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Annual Fisheries Science Report

2022

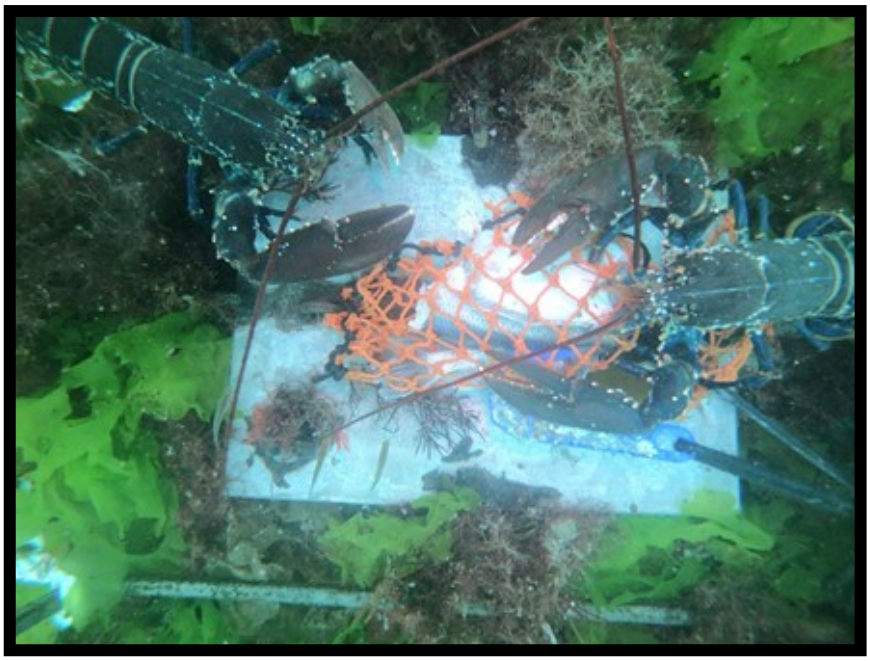
Sustainable Fisheries and Aquaculture Group

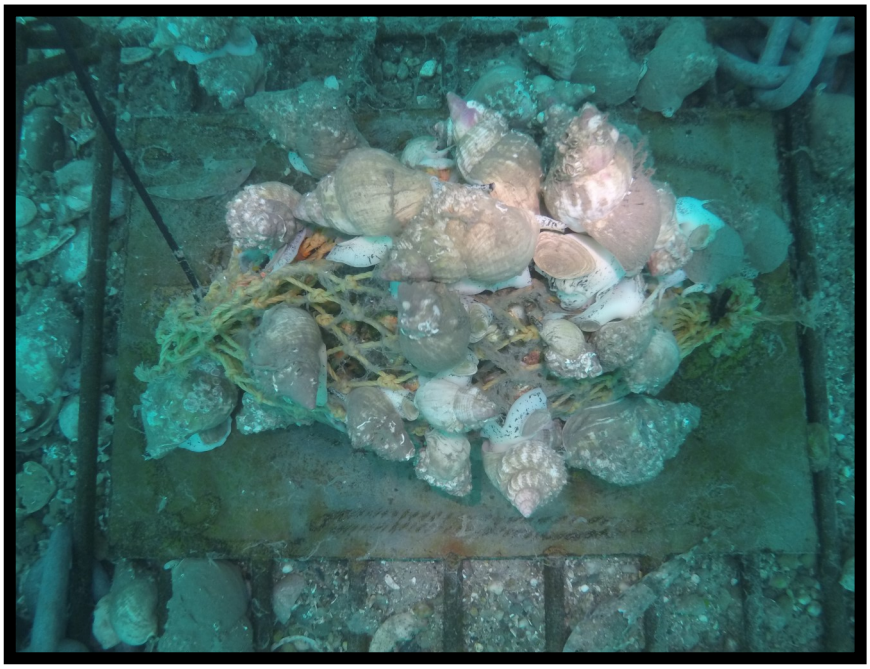
School of Ocean Sciences

Annual Report for 2022
(Report No. 8)

Isle of Man Fisheries Science

Sustainable Fisheries and Aquaculture Group
Bangor University





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Isle of Man Government
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Review of 2022 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.

2022 has seen the Isle of Man based team of Dr Isobel Bloor, Dr Matthew Coleman and Matthew Garratt effectively implement regular reporting to DEFA combined with investigation of novel assessment techniques to advance our ability to provide sound management advice. Novel approaches investigated during 2022 include the use of video as a stock assessment technique for lobster and whelk, and an investigation utilising variable pot spacing to assess the effective trapping area of pots for brown crab. Regular reporting on scallop stocks has been a feature of our work for many years. The combination of our Prince Madog scallop survey with the high-resolution industry survey is now well established. This, combined with regular weekly collation of scallop effort and landings and weekly SMB meetings allows important oversight of the king and queen scallop fisheries in real time. 2022 also saw preparations for the formal initiation of iVMS on the static gear fleet in early 2023. This important development will finally see us able to utilise spatially explicit data on crab, lobster and whelk in reporting to DEFA, bringing essential insight into these fisheries.

One of the important outcomes of the work of Bangor University with DEFA and industry over the past 10 years has been the positive way in which management of Manx fisheries is viewed by other jurisdictions in the UK and further afield. Part of this outward projection of the work undertaken on the island is achieved through the membership by Bangor University staff of ICES (International Council for the Exploration of the Sea) working groups on scallops (WGScallop) and crabs (WGCrab). Dr Isobel Bloor has recently been appointed co-Chair of WGScallop, reflecting her expertise and experience in scallop assessment and management. One part of her work with this group recognises the interconnected nature of scallop stocks across the Irish Sea. Collation of data from Ireland, Scotland, England and the Isle of Man is progressing to enable a stock assessment at the scale of the Irish Sea. This work will not only inform our own management regime but also that of neighbouring jurisdictions, helping facilitate sustainable levels of fishing across the Irish Sea.

In the WGCrab group Dr Matthew Coleman has been collaborating on work to understand how global climatic signatures such as the North Atlantic Oscillation (NAO) may be influencing brown crab abundance. A key part of our work is assembling long term datasets on stock health. It is vital in using such data to inform management that we understand not just local factors affecting stock such as fishing mortality, but also factors external to the Isle of Man. Matt has also been co-leading work to look at different assessment models for crab and lobster .

Other work to highlight during the year has Matthew Garratt's PhD investigations of the use of Baited Remote Underwater Video (BRUV) as a potential survey method for whelk. Here we benefited from the ability to collaborate with research projects undertaken by Bangor's Welsh fisheries team. Matt undertook trials of BRUVs in collaboration with a Welsh mark-recapture study which aimed to assess absolute levels of whelk abundance on the seabed. Matt's research is determining whether video can be a useful stock assessment method as well as adding to our understanding of the interaction of whelk with baited pots under different tidal conditions.

We look forward to 2023 with standard scallop reporting systems in place, and the potential to take a step change in our reporting on crab, lobster and whelk, both through the introduction of iVMS and related analytical options it gives us, and a range of developing novel approaches.

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Annual scallop surveys (2022)

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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 47 stations (fixed locations) between 2nd and 10th April 2022 (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).

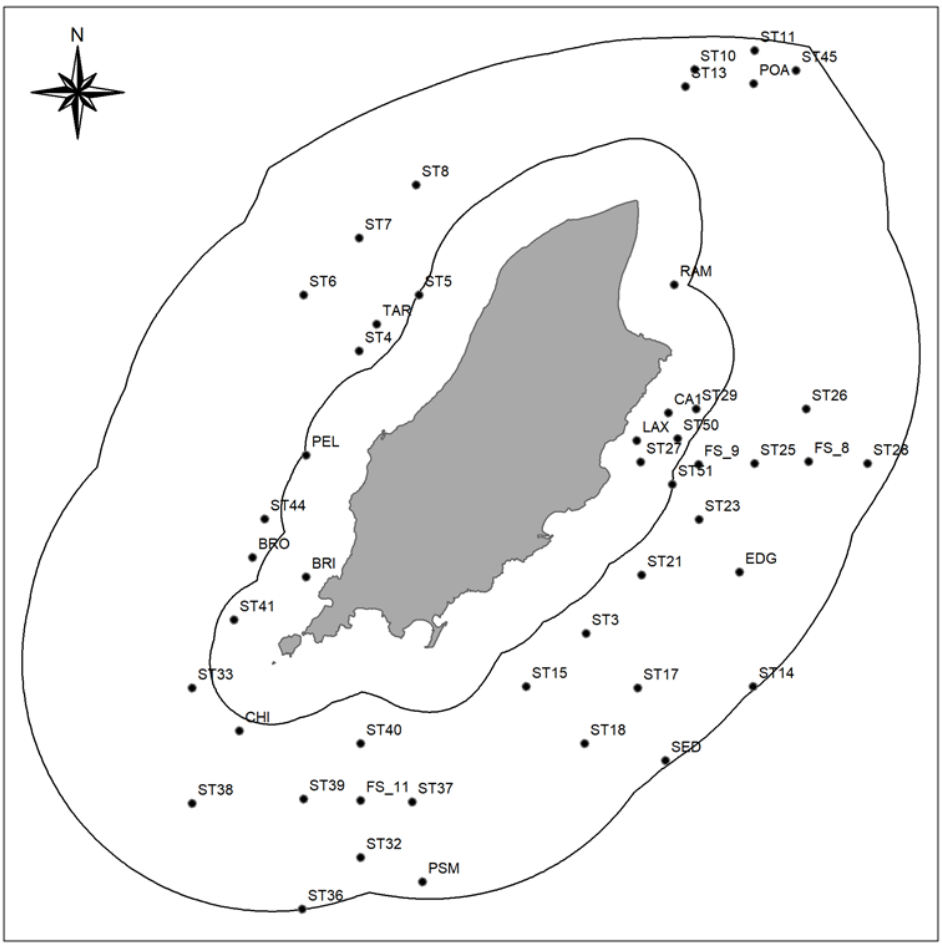


Figure 1: A map showing the location of fixed stations surveyed by the R.V. Prince Madog in 2022.

The F.V. Benolas and F.V. Sarah Lena surveyed 204 stratified random survey cells between 10th and 19th April 2022 [≈ 15 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.

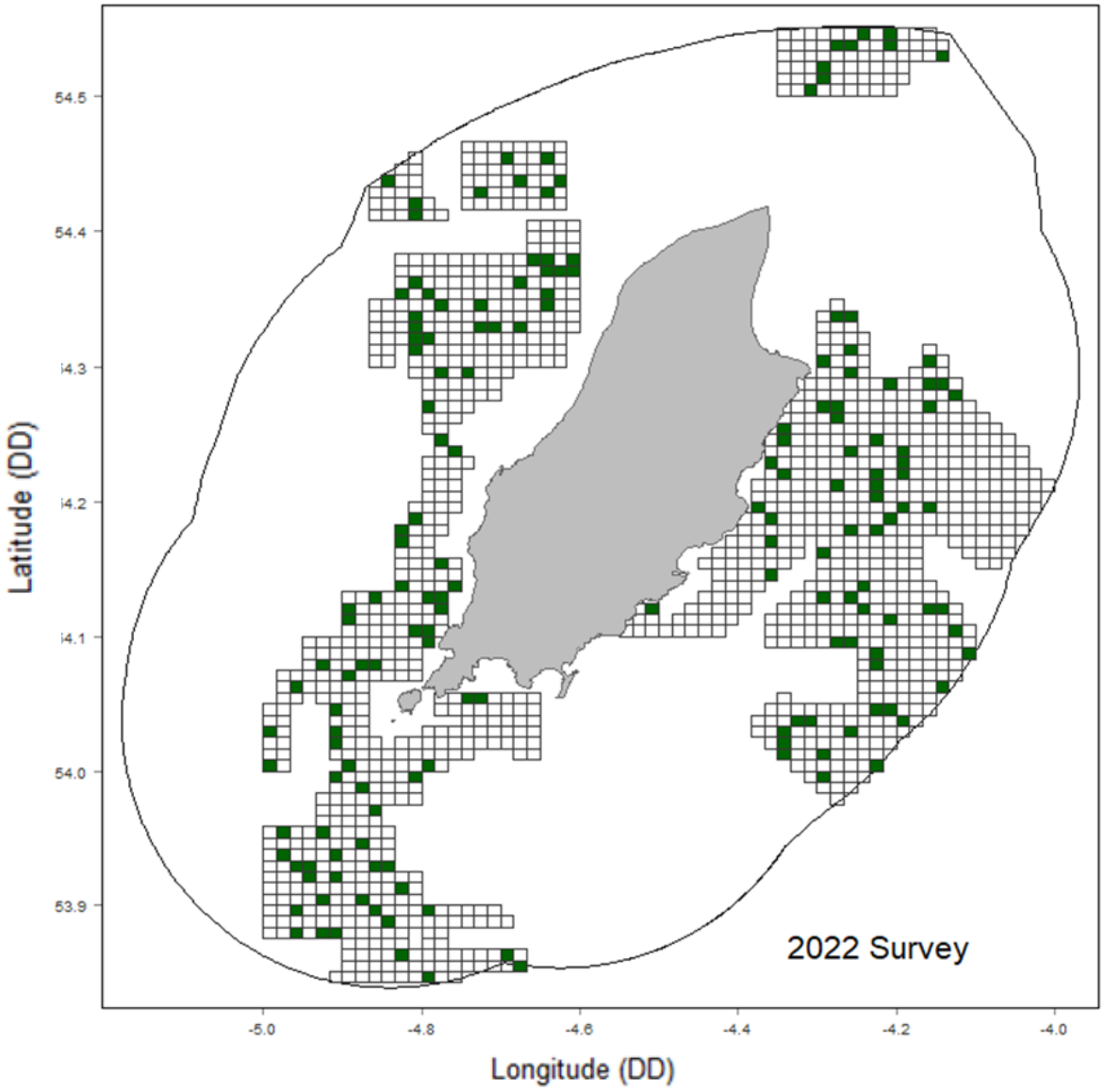


Figure 2: A map showing the survey grid for the fine-scale random stratified scallop survey undertaken by industry vessels. Green cells show the locations of randomly selected cells for surveying in 2022.

Long-term, Coarse-Scale Survey 2022: 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 two survey sites with the highest densities are ST6 (west coast; 192 queen scallops per 100m^2) and POA (north coast; 49 queen scallops per 100m^2). ST6 is located within a current restricted access area.

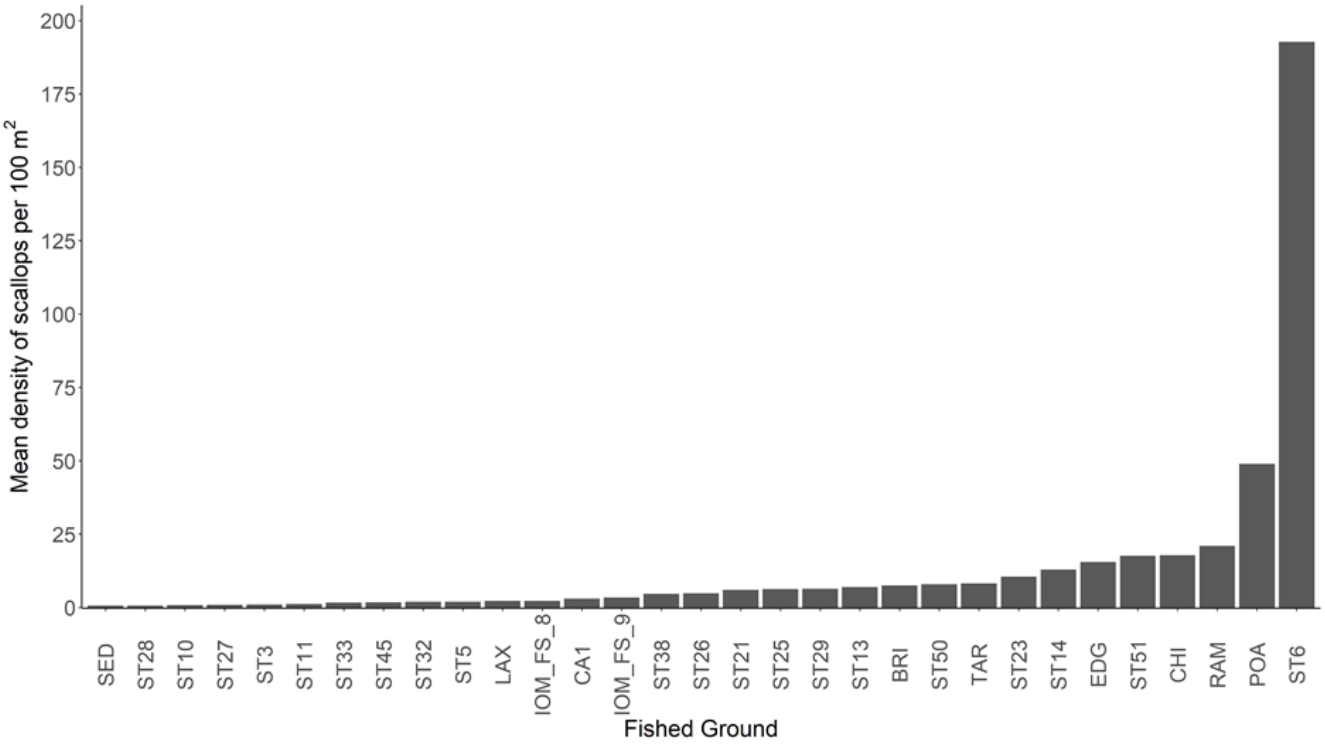


Figure 3: Average survey density (scallops per 100m^2) of queen Scallops from queen scallop dredges from all sites surveyed during the 2022 Prince Madog survey. For plotting purposes sites where QSC density was > 0.45 scallops per 100 m^2 are not displayed.

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 2022 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 2022 (91.7) is the highest recorded for recruits since 2009 (Figure 4) and is above the long-term mean of 79.4. The highest density of recruits is at a single station on the west coast (ST6) and is mixed with high densities of post-recruits.

The abundance index for post-recruits (scallops ≥ 55 mm) had an increasing trend from 2007 to 2010, reaching the highest levels on record in 2010. From 2012 to 2019 there has been a declining trend in post-recruit abundance (slight increase observed in 2016). The data for 2022 (132.9), although still well below the long-term mean (~399), is the highest recorded for post-recruits since 2017 (Figure 5).

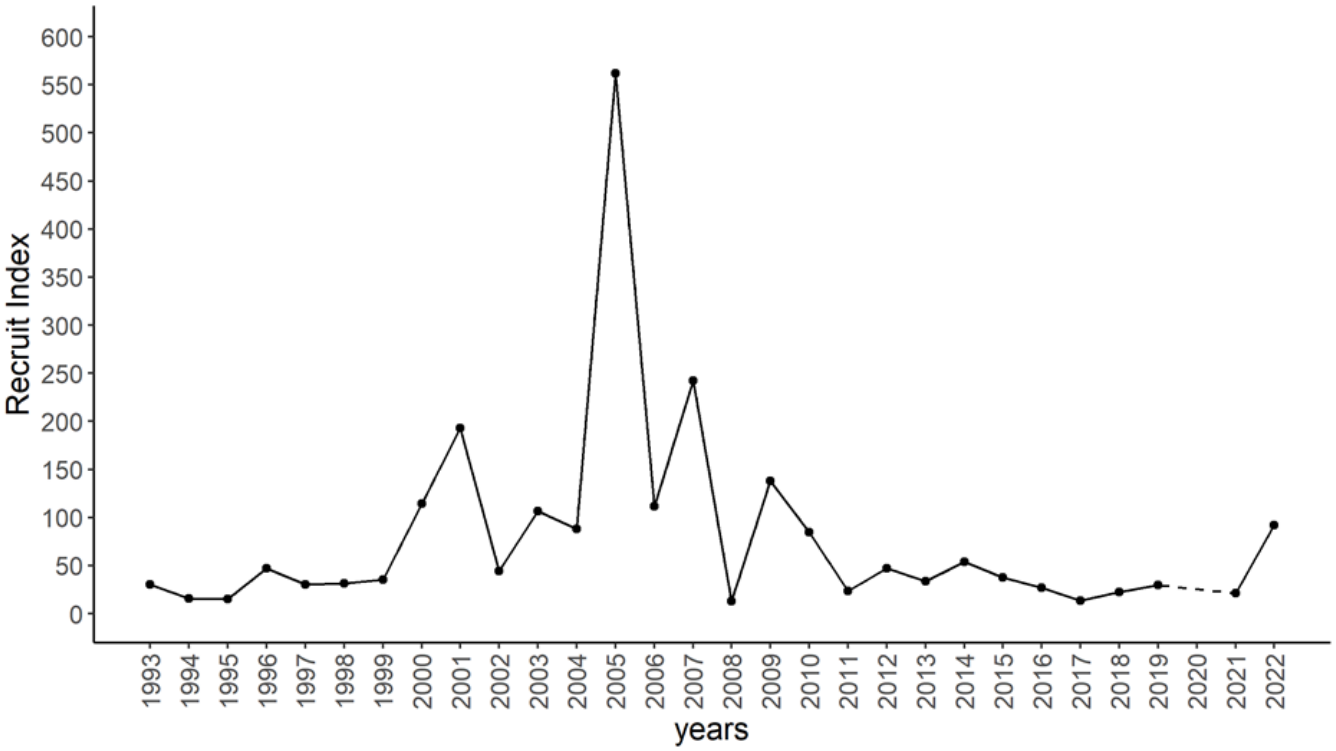


Figure 4 Abundance index (based on geometric mean) for recruits (under 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account for 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.

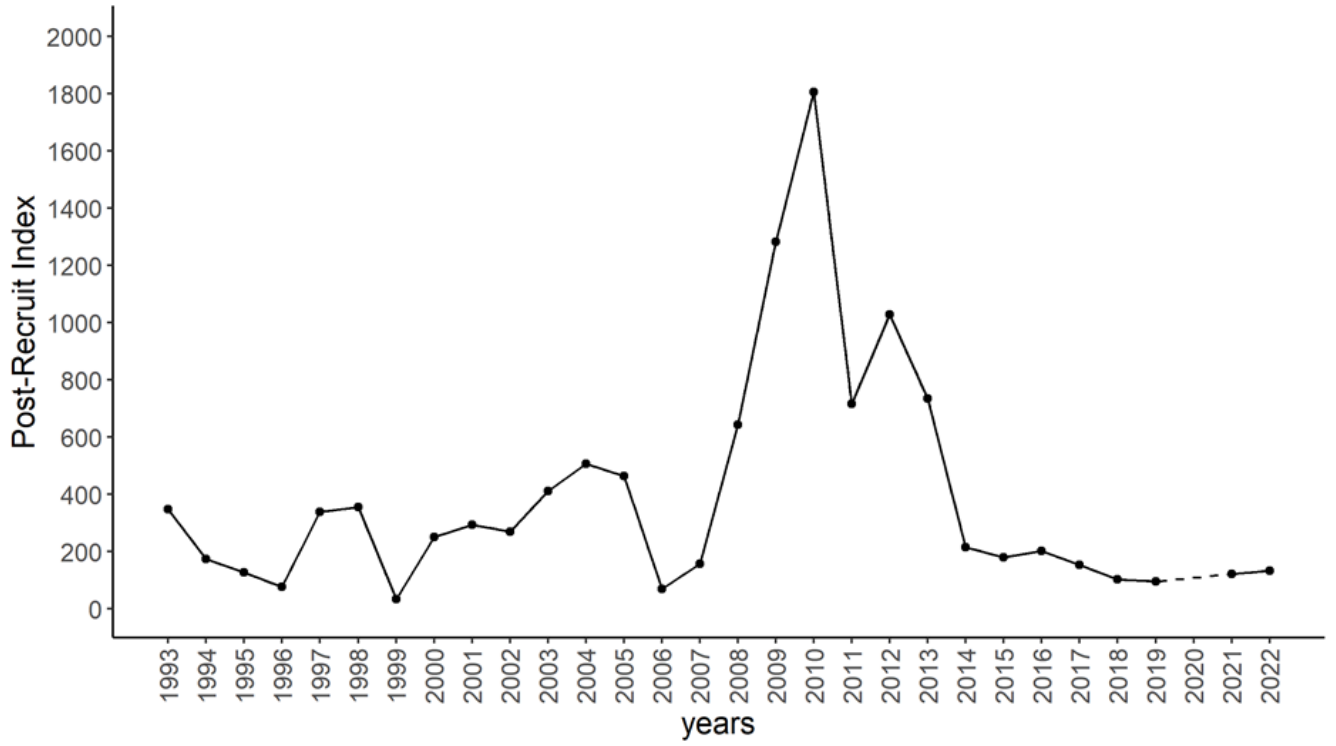


Figure 5 Abundance index (based on geometric mean) for post-recruits (over 55 mm) used in the catch survey analysis model. This is calculated using data from only the stations used in the stock assessment model. In order to calculate the geometric mean 0.01 was added to each site in order to account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

Long-term, coarse-scale Survey 2022: 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 4 years (2019 – 2022) (2022: median estimated biomass of 3322 t) *Note, that there is a missing year of survey data for 2020 in the input data.* The median biomass across the whole time series is 5568 t. Despite annual increases over the last four years biomass remains below that level.

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.

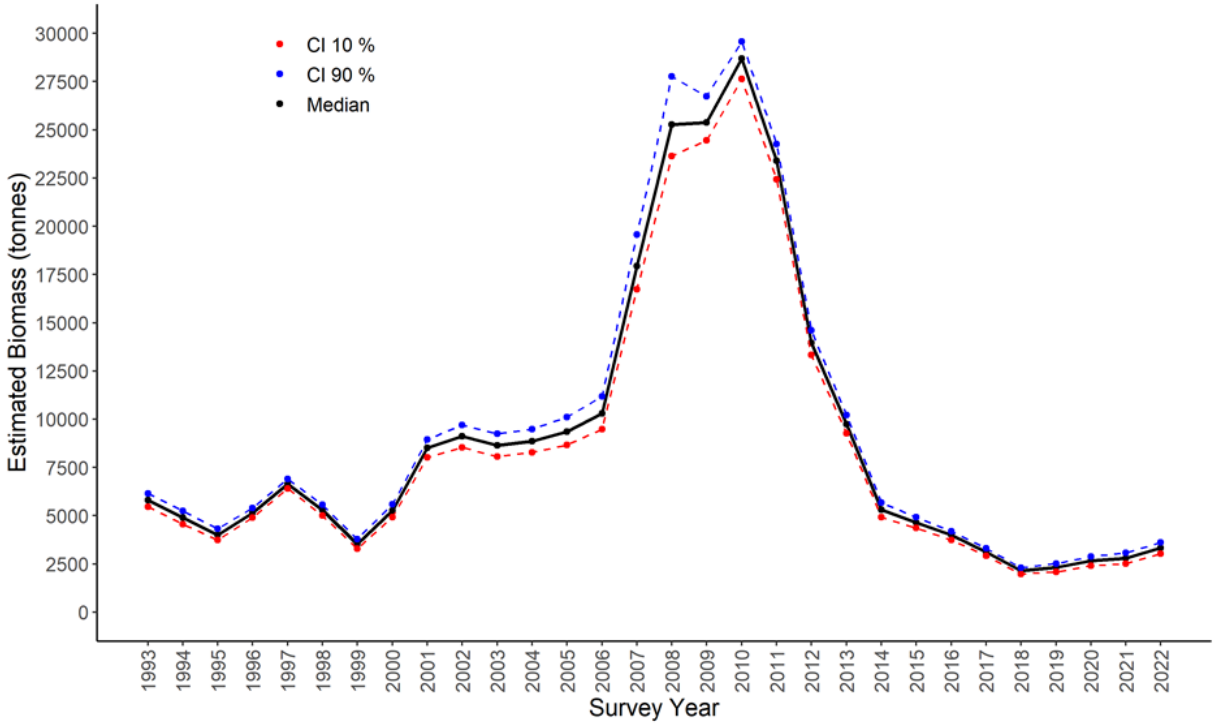


Figure 6. Estimated biomass for the stock assessment unit (Isle of Man territorial waters) MCMC results

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. (2022). Isle of Man Queen Scallop: 2022 Stock Survey Report . Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report. pp. 39.

Short-term, fine-scale survey 2022: 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.

The overall data for the TS (EDG, TAR and CHI combined; see Figure 7 for survey results) indicates that the survey index has increased for recruits (under 55 mm) **from 0.11 in 2021 to 0.14 in 2022**. At TAR there was a large increase in the recruit survey index from 0.36 in 2021 to 1.16 in 2022 and this was the predominant driver of the increase in the general recruit index. POA was the only other ground where the recruit index increased: from 0.77 in 2020 to 0.80 in 2022 (no survey data in 2021). The remaining three grounds (CHI, EDG and BRA) all recorded declines in the recruit survey index from 2021 to 2022.

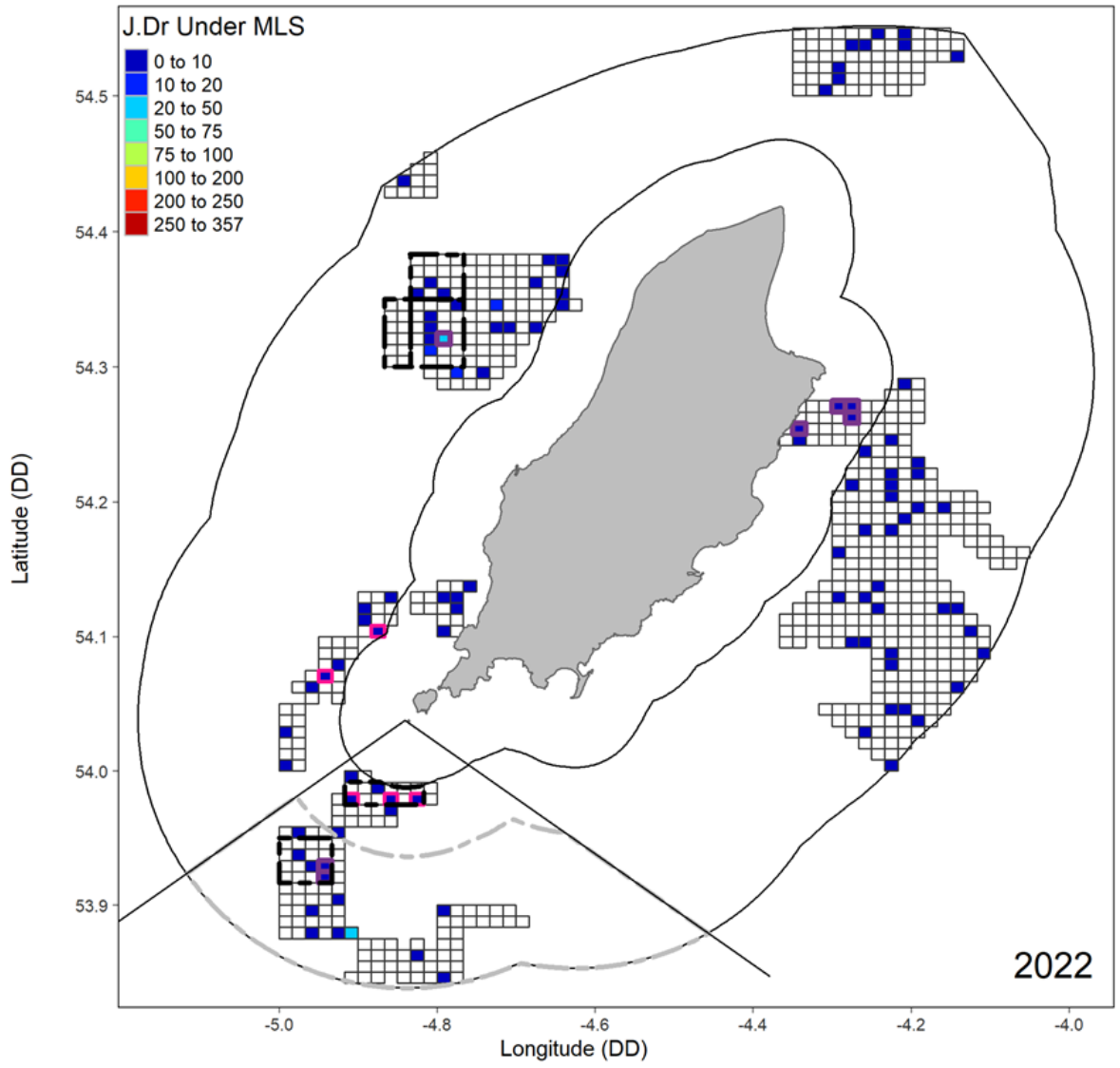


Figure 7. Map illustrating the survey densities for queen scallops under MLS from juvenile dredges for 2022. The pink cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis. In 2022, the purple cell borders indicate cells where size data was not collected due to faults with the electronic measuring boards and so are split into under and over MLS based on an average for all other cells surveyed at that ground. The black dashed boxes indicate closed or managed areas for the 2021 queen scallop fishery and the 2021/2022 king scallop fishery. The grey dashed line and solid black lines indicate the queen scallop dredge zone.

Short-term, fine-scale survey 2022: Queen scallops Cont...

The overall data for the TS (EDG, TAR and CHI combined; see Figure 8) indicates that the survey index has decreased for post-recruits (over 55 mm) from **1.84 in 2021 to 1.52 in 2022.**

For TAR, which supported the 2nd largest quantity of landings from 2021 (264.6 t), the survey index for the whole ground has increased for post-recruits (over 55 mm) from **4.84 in 2021 to 8.35 in 2022.** For CHI, which supported the largest landings in 2020 (517.9 t), the survey index has increased slightly for post-recruits (over 55 mm) from **0.63 in 2021 to 0.70 in 2022.** For EDG, which had landings of only 16.7 t during the 2021 fishing season, and a section of which was closed to fishing before the end of the season, the post-recruit index declined from **1.89 for 2021 to 0.74 for 2022**. For POA, which has not had any quantity of recent fishing activity (0 t in 2021) for queen scallops, there was a decrease in the post-recruit index from 4.59 in 2020 to 1.72 in 2022. For BRA, which has not had any quantity of recent fishing activity (less than 1.5 t in 2021) for queen scallops, there was a decrease in the post-recruit index from 2.25 in 2021 to 0.10 in 2022.

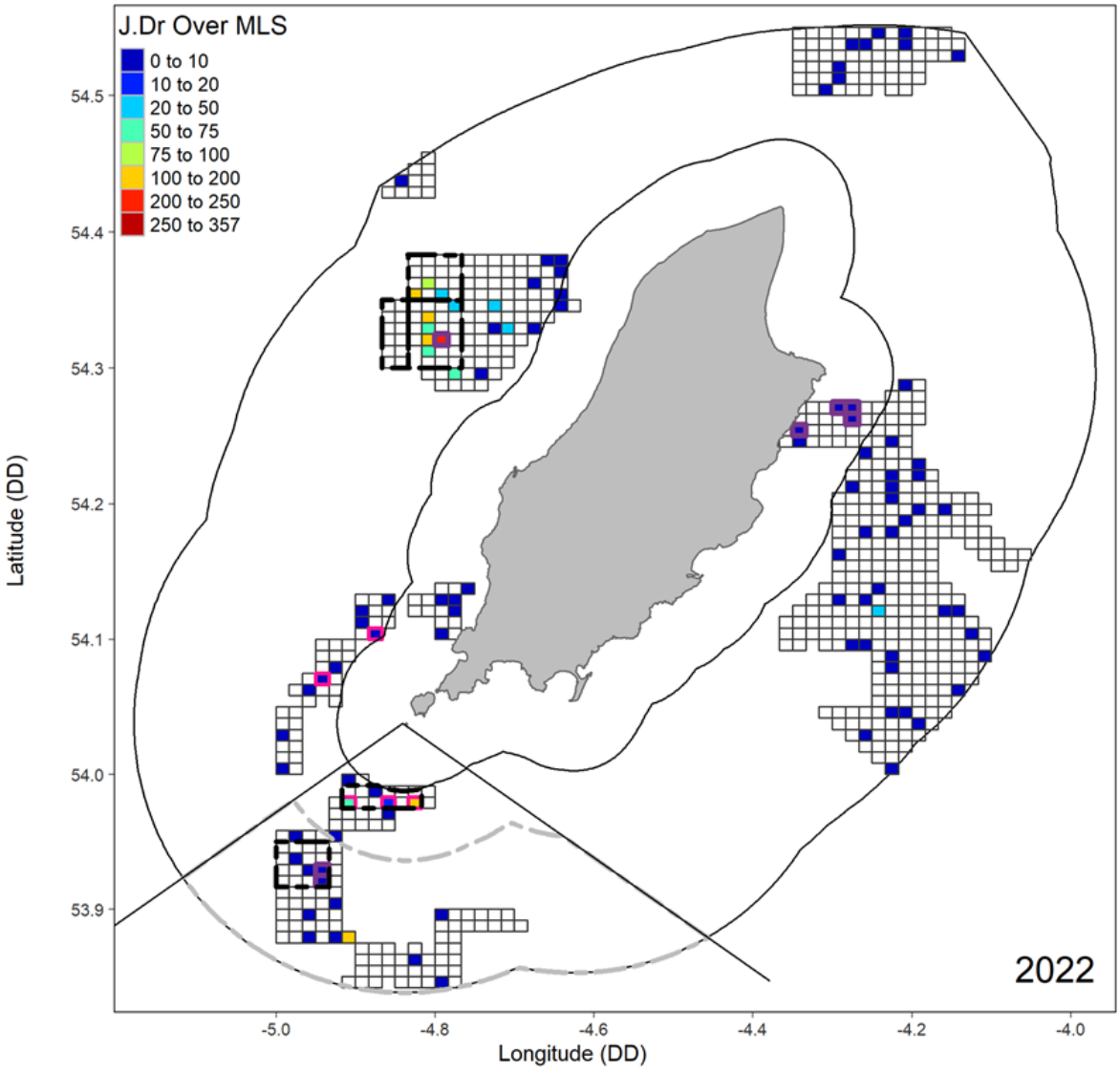


Figure 8 Maps illustrating the survey densities for queen scallops over MLS from juvenile dredges 2022. The pink cell borders indicate cells that were part of an additional targeted survey and are not included in the main analysis. In 2022, the purple cell borders indicate cells where size data was not collected due to faults with the electronic measuring boards and so are split into under and over MLS based on an average for all other cells surveyed at that ground. The black dashed boxes indicate closed or managed areas for the 2021 queen scallop fishery and the 2021/2022 king scallop fishery. The grey dashed line and solid black lines indicate the queen scallop dredge zone.

Queen Scallop Survey Summary 2022

Summary of survey findings

At the territorial sea level the coarse-scale survey shows an increase in both the recruit (under 55 mm) and post-recruit (over 55 mm) indices whilst the fine-scale survey indicates a slight increase in recruits but a slight decrease for post-recruits at the territorial sea scale (i.e. using data from EDG, TAR and CHI which are the only grounds which have been surveyed continuously since 2019). The numbers and size ranges of recruits detected in the coarse-scale survey were higher than in the fine-scale survey which uses targeted juvenile dredges, this may indicate a patchy distribution of recruitment not consistently observed between the two surveys.

TAR: Both surveys show similar spatial trends for high density areas with a high density hotspot identified at the Targets (TAR) fishing ground on the west of the island. High proportions of fishable sized queen scallops were recorded here. The fine-scale survey indicates that the hotspot covers a large area through both the current restricted, and the northern closed area.

CHI: Both surveys indicated that the Chickens (CHI) fishing ground in the south of the island had significant declines in the post-recruit survey index within the current restricted area following relatively high fishing pressure and landings (~ 483 t).

POA: The coarse-scale survey indicated good densities at stations in the North of the Island (Point of Ayre; POA) which weren't picked up in the fine-scale survey and may therefore indicate localised and patchy densities within the ground.

EDG: At East of Douglas (EDG) which is on the east coast of the Island the fishing ground was partially shut during both the 2020 and 2021 fishing seasons due to low commercial LPUE. Both surveys also indicate relatively low recruit and post-recruit values for the 2022 surveys within this ground.

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).

Improvements have been seen in queen scallop densities within the EDGERA since its closure in July 2017 from data collected as part of a separate monitoring survey (Bloor et al., 2022).

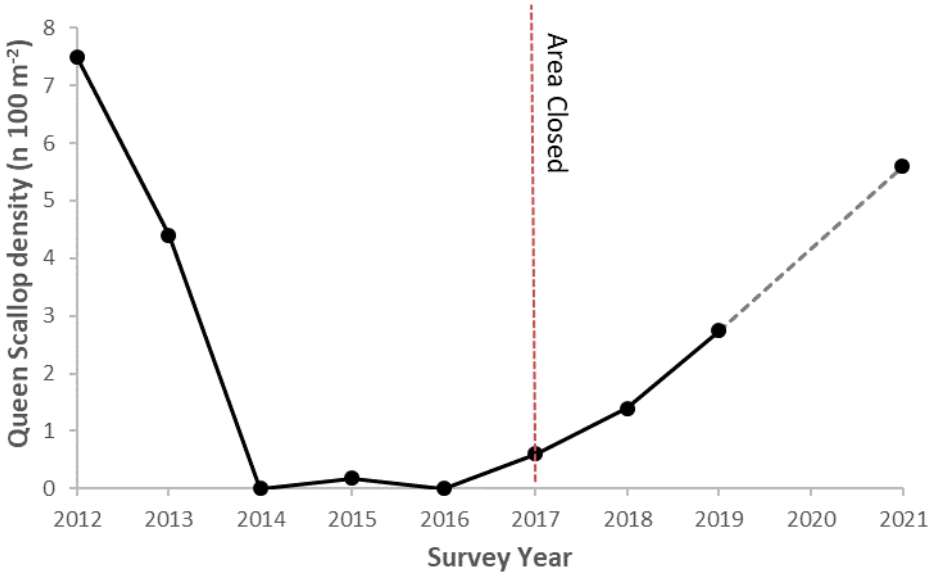


Figure 8a Queen scallop. Mean density (QSC per 100m^2) in EDG ERA from dredge surveys (queen scallops from queen scallop dredges) Source: Prince Madog stock assessment Station 29.

Queen Scallop Stock Advice Summary 2022

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

- Whilst at the territorial sea level the long-term, coarse-scale survey indicated a slight increase in post-recruit biomass (queen scallops over MLS) the short-term, fine-scale survey showed a slight decrease. As such, a precautionary management approach should be considered.
- The ICES Category 3 approach estimates a trawl TAC increase of 20% compared to the 2021 fishing season. However, it should be noted this increase is largely driven by increases in the scientific recruit index (i.e. below 55 mm), that there was a slight decrease in post-recruits in the overall industry survey index and that there are multiple values for the 2021 TAC that could be used as the starting point (i.e. starting TAC, end of season TAC, actual landings). For these reasons it is recommended that any uplift at the start of the season should be carefully considered and that any TAC set at the start of the season should remain flexible and adaptive to the in-season commercial data.
- Separate management for high density hotspots should be considered (i.e. restricted access and management of the high density fishing area at Targets for the 2022 fishing season). This high density area includes the current restricted area and the current closed area to its north (but does not include the current closure to the west of the restricted area situated in a muddy habitat). A days at sea regime and a daily catch limit for the high density area at TAR (outside of the weekly catch limit for the rest of the territorial sea) should be considered. Monitoring of LPUE and fishing intensity (swept area) is also required to ensure that overfishing of these spatially discrete areas does not occur which could lead to negative impacts for future fishing seasons. Separate LPUE thresholds for hotspot areas should be considered.
- Regular monitoring and triggered reviews of all fishing areas throughout the fishing season in terms of LPUE thresholds and total catch.
- The implementation of temporary closed areas for queen scallop in areas of high densities of recruits identified in the surveys. For 2022 this includes a patch of sites on the east coast where high proportions of under MLS queen scallops were identified in the scientific survey (i.e. EDG, ST21 and ST23). In season monitoring of commercial catch in these areas could determine whether an in season closure is useful in this area. In addition, consideration should be given to the continued closure of the current two closures at TAR and CHI situated in muddy habitats.
- Opening of the EDG ERA: The EDG ERA was closed in July 2017 to monitor natural recovery of queen scallop densities within the area. This monitoring has now concluded (improved densities of queen scallops have been recorded although the densities are not sufficiently high to be considered hotspots). Although this area is not considered high density, whether any managed opening of this area is required should be discussed by the SMB.
- Discussion of the dredge box and dredge fishery: LPUE from dredge vessels within the dredge box has been declining annually since 2014 with the lowest value recorded in 2020 and only 1 of the 5 licenced vessels fishing in 2020 (~ 250 kg) and no dredge fishing occurring in 2021. The current survey data in the dredge box continues to indicate low densities across the area (except for one survey cell for post-recruits). Given the annual decreases in commercial LPUE for the dredge metier from 2014 to 2020 and the lack of any fishing in 2021 combined with no significant improvements in survey data for the dredge zone it is recommended that the current dredge TAC is not increased for the 2022 fishing season.

Queen Scallop Trawl Fishery Update (2022)

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 trawl fishery had an initial starting TAC of 952 t (20% increase on the 2021 harvest quantity). A 10% uplift of the TAC was then approved in Week 14 of the fishery to enable the season to extend into October for socio-economic purposes (increased to 1047 t). The fishery opened on 1st July 2022 and closed on 31st October 2022. In contrast to previous seasons fishing was permitted on a Sunday during the 2022 fishery (i.e. fishing is allowed 06:00 to 18:00 Sunday to Friday to allow for fresh product to be available for shipping at the start of the week (fishing on a Saturday is still prohibited). For the trawl fishery, a weekly catch limit (WCL) of 4550 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 ~ 888.26 t (i.e. under the starting TAC) with 23 unique vessels (out of 38 licenced QSC trawl vessels) reporting landings from 439 fishing trips. The majority of landings came from Targets (799.6 t; Table 1) with Point of Ayre supporting the second highest landings (53.06 t) following the implementation of an additional "exploratory" fishing WCL. For 2022 there were no additional trawl landings from the Ramsey Bay permit only fishery which operates under a separate TAC (i.e. 0 t landed) and the dredge fishery, which is open in October within the dredge zone, at Chickens, also reported no landings (i.e. 0 t).

The SMB recommended that the restricted area at Targets remain in place for the start of the 2022 fishing season with fishing restricted to one day per vessel per week. In August the SMB recommended an increase to two fishing days per vessel per week within the TAR RA.

Table 1: Landings by ground for the 2022 queen scallop fishery (trawl and dredge)

Area	Landings (t)
IS9: Targets	799.6
IS6: Point of Ayre	53.06
IS15: East Douglas	13.25
IS10: Maughold	12.2
IS21: Chickens	10.75

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 ~ 8 – 15 for TAR). The mean weekly LPUE for all other grounds (POA, CHI, EDG, and MGH) was typically below 8 bags (35 kg) per hour fished per 10 fathom of net, with EDG and MGH both below 4 (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 2021 in Figure 10. The boxplot indicates that the median LPUE for the 2022 fishery was the third highest in the nine year time series with 2015 and 2021 the first and second highest respectively (Figure 10).

Queen Scallop Trawl Fishery Update (2022) (Cont…)

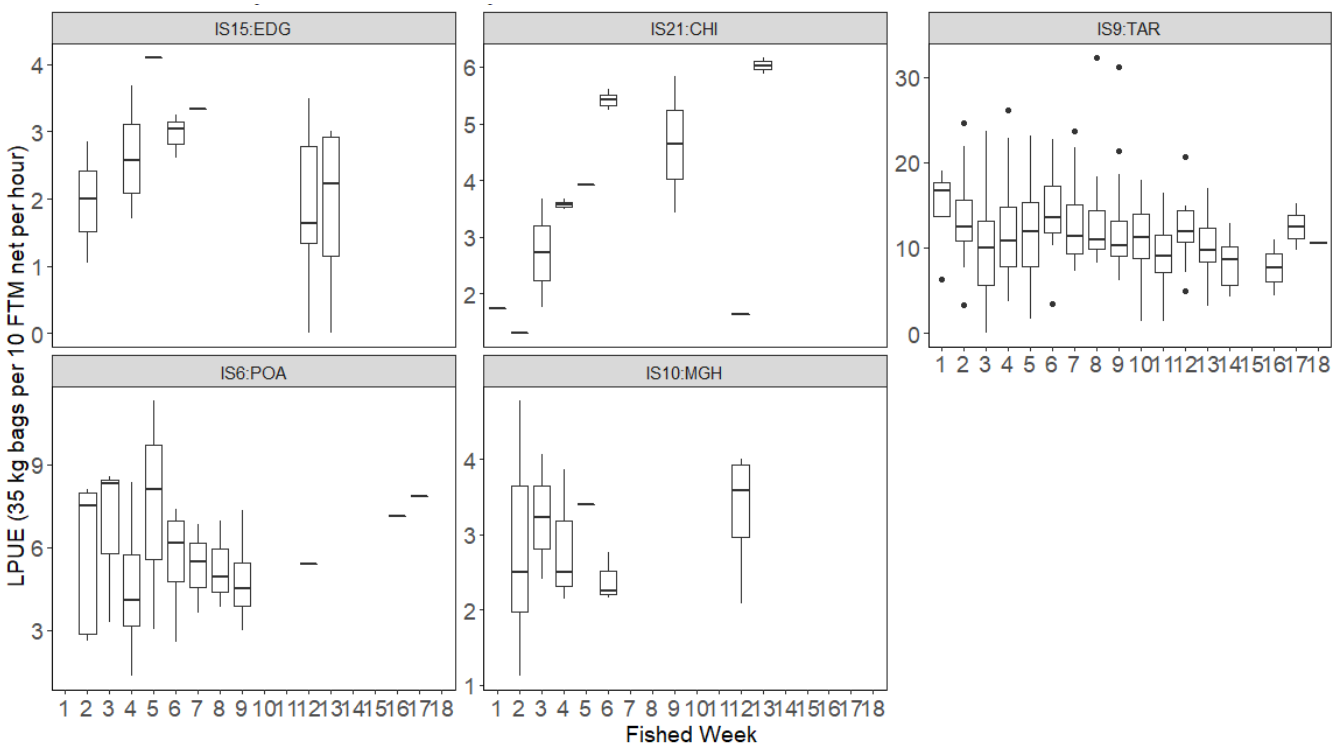


Figure 9 A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for the 2022 queen scallop trawl fishing season displayed by week and main fished ground. Note: Different scales on Y-axes.

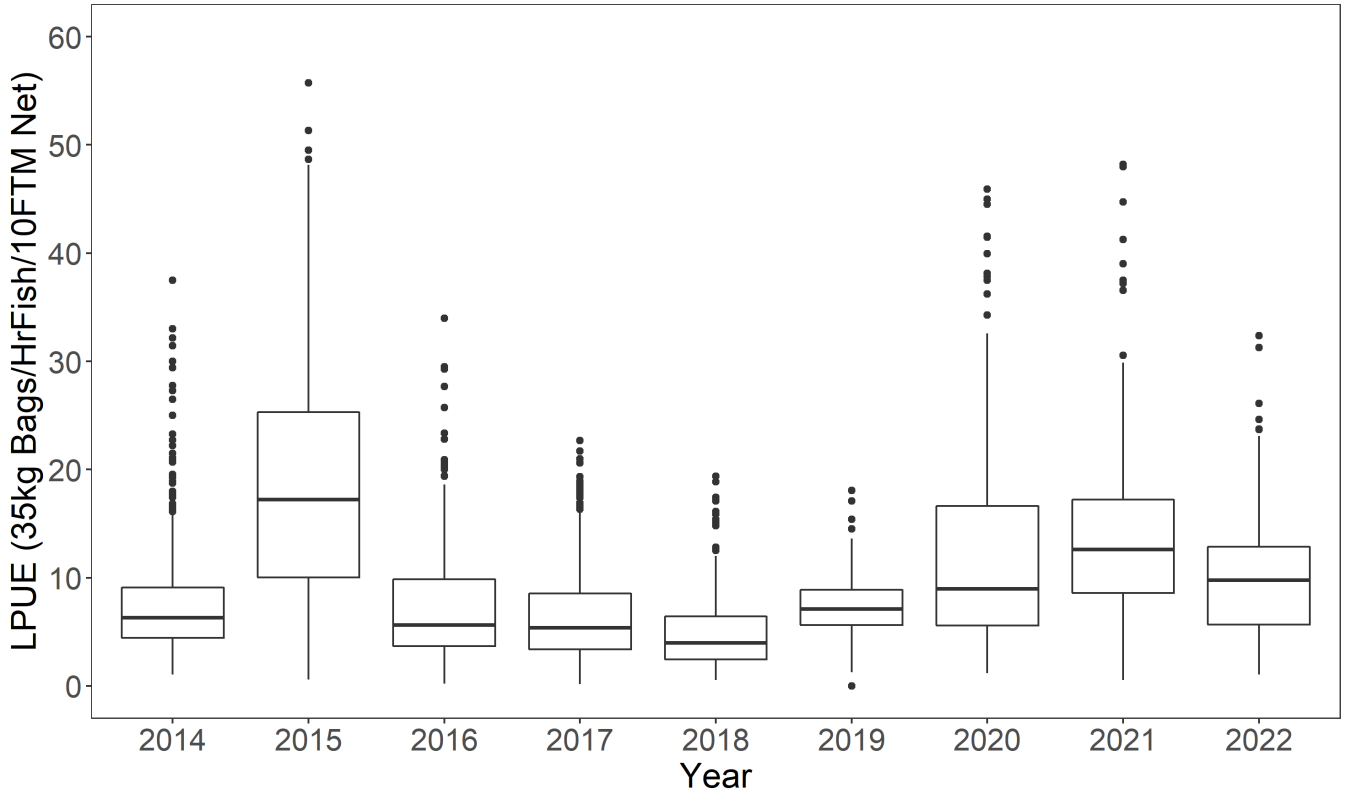


Figure 10 A boxplot of queen scallop trawl LPUE (35 kg bags per hour fished per 10 fathom of net) for all vessel trips by fishing season from 2014 to 2022.

Queen Scallop Dredge Fishery Update (2022)

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 ~58.3 t and the season ran from 1st to 31st October 2022. Each of the four eligible dredge vessels were allocated an individual quota of 14,575 kg which could be fished during the season as and when suited the vessel. Letters of comfort were issued by DEFA to both trawl and dredge vessels that may otherwise target the queen scallop fishery in 2022 to enable them to maintain a track record. None of the four licenced vessels reported landings for the second year in a row (2021 & 2022).

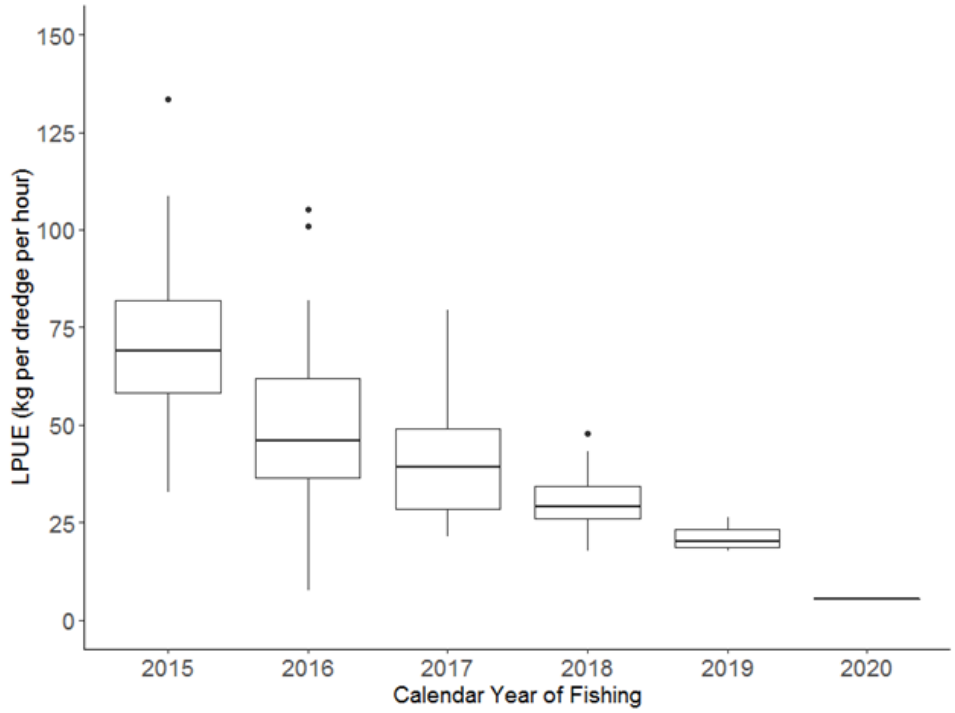


Figure 11 LPUE standardised to kg per dredge per hour for dredge vessels participating in the Isle of Man queen scallop dredge fishery which occurs within the dredge box located within the CHI fishing ground from 2015 to 2020 (note no landings reported in 2021 or 2022).

Queen Scallop Research Priorities for 2023:

- The priority for queen scallops for 2023 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
- 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 (2021/2022)

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 Monday 1st November 2021 and closed on Tuesday 31st May 2022. The total allowable catch (TAC) for the 2021/2022 Isle of Man king scallop fishery was 2049t. This was equal to the TAC set for the 2020/2021 fishing season. Total reported landings for the Isle of Man king scallop fishery during the 2021/2022 season were 1491t with 54 unique vessels [10 fewer than in the 2020/2021 season] reporting landings from 2661 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 2020/2021 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.

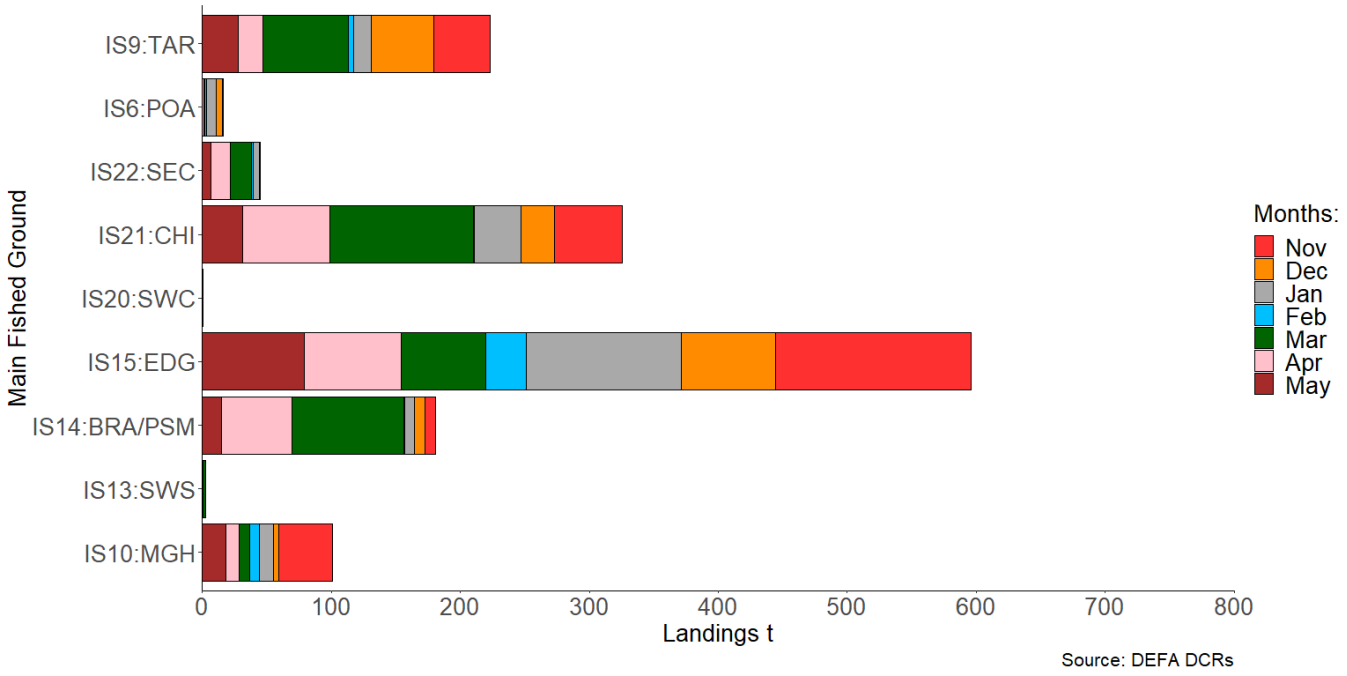


Figure 12 King scallop landings (t) from Isle of Man territorial waters displayed by main fished ground and month for the 2021/2022 fishing season.

The area with the highest fishing effort was the restricted area at Chickens which had a swept area of between 1.41 and 3.68 per survey cell (for highest effort survey cells this equated to around 70-100 fishing hours per survey cell).

The Daily catch limit for the 2020/2021 Isle of Man king scallop dredge fishing season within the 0- 12 nm limit was **700 kg** per vessel. At the start of the fishing season (November 2021) ~ 54 % of vessel trips were meeting the DCL (i.e. landing around 700 kg) whilst at the end of the fishing season (May 2022) this had reduced to ~ 43 % of vessel trips.

The 2021/22 average LPUE (**kg per hour fished per dredge**) at each of the main fished grounds is displayed in Figure 14 (green line) with comparisons for 2017/18, 2018/19, 2019/20 and 2020/21 (grey lines) by fished week. For 2021/2022 LPUE was highest at the limited permit only fishery that occurs in December within the Fisheries Management Zone of Ramsey Bay (~ 35-40kg/Dr/HrF) (*N.B. A commercial survey also took place in Ramsey Bay towards the end of the season*). For 2021/2022 the LPUE at all other grounds ranged between 0 and 12 kg/Dr/HrF. The LPUE at IS10 MGH, IS15 EDG , IS14 BRA/PSM and IS21 CHI were all within the top range of LPUE for these grounds over the last four fishing seasons. IS4 POA and IS9 TAR were all around average LPUE compared with previous seasons.

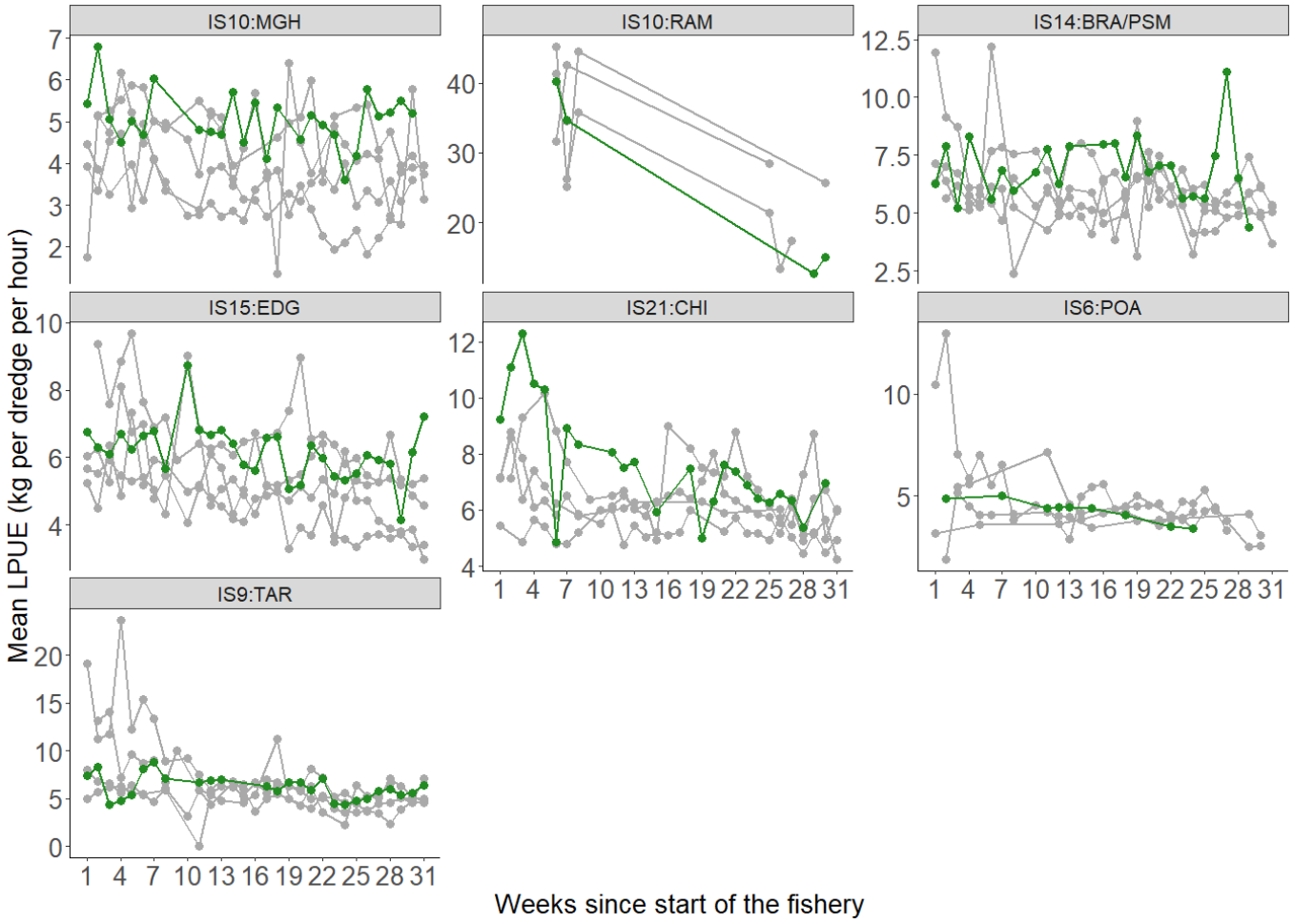


Figure 13 King scallop LPUE (kg per dredge per hour) for the 2020/2021 (green) and historic (grey) fishing seasons.

Research set aside scheme:

As of 24th January 2022 (Week 13), the Department enacted a pilot scheme that allowed industry to establish a Research Fund using 'excess scallops'. The industry research fund will be generated by the sale of excess scallops that vessels are currently required to discard in order to remain under the 700 kg 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. Initially the Scheme is limited to Island-based vessels and processors (vessels and processors must sign-up together and have a permit issued by the Department) and will be reviewed at the end of the 2022 king scallop season. The Scheme will initially be used to support the MFPOs high-resolution scallop surveys. During the 2020/21 fishing season the scheme landed 3.67 t of king scallops to contribute to the research set aside scheme fund.

Long-term, Coarse-Scale Survey 2022: 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 2022 survey is displayed in Figure 14 for all survey stations where the density is greater than 0.25 scallops per 100 m^2. In 2022 the fishing grounds in the southwest coast of the Island (BRI, ST44, and ST33) had the highest densities of king scallops per 100 m^2 (~6-7 king scallops per 100 m^2 respectively) (Figure 14). The next three highest density stations (ST51, LAX and ST27) were all on the east coast of the Isle of Man within the 0-3 nm limit (Figure 14).
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

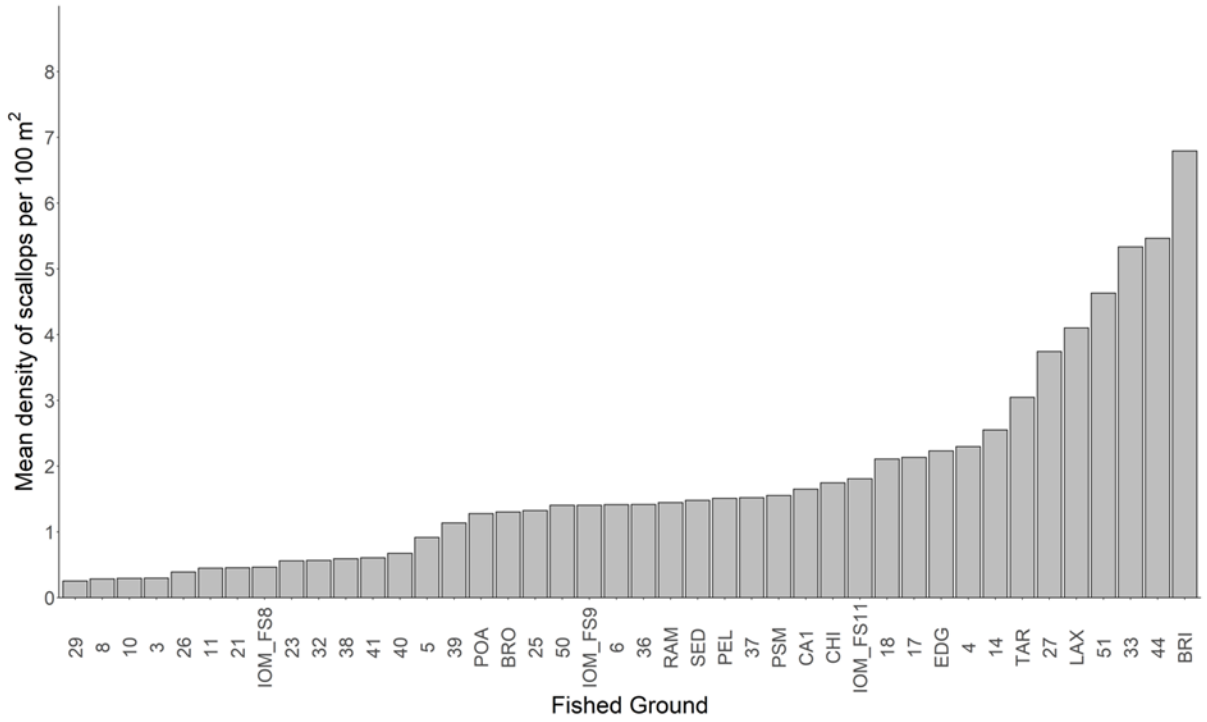


Figure 14 Survey densities (king scallops per 100 m^2) displayed by survey station for spring 2022 survey (average of queen scallop dredge data). Only sites with densities ≥ 0.25 king scallops per 100 m^2 are displayed.

subsequent year on year reductions until 2018, when the lowest estimate since surveys began was recorded. However, the three most recent years of data (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). 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).

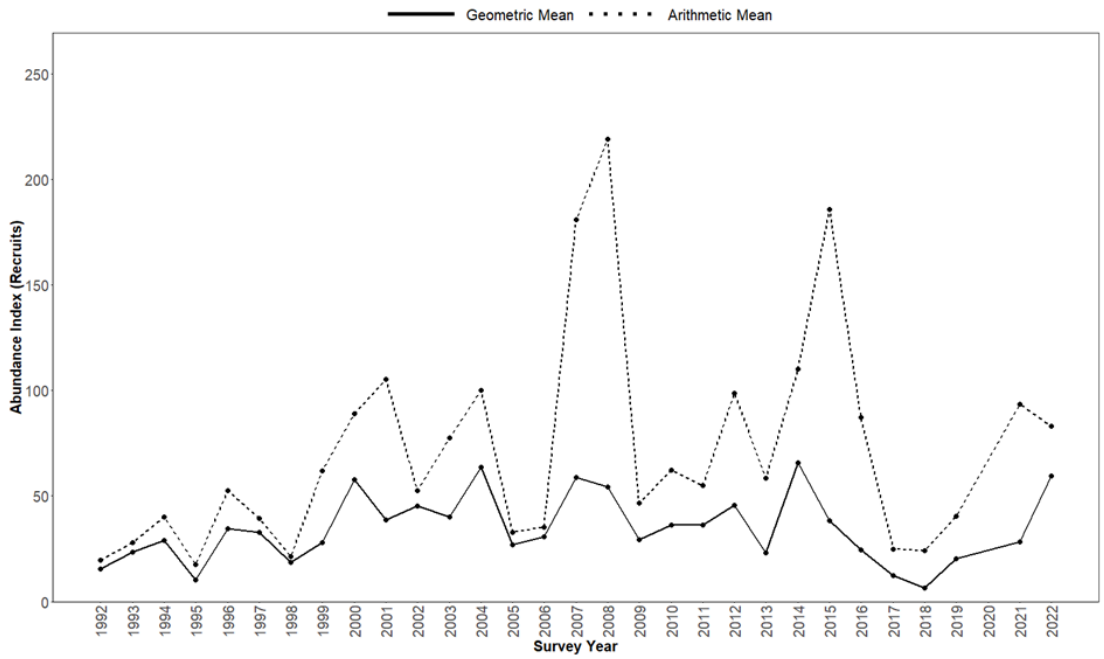


Figure 15 Recruit abundance index (scallops < 95 mm). Calculated based on length-based data where recruits were categorised as scallops under 95 mm at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. final day of 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 and a slight decrease in 2022. 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.

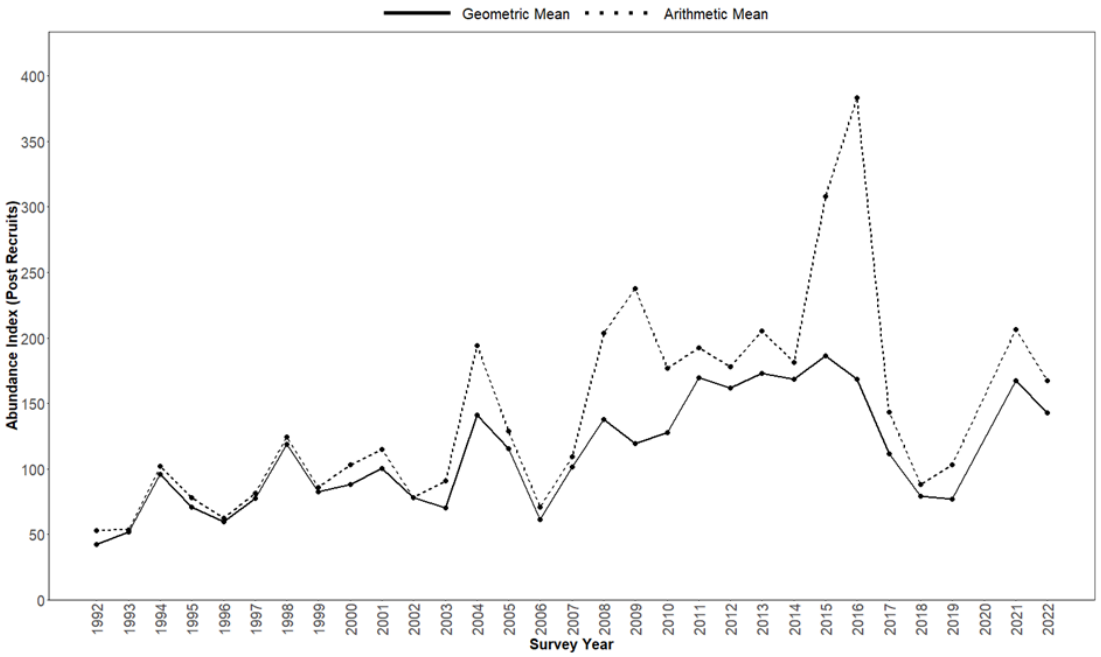


Figure 16 Post recruit abundance index (scallops ≥ 95 mm). Calculated based on length-based data where post recruits were categorised as scallops 95 mm or above at the time of the spring survey (generally April) which would typically be considered too small to grow into the fishery by 31st May (i.e. 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 2022: King scallops

The densities of juvenile king scallops from the short-term, fine-scale survey showed relatively little variation, except for two areas of higher density. These two areas were recorded on the West Coast of the Island, within the Targets (TAR) fishing ground, within an area that was subject to restricted access for the 2022 queen scallop fishery (dashed green box; Figure 18), and the south-west of the Island within Bradda fishing ground, just outside the 0-3 nm limit (Figure 18; targeted survey cells not included in overall analysis). Overall the abundance index was lower for 2022 than 2021 when all sites surveyed in both years (both within 0-3 and 3-12 nm limits; Table 2, Figure 17 are included (although sites within TAR fishing ground did record an increase from 2021 to 2022).

For post-recruits the highest densities recorded during the 2022 fine-scale survey were in the same locations as for recruits (i.e. west coast at TAR within current QSC restricted area and southwest coast at BRA just outside 0-3 nm limit). Overall the post-recruit index for 2022 within 3-12 nm (Table 2 TS; i.e. combined data from EDG, CHI and TAR – sites surveyed in all years) decreased from 2021. This was largely driven by decreases on the east coast at EDG (Table 2). There were however, increases in the post-recruit index at the inshore sites surveyed in both years (0-3nm: BRA and ECO; Table 2, Figure 17).

Area	Ground	2021 <95 mm	2022 <95 mm	Change	2021 >95 mm	2022 >95 mm	Change	Landings 2021/22 (t)
TS	T.S.	0.203	0.172	-	0.830	0.717	-	1491
3-12 nm	EDG	0.280	0.151	-	0.943	0.650	-	553
	TAR	0.158	0.265	+	0.837	0.872	+	223
	CHI	0.150	0.127	-	0.634	0.671	+	326
	POA	NA	0.123	NA	NA	0.278	NA	17
0-3 nm	ECO	0.238	0.220	-	0.600	1.120	+	89
	BRA	0.189	0.177	-	0.603	0.940	+	181
	MGH	NA	0.133	NA	NA	0.452	NA	101

Table 2: A summary of the changes in the abundance index (geometric mean) for over and under 95 mm by survey ground for the May Industry survey. Landings are also displayed in t from the 2021/2022 season for each ground based on data from the Daily Catch Return Forms and indications of fishing inside or outside of the 3nm limit (green indicates increase and red indicates decrease relative to previous season).

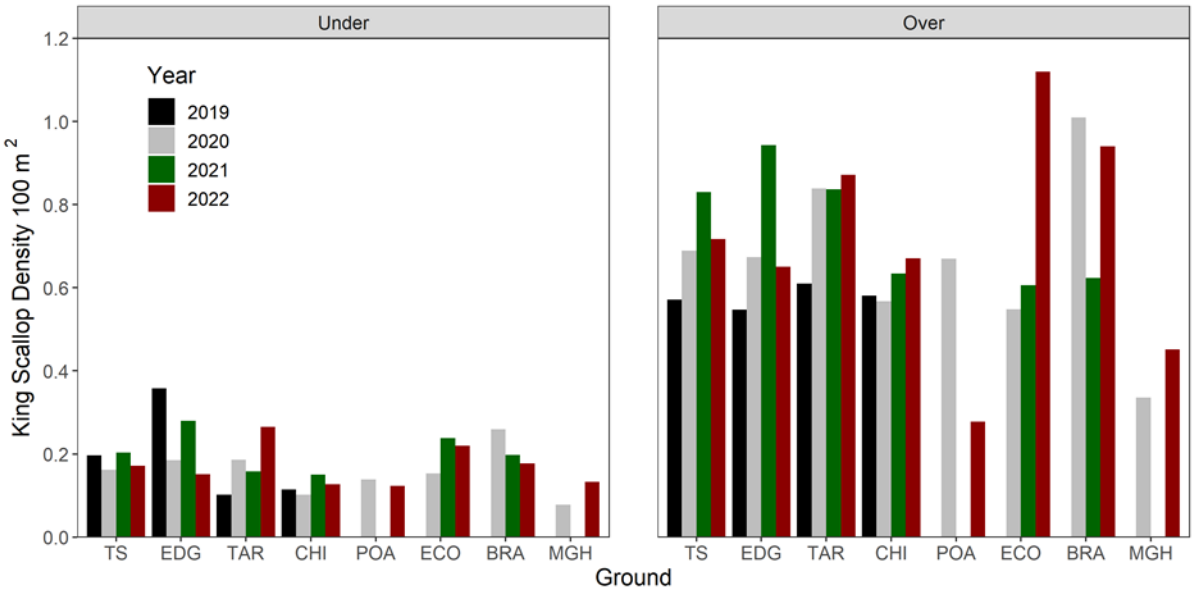
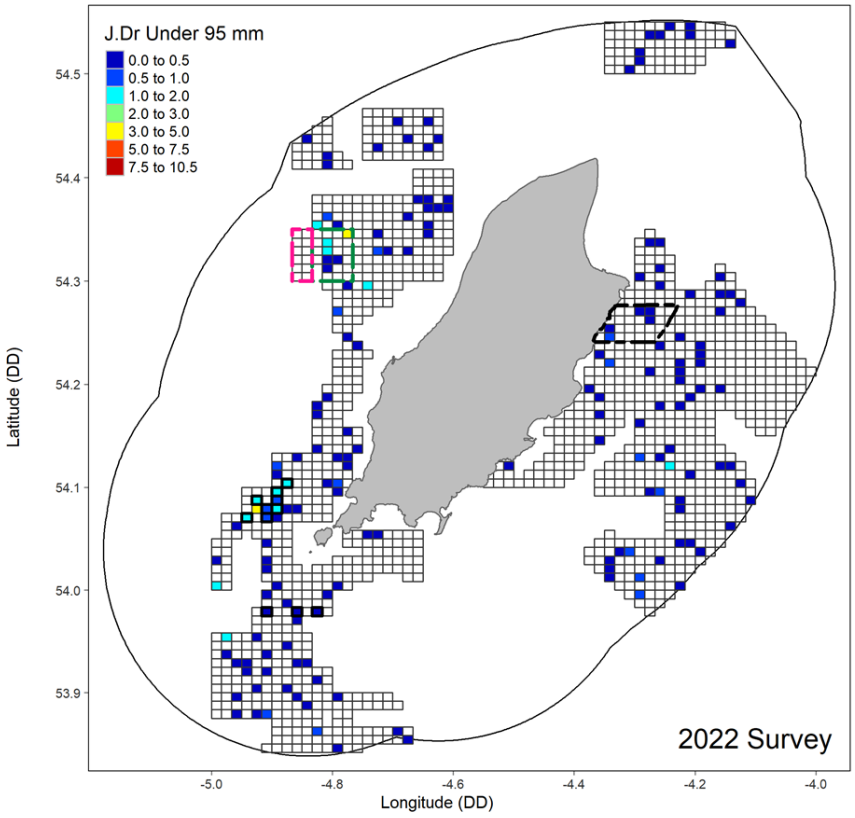


Figure 17 Comparison of king scallop abundance indices (geometric mean) (over and under 95 mm) by year and by ground for the fine -scale survey



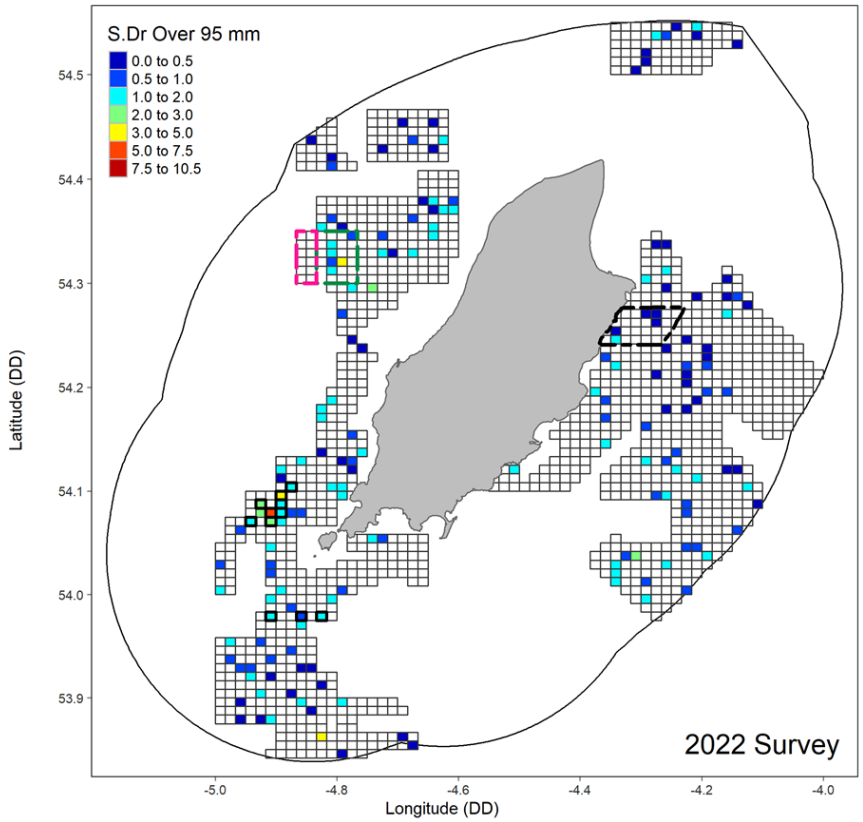


Figure 18 Maps illustrating the survey densities (scallops per 100 m^2) for king scallops under 95 mm (top) and over 95 mm (bottom) from standard king and standard queen scallop dredges for 2022. The north-east section of East of Douglas survey ground was omitted from the survey in 2022 due to limited survey time and resources. The green boxes indicate restricted access areas during the 2022 queen scallop fishing season and the pink boxes indicate areas closed for queen scallop fishing in 2022.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. and Jenkins, S.R. (2022). Isle of Man King Scallop 2022 Stock Survey Report. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 47.

King Scallop Stock Advice (2022/2023)

The advice below was provided by Bangor University to the Scallop Management Board for consideration for management of the 2022/2023 king scallop fishing season.

Summary of survey findings

Within the 3-12 nm territorial sea there has been an overall decrease in the abundance index (geometric mean) from 2021 to 2022 from the industry survey for both post-recruits and recruits when combining the three grounds, EDG, TAR and CHI which have been surveyed in all years. This decrease is driven by EDG which recorded the highest landings in the 2021/2022 fishing season. The Prince Madog survey shows the same decreasing pattern for the post-recruit abundance index from 2021 to 2022 although the recruit index shows a slight increase from 2021 to 2022. The declines in post-recruit abundance observed in both the industry and Prince Madog surveys follow 1491 t of landings from the whole territorial sea area during the 2021/2022 fishing season (from a total TAC of 2049 t).

While the abundance index for post recruits has shown a general decline across the Territorial Sea (EDG, CHI and TAR combined), the picture varies among individual grounds. Four grounds (TAR, CHI, ECO, BRA) showed an increase in the post recruit index. In both surveys BRA in the south-west of the Island recorded the highest densities for 2022. In the Prince Madog survey Stations at BRA, ST44 and ST33 all have high densities ranging from 6 - 7 scallops per 100 m^2 (all sizes). In the Industry survey the recorded densities in the surveyed area range up to 6.25 scallops per 100 m^2 (scallops over 95 mm only). The abundance index calculated for the BRA ground is lower as the targeted survey cells within this ground which recorded the high densities are not included in the standard analysis based on cells surveyed as part of the random stratified sampling methodology.

Both surveys also recorded high densities at the inshore east coast sites. The Prince Madog survey recorded densities of 4-5 scallops per 100 m^2 at sites ST51, LAX and ST27 while the industry survey recorded lower densities (1-2 scallops per 100 m^2). However these densities were still relatively high for post recruits (over 95 mm) compared to other survey grounds.

Recommendations

It was recommended that the management approach for 2022/2023 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 and 2022).
- A precautionary management approach should be considered in particular due to the decline in post-recruit abundance indices in both surveys despite only 73% of the TAC being achieved.
- An initial starting TAC based on either last years landings or a 20% increase of actual landings (TAC = 1790 t) is advised.
- Flexibility of decrease or increase of 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.
- Consideration of temporary closed areas implemented to protect any high densities of recruits identified in the survey. For 2022 survey cells within TAR and BRA 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

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King Scallop Research Priorities for 2023:

- Develop standardised logbook and VMS index for king scallops and assess the spatial issues associated with cleaning and merging VMS data.

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

- Progress Short Term Objectives highlighted in the king scallop long term fisheries management plan.

- Undertake a baseline Relative Benthic Status analysis for the king scallop dredge fishery including consideration of how this metric can be used in real-time management in the future

ICES Working Group on Scallop Stock Assessment

4th – 6th October 2022, Hybrid, Iceland

The ICES Scallop Assessment Working Group (WGScallop) was attended virtually 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.

Surveys: Surveys continue to be integral for many of the institutes and the WG discussed the possibility of staff exchanges between surveys and have also agreed to hold an intersessional meeting to discuss survey design and related common issues.

Data call: This was the third year of submitting a data call and there continues to be issues with the data quality. ICES Secretariat presented an overview of the Regional Database Estimation System (RDBES) and the group have agreed to use this framework. There will be a period of overlap and intersessional work will include a comparison between the datasets (WGScallop data call and RDBES).

Review paper: Several group members contributed to the review paper, "A global review of catch efficiencies of towed fishing gears targeting scallops" being published in "Reviews in Fisheries Science and Aquaculture". This paper provides an in-depth review and discussion of the factors which influence catch efficiency, relating the considerable variation in the catch efficiency estimates (0.1 to 0.7) to scallop size and substrate type as the two most important factors.

King Scallop Stock Assessment in the northern Irish Sea: Work on progressing a stock assessment for the Irish Sea included five intersessional subgroup meetings which involved members of the Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE). Members of WGScallop have been using available Vessel Monitoring Systems (VMS) data and logbooks to consider various models (Vector Autoregressive Spatial-Temporal Model (VAST) and Surplus Production in continuous time (SPict)) and standardized survey indices. A stock annex has also been drafted for king scallops in the Irish Sea.

Co-Chairs: Dr Isobel Bloor has been nominated and accepted as co-chair of WGScallop along with the current chair (Lynda Blackadder) over the next three year period.

The 2022 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. 2022. Scallop Assessment Working Group (WGSCALLOP; Outputs from 2022 meeting). ICES Scientific Reports. 5:08. 75 pp. https://doi.org/10.17895/ices.pub.22189654

The next meeting will be hosted by the Institute of Marine Research in Tromsø, Norway from 9th – 13th October 2023 (this will be a hybrid meeting virtual and in person as per ICES current advice).

ICES Queen Scallop Growth and Ageing work

As part of the collaboration with ICES WGSCALLOP Bangor University staff in the Isle of Man have been working with colleagues from Northern Ireland, Wales and England to collect and analyse queen scallops from within ICES areas as part of a collaborative study on queen scallop growth and ageing. The aim is to establish a standardised ageing protocol and assess whether variability in growth patterns of queen scallops occurs across ICES fishing areas.

To date, samples have been collected from around 11 sites around Wales, Isle of Man, Northern Ireland and the UK. These have been dissected to determine patterns of wet and dry weight and shells retained for growth ring analysis.

Provisional results from one site around the Isle of Man (closed area at Chickens— South of the Island) are presented below. This analysis will be further developed and expanded to the remaining sites sampled during 2023.

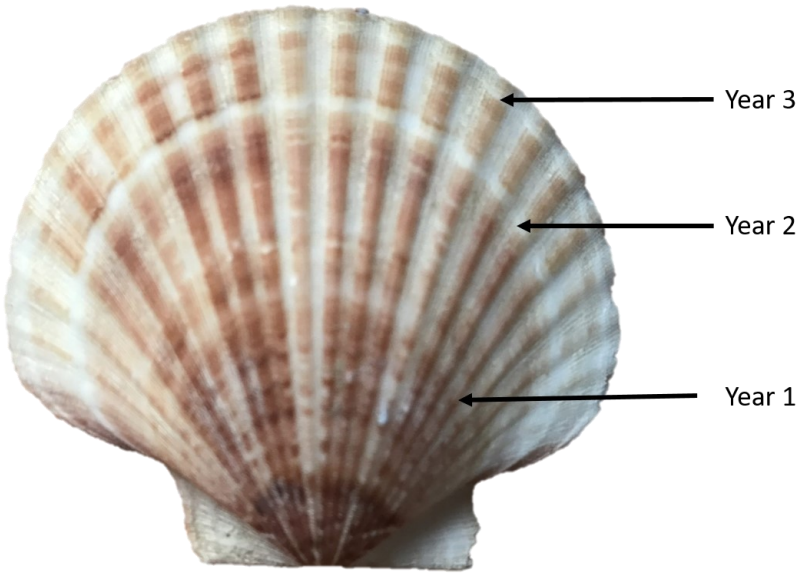


Figure 19: A cleaned and treated left valve of a queen scallop shell showing annual growth lines.

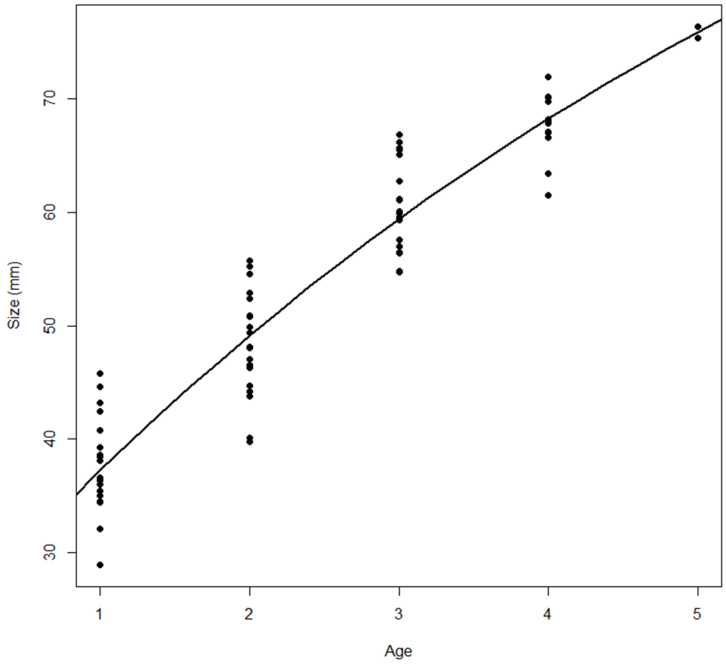


Figure 20 A plot of Size (mm) and Age (years) for queen scallops from a closed area in the South of the Isle of Man as part of Von Bertalanffy growth analysis.

Table 3: Estimated Height (mm) at age for queen scallops from a closed area in the south of the Isle of Man, From Von Bertalanffy growth analysis. Indicating that queen scallops in this area get to minimum landing size of 55 mm at around Age 3 (* by age)

Age	Mean Height (mm)
1	38.50
2	48.92
3	57.71*
4	65.14
5	71.41

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 2019 individually at a similar level to Queen Scallops (QSC) (2019 sales : QSC—£0.9million; Whelk—£1.1million; Crab £0.9million). A summary of the current status of these three static gear fisheries is presented along with complementary research undertaken in 2022.

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. Additionally, spatial information (VMS or equivalent) is absent for the vast majority of whelk fishing activity (i.e. landings by vessels <12 m length overall). Trends in fisheries-dependent data are therefore presented at a whole territorial sea level.

IN 2022, landings and effort reduced to 294 tonnes and c.173,000 , equal to an decrease of -49% and -50% relative to 2021 respectively. Monthly variation in pot lifts mirrored previous trends over the period 2015-2019 but effort was much reduced over most of year except January and March (Fig 21A). LPUE was generally highest over the first half of the year but declined from August onwards (Fig 21B). It was lower in all months relative to average values over the period 2015-2019. This was reflected in the trend for standardised LPUE (Fig 21C). There has been a steep decline since 2019 with 2021 and 2022 showing the lowest recorded level of ~1.6kg/pot. The explanation for continued low LPUE in 2022 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, with spatial information not routinely reported via logbooks. However, following the implementation of inshore vessel monitoring systems (iVMS) in April 2022 more precise spatial and temporal information can be added to logbook data, increasing our understanding and interpretation of long-term spatial 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.

In addition Bangor University is in the process of developing methodologies to assess whelk stock status using baited underwater video (BRUVs) alongside conventional mark recapture techniques (further information can be found on page 28-27). Stock assessment techniques, that can be used to further analytically assess whelk stocks in the Isle of Man territorial sea, are also being investigated.

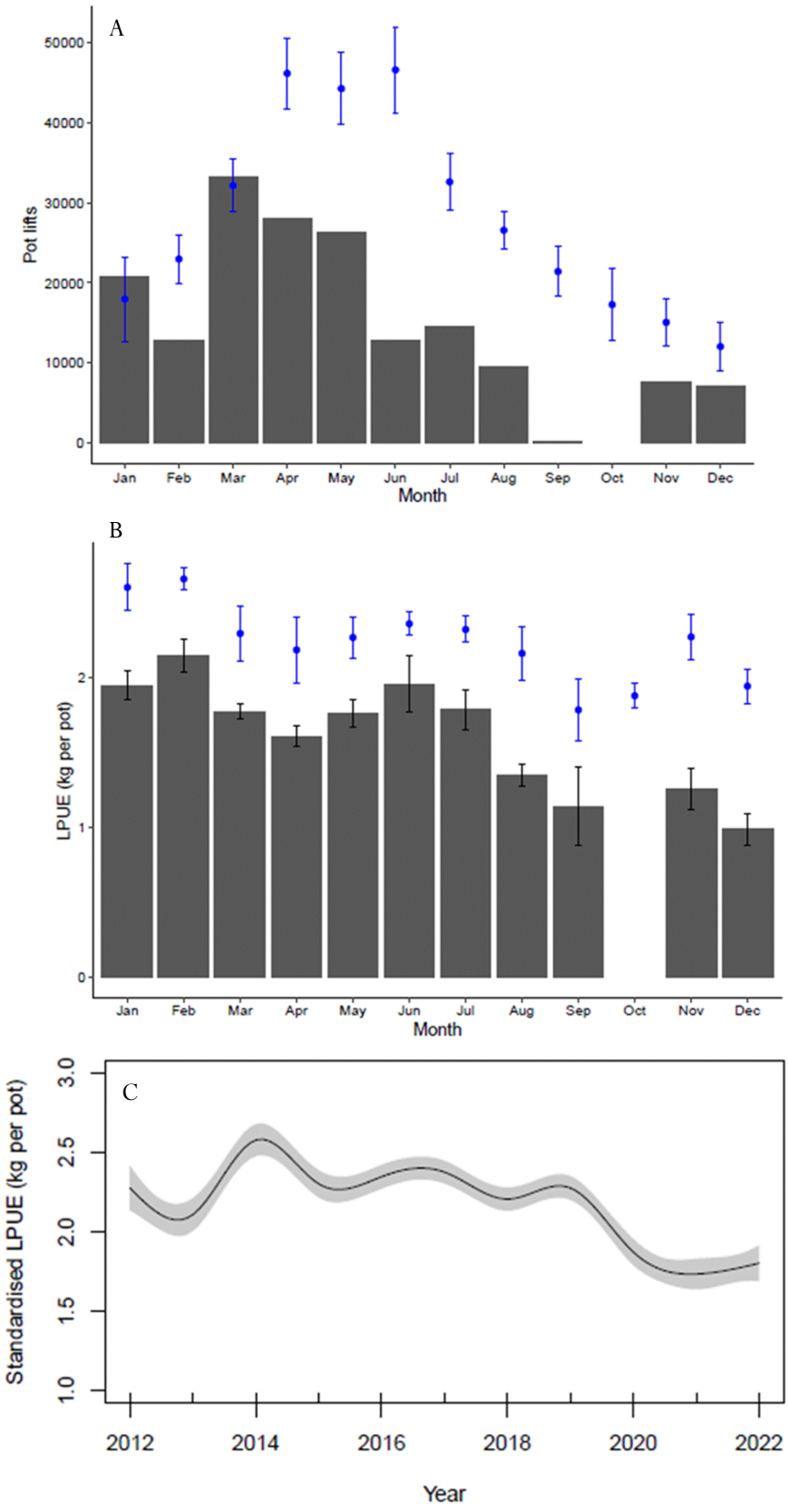


Figure 21. Common Whelk Fishery A) Monthly pot lifts declared in the Isle of Man Territorial Sea throughout 2022 (grey bars) relative to mean values (and standard errors) over the reference period 2015—2019. B) Monthly variation in LPUE (Kg./per pot lift) throughout 2022 grey bars) relative to mean values (and standard errors) over the reference period 2015—2019. . C) Long term standardised whelk landing per unit effort (LPUE) trend from 2012 to 2022.

Whelk Stock Assessment Survey Trials 2022—Baited Remote Underwater Video

In 2022, BRUV (Baited Remote Underwater Video) units were developed as a potential stock survey method for static gear species (lobster, crab and whelk). These consisted of standardised metal frames with a GoPro camera and waterproof lights positioned above a bait bag (Figure 22). Using extended GoPro batteries, the BRUVs provided up to 17 hours of footage on time-lapse, allowing us to explore variations in abundance over the full tidal cycle.

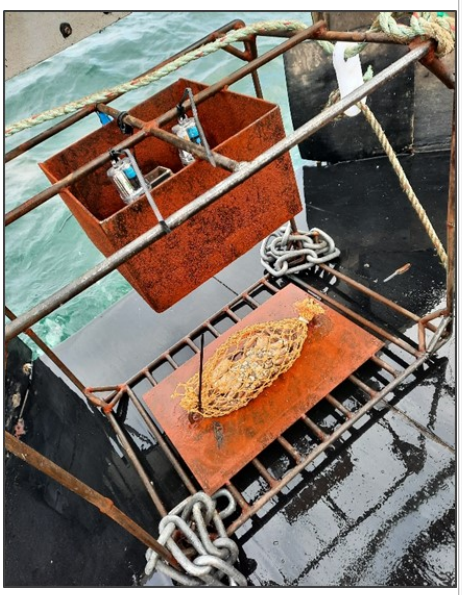


Figure 22 A BRUV unit being deployed during a whelk survey.

In summer (July-August) 2022 we collaborated with the Sustainable Fisheries Wales team in Bangor to deploy the BRUVs during mark-recapture abundance surveys for whelk. This allowed us to trial the BRUVs as a method for assessing whelk abundance, while comparing results with commercial pot CPUE (catch per unit effort) and population density estimated from mark-recapture. The surveys took place at two commercial fishing sites in North Wales, where strings of whelk pots were repeatedly fished at the same locations, with 1 BRUV unit added on the end of 5 random strings at each site.

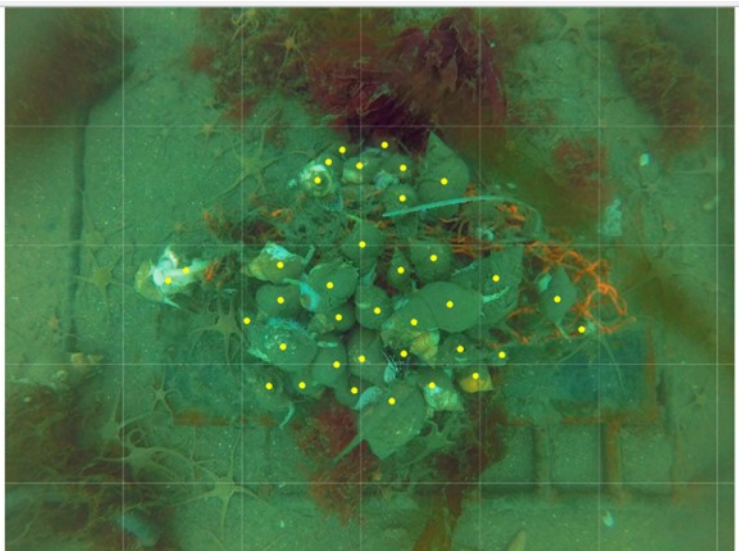


Figure 23. Screenshot displaying the software used to manually count whelks in BRUV images (DotDotGoose).

50 successful BRUV deployments were achieved across the two survey sites, and whelk abundance was assessed for each deployment using still images at 15-minute intervals (Figure 23). 3000 images were analysed in total and 35,000 whelks counted, with individual image counts ranging from 0 to 68 whelks. Whelk abundance differed considerably between the two sites, and there was also spatial variation within each site which remained consistent throughout the survey. As well as exploring temporal trends in abundance at each survey site, potential stock indices were calculated for each deployment: maxN (maximum abundance in one image); meanN (average abundance across all images); and T0 (time of first arrival). Preliminary results show a significant relationship between BRUV abundance indices and CPUE from pot strings. A full report will be circulated upon completion

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 return to previous levels (~475 tonnes). In 2022, landings and effort increased to 546 t and 377,000 pot-lifts, equal to an increase of +15% and +4% relative to 2021 respectively. These increases are reflected in monthly landings and effort relative to average values over the reference period 2015-19 (Fig 24 A, B) The fishery is historically an autumn fishery, this continued in 2022, with the highest landing per unit effort LPUE recorded in October (Fig 24 C).

The fishery is also monitored using standardised LPUE. The use of standardised LPUE enables the effect of vessel, seasonality of landings, area of operation and capture of other species to be accounted for. Standardised LPUE has declined since 2017, with an increases in 2021 but a subsequent decline in 2022 (Fig 24 D).

There are a number of issues with reporting effort for 'mixed' crab and lobster activity. However, 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

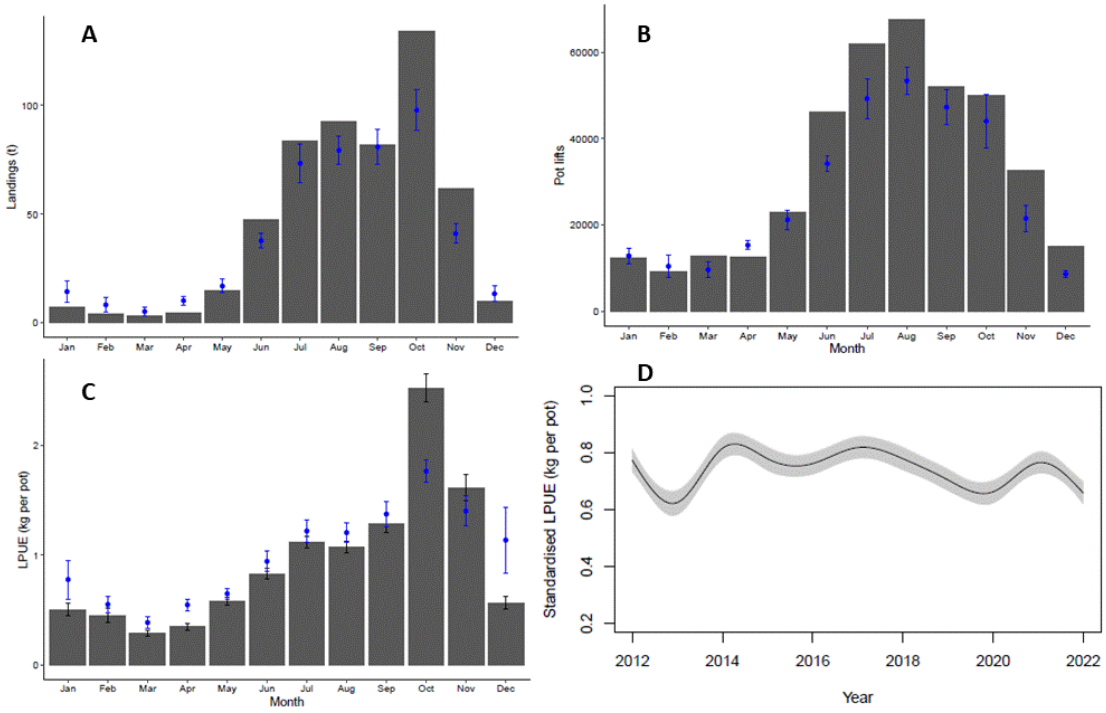


Figure 24. Brown Crab A) Monthly landings declared in the Isle of Man Territorial Sea throughout 2022 (grey bars) relative to mean values (and standard errors) over the reference period 2015—2019. B) Monthly pot lifts declared in the Isle of Man Territorial Sea throughout 2022 (grey bars) relative to mean values (and standard errors) over the reference period 2015—2019. C) Monthly variation in LPUE (Kg./per pot lift) throughout 2022, grey bars relative to mean values (and standard errors) over the reference period 2015—2019. D) Standardises Long term GAM LPUE trend (2012 –2022) for the Isle of Man territorial sea.

Estimating Fishing Area of commercial pots in a Brown Crab (*Cancer pagurus)* Fishery.

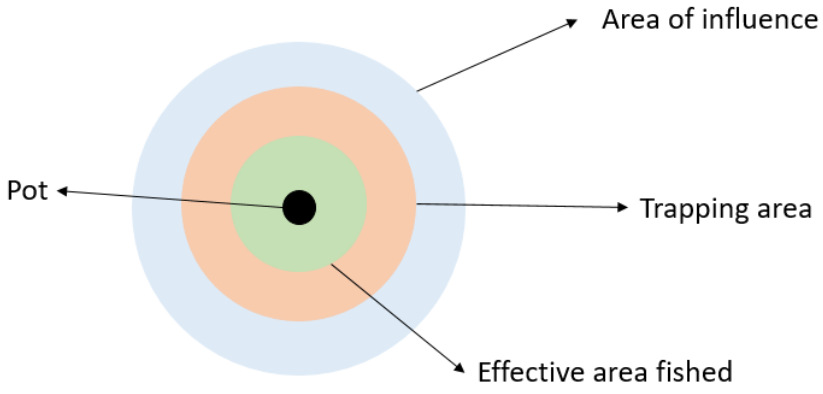
Standardised landing per unit effort (LPUE) data is commonly used to provide a metric of fishery health and overall stock abundance. There are however numerous biotic and abiotic factors that can affect catchability in crustaceans and hence the relationship between LPUE and stock abundance. These include temperature/season (Lizárraga-Cubedo et al., 2015), moulting (Ziegler et al., 2004), reproduction and the effect of conspecifics (Emmerson *et al*, 2022) .

An important factor however in the interpretation of LPUE as a function of population density is understanding the area over which pots attract the target species. This process can be split into 3 parts as described by Bell *et al*., (2001):

Area of Influence – described as the distance at which bait is detected, with a measurable response exhibited by the target species

Trapping area – Described as the area in which probability of capture of an individuals during deployment of the trap is greater than zero, also described as the total area from which catch is drawn. This area can be directly influenced by deployment length, environmental factors and target species making it potentially larger than the area of influence in some cases.

Effective area fished – a notional area of the seabed containing as many animals as were trapped



In the case of commercial crustaceans, estimates of area of influence and trapping area have primarily been undertaken using telemetry, with these estimates derived through the recording of behavioural responses pre and post baited pot deployment. The use of such technology, though useful, requires: a) a significant number of individuals to be tracked; b) a suitable sized sampling area to encompass home ranges; and c) significant financial cost.

In contrast similar estimates can be derived through the use of experimental potting, with pots spaced at increasing distances with asymptotic catch rate used as an indication of when pots no longer overlap and are fishing independently from one another, providing an indication of true trapping area of the pot.

Bangor University is currently assessing and trialling the use of baited underwater video systems (BRUV's) to potentially provide fishery independent estimates of both brown crab and European lobster abundance. These systems however benefit from understanding the area from which the number of animals are drawn and allow better estimates of population density. In response an experimental potting trail was conducted in August 2022 in the West coast brown crab fishery to estimate the effective area fished of commercial pots.

Experimental pots were arranged in 8 different string treatment spacings, with each treatment comprised of 5 pots per spacing group and treatment spacings ranging from 15 meters to 225 metres apart. All treatments were hauled three times.

A total of 298 *C. pagurus* were caught during the trial and ranged in size from 100 to 200 mm CW. Of these 244 were female with 54 being male. Size distribution centred on the minimum landing size (140mm), with greatest abundance observed in size classes 140 – 160mm (Fig 25 A).

Effective area fished was estimated based on CPUE asymptote to occur at a pot spacing of 134.3 metres/~73 fathom. This equates to a pot having an effective fishing area of 14,187 m^2 with density of catchable crab being 0.00073m^2, scaled to a density of 750Km^2 during the experiment (Fig 25 B).

Using this information in conjunction with the ongoing BRUV work Bangor University hopes to develop fisheries independent methodologies that can be used to supplement the long time series of fisheries dependant data already collected.

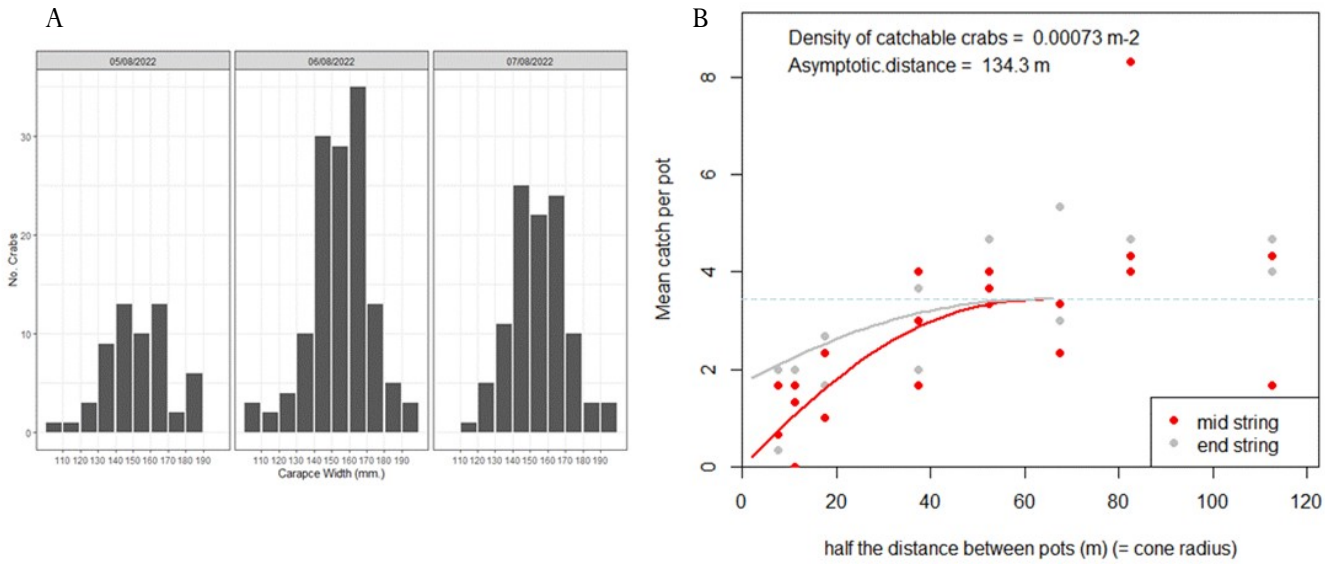


Figure 25. A) Size distribution of *C. pagurus* caught from each of the 3 deployment events during the survey. B) Estimation of effective area fished using a non linear approach.

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. Landings in 2022 were 43 tonnes, equal to an increase of 27.8% compared to 2020. Effort in the fishery also increased from 203,000 to 271,000 pot lifts, equal to an increase of 28.8% compared to 2021. These increases are reflected in monthly landings and effort relative to average values over the reference period 2015-19 (Fig 26 A, B).

LPUE was generally lower through the year than mean historical values (2015-2019) except for October and November (Fig 26 C). Analysis using standardised LPUE showed that the recovery in this measure in 2021 was not maintained, with a slight decline in 2022 (Fig 26D) .

Declines in LPUE in the fishery are difficult to verify from logbook data alone, considering that the lobster and edible crab fishery are reported as a 'mixed' fishery. Following the implementation of inshore vessel monitoring systems (iVMS) in April 2022 more precise spatial and temporal information can be added to logbook data, increasing our understanding and interpretation of long term trends. In addition Bangor University is also trialling the use of Baited underwater video systems (BRUV'S) as a method to independently monitor lobster abundance in partnership with industry which will help ground truth perceived changes in lobster abundance reported in logbooks

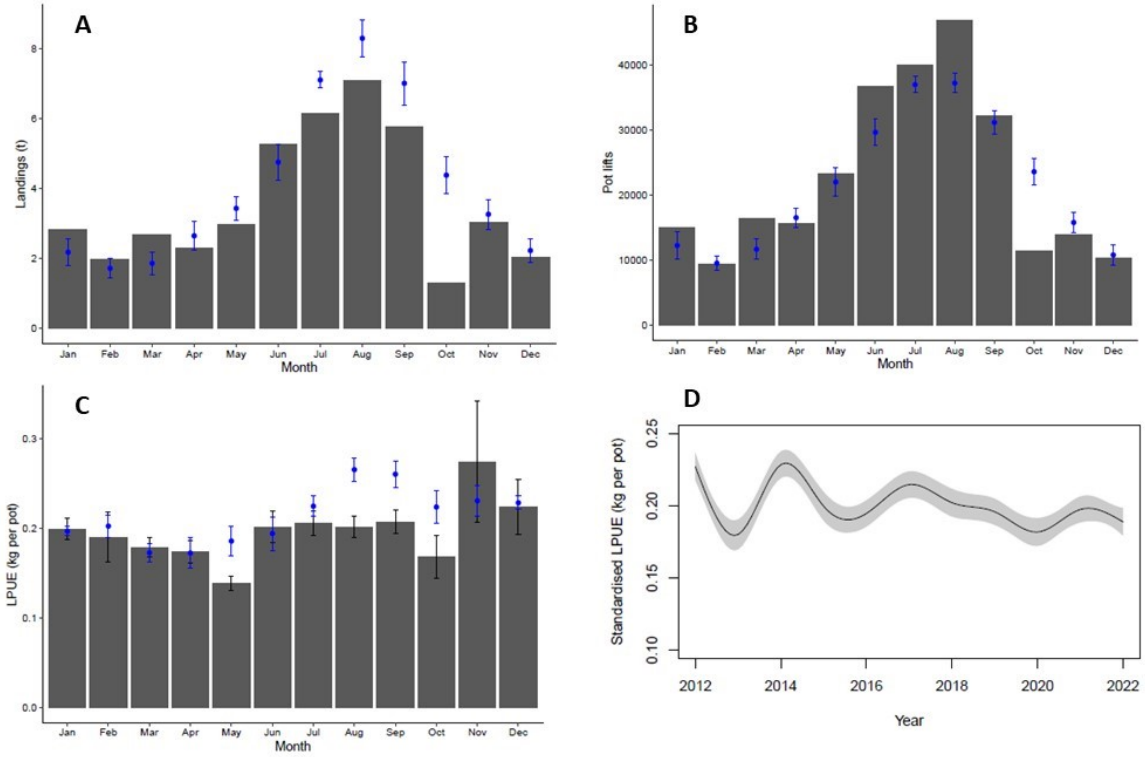
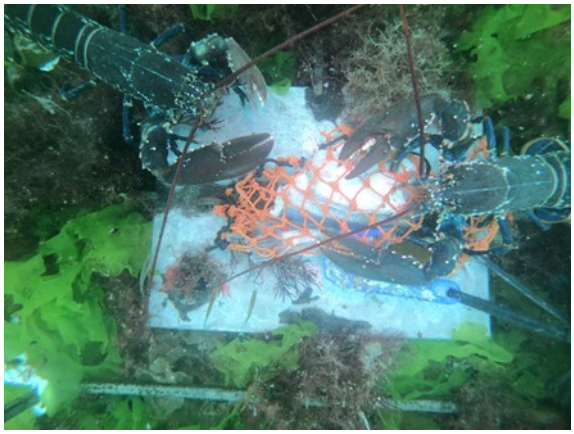


Figure 26. European Lobster A) Monthly landings declared in the Isle of Man Territorial Sea throughout 2022 (grey bars) relative to mean values (and standard errors) over the reference period 2015—2019. B) Monthly pot lifts declared in the Isle of Man Territorial Sea throughout 2022 (grey bars) relative to mean values (and standard errors) over the reference period 2015—2019. C) Monthly variation in LPUE (Kg./per pot lift) throughout 2022, grey bars relative to mean values (and standard errors) over the reference period 2015—2019. D) Standardises long term GAM LPUE trend (2012 –2022) for the Isle of Man territorial sea.

Use of new technology to address data deficiencies in assessment of static gear crustacean fisheries

In the case of static gear fisheries, current assessment techniques rely heavily on fisheries dependent data such as logbooks and generally lack dedicated independent surveys. The lack of fisheries independent surveys can leave such fisheries vulnerable to overexploitation due to honeypot sampling of commercial fisheries potential masking stock decline. This process is further complicated in static gear fisheries due to numerous abiotic and biotic factors than can affect catch rates and subsequent perceived abundance. Recent adoption of historic trawl data to provide independent estimates of abundance for brown crab have enabled more complex stock assessment techniques to be attempted in other fisheries. However such data is not available for European lobsters owing to the habitat type making use of trawl or dredge gear impractical.



Therefore in collaboration with a number of partners around the UK a project was implemented looking at utilising Baited underwater cameras (BRUV's) as a methodology from which fisheries independent data could be collected. Different systems are currently being trialled between project partners . The system currently being deployed in the Isle of Man is a meshless design, in order to remove some of the factors affecting catchability associated with meshed designs. The principle behind the deployment of such equipment is to compare "unbiased" estimates of abundance from camera observation to commercial fishery data collected simultaneously.

Initial deployments in 2022 have yielded positive results. Preliminary data analysis has highlighted the potential for a negative linear relationship between time at first arrival (T0 time at which the target commercial species arrives in frame) with catch per unit effort (CPUE), with low T0 corresponding to low commercial CPUE in both European lobster and brown crab (Fig 27). The project however will look to build on the successes of 2022 by increasing the number of deployments and increasing temporal coverage. The project will also look to use 360 degree camera system to address some key questions on understanding animal tracking in and out of camera view.

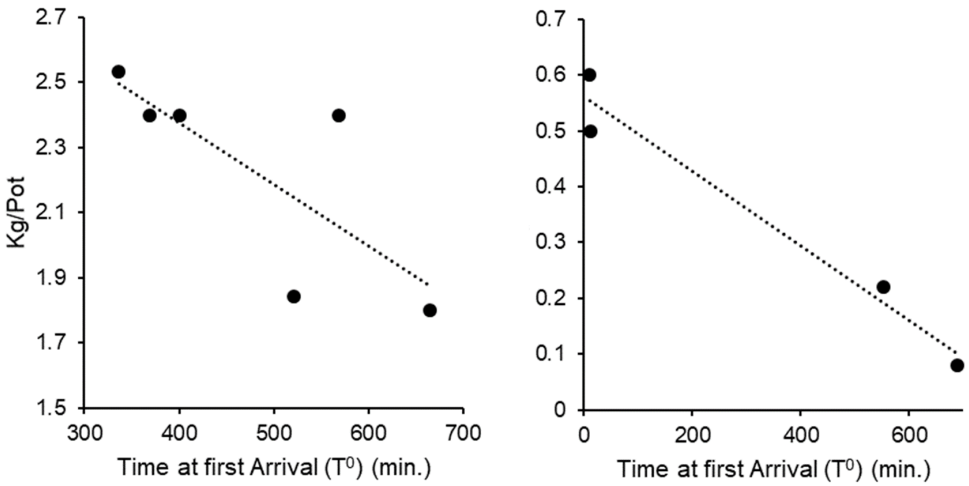


Fig 27. Negative linear relationship between left) Brown Crab and right) lobster LPUE and time at first arrival on BRUV deployments

ICES: WGCRAB

Copenhagen Hybrid Meeting 2022

The International council for the exploration of sea crabs and lobster working group met for the first hybrid meeting in Copenhagen, Denmark since the Covid-19 pandemic.

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 the use of surplus production in continuous time (SPiCT) models for its Brown crab fisheries on both the East and West Coast. This work builds on the work presented by the Irish Marine Institute and is directly informing the use of such models in the Isle of Man. Bangor University presented 3 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) an account of work estimating fishing area of pots to enable estimation of brown crab densities in the Isle of Man Fishery; 3) an update on the international collaborative project investigating the role of the North East Atlantic Oscillation (NAO) on Brown Crab *Cancer pagurus* abundance and the potential for an inverse relationship exhibited in the Snow Crab *Chionoecetes opilio*. This piece of work remains of high importance for both the Isle of Man and ICES WGCRAB, as the environmental drivers behind changes in stock abundance are currently unknown.

The WGCRAB modelling subgroup continues to be a forum in which stock assessment techniques and developments can be shared more regularly than the current annual meeting format. Matthew Coleman (Bangor University) and Guillermo Martin (Irish Marine Institute) were appointed joint chairs of this group. During the meeting the subgroups role in providing a workshop to investigate other assessment models in 2023 was discussed. A hybrid in person/virtual meeting will be held at Bangor University, School of Ocean Sciences in November 2023.

During 2022 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:

- Delargy, A.J., Blackadder, L., Bloor, I.S.M., McMinn, C., Rudders, D.B., Szostek, C.L., Dobby, H., Kangas, M., Stewart, B.D., Williams, J.R. and Stokesbury, K.D.E. (2022). A global review of catch efficiencies of towed fishing gears targeting scallops. Reviews in Fisheries Science and Aquaculture journal. DOI: 10.1080/23308249.2022.2139170
- Emmerson. J.A., Coleman, M.T., Bloor, I.S.M. and Jenkins, S.R. (2022). Enhancing fishery-dependent information in data-poor fisheries; integrating gear-in-gear-out sensors and mobile reporting technology in a mixed Irish Sea static-gear fishery. ICES Journal of marine Science. https://doi.org/10.1093/icesjms/fsac151

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Government Reports:

- Bloor, I.S.M. and Jenkins, S.R. (2022). Isle of Man Queen Scallop: 2022 Stock Survey Report . Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report. pp. 50.
- Bloor, I.S.M. and Jenkins, S.R. (2022). Isle of Man King Scallop 2022 Stock Survey Report. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 47.
- Coleman M. T., Bloor I.S.M., Jenkins S.R. (2022). Potential effects of a target green crab Carcinus maenas fishery using prawn creels on the retention of European lobster Homarus gammarus and edible crab Cancer pagurus. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 7.
- Coleman M. T., Bloor I.S.M., Hiddink J., Jenkins S.R. (2022). Estimating area of attraction in a Brown crab (*Cancer pagurus*) fishery using experimental potting. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 11.
- Garratt, M.J. Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2022). Benthic Habitat Mapping: Douglas Bay marine Nature Reserve. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 11.
- Garratt, M.J. Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2022). Benthic Habitat Mapping: Douglas Bay marine Nature Reserve. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 11.
- Garratt, M.J. Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2022). Benthic Habitat Mapping: Douglas Bay marine Nature Reserve. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 11.
- Garratt, M.J. Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2022). Benthic Habitat Mapping: Douglas Bay marine Nature Reserve. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 11.

- Garratt, M.J. Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2022). Benthic Habitat Mapping: Douglas Bay marine Nature Reserve. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 11.
- Garratt, M.J. Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2022). Benthic Habitat Mapping: Douglas Bay marine Nature Reserve. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report pp. 11

Meetings and Committees:

- International Council for Exploration of the Seas (ICES) Working Group on Scallop Stock Assessment. Virtual Meeting, 4th—6th October 2022, Hybrid, Iceland.
- International Council for Exploration of the Seas (ICES) Working Group on Crab. 8th—10th November 2022, Hybrid, Copenhagen, Denmark.
- Ministerial meeting March 4th 2022. DEFA—presentation of Isle of Man Fisheries Science contract
- Scallop Management Board meeting, LTMP King Scallops, Wednesday 6th April 2022, (Attended by Dr Isobel Bloor).
- Scallop Management Board meeting, Queen Scallop Management for 2022, Wednesday 18th May 2022, (Attended by Professor Stuart Jenkins).
- Scallop Management Board meeting, King Scallop Management for 2022/2023, Wednesday 28th September 2022, (Attended by Dr Isobel Bloor).
- Blue Carbon Monthly Steering Group Meetings (monthly through 2022 attended by Dr Isobel Bloor or Dr Matthew Coleman)
- Bangor University Chancellors Visit, Thursday 15th September 2022 at DEFA.
- UK Crab Management - Science sub Group. Seafish. 9th June 2022; 4th November 2022, (Attended by Dr Matthew Coleman).
- UK Whelk Management - Science sub Group. Seafish. 13th June; 11th June 2022, (Attended by Dr Matthew Coleman
- Static-Gear Advisory Group Meeting. DEFA. Wednesday 17th August 2022, (Attended by Dr Matthew Coleman)

Conferences & Outreach:

- Coastal Futures: Innovation for Ocean Recovery, Online Conference 18th—20th January 2022. Bloor, I.S..M., and Duncan, P. Cooperative Scallop fishery management in Ramsey Bay Marine Nature Reserve—update and implications after a decade of experience.
- University College Isle of Man. 27th April 2022. Dr Matthew Coleman. What size do lobsters start to reproduce and how do we tell? - Isle of Man Biosphere and Marine Management Series.
- Manx Radio, Perspective. 4th December 2022 with Bangor University (Dr Isobel Bloor), DEFA (Dr Jack Emmerson and Dr Peter Duncan) and the Manx Fish Producers Organisation (Dr David Beard). The Manx Fishing Industry—how bright is its future? Hosted by Phil Gawne.

Contact details:

Email:
i.bloor@bangor.ac.uk
m.coleman@bangor.ac.uk
s.jenkins@bangor.ac.uk

Website:
http://sustainable-fisheries-iom.bangor.ac.uk/

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

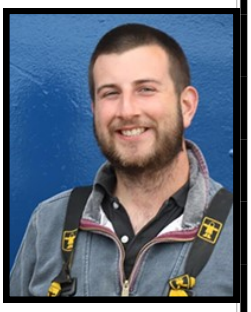
Professor Stuart Jenkins:

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.