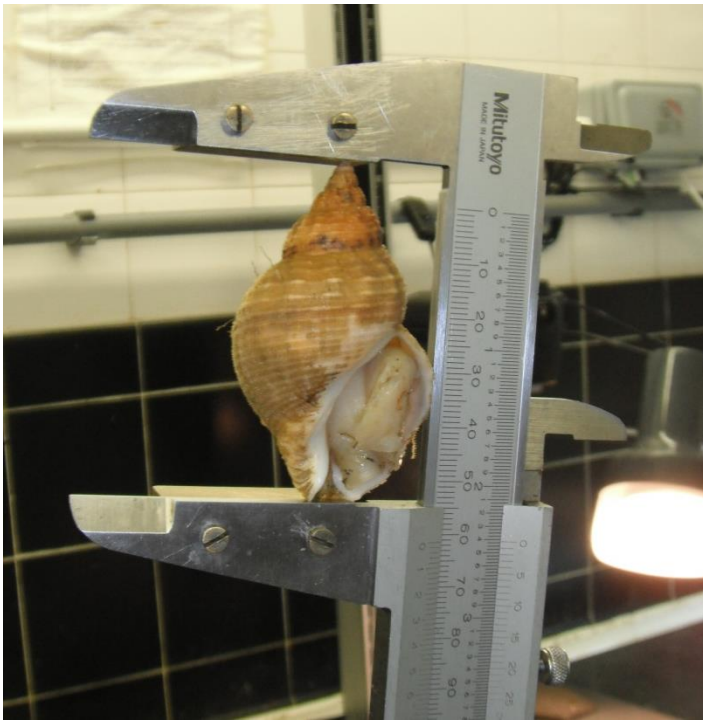
Determination of the Size of Maturity of the Whelk *Buccinum undatum* within the Devon & Severn IFCA District

Supplementary Report: Start Bay



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1. Executive Summary

Following Devon & Severn Inshore Fisheries and Conservation Authority's (D&S IFCA) original study to identify the Size of Maturity (SOM) of the common whelk, *Buccinum undatum*, landed into Exmouth and Ilfracombe, a request to the IFCA was made by a local fisher who pots for whelks in Start Bay. He believed whelks were smaller in this area and, therefore, the results of the original study would not be representative of his catch.

Samples were collected from Start Bay and analysed to produce estimates of SOM. The estimates of SOM by shell height were 57.8mm (female) and 64.4mm (male). These indicate that the current EU Minimum Conservation Reference Size (MCRS) of 45mm shell height is too low to protect the spawning stock and ensure the sustainability of the fishery. SOM based on shell width was also calculated: 25.9mm (female) and 28.2mm (male). The strong correlation between shell height and shell width mean that a MCRS based on shell width would be a viable alternative to the current management.

When the results of this study are looked at alongside those from Exmouth and Ilfracombe, they suggest that the EU MCRS is not adequately protecting whelk stocks in the D&S IFCA District, and local management measures should be considered. The combined results of these studies provide a strong starting point for the creation of a new MCRS. However, due to spatial variation of SOM within the D&S IFCA District zonal management may also need to be considered.

This is a supplementary report and should be read in conjunction with "Determination of the Size of Maturity of the Whelk Buccinum undatum *within the Devon & Severn IFCA District" (Stephenson, 2015) for the overall account of this project.*

2. Introduction

The UK whelk (*Buccinum undatum*) fishery has shown a rapid increase over the past decade. Whelk landings, in terms of both tonnage and value, approximately doubled between 2002 and 2012, and have continued to increase over the last few years. This increase in effort has raised concerns over the sustainability of the fishery, for which the stocks have never been formally assessed (MMO, 2012). Currently the only management measure for whelk fishing within the Devon & Severn Inshore Fisheries and Conservation Authority (D&S IFCA) District is the EU-wide Minimum Conservation Reference Size (MCRS) of 45mm shell height.

In 2013 D&S IFCA carried out a 12 month study to determine the Size of Maturity (SOM) of the whelk within the District. Monthly samples were collected from both Ilfracombe, to represent the north coast, and Exmouth, to represent the south coast. The study found that for the Exmouth fishery female whelks reached sexual maturity at 69.3mm shell height, and males 70.9mm. The SOM was slightly greater for Ilfracombe, with 76.6mm for females and 76.4mm for males. This implies that the EU MCRS of 45mm is currently doing little to protect the spawning stocks and, therefore, the sustainability of the population. Following the completion of this study the IFCA were approached by a fisher who pots for whelks in the Start Bay area. He believed that the whelks in this area are smaller than those found elsewhere in South Devon and, therefore, the results of the study would not be representative of the fishery in this area and so offered to provide samples from Start Bay for further analysis.

Start Bay is situated on the south coast of Devon, approximately 25 miles southwest of Exmouth and 23 miles east of Plymouth (Figure 1).

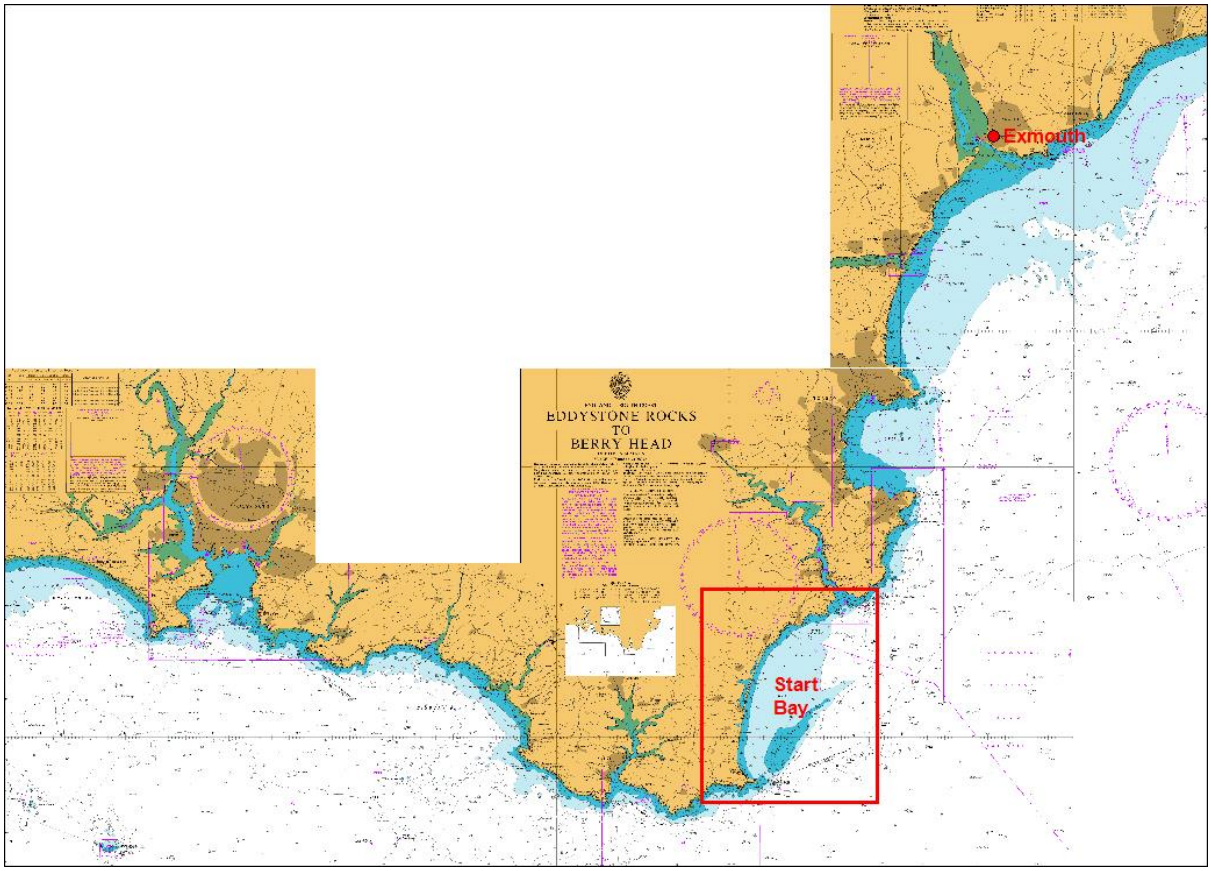

Fig. 1 Location of Start Bay on the South Devon coast.

3. Objectives

Primary aim:

1) To determine the size of maturity of whelks in the D&S IFCA District
    a) Acquire adequate size and sex stratified samples from Start Bay (South Devon).
    b) Process whelk samples and compile maturity data and biometrics into a database.
    c) Analyse data using logistic regression analysis to determine size of maturity by sex. Size of maturity will be determined by both shell height and shell width, to determine if a width based MCRS would be a viable alternative to shell height.

4. Methodology

Three samples of whelk were collected at different times of the year to eliminate any seasonal influence on the estimates of SOM.

The methodology for analysis for SOM is the same as that described in "Determination of the Size of Maturity of the Whelk *Buccinum undatum* within the Devon & Severn IFCA District" (Stephenson, 2015). The stage of maturity of the whelks, based on gonad development, was assessed in relation to both their shell height and shell width.

The size of maturity (SOM) is the size at which 50% of the population is mature, or the probability of a whelk being mature is 0.5. Whelks were classed as either mature or immature and the probability of a whelk being sexually mature by shell length (for each sex, and each site separately) was modelled using binomial logistic regression analysis using the "glm" function within the R statistical modelling software (R Development Core Team, 2013). The results were plotted onto a maturity ogive, using an R-script adapted from Harry et al. (2013), to report the SOM and 95% confidence intervals.

The Pearson's correlation between shell length and shell "minimum-width" was assessed using the "cor" function in R, to determine if there is a relationship between shell height and shell width.

The size of maturity calculations were repeated using the shell "minimum-width" measurement instead of shell length, to determine if a width based Minimum Size would be viable.

5. Results

A total of 175 whelks, across both sexes, were dissected to assess their reproductive status. The whelks analysed comprised of 89 females and 86 males, the uneven numbers between the two sexes are due to the availability each the required sizes for each sex within the samples collected.

Estimates of SOM are presented in Table 1, while Figures 2 and 3 show the maturity ogives, based on shell height, for each sex. Estimates of SOM are marked at the point where 50% of the population is mature.

Table 1 Estimates of SOM, with size (shell height) of smallest mature whelk and largest immature whelk in the sample.

Sex	Estimate of SOM (mm)	Smallest mature observed (mm)	Largest immature observed (mm)
Female	57.8	55	60
Male	64.4	52	73

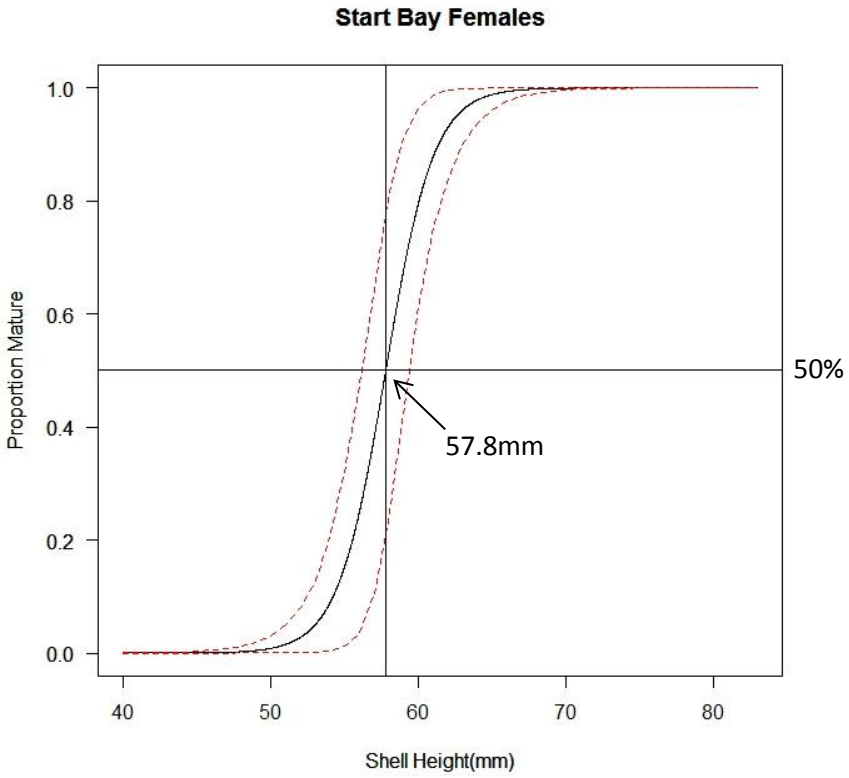

Fig. 2 Probability of a whelk being mature against whelk size, with 95% confidence intervals, for female whelks from Start Bay.

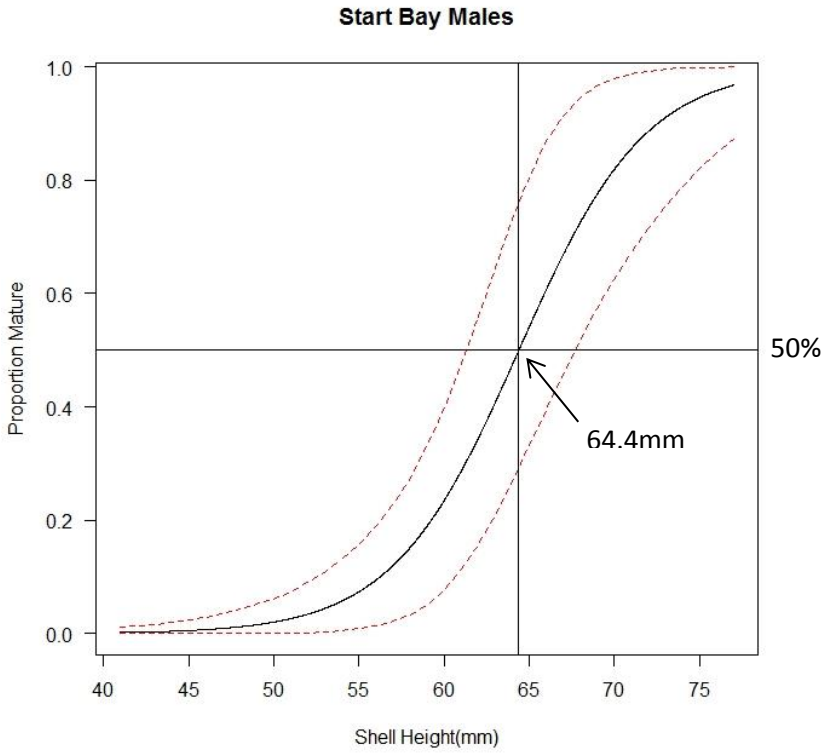

Fig. 3 Probability of a whelk being mature against whelk size, with 95% confidence intervals, for male whelks from Start Bay.

There is a strong positive correlation between shell height and the minimum shell width for both sexes, meaning that as shell length increases the shell width also grows at an equivalent rate. This is depicted in Figures 4 and 5. The Pearson's correlation coefficients for each sub-sample are presented in Table 2. The relationship between shell height and shell width means that for a MCRS or SOM based on shell height a corresponding shell width could be identified.

Table 2 Correlation between shell height and minimum shell width for each sex.

Sex	Pearson's correlation coefficient
Female	0.927
Male	0.953

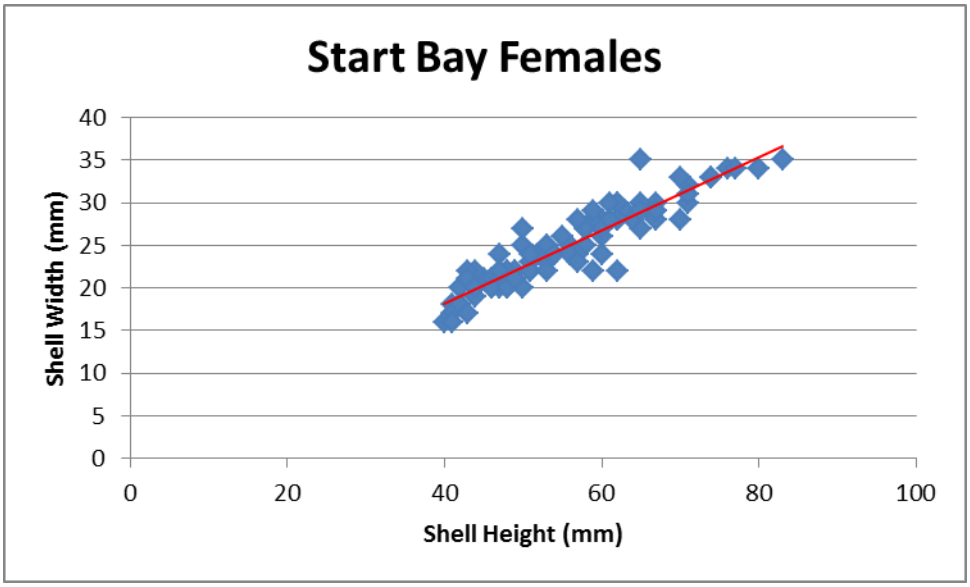

Fig. 4 Relationship between shell height and shell width, for female whelks from Start Bay.

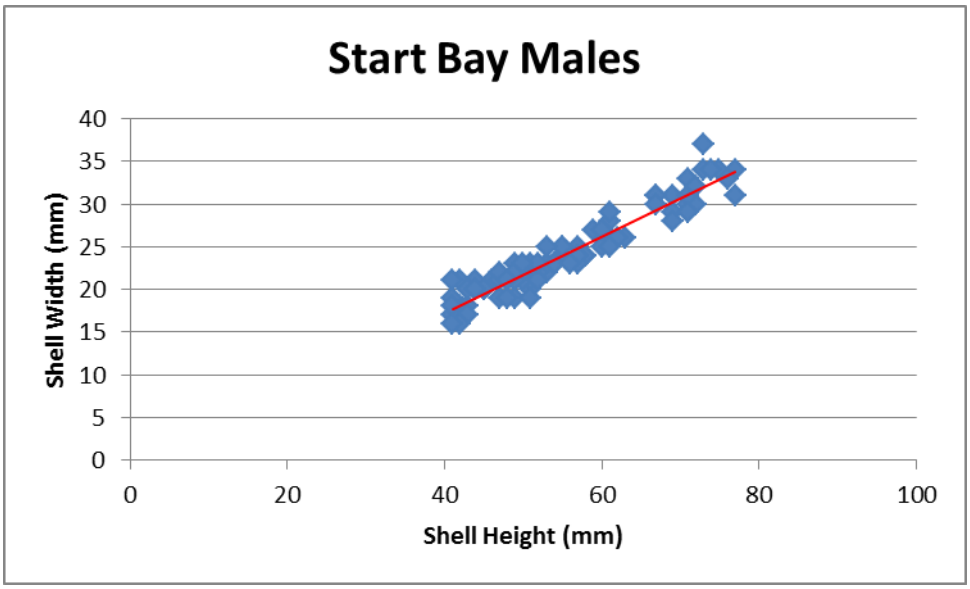

Fig. 5 Relationship between shell height and shell width, for male whelks from Start Bay.

Figures 6 and 7 show the maturity ogives for minimum shell width, for each sex. Estimates of SOM are marked at the point where 50% of the population is mature. Estimates of SOM are also presented in Table 3.

Table 3 Estimates of SOM using minimum shell width, by sex.

Sex	SOM estimate using shell width (mm)
Female	25.9
Male	28.2

Fig. 6 Probability of a whelk being mature against whelk size, with 95% confidence intervals, for female whelks from Start Bay.

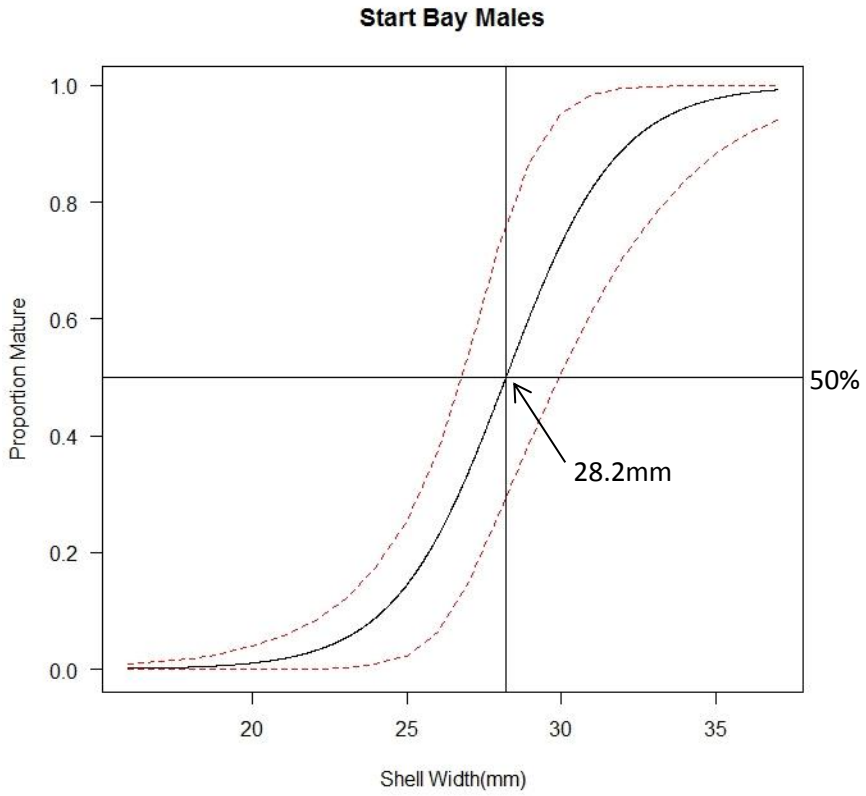

Fig. 7 Probability of a whelk being mature against whelk size, with 95% confidence intervals, for male whelks from Start Bay.

6. Discussion

In keeping with the findings from the study of Exmouth and Ilfracombe (Stephenson, 2015), the estimates of SOM for Start Bay are also much higher than the EU MCRS of 45mm, for both sexes, suggesting that the current MCRS is doing little to protect the spawning stocks in the D&S IFCA District. Estimates for SOM for all three areas are shown in Table 4. The Start Bay results indicate that SOM is smaller in this area than in the previous study areas. The reasons for spatial variation of SOM are fully explored in the previous study and will not be repeated here, but may include factors such as fishing pressure and water temperature. The smaller SOM of whelks from Start Bay could be caused by greater fishing pressure on this population than on the other populations. Short life is associated with a small size and early age at maturity, as increased adult mortality selects for earlier maturation at a smaller size (Rochet, 1998). However, the difference may also be explained by environmental factors, such as stronger currents across Start Bay or the fact that this population is closer inshore and, therefore, in shallower, warmer waters. Whelks have a slower growth rate in warmer waters than they do in deeper, colder waters, where they tend to grow to larger sizes. It is also possible that the different areas sampled have genetically distinct populations, rather be being sub-populations of the larger area. This was found to be the case in a recent study of the whelk populations in the Kent & Essex IFCA district (Kent & Essex IFCA, 2016), where genetic variability was compared between four areas. Only one population pairing did not show significant genetic difference.

Table 4 Estimates for SOM, based on shell height, for each site studied by D&S IFCA.

Site	Female SOM (shell height in mm)	Male SOM (shell height in mm)
Start Bay	57.8	64.4
Exmouth	69.3	70.9
Ilfracombe	76.5	76.4

There is a greater difference in SOM between the two sexes for the Start Bay population than was seen at the other sites, with males reaching maturity at 6.6mm greater shell height than females. The greater variation in this sample, indicated by the greater range in the confidence intervals, could be due to the sample size being smaller than those of the previous study.

As was described in the original study report, the results indicate that one broad-scale MCRS (the EU MCRS) does not provide adequate protection for the all the sub-stocks within European whelk populations and, given the variation of SOM within the D&S IFCA District, even a District-wide MCRS may not provide maximum benefit to all sub-populations. As explained by Tuckey et al. (2007) if an average size from across a large area is applied to all sub-stocks then for some sub-stocks restrictions will be too stringent, whilst for others the restrictions will not be sufficient to meet the management goals. Both these situations could potentially result in a loss of yield. However, the author suggests that if the MCRS for whelk was increased across an area such as the D&S IFCA district to a mid-point of all the SOM estimates then, although the level of protection would not be equal for each sub-stock, they would each be afforded more protection than is provided by the current MCRS. For example, if the MCRS was increased to 65mm then 98% of Start Bay females would be mature and 54% of the males, but only 19-27% of the Exmouth population would be

mature and even less in Ilfracombe at 6-10%. However, less than 1% of each population is mature at 45mm shell length (Table 5). If the MCRS was increased by 5mm increments over several years this would allow monitoring of the effect that the increasing MCRS is having on each sub-stock to be undertaken. Therefore, if recruitment over-fishing is the cause of smaller SOM Start Bay, you would expect to see an increase in SOM with the increased protection. But this may take several years to detect.

Table 5 Percentage of population mature in each sampled area, with increasing shell height.

		% mature at each shell height				
		45mm	50mm	55mm	60mm	65mm
Exmouth	Female	0.3	0.7	3	8	27
	Male	0.006	0.4	2	6	19
Ilfracombe	Female	0.09	0.5	1.6	4	10
	Male	0.002	0.2	0.5	2	6
Start Bay	Female	0.2	0.9	15	78	98
	Male	0.6	2	7.5	23.5	54

The results also suggest that a MCRS based on shell width could be a viable alternative to one based on shell height. Again, this is in line with the findings of the study of Exmouth and Ilfracombe whelk populations. A MCRS based on shell width would make sorting the catch with the use of on-board riddles more effective and accurate, as whelks fall through the riddle widthways. Therefore the spacing between bars could be adjusted to match the MCRS.

7. Conclusions

7.1 Management implications

The results of this study indicate that the current MCRS of 45mm for *B. undatum* is too small to adequately protect the spawning stock; it is therefore likely that recruitment over-fishing is occurring. The estimates of SOM from both this study and the previous study of Exmouth and Ilfracombe whelks could be used as a basis on which to form a new MCRS.

The findings of this study also demonstrates a strong relationship between shell height and shell width, so it can be concluded that a MCRS based on shell width would be a viable alternative to the current management. As was the case for the shell height SOM estimates, the width-based SOM estimates from Start Bay, when combined with those from Exmouth and Ilfracombe, would form a strong starting point for creating a new MCRS. However, given the variation of SOM (both height- and width-based) between sites, one MCRS may not be appropriate for the whole D&S IFCA District. It is likely the fishery would receive the most benefit from zonal management, e.g. different MCRSs for different areas, although this may be less practical from an enforcement perspective. A zonal approach to management would also require a much better understanding of the biogeography of the sub-stocks across the D&S IFCA district. To gain this level of understanding a much larger research project would be required, which is currently beyond the resources of the IFCA. An alternative to zonal management may be to bring in a phased increase of the MCRS up to a mid-point of the SOM estimates for each area over three or four years, e.g. increase to 60mm or 65mm shell height with 5mm increments per year. This way the IFCA could monitor each area and see if

there is an increase in SOM and if the populations shift to slightly larger whelks, which would help to better identify the fishing pressure impacts. This is likely to be the preferred management route.

7.2 Future work

Further to the future work suggested in the original study report, genetic analysis could be undertaken to confirm whether the whelk populations of Exmouth, Ilfracombe and Start Bay are indeed completely independent sub-stocks. This would enable D&S IFCA to determine whether the differences in SOM, particularly between the two sites on south coast, are due genetic differences between the stocks or are a reaction to fishing or environmental pressures.

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