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Annual Fisheries Science Report 2019

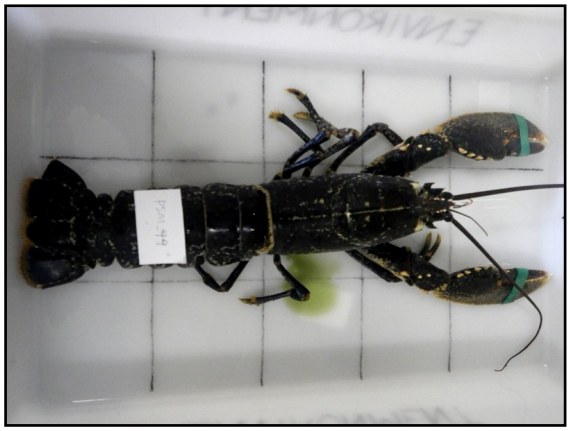
Sustainable Fisheries and Aquaculture Group

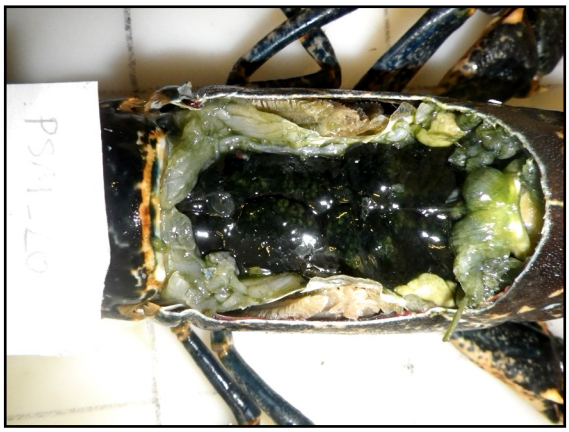
School of Ocean Sciences

Annual Report for 2019
(Report No. 5)

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 2019 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.

In reviewing the contents of our 2019 report it is clear it has been a busy year for our team in the Isle Man, with continuation of established sampling practices, which deliver high resolution data in a timely fashion to DEFA, as well as novel work in all aspects of Manx fisheries. One of the challenges of collection and analysis of fisheries data is to maintain continuity of data collection, using established survey techniques, but at the same time to innovate. Bangor has, over the past 14 years, continued and expanded the work of Dr Andy Brand and colleagues at Port Erin Marine Laboratory to build up a long term dataset on Manx scallop stocks. This dataset, alongside data generated in Welsh waters, has been used in 2019 to investigate different ways in which stock assessment models can be implemented. Further innovation has been evident this year in our close working relationship with industry to better understand the spatial pattern of queen scallop stocks in the Territorial Sea. Collaborative work between the MFPO and Bangor in a fine tuning assessment of queen scallop stock, through high resolution industry surveys, confirmed the assessment of our research vessel-led survey in the spring, whilst adding additional information on hotspots of queen scallop stock on the East Douglas grounds. We will continue this collaborative approach in 2020 to push forward with provision of data, analysis and advice which protect stocks but which may allow sustainable exploitation of queen scallop hotspots.

Innovation is also an increasingly important part of our work on the static gear fisheries for whelk, crab and lobster whose economic significance continues to rise. It is becoming clear that to maximise the long term value of these fisheries, effective and evidence-based management is needed to underpin them. Our work on whelk at the scale of the Irish Sea has shown that, just as in the scallop fishery, an understanding of spatial variation is key. Data indicate that whelk growth rates are strongly related to seawater temperature and hence vary a great deal over the Irish Sea. Such fundamental understanding of whelk biology is a key part of assessing stocks and hence providing management recommendations. Further insight into the crab and lobster fisheries has been gained through industry assistance in the deployment of automated loggers. The data analysed over the past year provide important information on how catchability varies with temperature and soak time. Such information is key as we move forward toward developing crab and lobster fishery assessments in the near future.

It has been pleasing to see how Bangor scientists continue to represent Manx fisheries at national and international level in both academic and industry contexts. Jack Emmerson has utilised his *Buccinum* expertise through contribution to a pan-Atlantic data workshop held in Cambridge while Isobel Bloor has provided leadership in hosting the ICES working group on scallop stock assessment in Douglas. She is leading this group's efforts to explore stock assessment options at an Irish Sea scale. Further afield, both Isobel and DEFA's Dr Peter Duncan attended the 22nd International Pectinid Workshop in Spain with Isobel presenting work on the success of the Ramsey Bay model of fisheries management.

Finally, throughout a challenging year it has been clear that communication among all groups is key to maintaining sustainable and profitable fisheries on the Isle of Man. Can I take this opportunity to thank all industry partners for their assistance and input throughout 2019 and invite all interested parties to join us at the Manx Fishing Industry Conference in June of this year.

Stuart Jenkins

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Annual Spring Scallop Survey (3rd—12th April 2019)

The 2019 stock assessment survey was undertaken using the RV Prince Madog over 10 days from 3rd – 12th April 2019. A total of 53 survey stations were sampled around the Isle of Man (Figure 1) using scientific dredges (four dredges positioned: King, Queen, King, Queen; with dredge cameras also attached to the tow bar). The footage from the dredge cameras is used to check the validity of the tows (i.e. dredges are fishing and are in contact with the seabed) and to obtain additional qualitative information on the seabed habitat and scallop densities.

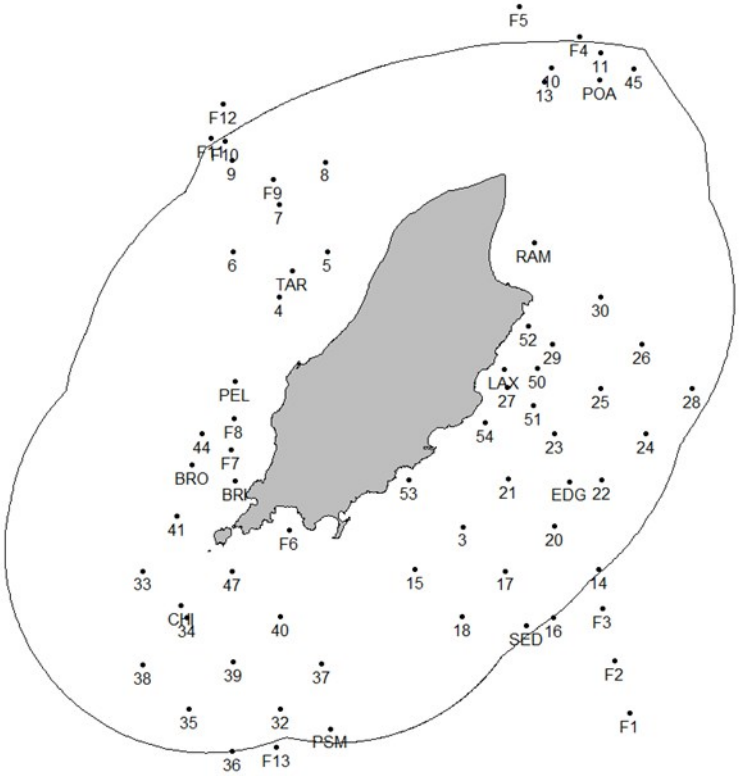


Figure 1. Map showing the locations of all spring scallop survey stations. Lettered stations (e.g. EDG) are historical stations that have been surveyed since 1992; Numbered stations (e.g. 1) have been sampled from 2012 onwards; stations pre-fixed with an 'F' (e.g. F1) are stations suggested by fishermen and have been sampled since 2016.

When the size data were split into individual historical stations it was clear that the majority of pre-recruits (i.e. Cohort 1) identified in the survey, for both king and queen scallops, were found at the Chickens fishing ground (Figure 2 and 3). If managed correctly these pre-recruits could represent an important post-recruit abundance for the fishery at this site over the next couple of years.

Survey stations at the Point of Ayre fishing ground (north coast) continue to have a good size range of king and queen scallops and densities remain relatively stable for both species. In particular relative densities of queen scallops were high compared to the rest of the Island with an average across the fishing ground of 21.4 queen scallops (qsc) per 100 m^2 (station maximum of 41 qsc per 100m^2).

The west coast fishing ground at Targets remains at relatively low density levels for both king and queen scallops when compared to the rest of the Island, with an average across the ground of 1.2 qsc per 100 m^2 and 0.79 king scallops (sce) per 100m^2. Station 6 which is within the current closed area has the highest density of small king and queen scallops on the west coast.

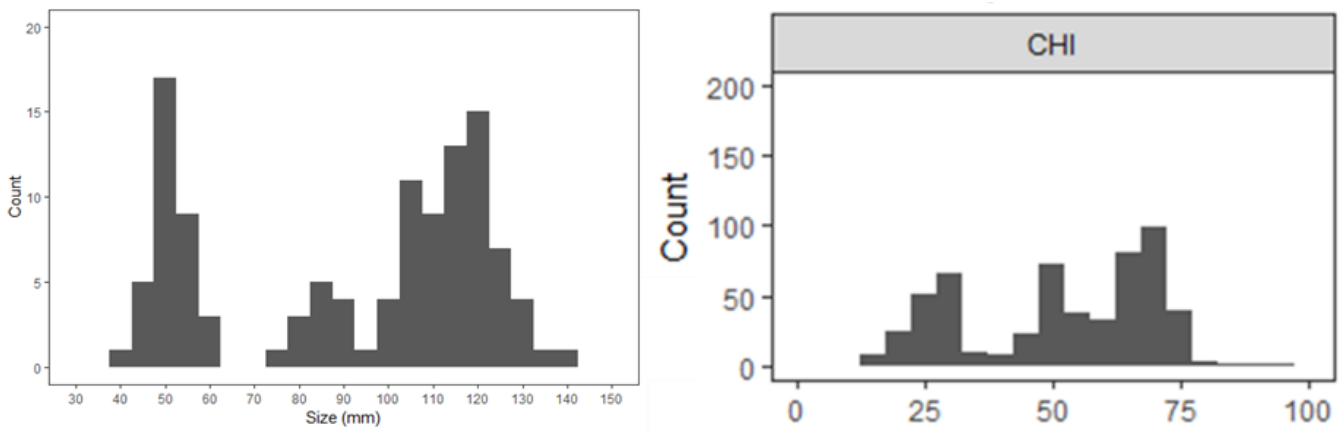


Figure 2. Left: Size frequency of king scallops caught from sites within the Chickens fishing ground; Right: Size frequency of queen scallops caught from sites within the Chickens fishing ground.

Ramsey Bay continues to have some of the highest densities around the Island with 4.31 sce per 100 m^2 and 33 qsc per 100m^2

A total of six scientists from Bangor University took part in the survey. We would like to thank all the scientific staff and research vessel crew for their time and assistance during the survey.

Figure 3. Top left: The R.V. Prince Madog in Port Douglas; Top right: Haul of queen scallop juveniles from Chickens; Bottom left: New electronic callipers trialled from Zebra-Tech; Bottom right: Haul of king scallop juveniles from Chickens.

Industry scallop survey (2019)

MANX FISH PRODUCERS ORGANISATION LIMITED

Survey methods:

A juvenile queen scallop survey was undertaken onboard two industry vessels (F.V. Benolas and F.V. Sarah Lena) from 19th – 27th June 2019. The survey was undertaken at three of the main queen scallop fishing grounds (Targets – 3 vessel days; Chickens – 3 vessel days and Douglas – 6 vessel days). Within each survey cell a 10 minute tow was undertaken at ~ 2.5 knots. Each vessel towed two dredge bars: a 'standard survey dredge bar' (two King and two standard queen dredges (10 teeth)) and a 'juvenile survey dredge bar' (two king and two juvenile queen dredges (17 teeth and a smaller internal mesh)). The catch from each dredge was counted and a subsample of up to ~ 50 kings and 50 queens were measured.

Key results:

Targets: The highest density of queen scallops from both the juvenile and standard dredges was recorded within the current closed area (2018/2019) within this fishing ground (Figure 5).

Chickens: The highest density of queen scallops from juvenile and standard queen dredges was recorded at an area along the 3 nm line. This area had already been identified in the April spring scallop survey onboard the R.V. Prince Madog. However, its extent was further delineated as part of the survey work undertaken in June (targeted sampling of juveniles). In addition high densities were also found in juvenile queen dredges on the west of the survey area just on the edge of the traditional fishing grounds and south of the survey area near 12 nm (Figure 5).

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

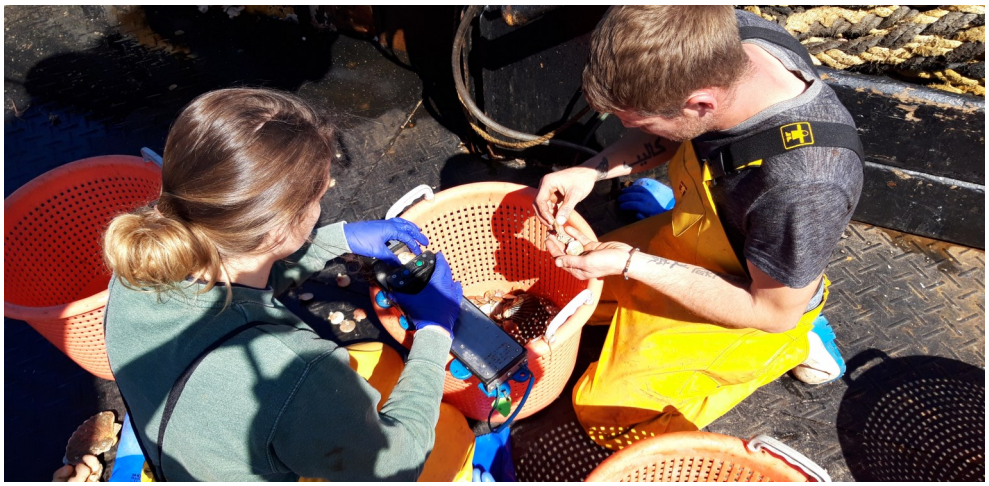


Figure 4: Industry and scientists working collaboratively on a scallop survey undertaken on-board MFPO industry vessels.

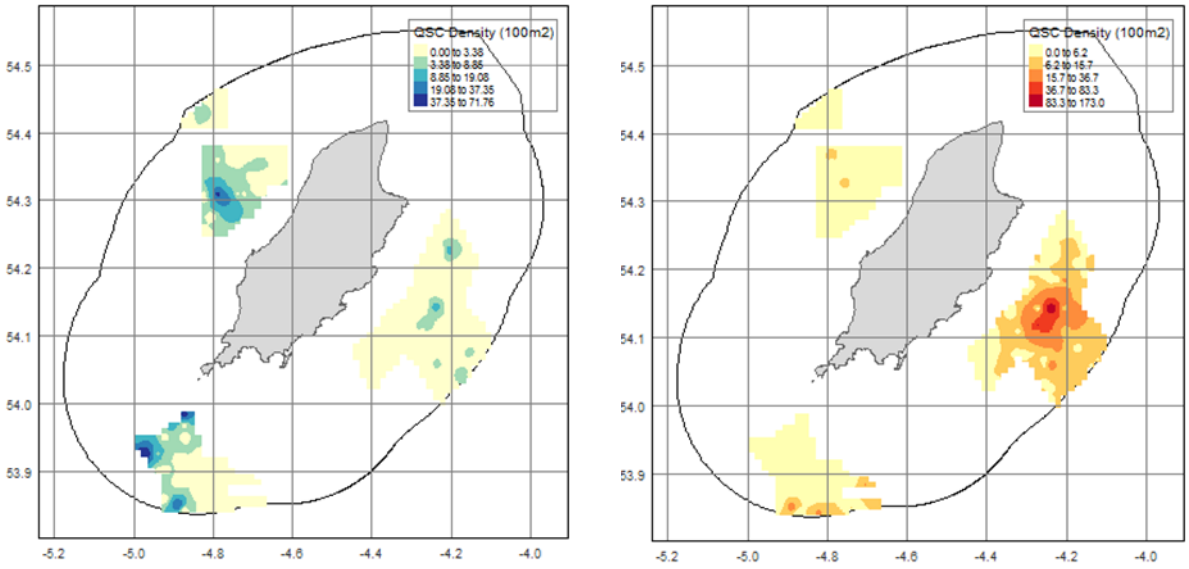


Figure 5: An IDW interpolation of queen scallop abundances showing spatial abundance trends from the June survey for queen scallops across all three surveyed fished grounds. Under MLS from Juvenile QSC Dredges only (left) and over MLS from Standard QSC Dredges only (right).

Key discussion points:

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

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

The data from both the long-term April survey and the new finer-scale June surveys combined with commercial catch data provide a level of data that may now support spatial management of this fishery for the first time (i.e. management at the level of fishing ground rather than overall Territorial Sea level). A joint report (co-authored with the MFPO) was prepared for the scallop management board (SMB) where members discussed the results.

The full report is available on request from i.bloor@bangor.ac.uk
Bloor, I.S.M., Beard, D., Emmerson, J. and Jenkins, S.R. (2019). June 2019 Queen Scallop Survey Analysis. SFAG Report No. 2, pp. 25

King Scallop Fishery Update (2018/2019)

Electronic monitoring via Nestforms Apps 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. The analysis, which is provided on a weekly basis, enables the SMB and DEFA to respond rapidly to conditions in the fishery as they occur.

The total allowable catch (TAC) for the 2018/2019 Isle of Man king scallop fishery was 2562 t. This represents a 20 % reduction in the quota following further declines in the survey abundance index in 2018. Total reported landings for the Isle of Man king scallop fishery during the 2018/2019 season were ~ 1833 t with 74 unique vessels reporting landings. This was 8 fewer unique vessels than in the previous season (2017/2018). Figure 6 shows the cumulative landings for the king scallop fishery by fished month (with totals for individual fished months marked by the points).

'Soft' monthly targets were introduced as guides to aid management of the fishery and to monitor the uptake rate of the TAC over the season (Table 1). Thus if a soft target was either exceeded or not achieved in a given month this provided a cue to the Scallop Management Board (SMB) to discuss whether current daily catch limits (DCL) remained appropriate. The soft targets were calculated by allocating the TAC proportionally among months based on historical landings patterns (averaged from 2012/2013 season to the 2015/2016 season). January was the only month where the soft target was exceeded; all remaining months landings in all other months were below the soft targets and so the DCL was maintained at 700 kg for the entire season. Total landings were around 25-30 % less than the actual TAC.

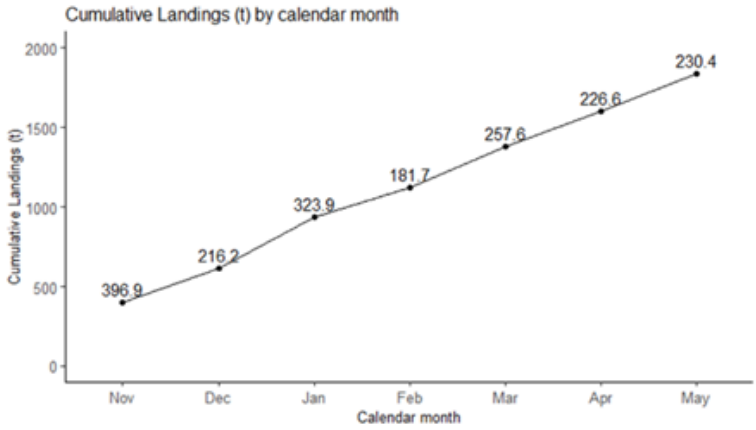


Figure 6. Cumulative landings (t) over the 2018/2019 king scallop fishing season in the Isle of Man. Points indicate monthly totals.

Month	Soft Target	Landings	Proportion
Nov	600	396.9	66.16
Dec	247	216.2	87.53
Jan	263	323.9	123.2
Feb	420	181.7	43.25
March	435	257.6	59.22
April	355	226.6	63.82
May	242	230.4	95.2
Total	2562	1833	71.56

Table 1: Soft monthly targets (t) based on average landings from previous seasons compare to actual landings per month (t). Proportion indicates the percentage of the soft targets achieved within each month.

Figure 7 illustrates the mean landings per unit effort (LPUE) by week standardised to kg per hour fished per dredge at each of the main fishing grounds. LPUE was highest at the limited permit only fishery that occurs in December within the Fisheries Management Zone of Ramsey Bay (N.B. A commercial survey also took place in Ramsey Bay towards the end of the season). The LPUE at all other grounds were between 2 and 8 kg per dredge per hour fished.

In Figure 8, landings are reported by main fished ground and separated by colour for each month to show the spatial location of landings. As observed last season, there was a relatively even split of landings across the season from the four main fishing grounds (IS9: Targets. IS21: Chickens; IS15: East Douglas and IS14: Bradda/Port St Mary).

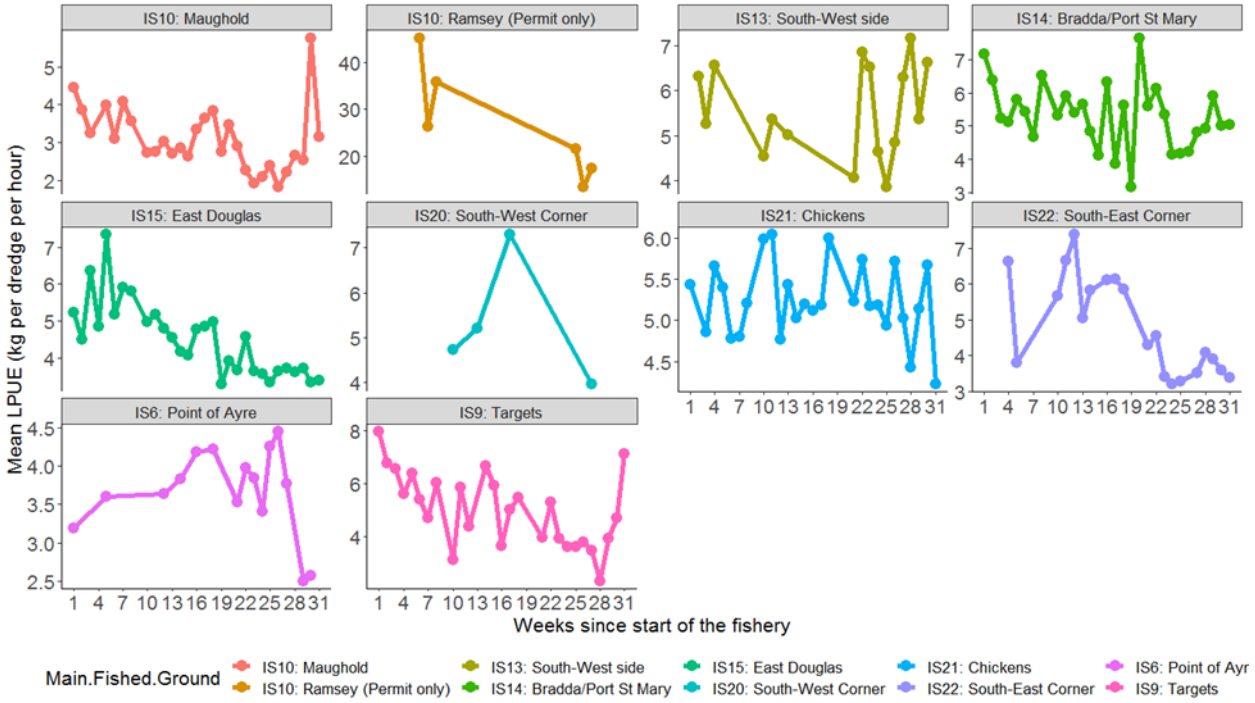


Figure 7. LPUE (kg per dredge per hour fished) for the 2018/2019 king scallop fishing season averaged by week and displayed by main fished ground. ***Note the different scales on the y-axes***.

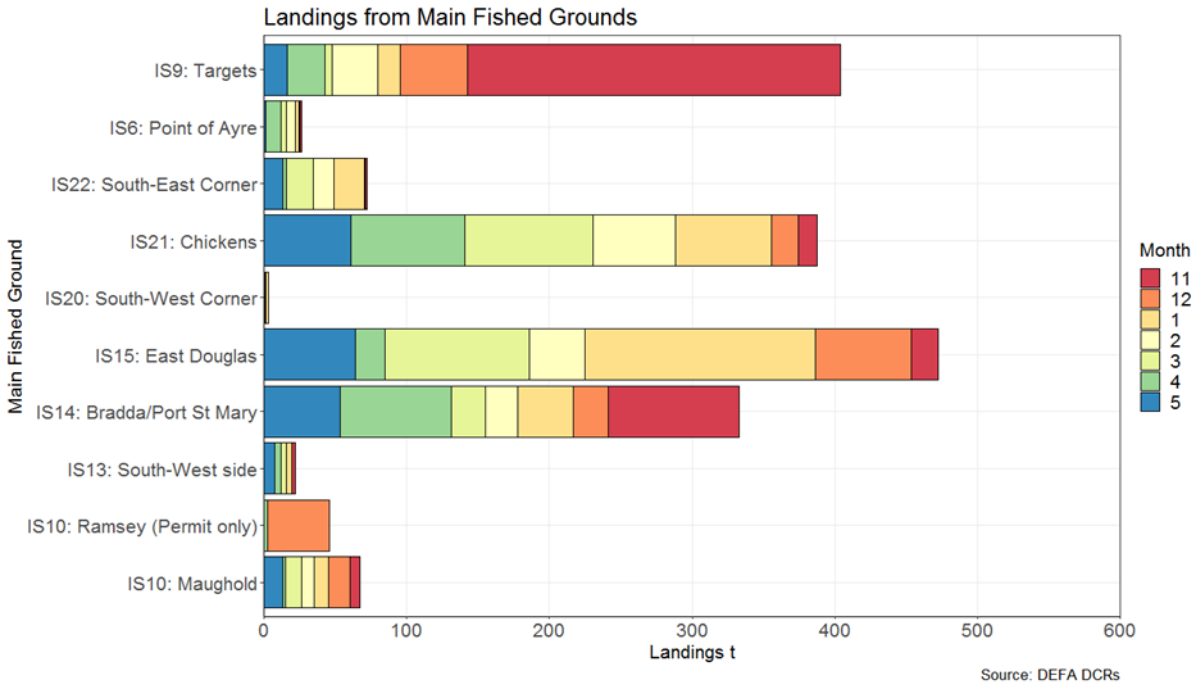


Figure 8: Total landings (t) of king scallops by month from the 10 main fished grounds.

King Scallop Stock Advice (2019/2020)

An annual assessment of the stock was undertaken using the long-term time series of data collected from annual scientific surveys. For the first time this data was supplemented by a fine-scale industry led survey which undertook 10 minute tows, in a randomised stratified design, across the fished area of the territorial sea. The analysed data from both surveys was used to provide advice to DEFA and the SMB. This advice is used by the SMB to make decisions on the Total Allowable Catch (TAC) and other management controls for the king scallop fishery.

The long-term survey data was analysed as abundance indices (i.e. the relative abundance of adult and juvenile scallops is compared for each year of the time series to assess whether the fishable stock (adults) and future stock (recruits) are increasing or decreasing). The length based abundance indices for recruits (< 95 mm) (Figure 9: Top left) and post-recruits (>95 mm) (Figure 9: Top right) from the April survey are presented below. Both indices have shown recent decreasing trends although there is a slight increase in the recruit index in 2019 compared to 2018. The commercial catch (ICES Rectangles 36E5, 37E5 and 38E5) has decreased since 2017 alongside the introduction of a TAC within the Isle of Man's territorial sea (Figure 9; Bottom left). There was a slight increase in the overall abundance index (all size scallops) in 2019 (Figure 9; Bottom right).

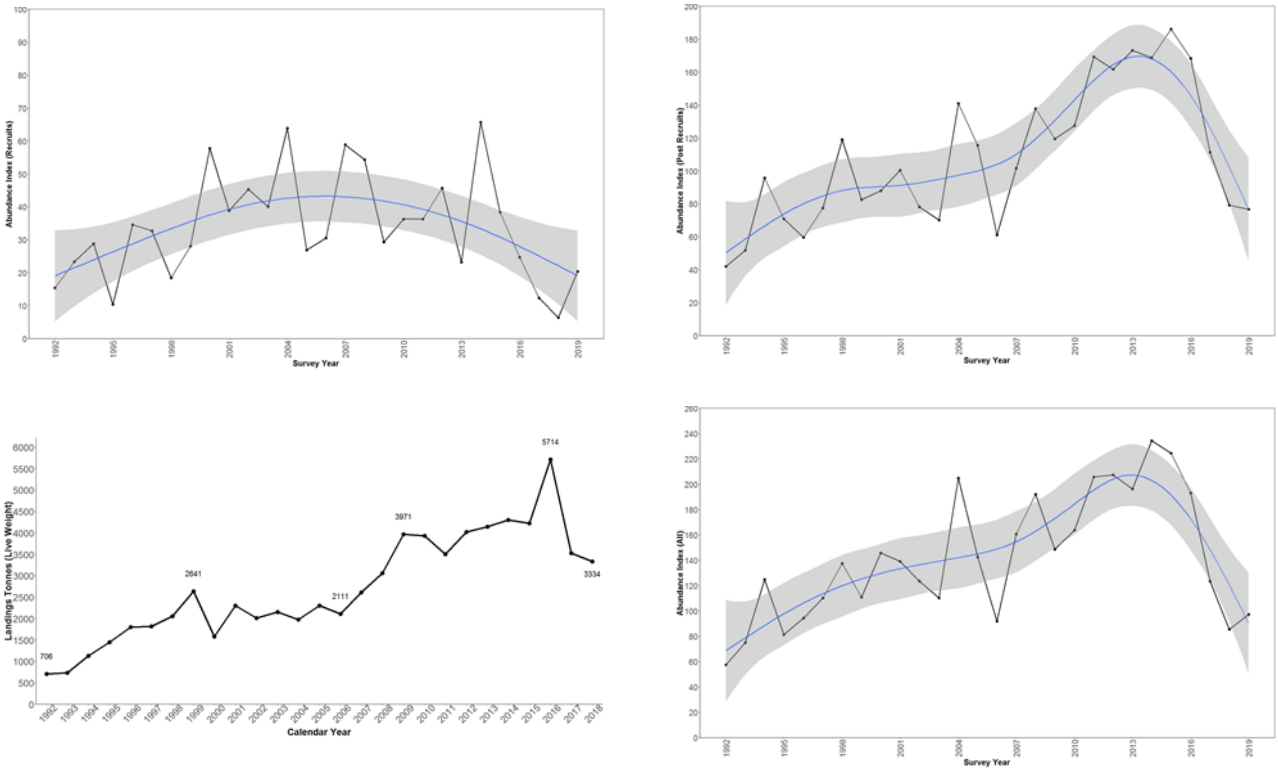


Figure 9: King scallops in ICES Rectangles 36E5, 37E5 and 38E5. Upper left, Recruit length abundance index from April survey; Upper right, Post-Recruit length abundance index from April survey; Lower left, landings from ICES Rectangles 36E5, 37E5 and 38E5 by calendar year; Lower right, length abundance index from April survey for all scallops combined.

2019/2020 Management Recommendations:

The survey data (abundance indices) indicated a declining trend in stock. As such, a decline in the TAC from the previous season of 20% was advised. As total landings from the previous season (2018/2019) were ~28% lower than the original TAC (i.e. 1883 t landed from 2562 t TAC), two scenarios for calculating the TAC for the 2019/2020 season were presented to the SMB (Table 2).

Scenario 1- a 20 % reduction of the 2018/2019; TAC ≈2049t and Scenario 2- a 20 % reduction of actual landings from the 2018/2019 season; TAC ≈ 1446t). It was recommended that in setting a TAC for the forthcoming season there was a discussion by the SMB of the merits of Scenario 1 versus Scenario 2. This discussion should recognise that Scenario 1 will set a TAC which is higher than total landings from the previous season. It was also advised that protection of areas surveyed in the April and June survey that recorded large proportions of pre-recruit (i.e. less than 95 or 100 mm respectively) should be considered by the SMB ahead of the fishing season in order to protect stock for future years. An additional recommendation that a review of the fishery should be undertaken by the SMB following the first month of the season to review the fishery dependent data collected (i.e. LPUE, Spatial distribution of landings, proportion of vessels meeting daily quota etc.) was also made.

Table 2: Calculations and catch advice for the Isle of Man king scallop fishery using the ICES methodology outlined for a Category 3 stock (Method 3.2). Index A is the average of the last two year's survey abundance indices (2018 – 2019); Index B is the average of the three preceding year's survey abundance indices (2015 – 2017); Index Ratio is a ratio of Index A divided by Index B. Survey indices can contain a level of noise within the data, as such a +/- 20% cap (Uncertainty Cap) on inter annual changes to the TAC from the Index Ratio is advised (ICES, 2012). These methods are designed to be precautionary and so where there is uncertainty due to a deficiency of information (i.e. stock status relative to references points or exploitation is unknown) a 'Precautionary Buffer' of a 20% reduction in catch is advised unless expert knowledge or evidence indicates that the stock is not reproductively impaired or that stock size is increasing (ICES, 2012).

	I	II
Index A (2018 - 2019)	91	91
Index B (2015 – 2017)	180	180
Index Ratio (A/B)	0.49	0.49
Uncertainty cap	0.80	0.80
TAC from 2018/2019 season	2562	1833
Discard rate	-	-
Precautionary buffer	NA	NA
Catch advice for 2019/2020**	2049	1466

*** For Scenario II: only 72% of the TAC for 2018/2019 was achieved. Therefore Scenario II: (actual landings for 2018/2019 x Uncertainty Cap)*

Additional Recommendations:

The fine-scale industry survey undertaken in June helped corroborate the April survey data and provided additional useful information. As such it would be useful if this fine-scale industry survey was continued to be undertaken annually alongside the existing research vessel survey in April.

Spatial management and assessment of king scallops should be developed and considered for future years. As part of this, a literature review and meta-analysis will be undertaken to review spatial management examples from both scallop fisheries and other sessile aggregating species to look at potential options, data analysis and management methods for spatial management in the 2020 fishery based on all available data. This will include ascertaining options for managing high densities of either juvenile ("protected areas") or adults ("Fishery Hotspot areas").

The Irish Sea king scallop fishery should be managed at the appropriate spatial scale. Unpublished genetic and oceanographic research indicates that the northern Irish Sea may be the most appropriate management unit for the fishery surrounding the Isle of Man. It is therefore vital that work continues towards achieving a collaborative management approach for king scallop stocks within the different regions of the Irish Sea.

Report: Bloor, I.S.M. (2019). Isle of Man king scallop (*Pecten maximus*) Stock Advice for 2019/2020 Season. SFAG Report No. 2, Bangor University. Pp. 36.

King Scallop Stock Assessment Progress

Collaboration during 2019 with Dr. Adam Delargy of Bangor University has led to substantial advances in developing bayesian stock assessment models for king scallops. Through making comparisons of the model outputs based on the long-term data from the Isle of Man king scallop fishery with that from a short term dataset from the Welsh king scallop fishery it has been possible to critically assess three different stock assessment models that have been adapted specifically for use with this species and these stocks.

The biological detail incorporated into historical reconstruction stock assessment models can affect model outputs and the effects are typically case-specific. The models were compared based on the data available, population characteristics and model fit. All three models were integrated analysis (multiple observed datasets) stock assessment models based on different characteristics of stock structure (length-, age- and un-structured respectively). Unstructured models are also known as surplus production or biomass dynamic models. All models were designed to operate with aggregated catch data (single sum of annual catch) as well as survey data as either length- or age-frequencies or total index. The models were designed to account for the seasonal patterns in scallop life history and fishing activities.

All models required basic data on the total landings and discards from the stock assessment area and a survey dataset for the same time period. The unstructured model has the least data requirements and has a very short run time (i.e. 5– 10 mins). The structured models (age or length) are more complicated in both their data input requirements (requiring survey data to be structured by age or length categories) and in their run times. The age model is structured by 1 year time steps in age which increases the model run time to around 4-5 hours. The length model is structured by 1 mm length steps and is thus very data intensive, increasing the model run time to 2-3 days.

Figure 10 shows an example output that can be produced from the models to assist with management decisions for the stock. Figure 11 is an example of a trial run of the unstructured model, which is the most simplistic of the three models in terms of the required data inputs. Such plots can be produced as standard from the stock assessment models to show reference points like carrying capacity (K), maximum sustainable yield (MSY), the biomass that enables a fish stock to deliver the maximum sustainable yield (BMSY) to assist with fisheries management.

Figure 11 show trial outputs from the age-structured model. The plots show the model fits in predictions of the age structures of the model data to the actual survey data. The age structured model output provides a good fit to the survey data for most years.

At present the stock assessment models are continuing to be refined and tested. Differences in estimates from the models highlight the importance of carefully considering the biological data that is used as input for stock assessment models. Once all models have been optimised then the outputs from all three: unstructured, age-structured and length-structured will be compared and an assessment made as to which is the most suitable for ongoing development and use for the Isle of Man king scallop stock. Further collaborative work is planned for 2020 to refine the model inputs and the model calculations with the aim of improving the model outputs. Trials will continue in 2020 with delivery of a workable model estimated for August 2020.

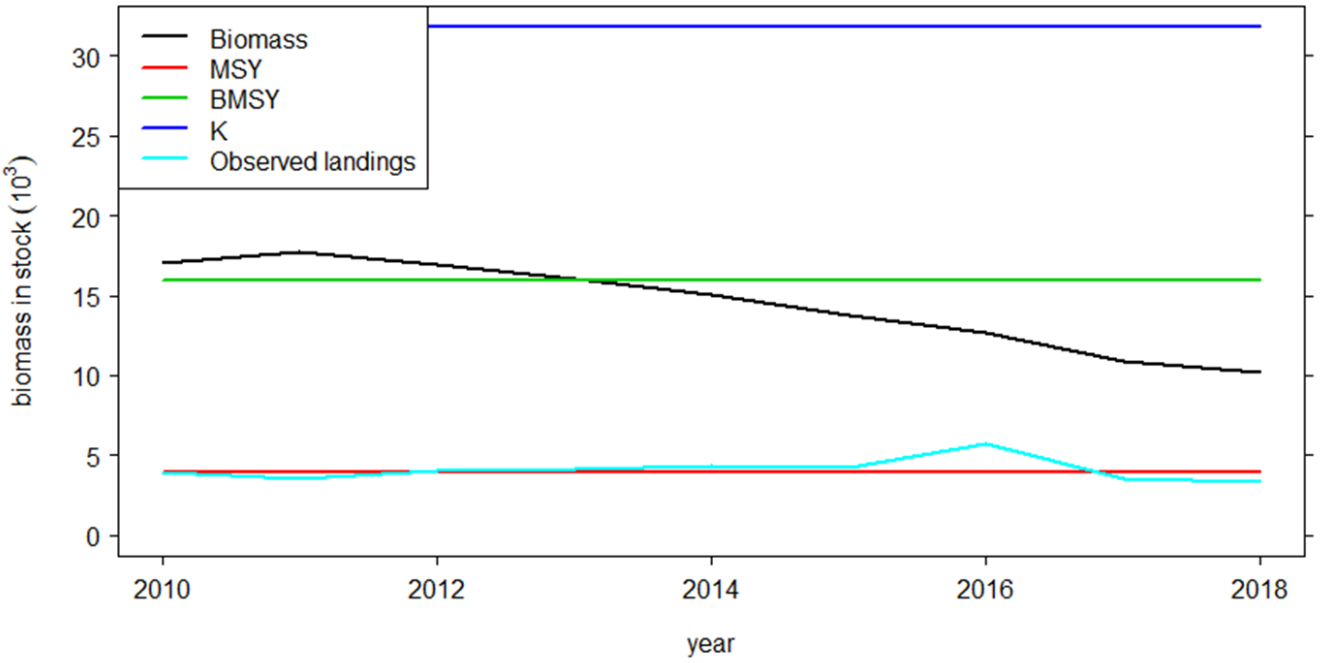


Figure 10: Example management outputs from the unstructured model. Which includes estimates of biomass, reference points for management: Maximum sustainable yield (MSY), Biomass maximum sustainable yield (BMSY), carrying capacity (K) as well as observed landings.

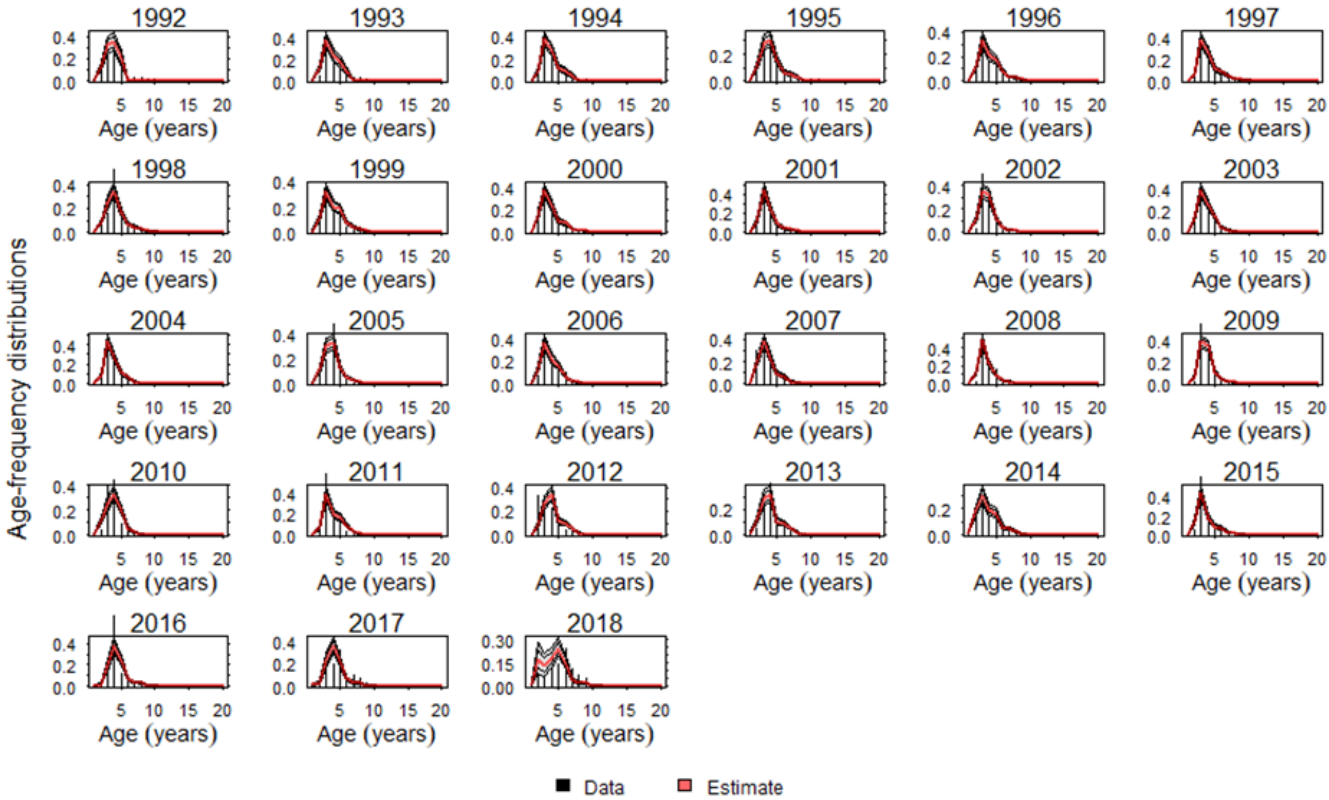


Figure 11: Trial outputs from the age-structured model using Isle of Man scallop data. A comparison of the survey data and modelled data for age frequency distributions as shown by year.

Queen Scallop Stock Assessment (2019)

Queen scallop stocks within the Isle of Man's territorial sea are exploited primarily by Manx and UK vessels using otter trawls with a small number of vessels continuing to use towed dredges. These fisheries are not governed by EU quotas but are subject to national TACs and the stocks have been routinely monitored and formally assessed since 2013.

2019 Stock Assessment

The 2019 stock assessment was conducted using the CSA (v4.3) model and included stations 3, 4, 5, 9, 10, 14, 17, 20, 21, 22, 23, 24, 25, 32, 35, 36, 38, 39 and 45 and historical stations (CHI, EDG, LAX, POA, PSM, RAM, SED and TAR). For the stock assessment unit (Isle of Man territorial sea):

- Landings had decreased from 992 t in 2017 to 722 t in 2018 (this decrease was also evident in the wider stock unit: 36E5 and 37E5) (Figure 13).
- Median estimated biomass had fallen from 1530 t in the 2018 fishing season to 1208 t in the 2019 fishing season (Figure 13)

The difference in mean survey density (scallops per 100 m^2) of queen scallops from queen scallop dredges between 2018 and 2019 is displayed for all stations used in the stock assessment in Figure 12.

Figure 12: Difference in average survey density (scallops per 100m^2) of queen scallops from queen scallop dredges between 2018 and 2019 (red bars indicate a reduction in scallop density and turquoise bars indicate an increase in scallop density from 2018 to 2019).

Advice for 2019

The following advice was given to inform management of the 2019 queen scallop fishery:

- Estimated biomass for the territorial sea remains low. Recent data from the fishery indicates that with estimated biomass removals of ~ 20% and over, biomass declined in each subsequent year, with insufficient recruitment to replace the losses from natural and fishing mortality combined. As such, while recruitment levels remain low, a precautionary approach should be adopted with biomass removals from fishing mortality limited to less than 20% of the median estimated biomass.

- Estimated biomass for 2019 is down from 2018 (Figure 13). As such, there is no scientific evidence that the stock can support the TAC from 2018 (794 t).
- Furthermore, although the Scallop Management Board agreed in 2017 to the use of the ICES Category 3 data-limited approach for calculating TACs, a 20% reduction of the current TAC using this method still equates to a removal of around 50% of estimated biomass, more than double the maximum scientific recommendation.

A Pan-Irish Sea Management plan is still urgently needed to develop and implement measures to substantially reduce fishing mortality within the wider stock. Following concerns raised by industry, a three month statutory closure of the queen scallop fishery (Areas VIa and VIIa) was introduced in 2018 and continued in 2019 to protect the stock during the spawning period.

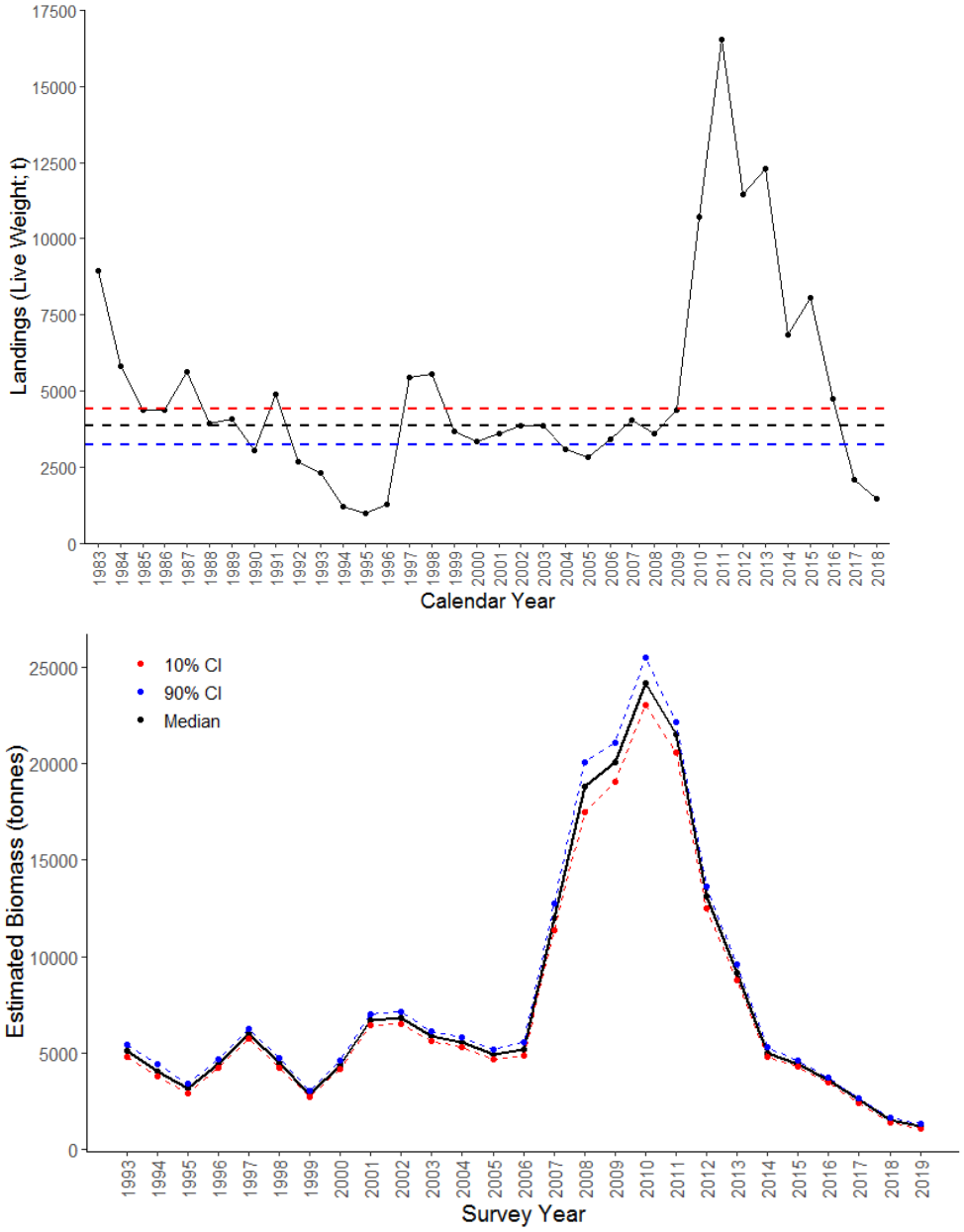


Figure 13: Top: Summary of estimated total landings (t) from ICES Rectangles 36E5 and 37E5 to the UK and Isle of Man. Bottom:. Estimated median biomass for the IoM territorial sea as estimated from the length based stock assessment using CSA. Dotted lines indicate 10% and 90% confidence intervals.

A full report is available on request: Bloor, I.S.M., Emmerson, J. and Jenkins, S.R. (2019). Assessment of Queen Scallop stock status for the Isle of Man territorial sea 2019/2020. SFAG Report No. 1, pp. 18

Queen Scallop Trawl Fishery Update (2019)

The quota for the 2019 Isle of Man queen scallop fishery was 476 t. This represented a 40 % reduction in the quota following a decline in the survey abundance index. The quota was subdivided into 417.71 t for the trawl fishery and 58.29 t for the dredge fishery. In Week 8 of the trawl fishery the majority of the territorial sea was closed to fishing on completion of the initial TAC. The Douglas fishing area (on the east coast) remained open to allow fishing to continue in a high density area. Fishing was allowed to continue until either the TAC reached 557 t (a decrease of 20 % relative to the 2018 quota) or an average LPUE threshold was triggered. Total reported landings for the trawl fishery during the 2019 season were ~549 t (99 % of the revised TAC) with 30 unique vessels reporting landings. In addition, 38.6 t was landed from the permit only fishery in Ramsey Bay. Figure 14 shows the cumulative landings (t) for the queen scallop trawl fishery by fished week (with totals for individual fished weeks marked by the points). Figure 15 shows the spatial distribution of landings within the fishery. In contrast to 2018 when landings were split relatively evenly within the four main fished grounds, 2019 Landings came almost entirely from IS15: East Douglas where a high density patch of queen scallops was located.

Landings per unit effort (LPUE) was standardised to 35 kg bags per hour fished per 10 fathom net. Figure 16 shows the mean LPUE (and distribution of LPUE) by week at each of the fished grounds. LPUE at East Douglas which was the predominant ground fished saw a steady decrease over the season but with average LPUE maintained above 4 bags per hour fished per 10 fathom net. LPUE was lower in Ramsey Bay in 2019 compared to 2018 with a drop from 14 bags to ~ 7-11 bags per hour fished per 10 fathom net.

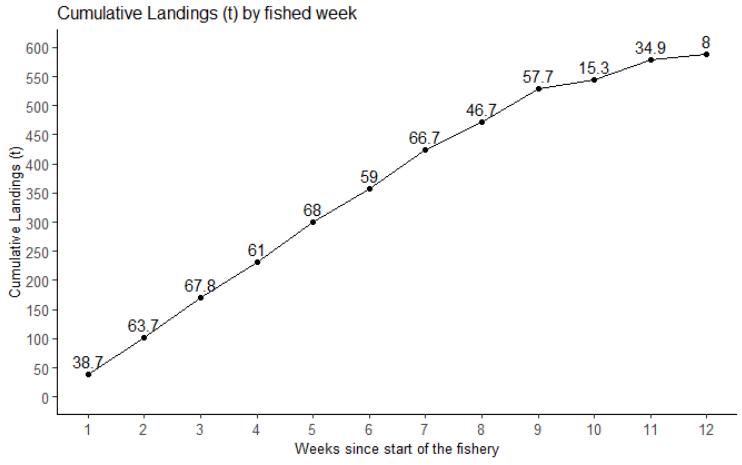


Figure 14: Queen Scallop trawl fishery cumulative landings (t) and landings by week for 2019.

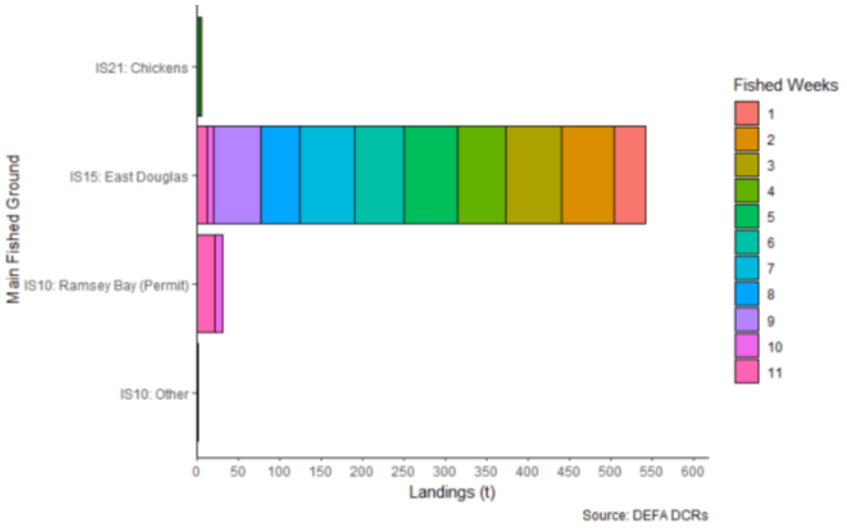


Figure 15: Total landings (t) of queen scallops by week from four of the main fishing grounds (2019 trawl fishery)

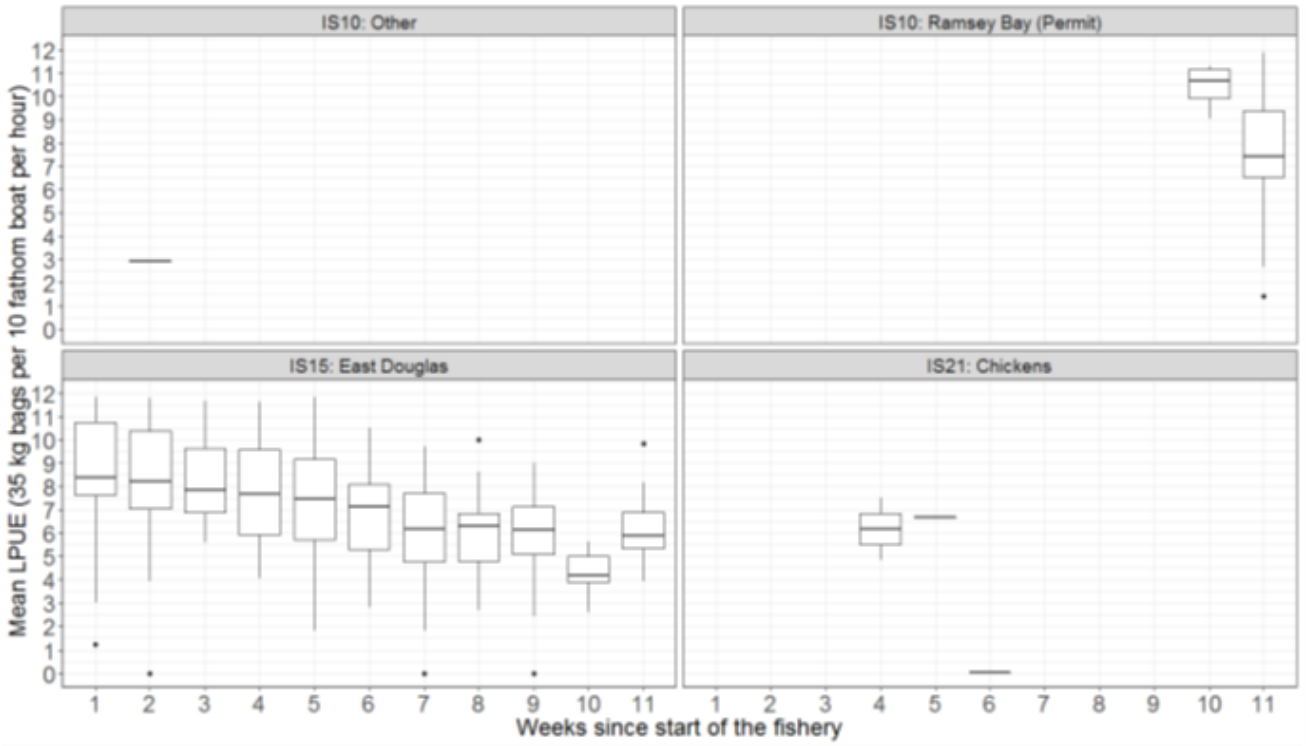


Figure 16: Boxplot illustrating mean LPUE and distribution of LPUE (standardised to 35 kg bags per 10 fathom net per hour) by week at each of the fished grounds.

Queen Scallop Dredge Fishery Update (2019)

The quota for the 2019 Isle of Man queen scallop dredge fishery was 58.29 t. This represented a 40 % reduction in the quota following a decline in the survey abundance index. Total reported landings for the 2019 dredge fishing season are ~ 18.48 t with only 2 unique vessels reporting landings (data correct as of 7th January 2020; however the fishery remains open until 31st March 2020). This is a reduction of 2 unique vessels targeting the fishery compared to the previous 2018 fishery when 4 unique vessels fished.

Landings per unit effort (LPUE) were standardised to kg per dredge per hour fished and averaged 20 and 23 kg per dredge per fished hour in Week 1 and Week 3 respectively (down from 34 and 27 kg in 2018 for Week 1 and Week 2 respectively and a continued decrease from 2017). Management of the dredge fishery continues to operate differently from the trawl fishery with each vessel being allocated an individual quota that could be fished as and when suited by the vessel during the season.

Although the SMB has had discussions about changing the location of the queen scallop dredge fishery, at present the fishery continues to be restricted to a dredging zone on the south of the Island within the Chickens fishing ground and this section of the queen scallop fishery is targeted exclusively by UK vessels.

Landings Obligation: Plaice survivability in the Isle of Man queen scallop trawl fishery

Introduction:

The EU Landings Obligation (LO), which came into effect for scallop fisheries in January 2019, was introduced to eliminate discarding as whole, and provides an incentive to fishermen to use more selective modes of fishing. The LO requires that all fish caught and landed on deck, including undersized fish, have to be landed by law, regardless of whether the proper licence or quota is held. This means that if bycatch quotas are exceeded prior to the target fish quota being fulfilled, a fishery would have to close (i.e. it would be choked). For fisheries managers and industry, options to avoid such a scenario include: buying or retaining sufficient quota for their fleet to land the bycatch of quota species; trying to implement strategies to fishing practice to reduce the amount of bycatch caught and applying for an exemption to continue discarding if circumstance are favourable.

Among the common quota species caught in the Isle of Man queen scallop fishery, plaice (*Plueronectes platessa)* is one of the most common species caught as bycatch. Plaice have been identified as a potential "choke" species and a great concern for the Isle of Man fisheries managers. However, in several previous studies plaice have presented an elevated survival potential. The objective for this study was to collect data to assess whether a proposal to exempt plaice from the landings obligation could be made for this fishery due to high survivability of this species.

Methods:

A combination of at-sea assessment and on-shore monitoring was used to assess survivability of plaice under regular commercial fishing practices within the Isle of Man territorial sea. At the point where the fish would normally have been discarded before the landing obligation, scientists and crew separated plaice to assess length, vitality, injury, and reflex impairment to get an estimate of the condition of the fish and the proportion of which were dead. Vitality was assessed using a scoring method from 1 Excellent to 4 Moribund. Each trip was for a maximum duration of 12 hours, the fish were kept on board for periods no longer than 12 hours, then were transferred to onshore facilities. The Holding tanks were setup at Lewis Seafood in Peel, supplied by the Manx Fishing Producers Organization (MFPO). Captive monitoring started directly after the fish were placed into the tanks on-board and onshore. The fish were fed and monitored daily (every 24 hours for 7 days) at the laboratory for survival. If a fish started to show signs of lethargy, i.e. the individual had no reflex response to a tail grab after 5 seconds, the fish was removed from the monitoring tanks, identified, recorded, then terminated using a schedule 1 procedure. At the end of the monitoring period all fish were individually removed from the observation containers, measured, identified, assessed for a reflex response, and then were terminated or released. The fish were terminated following ethical guidelines using a schedule 1 procedure to anesthetize then destroy the brainstem.

Results:

At sea monitoring: The minimum conservation size (MCRS), which is the size at which fish can be landed for human consumption, is 27cm for plaice. During this study 63% of plaice landed were over MCRS (n=121) (Figure 17). Around 30% of these had a vitality score of 1, while 19%, 30% and 21% had a vitality score of 2, 3 and 4 respectively.

Out of the 37% of plaice caught under MCRS (n=66), only 16% were scored as vitality 1, while 31%, 31% and 20% scored as 2,3 and 4 respectively. The amount of time each plaice was on deck varied from 3 minutes to 40 minutes. There was a clear relationship between the time on deck and vitality score. A total of 75% of plaice sorted in the first ten minutes were recorded with a vitality score of 1 or 2. After 10 minutes the number of plaice recorded with a vitality score of 1 decreased rapidly to 17%. After 20 minutes on deck, 90% of plaice were vitality 3 and 4 (Figure 17).

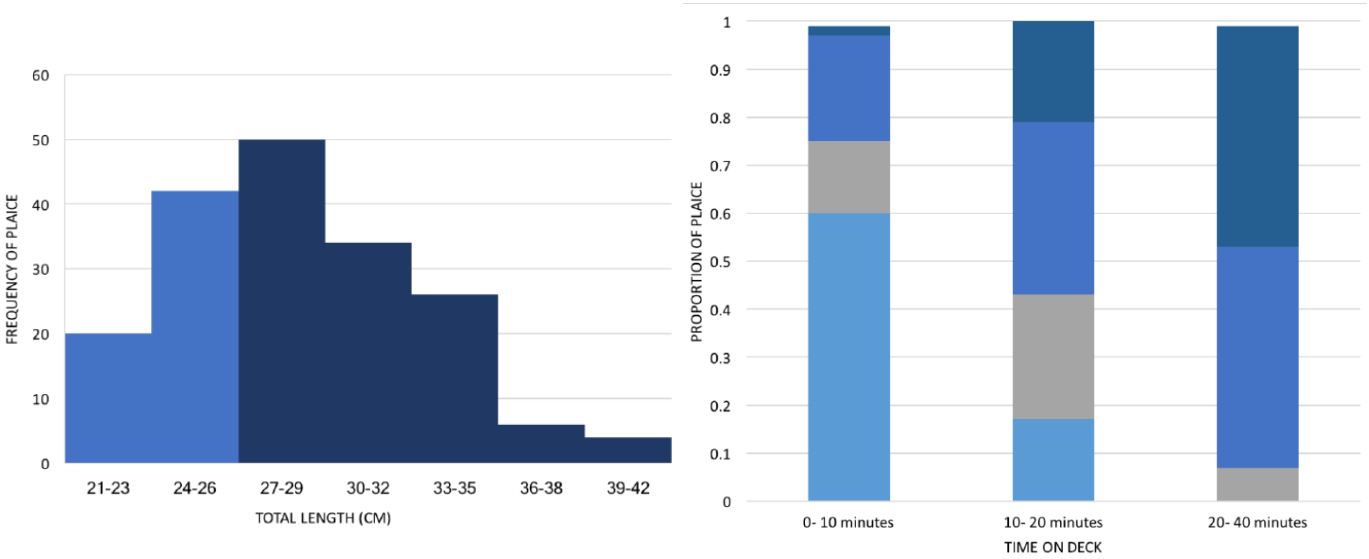


Figure 17: *Left: Frequency of plaice per length recorded. Light blue represents fish under MCRS and dark blue represents fish over MCRS. Right: Percentage of plaice in each vitality score per 10 minute interval. The 20 – 30 and 30 – 40 minute groups were combined to increase the sample size. Vitality 1 = Light blue, Vitality 2 = Grey; Vitality 3 = navy blue and Vitality 4 = Dark blue.*

Onshore monitoring:

A total of 44 plaice were retained for captive observation from two of the fishing trips. The length distribution was comparable to the total catch of plaice assessed during the study (20cm- 41.5cm; mean length 28.3 cm). Fish were observed in captivity for 192h. Plaice survival reached an asymptote at 144 hours when 4 plaice or 11% had survived the capture, transport, and captivity process. Vitality 1 had a mortality rate of 45%, vitality score 2 had a mortality rate of 71% and vitality 3 had 94% mortality. Plaice in vitality score 1 have the highest potential for surviving after discard. After 196 hours of observation, 4 plaice or 11% of the total observed fish were still alive.

Discussion:

This research aimed to quantify discard survival rate of plaice and the factors that influence the survival rate of plaice on-board a commercial queen scallop vessel. Based on the on-board vitality assessment and reflex and injury assessment we found that 48% of plaice that are brought on-board a commercial trawler are in excellent/good condition. Although the captive observation experiment resulted in an extremely low survival rate of 11%, many interesting results were found. Deck time had the biggest influence on the vitality score, therefore on discard survival rate. When fish were assessed within 10 minutes, 75% of fish were in excellent/good condition. To potentially increase the survival rate for future studies and for exemption purposes sorting the fish within 10 minutes is critical.

Elias, A. (2019). Choke species and the Landings Obligation: Survivability of plaice in the Isle of Man queen scallop trawl fishery. MSc thesis, Bangor University [available by request from i.bloor@bangor.ac.uk]

UK Scallop Management Conference

4th –5th February 2019, Fishmonger's Hall, London

The UK Scallop Management Conference 2019 was an industry led event organised by the Fishmonger's Company in partnership with Macduff Shellfish (Scotland) Ltd. It was supported by Seafish and held over two days in February in London. The event had a total of 82 participants including representatives from the fishing industry, fishery science and the UK government.

The objectives for the conference were:

- To advance thinking and dialogue around the future management of scallop fisheries upon which UK fleets are dependent, and to better inform stakeholders about management tools and strategies that could be applied in a domestic context through exploring management case studies from across the world.

- To learn about the biological, environmental, social and economic consequences of different fisheries management models in order to inform the development of a sustainable harvesting strategy for scallops in the U.K.

The conference included a range of talks from invited speakers from across the world as well as panel and discussion sessions and live polling questions. Along with other case studies of scallop fisheries management from USA, Canada, Patagonia, Shetland and France, a presentation on the Isle of Man King Scallop fishery was given by David Beard titled "Management of Inshore King Scallop Fisheries in waters around the Isle of Man: With reference to Ramsey Bay MNR and the 0-3 mile zone". This presented collaborative (industry, science and government) research and analysis from the Isle of Man.

Attendees from the Isle of Man included representatives from DEFA (Peter Duncan and Neil Milsom),

Figure 18: *Left: Presentation from Dr David Beard on Isle of Man scallop fisheries and management; Right: Lynda Blackadder Chair of the ICES Working Group on Scallop Stock Assessment presenting the aims and terms of reference of the working group.*

22nd International Pectinind Workshop

24th –29th April 2019, Santiago de Compostela, Spain

Since 1976 the International Pectinid Workshop has been a biennial event for scallop researchers from all over the world. Pectinids (scallops) are of worldwide importance and the aim of the workshop, which this year was attended by around 50 participants from 15 countries, is to disseminate knowledge concerning the scallop species of the word.

Theme sessions included:

- Resource Management,
- Fisheries,
- Biochemistry,
- Genetics and Physiology and
- Aquaculture.

Two representatives from the Isle of Man attended the Workshop (Dr Isobel Bloor, Bangor and Dr Peter Duncan, DEFA). A presentation was given by Dr Isobel Bloor on "Lessons learnt and future management scenarios for a commercially-managed experimental scallop fishery in Ramsey Bay Marine Nature Reserve, Isle of Man".

The 23rd International Pectinid Workshop will be held here in the Isle of Man in April 2021. This is a fantastic opportunity for the Island to host an international conference and to showcase its long tradition of scallop fishing, science and management.

Figure 19: Global representatives of scallop science at the 22nd International Pectinid Workshop, Santiago de Compostela, Spain.

ICES Working Group on Scallop Stock Assessment

8th –11th October 2019, iMuseum, Douglas Isle of Man

Bangor University and the Isle of Man Government hosted the annual international Scallop Assessment Working Group meeting at the iMuseum in Douglas between the 8th and 11th of October 2019. The working group, which forms part of the International Council for the Exploration of the Sea (ICES), brings together scientists with knowledge and experience of king and queen scallop fisheries to exchange data, analysis methods and expertise. The meeting, chaired by Lynda Blackadder from Marine Scotland, was opened on 8 October by the Minister for Environment, Food and Agriculture, Geoffrey Boot MHK and was attended by 18 participants from 10 countries (including England, Wales, Isle of Man, Northern Ireland, Ireland, USA, Norway and Iceland) and 12 institutions.

Figure 20: ICES Working Group meeting held in the Isle of Man in October 2020.

The aim of the Scallop Assessment Working Group (WGScallop) is to develop and improve stock assessment methods for scallops and increase understanding of scallop populations and fisheries. This is achieved by sharing expertise on survey methodologies, advances in technology and recent studies on various scallop species (i.e. dredge efficiency, incidental and discard mortality, growth, and genetics). Progress at the meeting included:

- One of the terms of reference of the Working Group is to assess scallop stocks at the level of the Irish Sea. For this purpose a list of available data (landings, effort, survey, observer, catch sampling, VMS, habitat data) for scallop fisheries in the Irish Sea region was produced at the meeting and the extent of the initial stock assessment area has been agreed. The group will now progress with checking the format of the data sources and collating the data.

- Stock assessment work has been undertaken to examine the potential modelling options for data limited stocks (cohort analysis and SPiCT) and the group improved the performance of three different models applied both to a temporally data-limited scallop stock (Wales) and a scallop stock with a longer data time series (Isle of Man).

- Significant progress has also been made in the collation of landings and effort data and the group now have access to data currently held in the Regional Database (RDB). Data checking will be attempted using the app developed by the Working Group on Mixed Fisheries Advice (WGMIXFISH).

- Preliminary results from an exchange of scallops for age determination showed inconsistencies within and among exchange participants and institutes. For this reason the group will support a Workshop on Scallop Aging (WKSA) in 2020 to identify ways to improve accuracy and consistency and produce a standard methodology for aging king scallops.

Figure 21: International delegates at the ICES Working Group meeting held in the Isle of Man in October 2020.

The full 2019 Report of the Scallop Assessment Working Group (WGScallop) is now available on the WGScallop community page. The citation for this report is:

ICES. 2019. Scallop Assessment Working Group (WGSCALLOP).
ICES Scientific Reports. 1:90. 31 pp. http://doi.org/10.17895/ices.pub.5743

The next meeting will be hosted by the Marine & Freshwater Research Institute in Iceland from 6th – 9th October 2020.

Potting Sector Fisheries: Crab, Lobster & Whelk

The potting sector of the fishing industry on the Isle of Man remains defined by three target species; crab (*Cancer pagurus*), lobster (*Homarus gammarus*) and whelk (*Buccinum undatum*). These three fisheries face separate challenges and gaps in scientific knowledge, but with some common themes. By collaborating closely with industry and DEFA, Bangor University is working to understand and address these challenges. Our work comes at a potentially pivotal period in static-gear fisheries research on the Isle of Man, as the economic significance of all three fisheries continues to grow. However, in order to maximise the long-term value of these fisheries, effective and evidence-based management needs to underpin them.

Whelk (*Buccinum undatum*) Fishery Update

The whelk fishery in the Isle of Man territorial sea is the only such fishery in the British Isles that:

- Has a restricted access licensing system ;
- Has a pot limitation applied to each unique licence;
- Restricts harvests according to a biologically-referenced minimum-landing-size (MLS);
- Is monitored monthly in terms of landings-per-unit-effort (LPUE).

In 2019, the landings of whelk into the Isle of Man exceeded 800 tonnes. The total effort by Isle of Man registered vessels was c.365,000 pot-lifts from 773 vessel-days. Therefore, the average Manx whelk vessel lifts c.472 pots per day-at-sea.

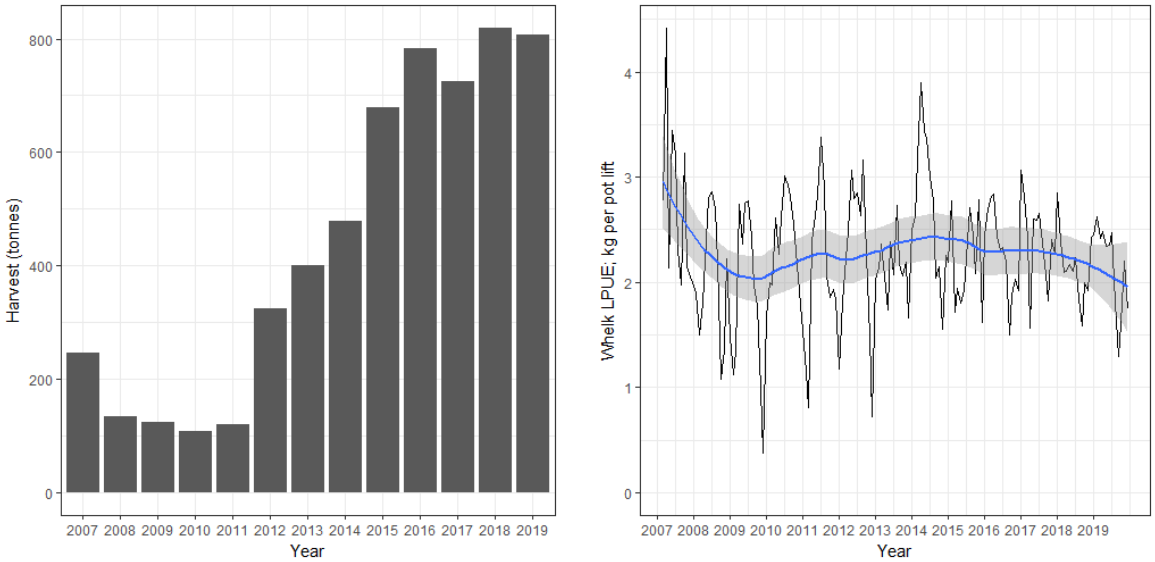


Figure 22. The harvest (left) and estimated landings-per-unit-effort (LPUE) of the common whelk (*Buccinum undatum*) fishery in the Isle of Man territorial sea (right). Data: DEFA.

Whelk continued...

The data also shows that fishing effort has increased approximately 8-fold over an 8 year period from c.40,000 pots in 2009 to c.365,000 pots in 2018. Seasons are characterised by low winter LPUE, with an increase of 50-60% during the spring and into the summer as female whelk begin feeding to recover energy reserves after egg-laying in late winter.

As the trends in Figure 22 suggest, the LPUE in the whelk fishery varies significantly within and between years but the long-term trend (2009-2019) is relatively stable with a mean average LPUE of 2 to 2.5 kg per pot.

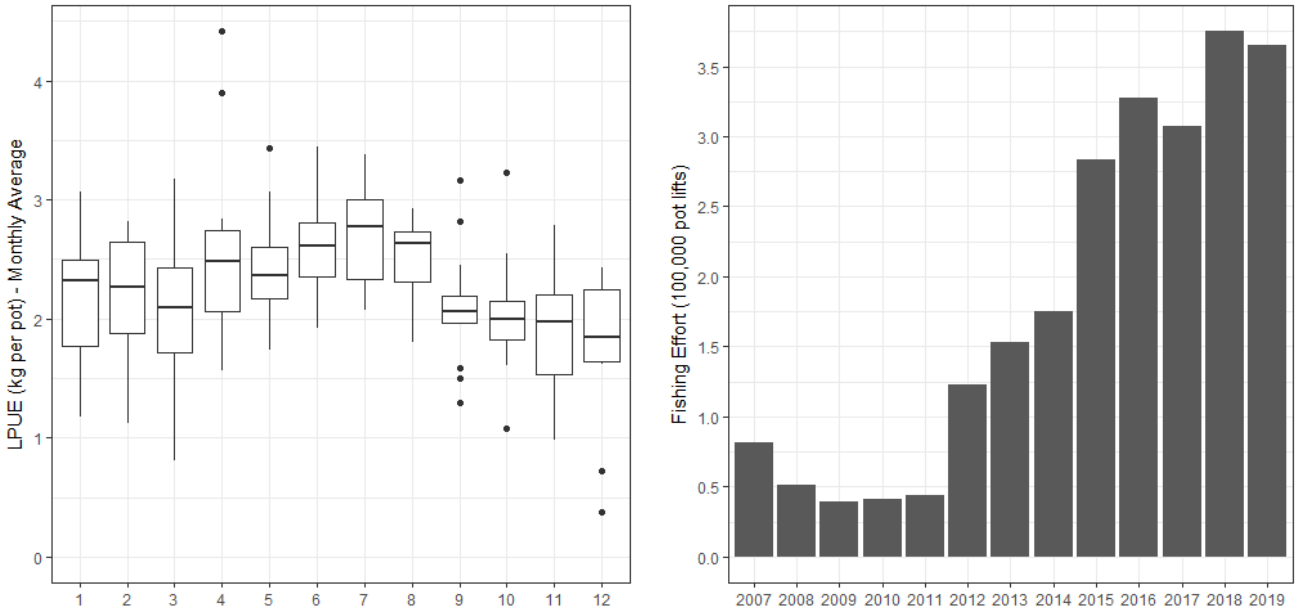
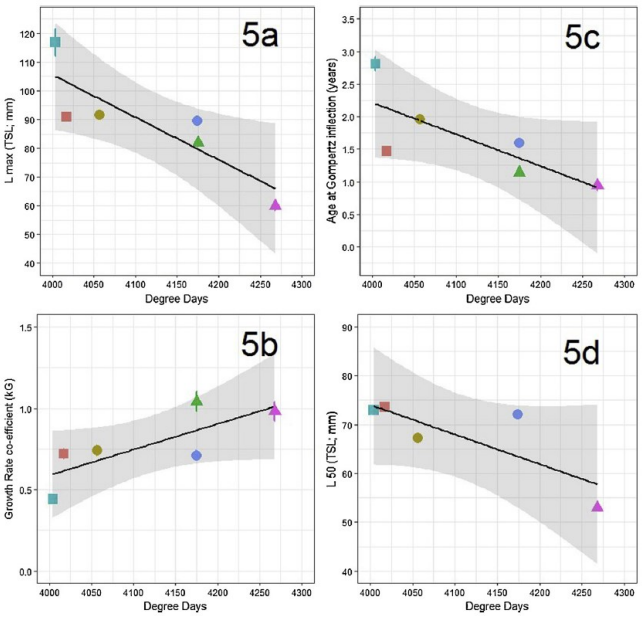


Figure 23. The modelled size-at-age relationship for whelk (*Buccinum undatum*) in various locations in the Irish Sea.

Whelk growth—Environmentally determined patterns

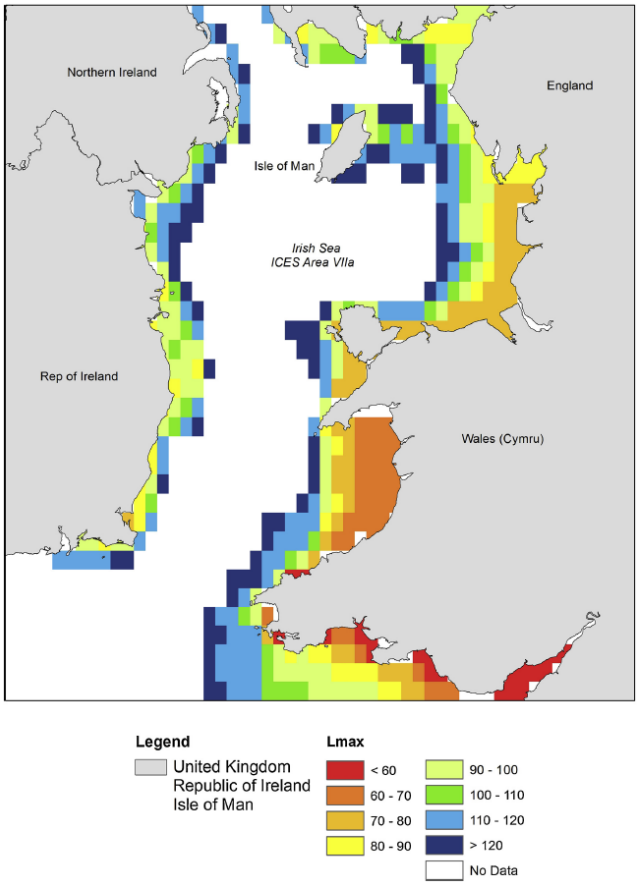
In collaboration with colleagues in Wales, samples of whelk were collected and their statoliths (a calcareous structure inside the central nervous system) were extracted. From Swansea Bay in south Wales to the Point of Ayre north of the Isle of Man, samples were assessed under a microscope and the size-at-age modelled for each population (see Annual Report 2018). Broadly, there was a latitudinal trend where whelk population size structure was smaller among southern populations. At the same time, whelks sampled further south appeared to undergo a more rapid period of growth in the initial few years of life, before reaching an asymptote at a relatively small maximum size.

We investigated this pattern in greater detail by comparing the trends against a latitudinal gradient of modelled sea-bottom-temperature (SBT) over the period 2010-2016 for each area. From the temperature data, we constructed a variable that was able to explain the patterns in growth we observed, called Degree-Days. Degree-days is simply the sum of average daily temperatures observed over a period of 1 year For example, a week-long period where the SBT is 10°C would give 70 degree-days. We plotted these data against the growth parameters that were modelled using the statolith rings, including a) Lmax (maximum shell length), b) growth-rate coefficient (the maximum **rate** of growth), c) age at inflection in growth (when growth rate begins to slow down) and d) sexual maturity (size at which 50% of the population exhibit signs of reproductive maturity) (Figure 24).



As can be seen on the left, the more degree-days a site has, the smaller Lmax reached by whelk populations in that area. Similarly, warmer waters also mean that whelk growth begins to slow at a younger age. The only positive relationship was observed between degree-days and the maximum rate of growth in that whelk population.

To summarise, warmer waters mean whelk grow more quickly during a short initial period, but reach a smaller maximum size thereafter. We also observed that warmer waters also generally means that the L50 will be lower. Using an Irish Sea-wide dataset for SBT and the model results above, we are able to predict the growth patterns of whelks throughout the Irish Sea, as shown to the left where we predict average maximum size (Lmax).



These population parameters (growth rate, maximum size, age at first spawning) are essential pre-requisites for many stock assessment methods. Through the new understanding of how these parameters vary around the Irish Sea due to temperature, we can begin to consider the scale at which the Irish Sea fisheries should be assessed.

Looking forward, we will encourage a common pan-Irish Sea approach to fishery assessments and will use the evidence here to advise on what levels of local assessment might be appropriate for area-based management.

Figure 24. The relationship between degree-days and various growth parameters for whelk populations in the Irish Sea (top). A spatial visualisation of the Lmax model for whelk throughout the Irish Sea (above).

Edible 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 (c. 475 tonnes). The fishery shows inter-annual and seasonal variability in LPUE. Examination of seasonal trends shows peak LPUE in autumn at about 2—2.5 kg per pot, which is induced by a peak in sea bottom temperature (Figure 25).

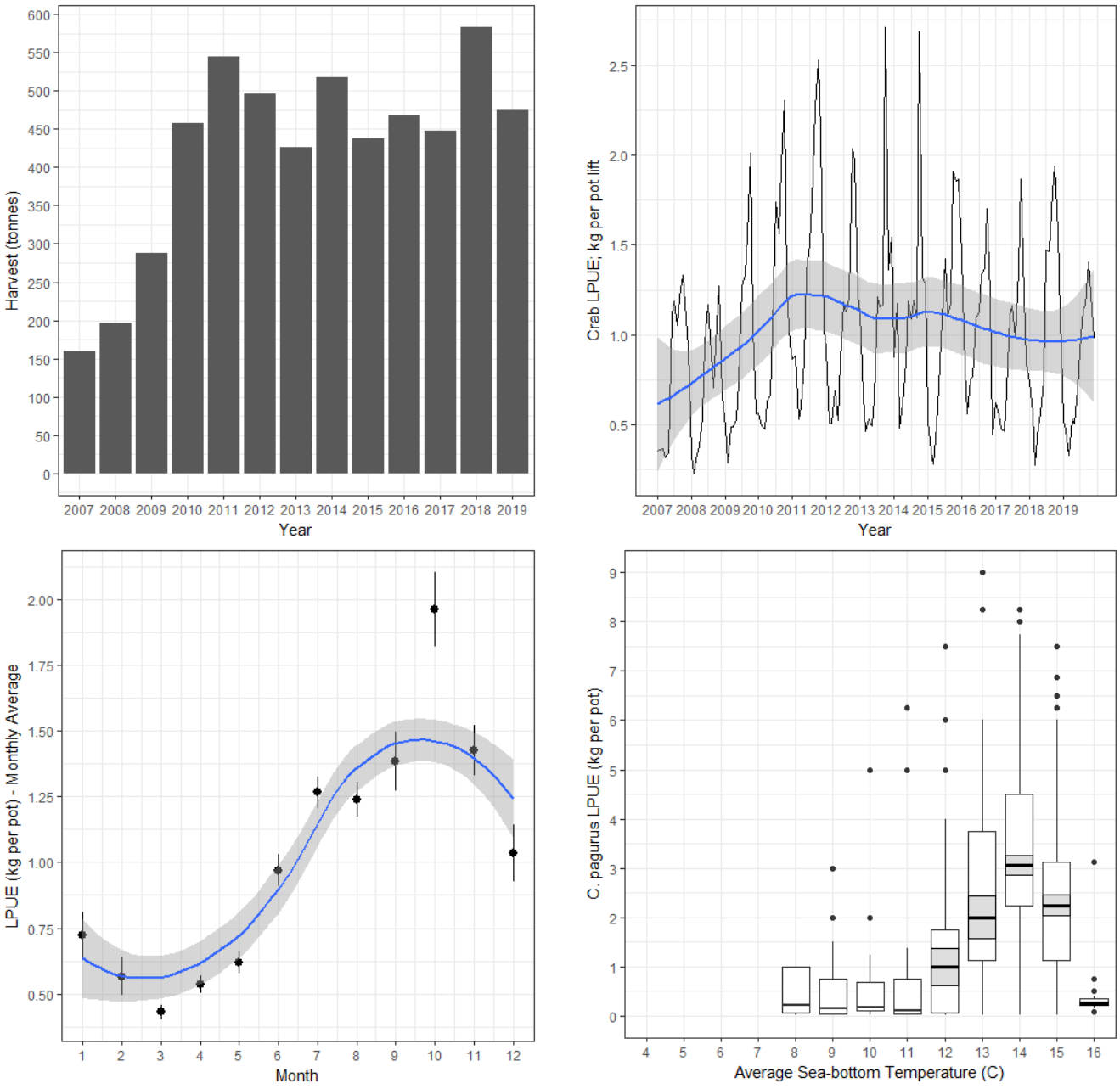


Figure 25 The harvest (top-left) and estimated landings-per-unit-effort (LPUE) of the edible crab (*Cancer pagurus*) fishery (top-right) in the Isle of Man territorial sea. The monthly average LPUE (bottom-left) and average LPUE by temperature (bottom-right). Data: DEFA.

The long-term annual average LPUE trend observed in Figure 25 (top-right) suggests that the fishery remains within historic thresholds, although the peak autumn LPUE was at its lowest level since 2009. There were 1,491 vessel days in 2019 (12% increase from 2018), with c. 430,000 pot-lifts throughout the year (27% increase from 2018). This means that licensed vessels are spending more time at sea and are hauling more pots, on average, each day. This is despite the reduction in harvests compared to 2018. Increasingly capable vessels have recently entered the fishery (large 10 m+ catamarans), which will have reduced the poor-weather restriction on the fleet. Increased effort may also have been a consequence of expectation of a similar autumn harvest to 2018 but not realised in the 2019 fishery.

Crab Tagging Mortality Investigation

In July 2019, preliminary investigations into the effect of t-bar tag application on the edible crab were undertaken in Peel Bay. 22 crabs of both sexes and across a size range (130—210 mm carapace width; CW) were tagged and kept in stock pots for a period of 4 weeks. A mortality rate above that which could be considered acceptable was observed, particularly among ‘damaged’ and ‘black’ crabs (i.e. have black spot). Similar trials are being carried out in Welsh waters and we will work with our colleagues at Bangor to understand how mortality can be reduced. Mark-recapture experiments in Scotland and England have shown crabs move 100s of km and a study in the Isle of Man will help understand connectivity in the wider Irish Sea region. Those which survived the tagging procedure (n = 16) were released in Peel Bay. One crab was recaptured several weeks later and had moved 1 mile north from the bay.

Figure 26. A t-bar tag applied to an edible crab (left) and stored on the seabed in Peel Bay (right).

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 over the period 2007-present (Figure 27). Harvests were observed in 2019 with c.50 tonnes landed into the Isle of Man. The fishery data show trends that follow seasonal patterns that reflect the reproductive cycle of the species — egg-bearing lobster are protected in the Isle of Man territorial sea. Peak LPUE and harvests are observed in late summer and although this peak-LPUE has been declining since 2016, as well as declining average LPUE, data suggests that the fishery has not dropped below historic harvest rates (2013) at c.0.20 kg per pot (Figure 27).

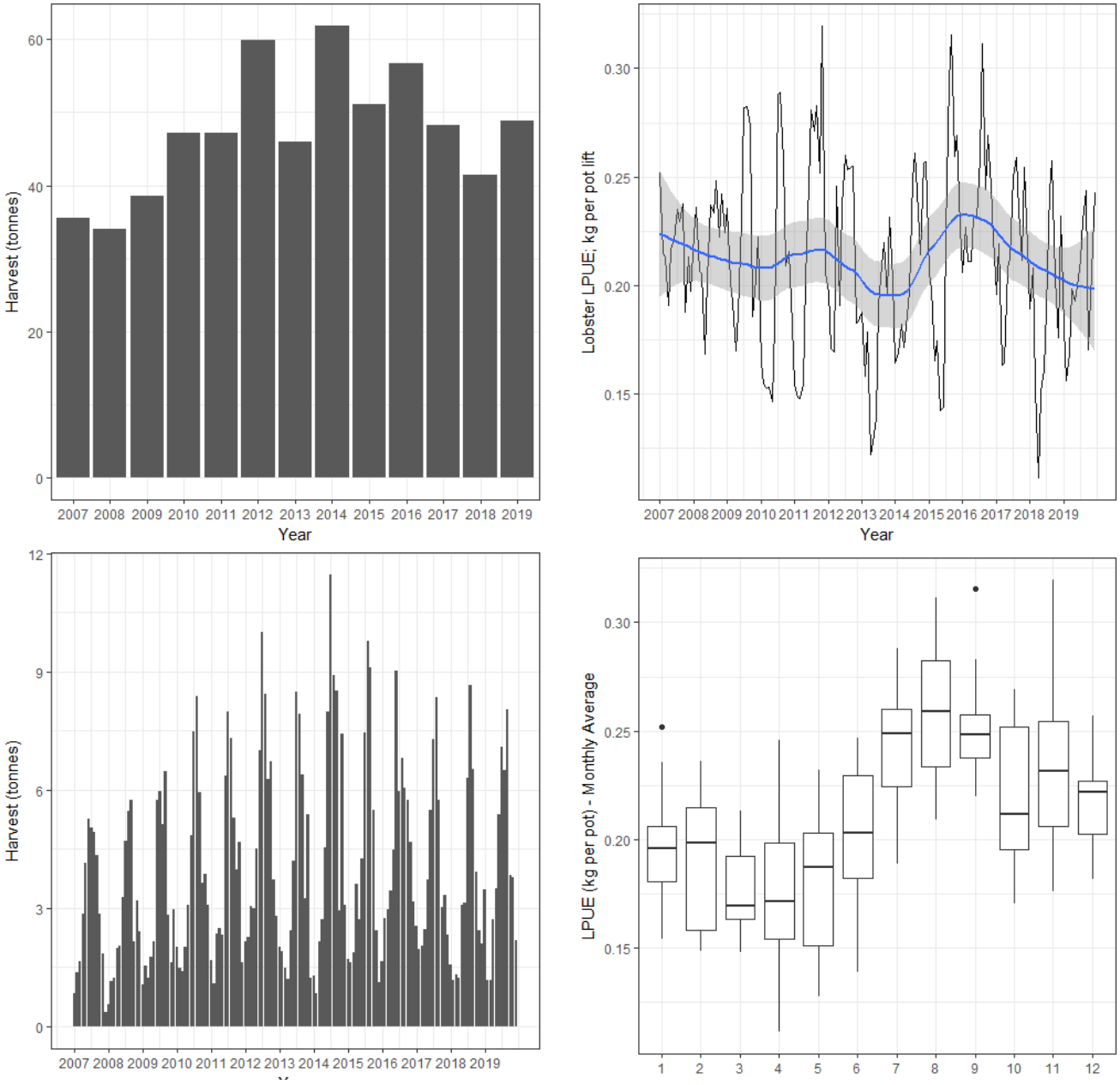


Figure 27. The harvest (top-left) and estimated landings-per-unit-effort (LPUE) of the European lobster (*Homarus gammarus*) fishery (top-right) in the Isle of Man territorial sea. The monthly average LPUE (bottom-right) and harvest by month (bottom-left). Data: DEFA.

Size-at-maturity of European Lobster; dissection analysis

Despite being a well-established and traditional fishery, there are currently several knowledge gaps in the species biology of European lobster that are necessary to inform evidence-based management. In lieu of data concerning size-at-maturity, the Isle of Man currently enforces the Europe-wide minimum landing size (MLS) of 87 mm (CL). However it is accepted that size-at-maturity can vary regionally and therefore the MLS may not be biologically appropriate — work is now being done in Scotland (Orkney Islands), Wales and the Isle of Man to address this issue.

92 female Manx lobsters (Port St Mary) ranging in size from 63 to 120 mm (CL) have been collected and analysed using a standard dissection protocol (also being used in Scotland and Wales). Various measurements used to assess maturity are taken including carapace length (CL), abdomen width (AW), crusher claw dimensions, gonad maturity stage (Figure 28), gonad weight and egg diameter. In addition we have morphometric data for a further 49 females and 63 males. This data is currently being collated with Welsh data for a comparison and analysis will soon follow.

Figure 28. *Isle of Man lobsters (Homarus gammarus) at ovary maturity stages 1 through 6, assigned based on a combination of factors: colour, ovary size/weight and egg size.*

Research priorities for commercial fisheries Up to August 2020 (end of current contract)

King and Queen Scallop Fisheries

- **2020 Spring Scallop Survey**

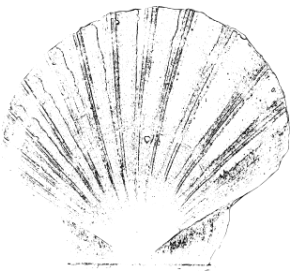
⇒ 3rd – 16th April 2020 (R.V. Prince Madog)

- **King Scallop Stock Assessment**

⇒ August 2020

- **Queen Scallop Management**

⇒ Development of fine scale industry survey
⇒ Management advice at finer spatial scales



- **Seismic Survey**

⇒ Example methodology for permit conditions to assess potential impacts of seismic surveys on scallops

- **East of Douglas Experimental Research Area**

⇒ Assessment of three year trial

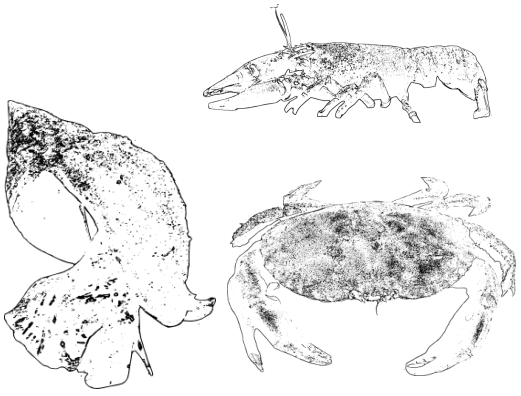
Static Gear Fisheries

- Lobster functional maturity assessment methods

⇒ Analysis of data

⇒ Collaboration with Wales

⇒ Standardised protocol



- Impact assessment for crab and lobster consultation

⇒ Provision of an impact assessment (or equivalent) to accompany any consultation on this topic

- Analysis and evaluation of electronic monitoring system trials for static gear

⇒ Analysis of data collected

⇒ Report and scientific publication

⇒ Consideration of alternative methods being developed in the UK (i.e. IVMS; electronic apps, etc.)

Habitat Mapping

In order to feed into management plans, habitat surveys were completed in 2016 in each of the Isle of Man's existing Marine Nature Reserves (MNRs): Ramsey Bay; Laxey Bay; Douglas Bay; Baie ny Carrickey; Port Erin Bay; and Niarbyl Bay. The data from four of these areas were analysed by MSc students from Bangor at the time. In 2019 we analysed the survey data for the remaining two areas: Douglas Bay MNR and Port Erin Bay MNR (Figure 29). This data provides crucial information on species distributions, scallop abundance and seabed habitat types in our protected areas, which are key in safeguarding the long-term sustainability of our fisheries.

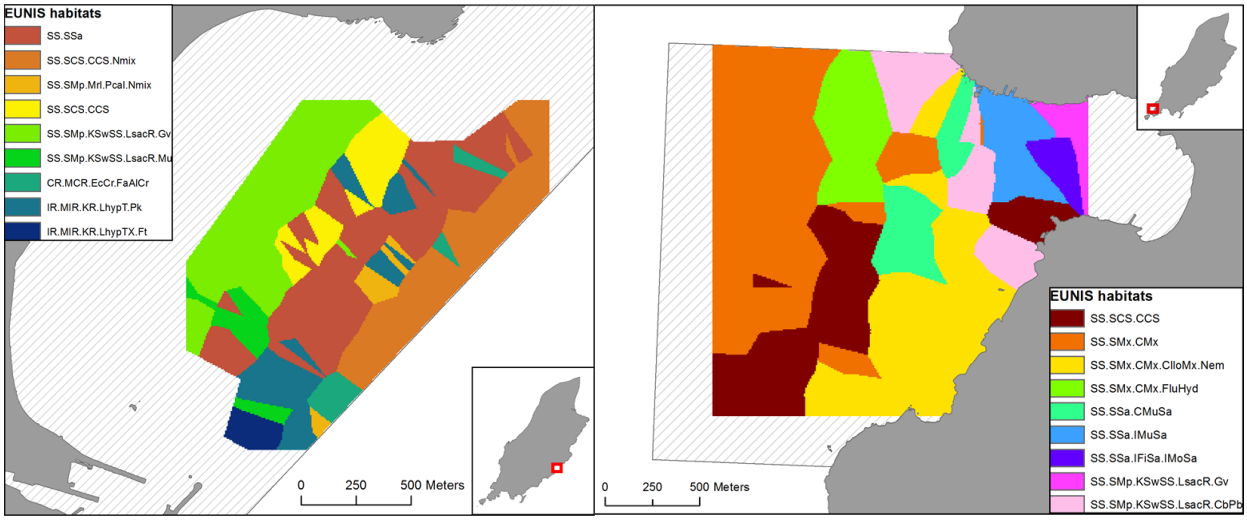


Figure 29. Maps of seabed habitats surveyed in Douglas Bay MNR (left) and Port Erin Bay MNR (right), identified using the European habitat classification system (EUNIS).

Habitat mapping was accomplished using underwater cameras attached to a towable sledge (Figure 30), geo-referenced to GPS data. Continuous video footage was recorded using a GoPro in addition to high quality still images at 10 second intervals using a digital SLR camera in waterproof casing. Detailed species identification was mainly achieved using the still images, while the video footage provided more comprehensive data with regard to seabed habitat types. A wealth of information has been extracted from the camera footage, including species data (presence/absence and abundance counts), percentage cover data (accounting for substrate types), scallop counts and the distribution of EUNIS habitats.

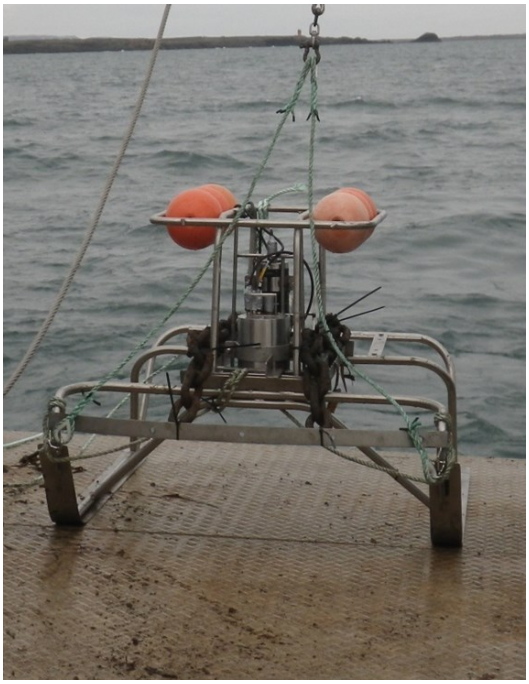


Figure 30. Survey equipment: metal sledge with cameras and underwater lights attached.

17 camera tows were completed in Douglas Bay MNR, with 9 habitats and 117 taxa identified. The area was generally quite patchy in nature, containing a network of sedimentary and rocky habitats (Figure 29). Sensitive or priority habitats present included maerl beds, kelp forest/park and sublittoral sands. Notably, sublittoral sands were characterised by delicate solitary hydroids (*Corymoypha nutans*) and the rare nudibranch *Cumanotus beaumonti*, only found in a few locations worldwide.

23 camera tows were completed in Port Erin Bay MNR, with 9 habitats and 137 taxa identified. In comparison to Douglas Bay, Port Erin Bay was less varied, and was dominated by mixed sandy habitats. Being the oldest closed area in Manx waters, scallop abundance (*Pecten maximus*) was far greater in this area, averaging at 27 per 100m^2. Abundance in the 23 camera tows ranged from 0 to 92 scallops per 100m^2, and varied significantly between habitat types (Figure 31), with the highest densities found in circalittoral gravel (SS.SCS.CCS) and circalittoral mixed sediment habitats characterised by hydroids and bryozoans (SS.SMx.CMx.ClloMx.Nem, SS.SMx.CMx.FluHyd).

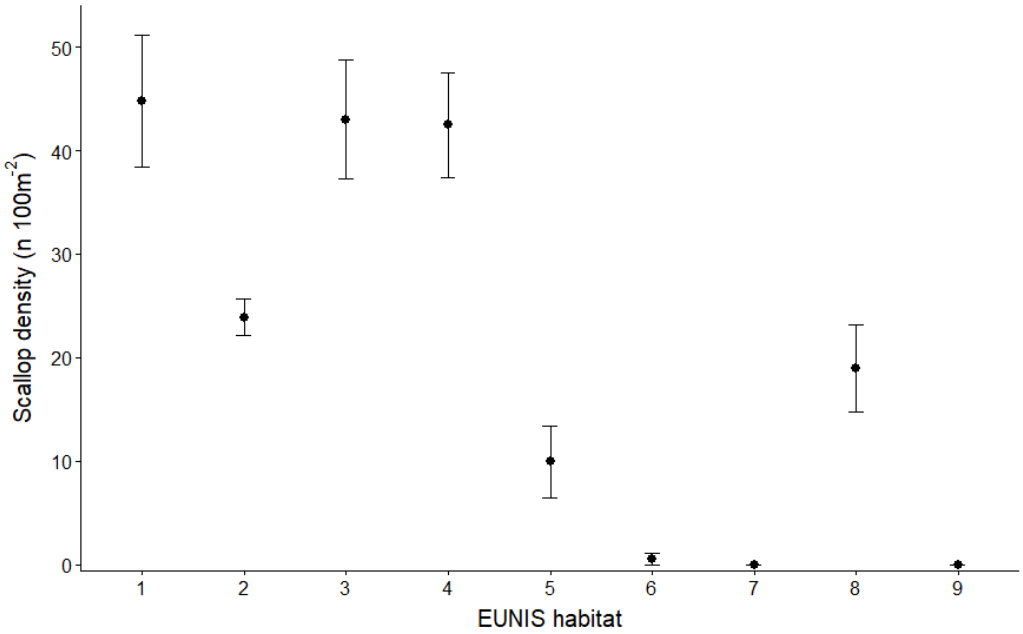


Figure 31. Mean (± S.E.) density of scallops (Pecten maximus) by EUNIS habitat type in Port Erin Bay MNR: 1 = SS.SCS.CCS; 2 = SS.SMx.CMx; 3 = SS.SMx.CMx.ClloMx.Nem; 4 = SS.SMx.CMx.FluHyd; 5 = SS.SSa.CMuSa; 6 = SS.SSa.IMuSa; 7 = SS.SSa.IFiSa.IMoSa; 8 = SS.SMp.KSwSS.LsacR.CbPb; 9 = SS.SMp.KSwSS.LsacR.Gv.

The data from our MNRs will feed into management efforts and provides useful baseline information with regard to species records and future monitoring. The overall aim is to work towards zoned management approaches based on this habitat information. In 2018, four additional MNRs were established (West Coast, Langness, Calf and Wart Bank, and Little Ness), increasing the total protected area of the inshore territorial sea (0-3 nm) to 52%. A high priority in the future will be to survey these areas, using the same methods.

Full reports available on request:

Garratt, M.J., Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2019) . Benthic Habitat Mapping: Douglas Bay Marine Nature Reserve. Bangor University Report.

Garratt, M.J., Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2019) . Benthic Habitat Mapping: Port Erin Bay Marine Nature Reserve. Bangor University Report.

East of Douglas Experimental Research Area (EDG ERA)

The East of Douglas Experimental Research Area (EDG ERA) was established as an experimental closed area for three years in July 2017, encompassing a region where the queen scallop stock had rapidly declined (Figure 32). Prior to closure, there was little sign of improvement in the region. The aim was to monitor scallop densities in the closed area over these three years and test artificial spat receptors as a potential means of promoting/enhancing fishery recovery.

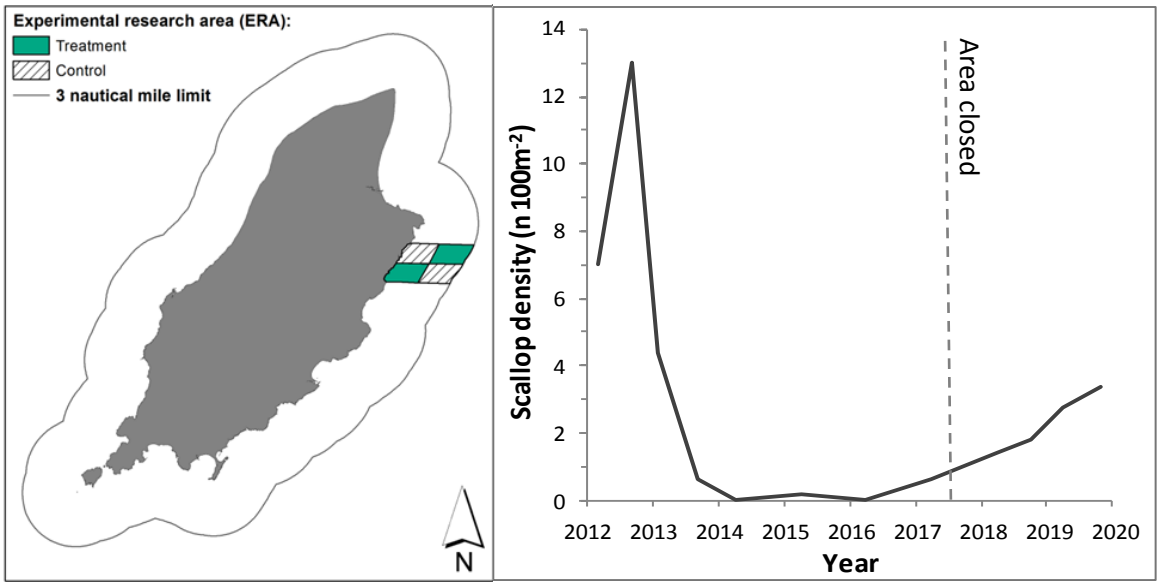


Figure 32. Left: Map showing the location and survey design of EDG ERA; Right: Mean queen scallop density in EDG ERA from dredge surveys (Prince Madog stock assessment station 29 and recent F.P.V. Barrule surveys).

Since 2017, the area has been monitored annually during autumn (October-November) from the F.P.V. Barrule. This includes beam trawl surveys (2017, 2018, 2019) assessing queen scallops and bycatch, dredge surveys (2018, 2019) for queen and king scallops, and a drop-down camera habitat survey (2018). The survey design consisted of a grid of sampling stations distributed between two "treatment" areas, where artificial spat receptors will be deployed to test whether recruitment can be increased by providing artificial receptors to increase the amount of naturally occurring structures available for spat settlement , and two "control" areas for comparison where recruitment is reliant on the availability of only natural spat receptor structures (Figure 32). Additionally, the annual Prince Madog dredge survey in the spring samples a station within EDG ERA.

In May 2019, four trial "X-shaped" artificial spat receptors based on the design of Fegley et al. (2009) were built and two were deployed in each of the "treatment" areas (photo on front cover of report). Two additional receptors were deployed in Ramsey Bay MNR, where there is known to be good scallop recruitment, to further assess the performance of this design. The design has proven successful in collecting good numbers of queen scallop spat. However deployment/ enforcement requires further evaluation as all four of the receptors in EDG ERA have now been lost despite robust mooring. One was dredged up during the survey in November 2019, and examination showed the mooring rope had apparently been cut.

Results Summary:

Beam trawl data showed a positive trend in queen scallop abundance in EDG ERA during its three years of closure, averaging at 14 ± 2 scallops per 100m^2 in 2017, 17 ± 3 in 2018, and 26 ± 5 in 2019 (Figure 33). Additionally the mean density of queenies from dredge surveys nearly doubled from 1.8 per 100m^2 in 2018 to 3.4 in 2019, However, no statistically significant increase could be detected owing to large spatial variation.

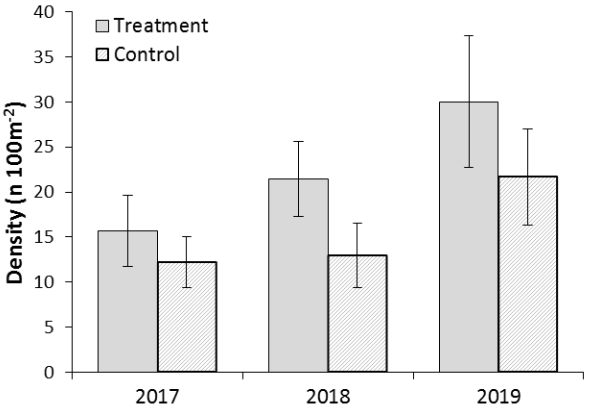


Figure 33. Mean (± S.E.) density of queen scallops in the "treatment" and "control" areas of EDG ERA from beam trawl surveys in October 2017, October 2018 and November 2019.

The average size (shell height) of queen scallops in beam trawl surveys increased from 37 mm in 2017, to 48 mm in 2018 and 55 mm in 2019. Mean size in dredge catches increased from 52 mm in 2018 to 59 mm in 2019 (Figure 34).

The community structure of beam trawl bycatch significantly varied between survey years (adonis; p = 0.02). However in general it was dominated by consistently occurring species, predominately brittlestars, sea urchins, starfish, hermit crabs, spider crabs, *Alcyonium digitatum*, *Callionymus lyra* and whelks. Total bycatch abundance did not vary between years, although species richness (number of species) and diversity (Shannon's index H') were significantly greater in the most recent survey (November 2019).

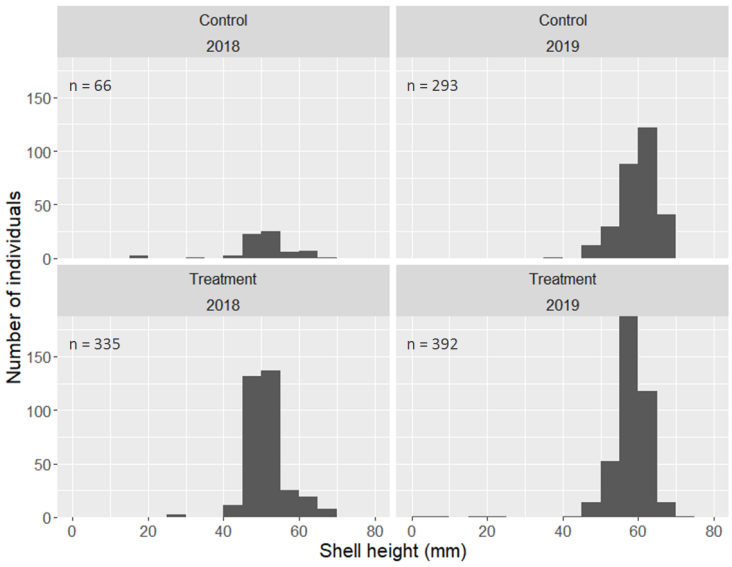


Figure 34. Size distribution of queen scallops in the "treatment" and "control" areas of EDG ERA from dredge surveys in October 2018 and November 2019. n = number of individuals.

Drop-down camera footage was collected in October 2018 at 10 stations in EDG ERA that were sampled by the beam trawl that same month, in order to identify potential inherent differences between the "treatment" and "control" areas and its relationship to scallop abundance. Three general habitat types were identified from the footage: gravelly sand, mixed/medium sand and clean/ fine sand. Stations classed as gravelly sand contained the highest mean density of queen scallops (2018 beam trawl data) and were located in the inshore "treatment" area, likely explaining why scallop abundance was consistently higher on average in "treatment" areas (Figure 33; Figure 34).

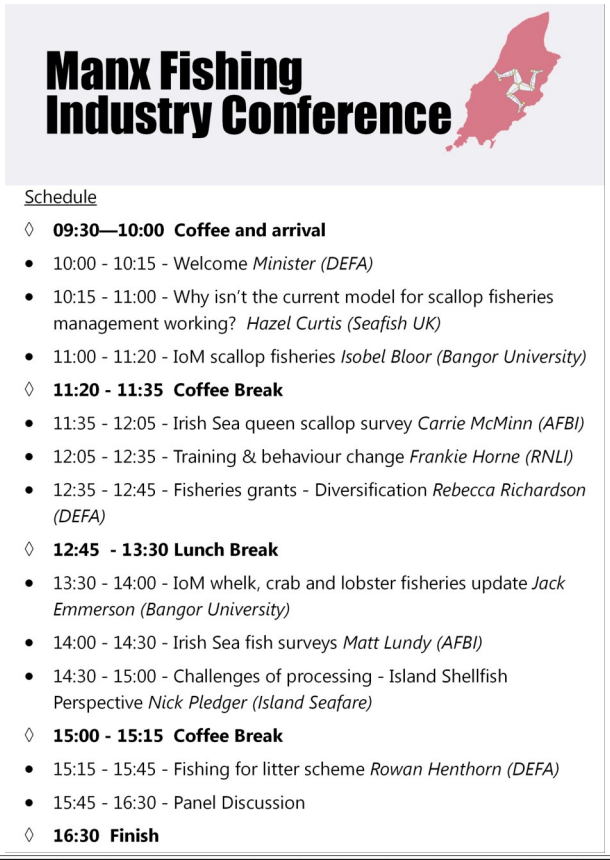
Full report available on request: Garratt, M.J., Bloor, I.S.M., Emmerson, J.A. Duncan, P. and Jenkins, S.R. (2020). East of Douglas Experimental Research Area: Three-Year Review. Bangor University Report.

Manx Fishing Industry Conference (June 2019)

Monday 24th June 2019, Masonic Hall, Peel

The annual Manx Fishing Industry Conference (MFIC) took place this year on 24th June 2019 at the Masonic Hall in Peel. The format of the conference has continued to evolve in order to try and improve industry engagement. As such, this year the MFIC opened with a welcome from the Minister followed by open questions from the audience. These questions were all answered directly by the Minister and covered a range of broad topics including grant access, diversification, industry involvement with science, Brexit and current and future fleet structure. This year's key note speaker was Hazel Curtis from Seafish UK who spoke on "Why isn't the current model for scallop fisheries management working?" which raised a lot of interesting problems with scallop fisheries management in the UK that parallel many of the challenges faced in the IoM too. Another change to the conference format was the inclusion of talks from other jurisdictions. This year Carrie McMinn and Matthew Lundy from AFBI, Northern Ireland, both gave interesting talks on the Irish Sea queen scallop survey and Irish Sea fish surveys that are undertaken by AFBI. In addition, talks from industry including Nick Pledger from Island Seafare processors and Frankie Horne from RNLI were also very well received. The conference ended with a panel discussion with representatives from government and science taking questions from the audience. Again this was a wide-ranging discussion with questions on the Fisheries Management Agreement, grant schemes, industry-science partnerships, stock assessment, queen scallop fisheries management etc.

There were 42 attendees (including representatives from industry, government and science) at this year's conference. We would like to thank everyone that attended and presented at the 2019 MFIC for making the event such a success. We will be hosting another conference in 2020 (Monday June 29th 2020 at the Masonic Hall in Peel) and will continue to evolve the format to hopefully continue to develop more industry involvement at the event.



Lunch and Learn Series

Lunch and learn is a series of monthly presentations that we organise at DEFA during the lunch hour. All staff are invited and encouraged to bring along their lunch and listen to a different speaker each month. The presentations are around 30-45 minutes long with time for a lively and interesting discussion afterwards.

2019 has continued to see a positive response to these sessions and a good variety of speakers and topics from Bangor University, DEFA and external speakers:

- **January:** Isobel Bloor (Bangor) – The Isle of Man King Scallop Fishery
- **February:** Peter Duncan (DEFA) – Biodiversity in Costa Rica
- **March:** Stuart Jenkins (Bangor) – Science in Antarctica
- **April:** Adrian Cowin (IoM Gov) - Climate Change and Severe Weather Impacts
- **May:** Karen Galtress (DEFA) – Native fish populations in Manx rivers, conservation challenges and management
- **July:** Glen Geeves (DEFA) – To shoot or not to shoot? Botwsana's dilemma between Western pressures and a potential ecological and social disaster
- **August:** Philippa Tomlinson – Extinction Rebellion: Why I'm involved
- **September:** Matthew Garratt (DEFA/Bangor) – Habitat mapping in Marine Nature Reserves: Port Erin Bay & Douglas Bay
- **November:** Matthew Garratt (DEFA/Bangor) – Marine Nature Reserves: Habitat mapping and fisheries sustainability

We would like to thank everyone who has given a presentation at the Lunch and Learn series during 2019 and everyone who has attended and participated in the discussions to make this series a success. We will be continuing in 2020 and if anyone would like to volunteer to present please contact i.bloor@bangor.ac.uk.

EMFF and IOM Project meeting (DEFA and Bangor)

Tuesday 15th October 2019, Bangor University, Menai Bridge, Wales

A one day meeting was held in Wales to bring together the Welsh EMFF and the Isle of Man Fisheries teams along with representatives from the Isle of Man Government's Department of Environment, Food and Agriculture (DEFA) to explore synergies between the two projects in the short, medium and longer term. The format of the day was a series of ten presentations from members of both the Welsh and Isle of Man teams on current and upcoming research. In addition to the presentations, discussion sessions were held on how collaborative research between the two areas and teams could be undertaken in both the short and medium term. Discussions on developing the appropriate methods for assessing lobster functional maturity were also fostered along with an assessment of the value of pleopod assessment for the European lobster in comparison to the American lobster. Discussions on scallop stock assessments and the correct spatial scale for surveying stocks of each species were held.

This one day event was a great opportunity to combine the knowledge and expertise from both teams to support the future of fisheries research in both Wales and the Isle of Man and it is hoped to make this an annual event.

Agenda: EMFF/ IOM fisheries one day meeting 15th October

0930-0940 Welcome and introductions

0940-0950 *Stuart Jenkins* Overview of the Isle of Man contract

0950-1000 *Natalie Hold* Overview of the EMFF project

Presentations

1000-1030 *Jack Emmerson* Environmental parameters in relation to the catch-statistics for IOM static-gear fisheries - implications for stock assessments.

1030-1100 *Natalie Hold* Current and planned lobster research 20-30mins

1100-1130 Coffee

1130-1200 *Alec Moore* Edible crabs (Wales) and bass & rays (northwest England)

1200-1230 *Samantha Simpson* EMFF finfish project

1230-1300 *Matt Garratt* Marine nature reserve habitat mapping

1300-1400 Lunch

1400-1445 *Isobel Bloor* Appropriate spatial scales for managing and assessing scallop stocks

1445-1515 *Adam Delargy* Welsh scallop research and stock assessment.

1515-1545 *Peter Duncan* Management of Manx coastal habitat

1545-1600 Coffee

1600-1700 Thematic discussions

During 2019 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, peer reviewed publications in scientific journals, presentations at international conferences and during attendance at national and international committees, working groups and meetings.

Qualifications:

- PGCERT HE Level 1: Higher Education Teaching Certificate—Dr Isobel Bloor (December 2019)

Government Reports:

- Bloor, I.S.M. (2019). Isle of Man king scallop (*Pecten maximus*) Stock Advice for 2019/2020 Season. SFAG Report No. 2, Bangor University. pp. 36.
- Bloor, I.S.M., Emmerson, J. and Jenkins, S.R. (2019). Assessment of Queen Scallop stock status for the Isle of Man territorial sea 2019/2020. SFAG Report No. 1, pp. 18
- Bloor, I.S.M., Beard, D., Emmerson, J. and Jenkins, S.R. (2019).June 2019 Juvenile Queen Scallop Survey Analysis. SFAG Report No. 2, pp. 25
- Garratt, M.J., Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2020) . East Douglas Experimental Research Area: Three year review. Bangor University Report.
- Garratt, M.J., Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2019) . Benthic Habitat Mapping: Douglas Bay Marine Nature Reserve. Bangor University Report.
- Garratt, M.J., Bloor, I.S.M., Emmerson, J.A. and Jenkins, S.R. (2019) . Benthic Habitat Mapping: Port Erin Marine Nature Reserve. Bangor University Report.

Publications:

- Emmerson, J.A., Hollyman, P.R., Bloor, I.S.M. and Jenkins (2020). Effect of temperature on the growth of the commercially fished common whelk (*Buccinum undatum,* L.): A regional analysis within the Irish Sea. Fisheries Research 223:
- Southworth, L.K., Ratcliffe, F.C., Bloor, I.S.M., Emmerson, J., Watson, D., Beard, D. and Kaiser, M.J. (2020). Artificial light improves escapement of fish from a trawl net. Journal of the Marine Biological Association of the United Kingdom 1-9.

Meetings and Committees:

- International Council for Exploration of the Seas (ICES) Working Group on Scallop Stock Assessment, Isle of Man, , 8^{h} – 11^{th} October 2019 (Attended by Dr. Isobel Bloor).
- Pan-Atlantic *Buccinum* data workshop, with Hawkins shellfish laboratory, New Jersey and British Antarctic survey, November 2019 in Cambridge, U.K. (Attended by Jack Emmerson)

Work experience:

- Jacques Williams summer 2019 on the temporal and spatial variability of scallop reproduction and gonad condition within the Isle of Man territorial sea.

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Facebook:
https://www.facebook.com/sosbangor

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.

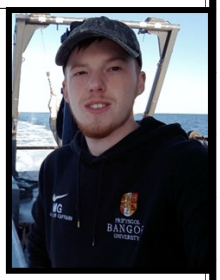
Dr Isobel Bloor:

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.

Jack Emmerson:

I am a fisheries scientist focussing principally on the interaction between commercial static-gear fisheries in the Irish Sea and the biology of the shellfish resources they depend upon. I gained my BSc and MSc degrees at York University and have worked as a shellfish research scientist for the Holderness Fishing Industry Group, Orkney Sustainable Fisheries and the Cardigan Bay Fisherman's Society. I am part of the Fisheries and Conservation Science group at Bangor University and am based on the Isle of Man within the Department for Environment, Food & Agriculture. I am leading on research related to the biology and life-history of lobster (*H. gammarus*), edible crab (*C. pagurus*) and whelk (*B. undatum*) and am contracted to supply evidence to inform sustainable management of static-gear fisheries within the Isle of Man territorial waters, whilst working towards a part-time PhD "*Sustainable static-gear fisheries in the Irish Sea*".

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. With the valuable experience that I have gained at DEFA I hope to pursue a career in fisheries science.