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Proposals for Future Management of the Isle of Man Common Whelk Fishery:

The Current Evidence Base

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Contents

List of Figures

Non-technical summary

The common whelk (*Buccinum undatum*) is a large mollusc that lives on the seabed in many areas of the Atlantic continental shelf. Inshore populations have been prosecuted by a small-scale artisanal fishery since the 1920s and traditionally supplied the European market. However, demand from far-east Asia (South Korea and Japan) began to develop in the 1970s in line with economic growth in the region and decreasing logistical costs of global trade. These factors facilitated investment in the whelk fishery in the 1990s and landings increased dramatically (FAO, 2017).

Much of the increase in fishing activity since the 1990s has been in north-western Europe. This is a reflection of the species global distribution, but was also driven by declining commercial opportunities in other sectors of the fishing industry (e.g. finfish). The whelk fishery, which was relatively unrestricted and lacked effort controls throughout the vast majority of jurisdictions, absorbed displacement from other sectors and has subsequently expanded spatially and in terms of fishing capacity.

Landings data from UK vessels within the Irish Sea (ICES Area VIIa) is evidence of the expansion on a regional scale, showing an increase of 447% during the period 2000 – 2016. Moreover, the landings-per-unit-effort data available for analysis is beginning to show a downward annual trend inside the Isle of Man territorial sea.

The recent trends are concerning considering the species life-history. Whelk are late maturing, slow moving and do not have a planktonic phase through which widespread dispersal is possible during spawning. Populations are therefore understood to be spatially discrete and inherently vulnerable to overexploitation. There is a high-risk that populations may become depleted through recruitment overfishing (where the sexually mature 'spawning' biomass is reduced beyond the point where it has the capacity to effectively reproduce and sustain the population).

One method of reducing the risk of recruitment overfishing is to only harvest animals that have reached 'functional maturity' (defined as the size at which 50% of the population has had the opportunity to reproduce). Recent evidence suggests this size to equal approximately 80 mm total shell length (TSL) for sampled populations within the Isle of Man territorial sea. However, a biologically-appropriated minimum landings size on its own may not sufficiently reduce the risk of overfishing within the fishery. Other measures, which are highlighted in the consultation document, are being proposed as part of a precautionary approach to ensuring the whelk fishery within the Isle of Man territorial sea is managed in line with the Isle of Man Governments Future Fisheries Strategy.

1. Introduction

The common whelk (*Buccinum undatum*, Linnaeus, 1758), a neo-gastropod mollusc that is found in subtidal waters of the North Atlantic to depths of 1200 m (Ager, 2008), is widely distributed on the Atlantic continental shelf; from within the arctic circle (76°N) as far south as the Delaware Bay, USA (39°N) at the western-most extent (Van Guelpen, et al., 2005). Populations are most frequently observed in abundance in the northeast Atlantic, particularly in the waters of north-western Europe from the Celtic and Irish Sea through to Skagerrak and Kattegat Bay, including northern populations observed in Norwegian, Faroese and Icelandic waters (Ocean Biogeographic Information System, 2017).

This common whelk is the largest edible marine gastropod in the North Atlantic (TSLmax = 150 mm; Hancock, 1967). It exhibits late sexual maturation (Hancock, 1963) and low fecundity (Martel, et al., 1986a), rendering commercially targeted populations vulnerable to recruitment overfishing (Shrives, et al., 2015). The reproductive strategy, i.e. the absence of a larval stage by which widespread dispersal of individuals to other areas is possible, combined with evidence of limited range of movement even after having recruited into the adult population (Robinson, 2015; Bolger, 2016), means that populations may be isolated even within small geographical areas.

Within the Isle of Man territorial sea (TS), there is increasing commercial interest in prosecuting whelk stocks. The expansion of the fishery is most likely in response to increased economic returns resulting from the supply-chain opening lucrative markets in the Far-East, but also declining fishing opportunities in other sectors of the fishing industry. The Isle of Man Governments' Department for Environment, Food and Agriculture (DEFA) is consulting on proposals to align the sector with its' Future Fisheries Strategy (DEFA, 2015).

This document supplements the consultation as an *evidence-base* in lieu of an Impact Assessment (IA). This approach is justified given the i) nature of the proposals and ii) the limited data from which to quantify potential impacts.

2. Fisheries context

Whelk are opportunistic scavengers that feed mainly on carrion (decaying flesh) (Nasution & Roberts, 2004) and detect feeding opportunities with a very acute chemo-sensory system. This strategy allows the species to be commercially exploited with baited traps by fishers. Inshore whelk populations have been exploited by a mixed artisanal fishery in Europe since the early 20th century (Dakin, 1912) and European waters remain the principal area of commercial production. The fishery has undergone significant economic and geographical expansion due to capital investments made in response to emerging Asian markets, with global landings increasing from 7,000 tonnes yr^{-1} to over 35,000 tonnes yr^{-1} between 1990 and 2014 (Fig. 1; FAO, 2017).

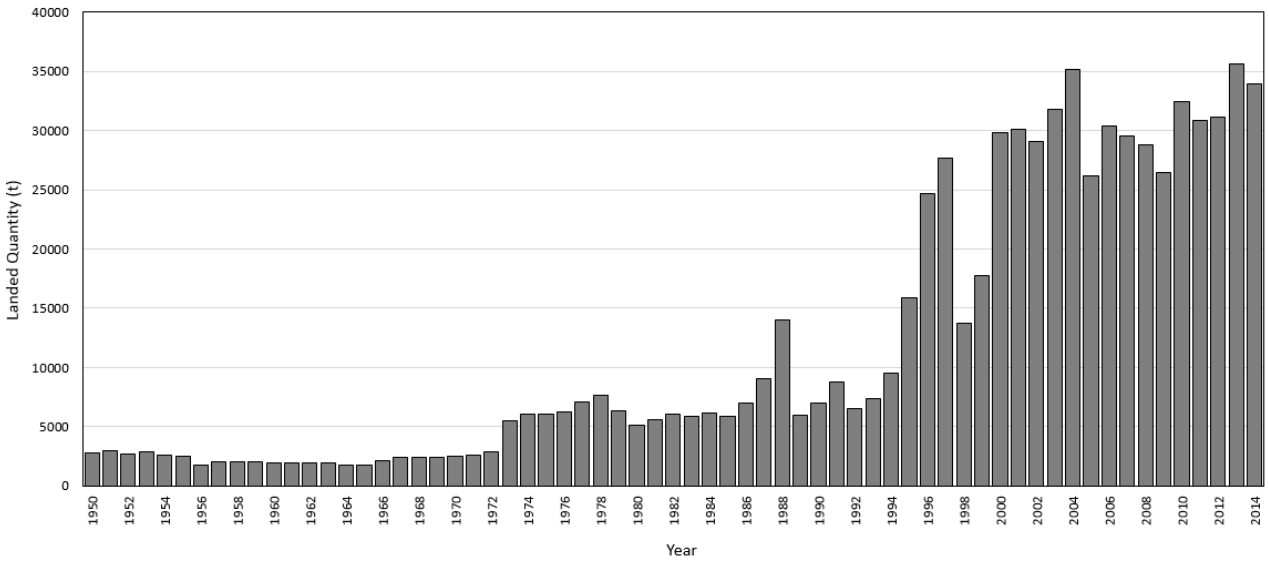

Figure 1. Global whelk landings, *Buccinum undatum*, by Year (FAO, 2017)

The trend in global landings (Fig 1) is representative of the trends in landings observed in the fisheries administrations throughout Western Europe including the UK. Total UK landings in 2016 was 21,606 tonnes equating to a value of £21.7 million (MMO, 2017). Regionally, the Irish Sea (ICES Area VIIa) has seen a 447% increase in the total landed weight of *Buccinum undatum* between 2000 and 2016 with considerable increases observed 2003 to 2006 and again 2011 – 2016 (Figure 3). A substantial proportion of the increased biomass removal was from waters around the Isle of Man and Wales (Figure 2).

There is currently very little management of the fishery at a regional (e.g Irish Sea), national (IoM / UK) and EU level. A minimum landing size (MLS) of 45 mm total-shell-length (TSL) is enforced throughout Europe with some local variations including in Isle of Man TS, which operates a MLS of 70 mm TSL. MLS has been re-assessed in several studies and found to be biologically unsuitable for many populations (McIntyre, et al., 2015; Haig, et al., 2015). Shelmerdine et al. (2007) suggests that management measures should be considered on a region by region basis having found that the life-history characteristics varied significantly between samples from Shetland and the south coast of England. The fishery is not subject to management through the Common Fisheries Policy (CFP) and there is an absence of harvest-control-rules (HCRs) that safeguard against overfishing, despite the species' vulnerability to depletion (Nicholson & Evans, 1997).

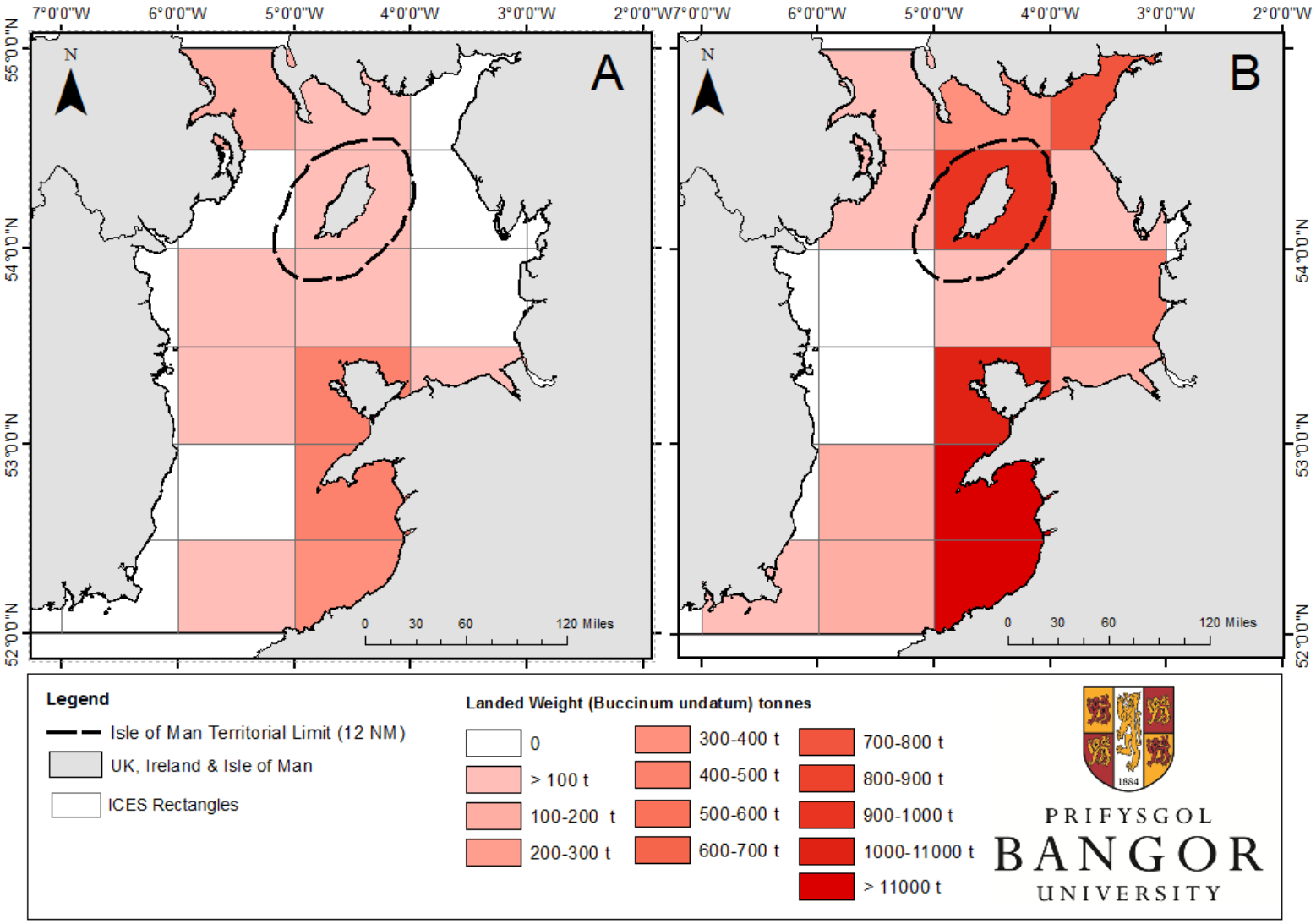

Figure 2. The spatial distribution of whelk *(Buccinum undatum)* landings in ICES Area VIIa by British vessels in 2000 (A) and 2016) (B) by ICES Rectangle. Source: IFISH2. N.B that pre-2011 IFISH data may under-report Manx registered vessels.

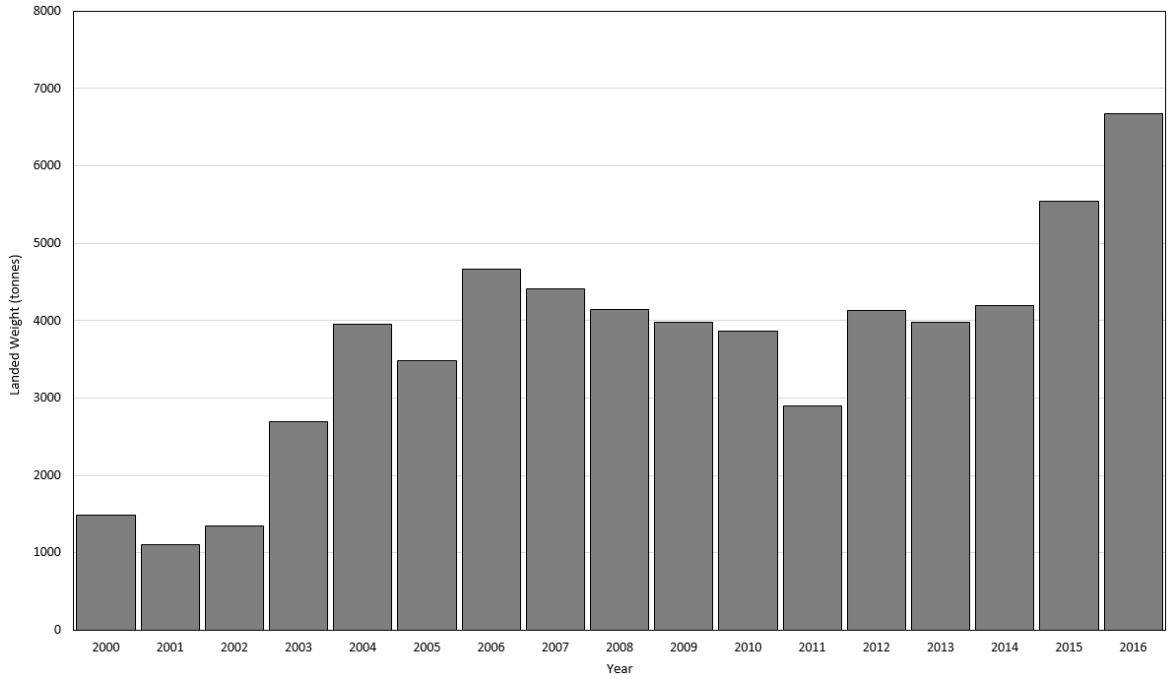

Figure 3. Whelk *(Buccinum undatum)* landings in ICES Area VIIa by year, since 2000 (Source: IFISH2). N.B that pre-2011 IFISH data may under-report Manx registered vessels.

In the Isle of Man, a specific whelk license is not required in order to prosecute the whelk fishery in the 3-12 nautical mile (NM) zone of the TS. At present, any vessel with an Isle of Man License can target whelk with unrestricted effort (number of pots) in the 3-12 nautical mile zone. A pot limit (total = 3,600) is applied in the 0-3 NM zone.

Assessing the total effort and biomass removed from within the Isle of Man TS is difficult. There is no obligation to land catch into the Isle of Man and the quality of catch data supplied via statutory reporting mechanisms varies according to vessel size due to different legislative requirements. The over-12 m fleet, which includes vessels that fish inside and outside the Isle of Man TS, submit landings (kg) via electronic logbook at the resolutions of ICES rectangles and very rarely include effort data. Similarly, vessels between 10 and 12 m length report landings, but not effort, via paper logbooks to ICES Rectangles. The under-10 m fleet is required to report daily landings (kg) and fishing effort (number of pots lifted) on a monthly basis via the DEFA Monthly Shellfish Activity Log (MSAL) at a higher spatial resolution. MSAL data can be considered representative of the overall fishery within 37E5 when investigating trends in effort, landings and productivity as the data represents ≈ 80% of active vessels.

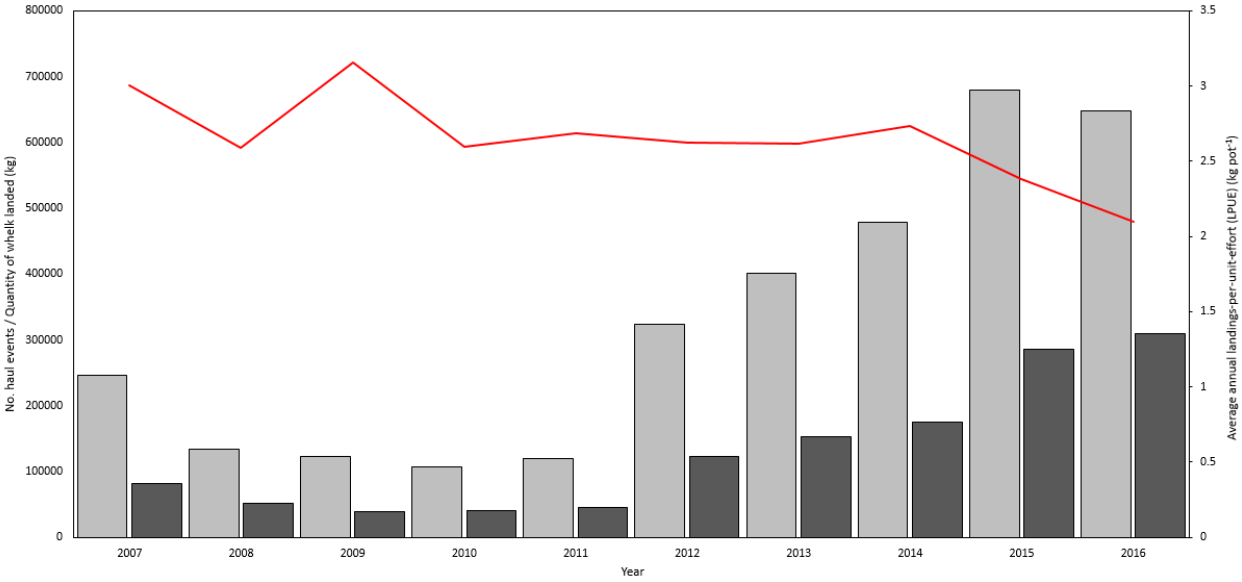

Figure 4. Annual landings (light-grey; kg) and effort (dark-grey; pot-lifts) and average annual LPUE (red line; kg pot^{-1}; right axis) of the under-10 m fleet (all nationalities) prosecuting whelk *(Buccinum undatum)* within the Isle of Man territorial sea, 2007-2016 (Source: DEFA; MSAL).

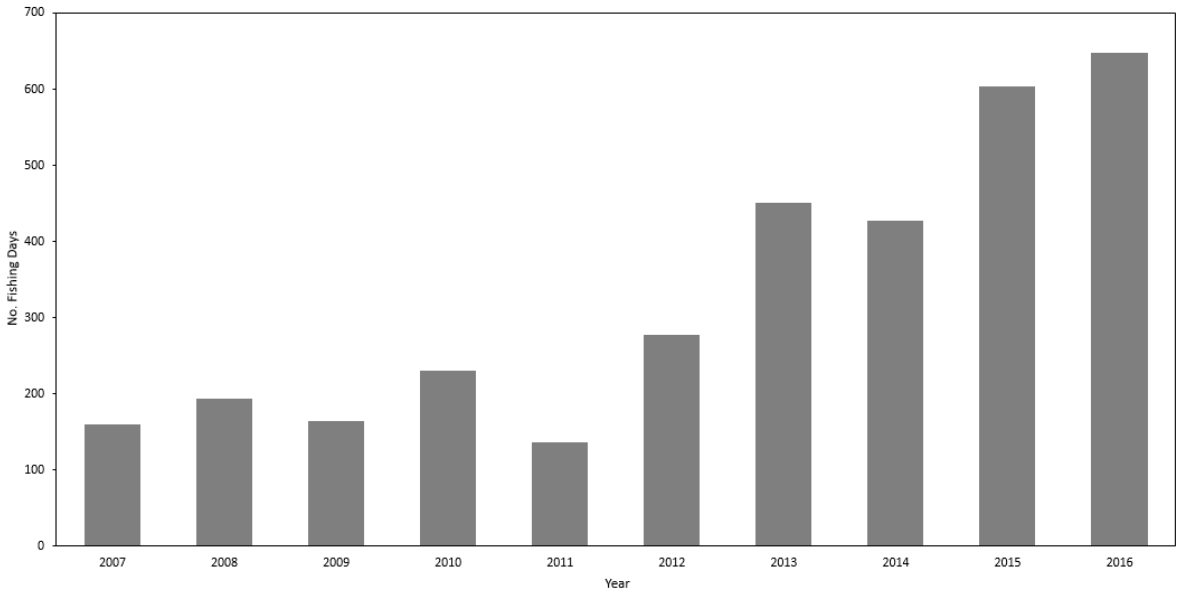

Figure 5. The annual number of days spent at sea prosecuting whelk *(Buccinum undatum)* by the under-10m fleet (all nationalities) within the Isle of Man territorial sea 2007-2016 (Source: DEFA; MSAL).

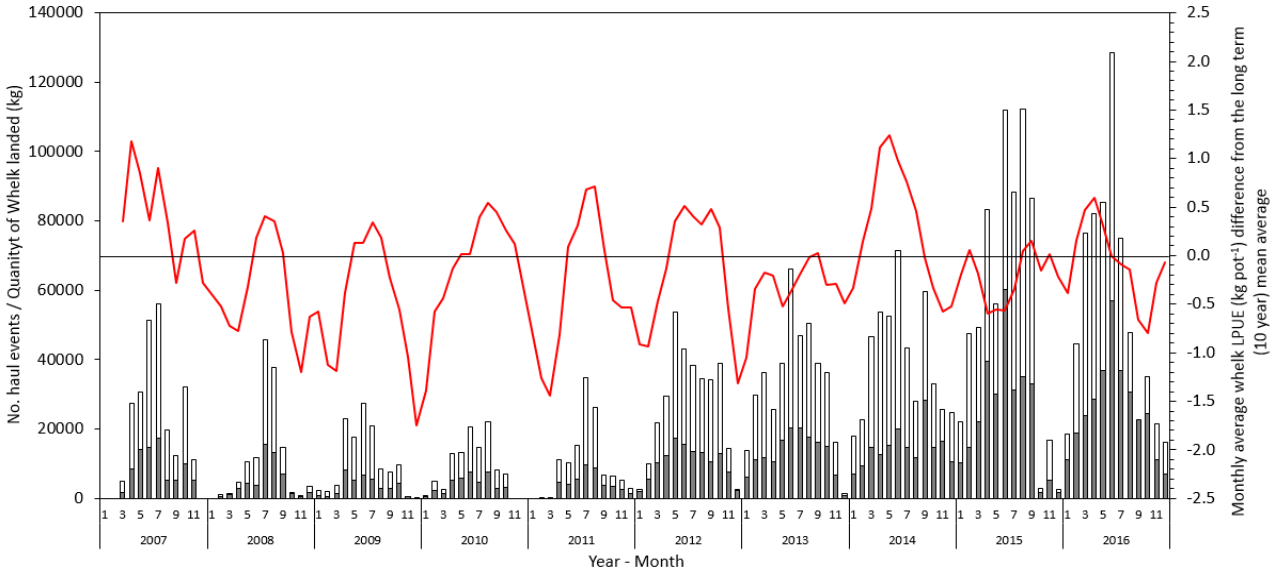

Figure 6. The monthly total landings (hollow bars; left-axis; kg), effort (dark-grey bars; left-axis; pot-lifts) and average landings-per-unit-effort (LPUE) variation (red line; kg pot^{-1}; right-axis) from the 10-year mean average 2007-2016 (black line represents a baseline = 0; kg pot^{-1}; right-axis) of whelk *(Buccinum undatum)*. (Source: DEFA, MSAL).

The whelk fishery has expanded significantly during the last decade (Fig. 4 and 5) and is characterised by seasonal peaks in effort, landings and productivity (LPUE) (Fig. 6). These peaks in activity have been successively increasing since 2011 (Fig. 6) and each year, the number of days spent targeting whelks has increased (Fig. 5) with the exception of 2014. The status of the fishery is difficult to ascertain in the absence of a time-series of data collected within a formalised assessment protocol, however there is concern that landings (and LPUE) are beginning to decline as effort continually increases (Fig. 4).

The fishery operates throughout the year with no closed season. On average, effort declines over the winter and peaks in summer (Fig. 6 and Fig. 7), likely due to a combination of factors including weather restrictions and spatial competition with mobile-gear fisheries.

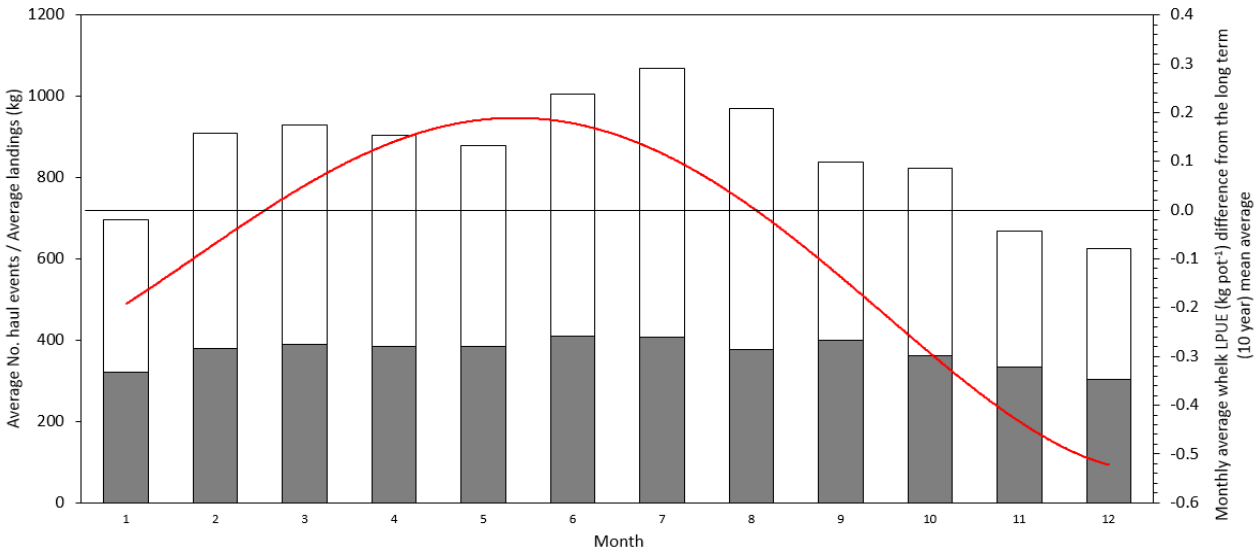

Figure 7. The average daily landings (white; left-axis, kg) and effort (dark-grey; left-axis, pot-lifts) and average landings-per-unit-effort (LPUE) variation from the 10-year mean average (smoothed using a polynomial x^4 function; red line; kg pot^{-1}, right-axis) by month over the period 2007-2016 of whelk *(Buccinum undatum)* (Source: DEFA, MSAL).

3. Biological context

For the management of a fishery to be effective, it must be relevant to the life-history, biology and ecology of exploited populations. For that reason, the Fisheries Directorate at DEFA facilitates a scientific steering committee which is constituted of a number of subgroups representing each of the catching sectors (e.g scallop, crab & lobster, whelk) in the Isle of Man. Throughout 2016, the whelk subgroup has been co-ordinating a 12-month scientific programme, in collaboration with both Isle of Man and UK registered vessels active in the fishery within the TS, that will culminate in an assessment of the population characteristics of whelk. A final report of findings is expected mid-2017; however, initial results of the monitoring programme are presented here.

To date, a total of 4,422 individual whelks have been analysed from pot-samples in key fishing areas in the Isle of Man TS. All samples exhibited a near 50:50 sex ratio. The samples have been assigned to fishing 'areas', which have been mapped based on discussion with industry representatives (Fig. 8).

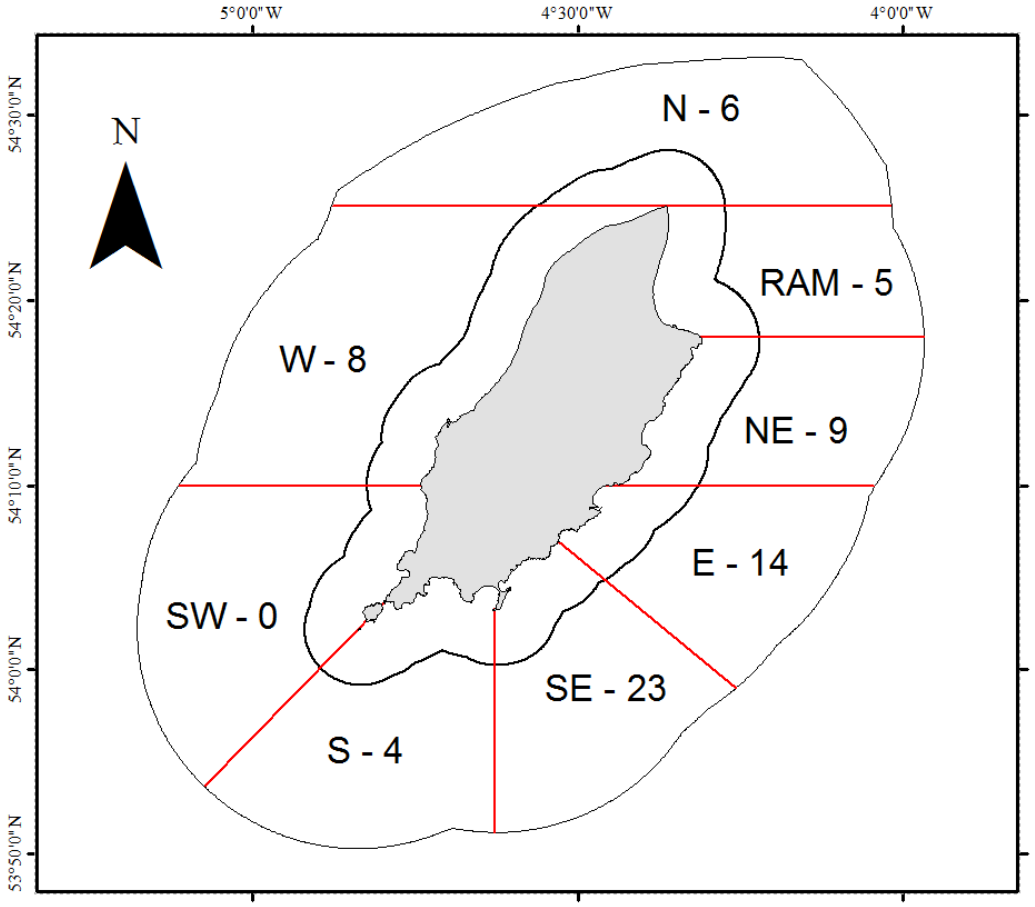

Figure 8. The spatial distribution and number of whelk pot-samples by area that have undergone analysis as of 20/02/2017. Area codes are abbreviations of cardinal directions and the number indicates the number of samples analysed. N.B 'RAM' = Ramsey.

Comparison with data from standardised studies elsewhere in the Irish Sea indicate that fishing grounds in the Isle of Man generally support a larger whelk (Fig 9, compare to Fig. 10 in Haig et al., 2015, p9).

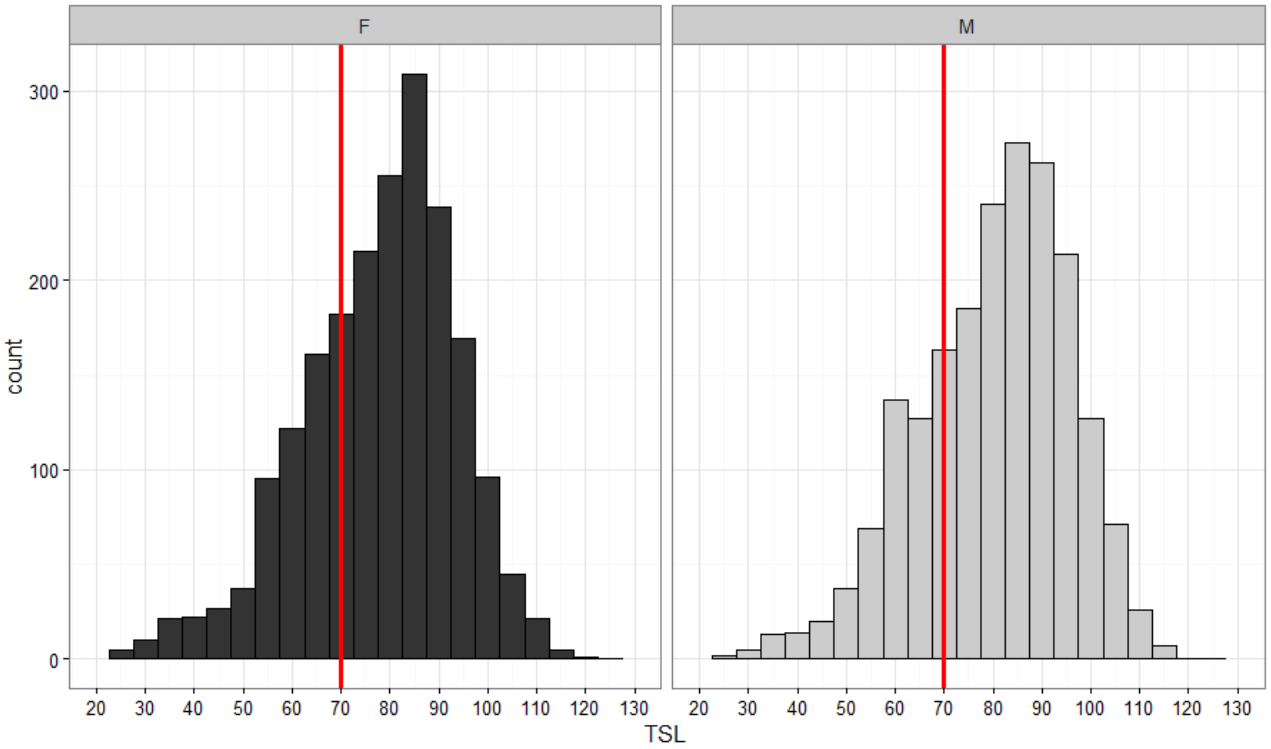

Figure 9. Size frequency histograms showing the populations structure of female (black bars) and male (grey bars) whelk (*Buccinum undatum*) sampled in 2016 within the Isle of Man territorial sea (Emmerson, J., *unpublished data*). The red vertical line represents the current MLS of 70 mm TSL.

Whelk size-at-maturity has been shown to vary over small spatial scales (McIntyre, et al., 2015) and was investigated in the Isle of Man by researchers the Port Erin Marine Laboratory (PEML) (University of Liverpool) in the early 1990s. At that time, functional maturity (the size TSL at which 50% of the population show characteristics of sexual maturity; L_{50}) was estimated to be achieved at a size 60-75 mm TSL (Kideys, et al., 1993), which informed the current MLS of 70 mm.

However, data collected in 2016 has reassessed L_{50} using methods employed in similar studies elsewhere in the Irish Sea (see Haig, et al., 2015). The size at maturity (L_{50}) for whelk populations in Isle of Man TS is estimated to be approximately 80 mm. The proportion of individuals that have achieved sexual maturity is low at the current MLS (70 mm) and is estimated to be in the region of 20% of individuals, although this varies spatially (Fig 10). Kideys (1993) used a methodology that was not as sensitive nor statistically robust as the one employed in 2016, hence the disparity between the two studies.

Whilst there is spatial variation in L_{50} (Table 1, Fig 10) in the Isle of Man TS, it is to a lesser extent than elsewhere in the Irish Sea (see Haig et al., 2015 for examples of spatial variation in Welsh waters). The confidence in the data varies between different sampling areas (see the 95% confidence intervals in Fig 10) due to varying sample sizes (Table 1). The evidence suggests that an increase in MLS to 80 mm TSL would help protect the spawning biomass and reduce the risk of recruitment overfishing. However, there will be economic implications of any change in MLS on existing fishing interests.

Table 1. The estimated L_{50} values for subsets of pot-sample data based on sex, inshore/offshore and fishing area.

Data subset	L_{50} (cm)	Sample Size (n)
No subset (all data)	*79.8*	*2098*
Male	81.1	1076
Female	78.4	1016
Inshore (0-3 NM)	80.4	776
Offshore (3-12 NM)	79.5	1117
North	73.7	140
Ramsey	82.2	125
Northeast	77.9	277
East	79.5	328
Southeast	80.0	655
South	80.5	171
Southwest	-	-
West	87.5	197

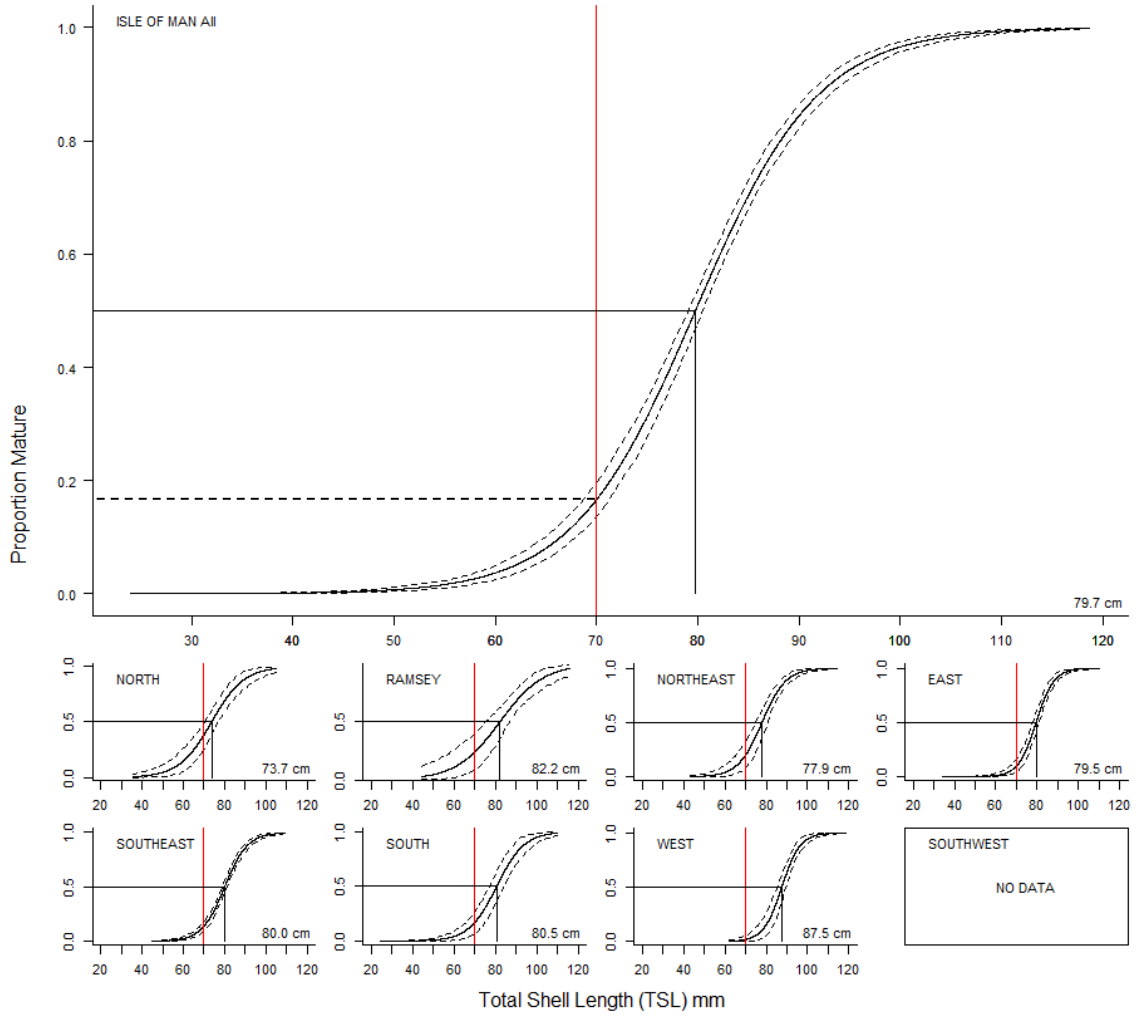

Figure 10. Maturity ogives showing the functional maturity (L_{50}) of whelk (*Buccinum undatum*) populations sampled in 2016 within the Isle of Man territorial sea (Emmerson, J., *unpublished data*). The black line indicates the functional size-at-maturity. The red vertical line indicates the current MLS (70 mm TSL).

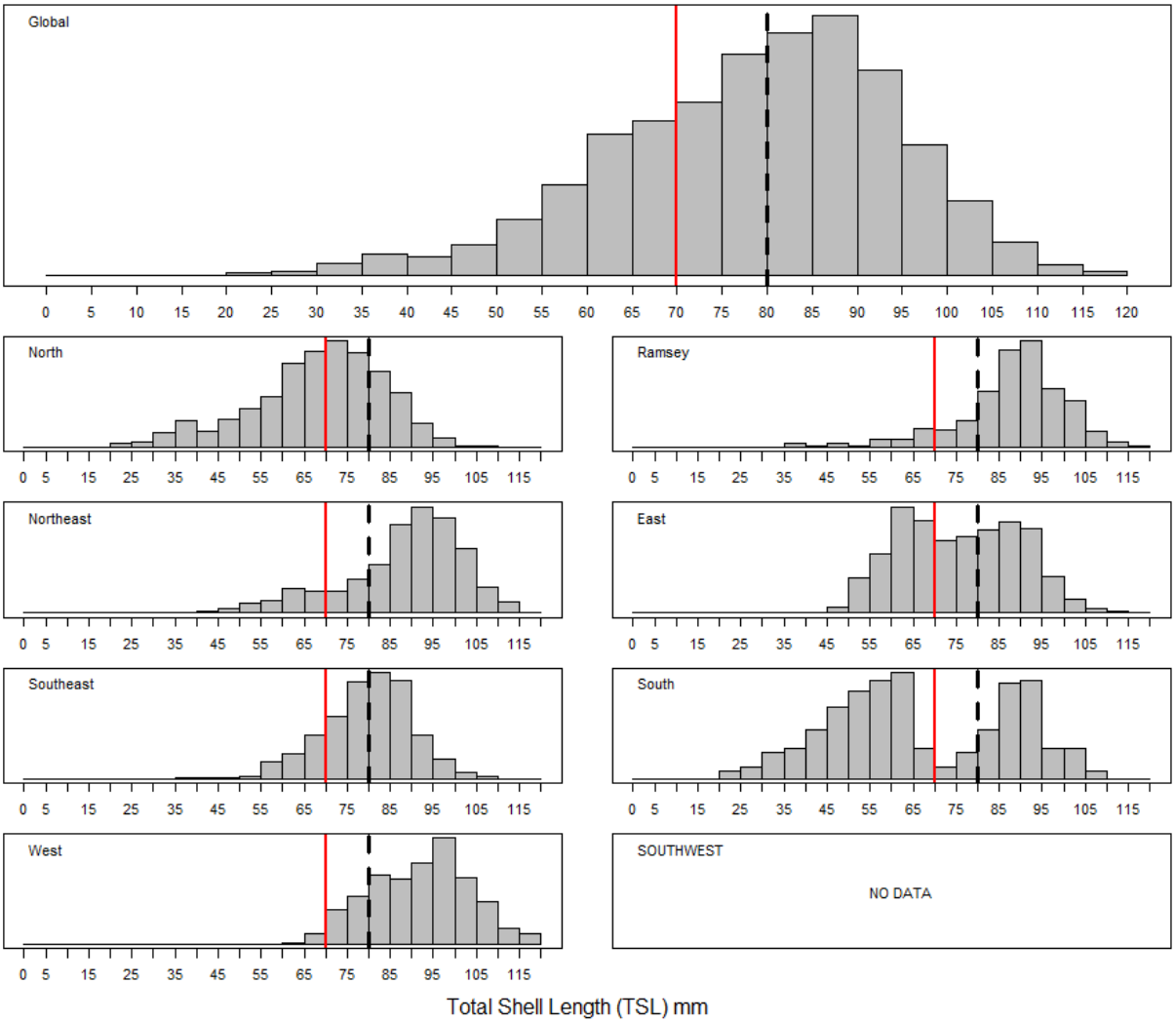

Figure 11. Size distribution (TSL, mm) of whelk (*Buccinum undatum*) in the Isle of Man territorial sea. The red vertical line indicates the current minimum landing size (70 mm TSL). The dashed black vertical line indicates 80 mm TSL.

According to the data collected with pot samples in 2016, the impact of a change in MLS to 80 mm will vary spatially. Inspection of area-specific size-frequency histograms and boxplots provide a useful indication of the proportion of the catch that is between 70 mm and 80 mm by area in the TS (Fig. 11 and 12).

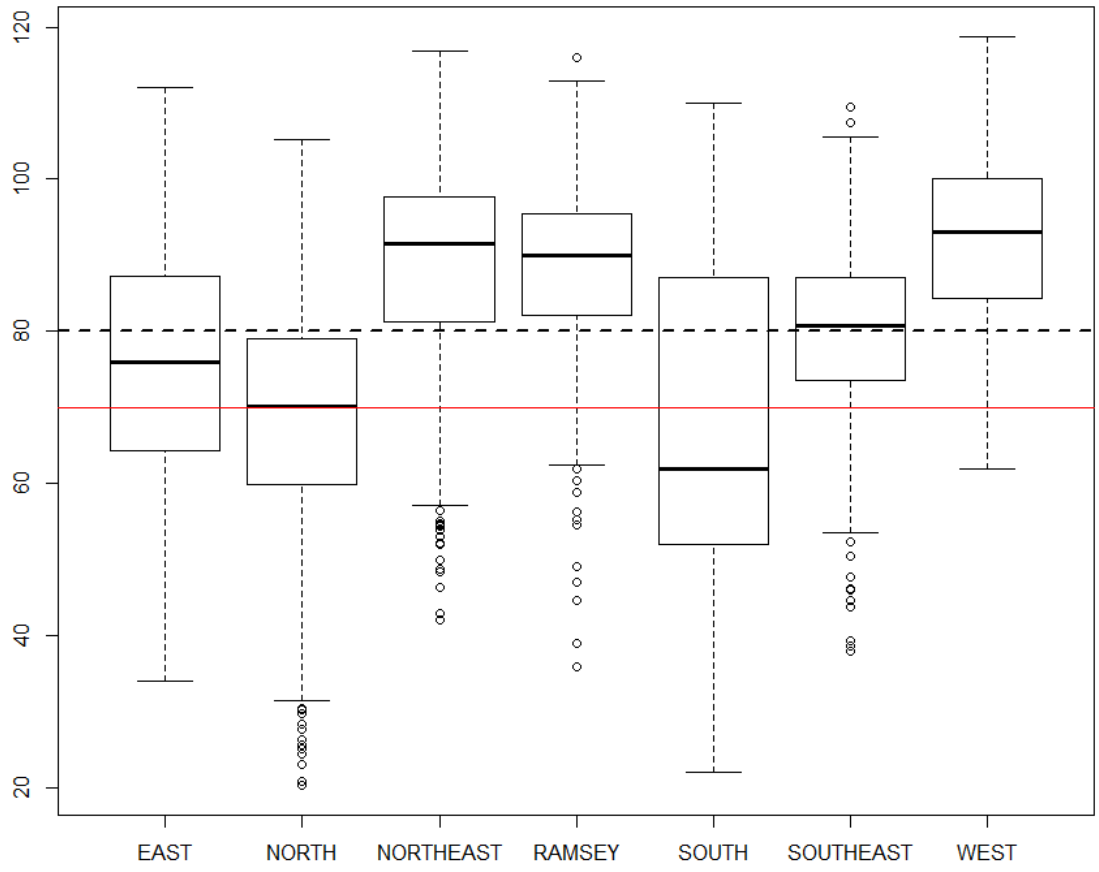

Figure 12. Boxplots showing the size distribution (TSL, mm) of whelk (*Buccinum undatum*) in Isle of Man territorial sea. The horizontal line indicates the current minimum landing size (70 mm TSL). The dashed black horizontal line indicates 80 mm TSL. The box represents the interquartile range (50% of data) and the solid black line shows the median average value. The 'whiskers' show the range of 95% of data and points represent outliers.

The reduction in landed weight due to a change in MLS is expected to have an impact in the short-to-medium term only (1 to 2 years) as the portion of the population that is between 70 mm and 80 mm is expected to grow to a harvestable size (> 80 mm) within that timescale.

Kideys (1996) summised that whelk, which were sampled in the 'East' area of the Isle of Man, recruit after four years using an adjusted length-frequency-analysis (LFA) method (Table 2). Further, Kideys (1996) found that the whelk would reach a size of 80 mm TSL after an additional one years growth. This is parallel to observations made in the data collected as part of the 2016 sampling programme (Fig. 13).

The age and growth rate is difficult to determine, however a method has been developed whereby annual growth rings are counted within the statolith structure (Hollyman, 2015). Post-dissection samples have been retained from the 2016 sampling programme in order to better understand the size-at-age relationships in Isle of Man TS. However, in the absence of statolith analysis of Isle of Man samples, length-frequency-analysis (LFA) methods are employed (Fig 13).

Table 2. The size-at-age of whelk (*Buccinum undatum*) as shown in Kideys (1996) length-frequency-analysis (LFA). The sample size (n) is shown on the left. The stages (I, II, III, IV and V) represent 1, 2, 3, 4 and 5 years of 'completed' growth, i.e I = 12 months, II = 24 months.

Adjusted LFA n = 705	Size (mm) at age				
	I	II	III	IV	V
	28.5	45.8	59.9	71.5	81.0

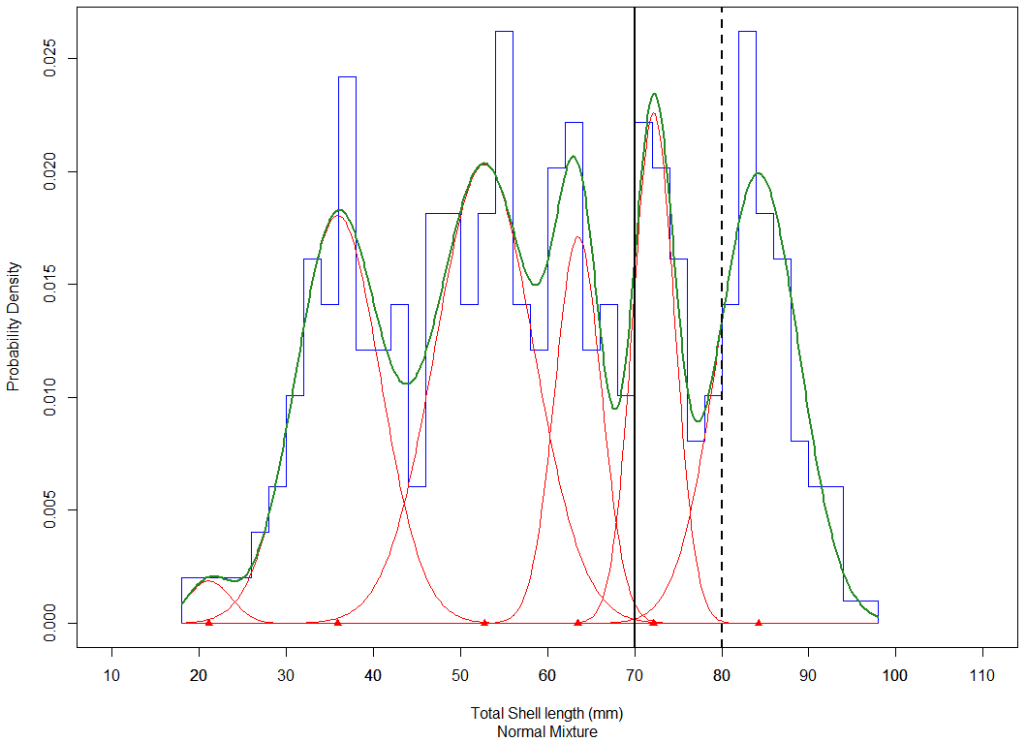

Figure 13. Length-frequency-analysis (LFA) of a whelk (*Buccinum undatum*) sample collected in March 2016 in the Isle of Man territorial sea (Area = North, Month = March, n = 248).The green line represents the TSL probability density, while the red lines represent the estimated probability density TSL of discrete components within the mixed distribution (i.e. population cohorts). The red arrows (x-axis) represent mean average size of components.

Results from the reproductive cycle analysis (seasonality and spawning periods) has yet to be fully analysed using the data collected during 2016. However, Haig et al., (2015) found the gonadosematic index to vary through the year, peaking during autumn and corresponding with a ripening of the ovaries before the spawning season – a similar pattern has been observed in the Isle of Man (Emmerson, J. *pers. obs.*). Whelk were shown to spawn during winter in Wales (Haig et al., 2015), which corresponds with Kideys, et al. (1993) who found populations on the east cost of the Isle of Man spawn from November through to January.

Females attach egg capsules to hard substrate on the seabed in the weeks after copulation, which is likely triggered by environmental thresholds such as temperature (Martel, et al., 1986a). Martel and Larivée (1986) found a single egg mass is made up of an average of 140 capsules but many contain up to several thousand capsules (≈3200). Multiple females can contribute to a single egg-mass, making estimations of fecudity outside of a laboratory setting difficult to assess. Valentinsson (2002) found i) egg production follows a linear relationship with total weight and ii) egg quality is indepdent of size.

After 5-8 months of development, ≈30 juveniles measuring ≈ 3 mm TSL emerge from each capsule that has remained viable throughout that period (surviving distrurbance from predation, weather and anthropogenic impacts such as scallop dredging, all of which is unquantified). The survival rates during early life-stages has not been estimated. Given that mark-recapture studies of whelk in the Isle of Man have also found spatially restricted movement, with an estimated average daily movement of less than 10 m day^{-1} (Bolger, 2016; Robinson, 2015), there is an inherent risk of localised depletion via recruitment overfishing associated with this fishery.

4. Current status of the Isle of Man whelk stock

The relatively unrestricted nature of the existing fishery in the 3-12 NM zone equates to an absence of effective management. Although a formal assessment is not yet available, the current status of the fishery can be considered high-risk given what is known about i) the biology and life-history of the species, ii) significant increases in fishing effort and iii) decline in average annual LPUE.

The whelk subgroup of the scientific steering committee has begun developing a formalised, long-term monitoring programme so that a scientific assessment (similar to Shrives et al. (2015)) of the fishery will be possible in the future. Further, the subgroup seeks to improve reporting and monitoring of the fishery, which will facilitate an understanding of temporal-spatial variation in basic fishery indices (effort, landings and LPUE). Importantly, the group recognises the importance of making the reporting mechanism common for all vessels irrespective of size, nationality and pre-existing legislative requirements.

5. Conclusion

- Current data suggests that a revision of the MLS to 80 mm TSL is required in order to protect the spawning stock biomass and safeguard against recruitment overfishing. Existing information on growth suggests one additional year would allow whelk to increase from 70 mm to 80 mm.
- The continued expansion of fishing effort within relatively unrestricted management regime is considered high-risk and a precautionary approach should be adopted with regard to effort control.
- Implementation of a formalised, long-term scientific assessment of the fishery is necessary in order to implement appropriate management.
- Consideration of the species life-history, particularly the reproductive cycle (spawning season and nursery areas) is needed for robust fisheries management. Temporary closed areas may deliver a long-term benefit to the fishery by affording protection to the spawning stock at critical periods of the year.
- Co-management platforms (industry-science-government co-operation) have proven effective at designing, implementing and monitoring spatial management measures in other fisheries and would be applicable to the whelk fishery.

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