- International Council for Exploration of the Seas (ICES) Working Group on Crabs and Lobsters. Hybrid Meeting, 7th—9th November 2023, Hybrid, Wales.

- Seafish Crab and Whelk Management Science Group - Multiple

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Bangor University has undertaken research for the Isle of Man's Department of Environment, Food and Agriculture since 2007. The research focuses on achieving sustainable and economically viable fisheries within an ecosystem context. We are assessing scallop, crustacean and mollusc stocks and quantifying bycatch, as well as focusing on the ecosystem through habitat surveys and studies examining the impacts of different fishing gears. We also use state of the art techniques utilising fishery-dependent data to understand how the Island's scallop fisheries are exploited and how their management can be improved.

The work is funded by the Isle of Man's Department of Environment, Food and Agriculture

Professor Stuart Jenkins:

I graduated in Zoology from Cambridge University in 1990 and undertook my PhD at Port Erin Marine Laboratory between 1991 and 1995. I remained at Port Erin for a further 6 years, working first on intertidal rocky shores and then with Dr Andy Brand and colleagues at Seafish, examining the effect of scallop dredging on the wider marine ecosystem. In 2001 I moved to Plymouth to the Marine Biological Association where I developed a research group in coastal ecology and in 2007 moved to the School of Ocean Sciences, Bangor University. My research interests are varied, addressing questions in both fundamental and applied ecology. I have particular interests in recruitment dynamics, non-native species, the role of key species over large geographic scales and effective management of marine resources.

Dr Isobel Bloor:

After graduating from Queen Mary's University of London with an MSc in Marine Ecology and Environmental management, I worked as a marine ecologist at a small independent marine consultancy managing the impacts of marine related projects. I then worked on a cross-Channel EU project on cephalopod ecology and completed my PhD in conjunction with the Marine Biological Association and the Marine Institute, University of Plymouth on Cephalopod ecology, movement and behaviour. My research has been predominately fisheries and field-work based working directly with inshore potting fishermen, undertaking acoustic and data storage tagging studies and completing *in situ* scuba surveys of spawning grounds. I also have experience in developing presence-only and presence-absence species distribution models. My current role as a postdoctoral fisheries scientist on the Isle of Man involves developing and undertaking stock assessments and providing the science necessary to assist the government in managing all their commercial fisheries.

Matthew Coleman:

I am fisheries scientist focusing on the management and the interaction of biological characteristics of crustacean stocks in static gear fisheries. I gained a BSc in Zoology from the University of Exeter and a MSc Marine Biology from Bangor University. Following graduation from Bangor University I have worked as a fisheries scientist for Orkney Sustainable Fisheries in Orkney, Scotland for the past 7 years. During my time in Orkney, I undertook a part-time industry funded PhD with Heriot-Watt University focusing on addressing key knowledge gaps on reproductive biology of the European lobster and their incorporation in sustainable regional management, working collaboratively with other researchers from France to Norway. My current role on the Isle of Man focuses on the static gear fisheries providing scientific advice for sustainable management of crab, lobster, and whelk fisheries.
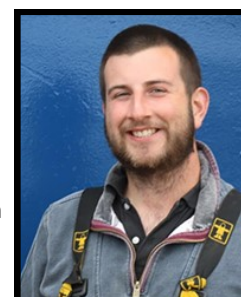
Matthew Garratt:

I graduated from Bangor University in 2017 with a BSc in Ocean Science before completing an MSc in Marine Environmental Protection the following year. I then began a 3-month work placement on the Isle of Man based at DEFA as a research assistant for Bangor University. Following this period I was contracted by DEFA to continue this work part-time, and have been tasked with a variety of projects, including benthic habitat mapping, closed area assessments and lobster size-at-maturity analysis. I have also assisted on a number of offshore surveys, including the annual Prince Madog cruise. In April 2021 I began a PhD with Bangor University focusing on whelk biology and fisheries management in the Isle of Man.