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The complexities and challenges of conserving common whelk (*Buccinum undatum* L.) fishery resources: Spatio-temporal study of variable population demographics within an environmental context

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ABSTRACT

The commercial fishery for common whelk (*Buccinum undatum* L.) has expanded significantly in the Irish Sea since 1990 and continues to grow, particularly in Welsh waters and the Isle of Man territorial sea, with landings throughout the region increasing by 227% between 2011 and 2016. Whilst whelk populations are known to be vulnerable to localised overexploitation due to inherent life-history parameters, fisheries remain relatively unrestricted by conservation measures in comparison to other fisheries operating in the area. With the exception of the northernmost fishing ground between the Isle of Man and Scotland (Point of Ayre), the size-at-maturity (L_{50}) estimate for populations sampled during peak-aGSI (the months in which adjusted gonadosomatic index is highest) indicates that whelk are being fished before the time at first spawning throughout the study area. A correlation was detected between the size (total shell length) and depth, with smaller whelks found in deeper waters where there generally is greater fishing effort, although effort data is not available at a resolution to investigate this relationship quantitatively. No clear link between benthic infauna biomass and the average size (total shell length) or reproductive capacity (aGSI) of whelk sampled throughout ICES Area VIIa was found, indicating that the ecological energetics of whelk populations are more likely to be a function of scavenging opportunities than predation on benthic communities. A mixed cohort analysis utilized length-based data to infer a size-at-age relationship in the absence of direct age observations (*e.g.* statolith rings), with whelk recruiting into the Isle of Man fishery five years after hatching. The evidence presented in this study suggests that, prior to recommending a MLS that will adequately protect the spawning stock biomass, L_{50} values should be adjusted for pre-spawning growth between the ideal time of assessment (when aGSI values are at a peak) and the spawning season (when aGSI values decrease).

1. Introduction

The common whelk (*Buccinum undatum*, Linnaeus, 1758) is a neogastropod mollusc that is found in the subtidal waters of the North Atlantic to depths of 1200 m (Ager, 2008). It is widely distributed on the Atlantic continental shelf; from within the arctic circle (76° N) as far south as New Jersey, USA at the western-most extent (38° N) (Van Guelpen et al., 2005; Borsetti et al., 2018). 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 the Skagerrak and Kattegat Bay, including northern populations observed in Norwegian, Faroese and Icelandic waters (Ocean Biogeographic Information System, 2017).

Whelk are opportunistic scavengers that feed mainly on carrion (Nasution and Roberts, 2004) and detect feeding opportunities with a very acute chemo-sensory system (Himmelman, 1988). This allows whelks to be commercially exploited by fishers, who typically use specifically designed baited traps. Inshore whelk populations have been exploited by a mixed artisanal fishery in Europe since the early 20th century (Dakin, 1912). Annual landings in England and Wales equated to 4500 t in 1911 (Dakin, 1912) and European waters remain the principal area of fishing effort (FAO, 2017). The fishery has undergone significant economic and geographical expansion in response to emerging Asian markets, with global landings increasing from 7000 t yr^{-1} to over 35,000 t yr^{-1} between 1990 and 2014 (FAO, 2017). The effects of fishing mortality (F) on the phenotypic traits of *B. undatum* may be significant, especially considering the expansion in commercial exploitation (Kuparinen and Merilä, 2007). Whelk are now amongst the most economically important shellfisheries in the UK (Haig et al., 2015) with total UK landings (21,606 t) equating to a value of £21.7 million in

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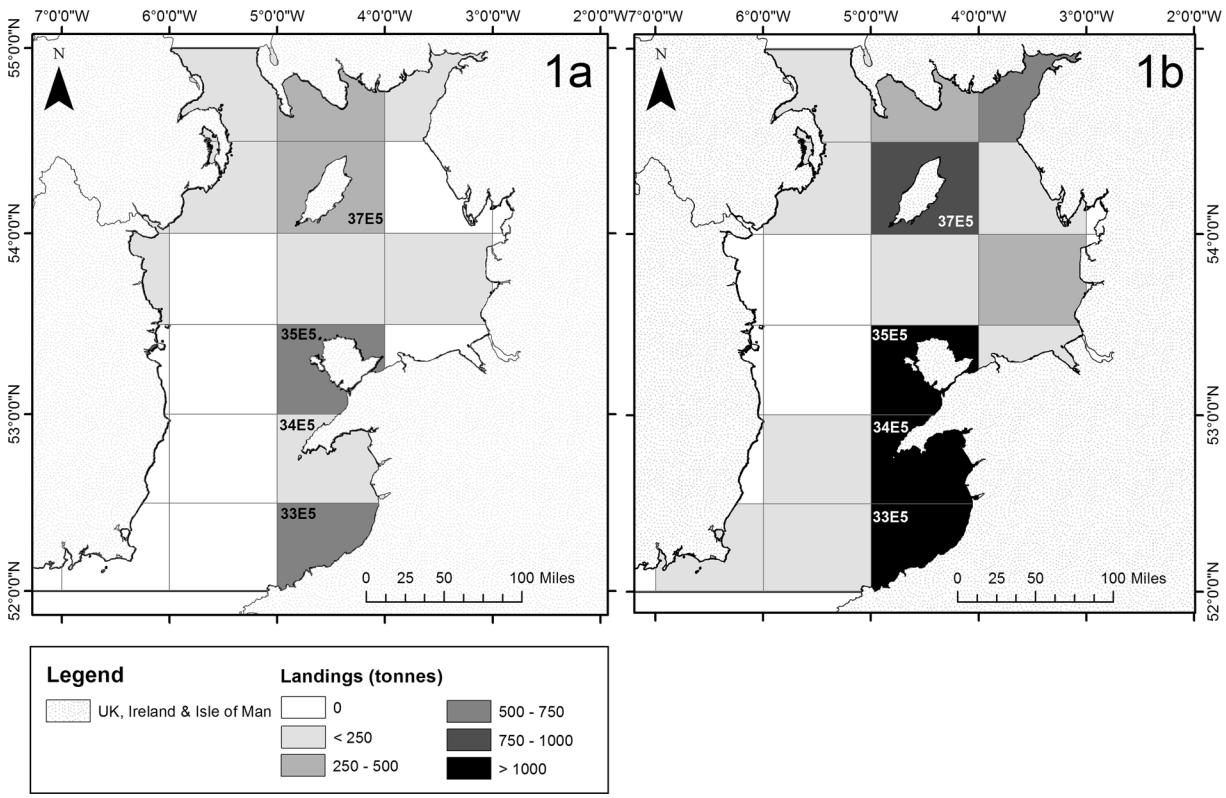

Fig. 1. The spatial distribution of whelk (*Buccinum undatum*) landings in ICES Area VIIa by British vessels in 2011 (A) and 2016 (B) by ICES Rectangle. Source: IFISH2 database.

2016 (MMO, 2017). Regionally, the Irish Sea (ICES Area VIIa) has seen an estimated 227% increase in the total landed weight of whelk between 2011 and 2016 and is the source of approximately 10% of global landings for this species. The most substantial increases in recorded landings in the region are from within the Isle of Man territorial sea (ICES rectangle 37E5) and Welsh waters (ICES rectangles 33E5, 34E5, 35E5) (iFISH2, 2017; Fig. 1).

Within ICES Area VIIa, management regimes are not consistent. Similar to many other jurisdictions in the UK, whelk fisheries within Welsh waters are managed solely by a minimum landing size (MLS = 45 mm Total shell length; TSL) established by the European Union (EU), which has been shown to be inadequate in several studies (Shelmerdine et al., 2007; Haig et al., 2015). However, Isle of Man fisheries are subject to a MLS of 70 mm TSL, informed by Kideys et al. (1993) and the fishery now includes a restricted number of species-specific licenses, each of which has effort (pot number) restrictions.

The phenotypic plasticity displayed by other marine gastropod populations can be closely related to mortality and growth rates (Stearns and Koella, 1986), which vary spatially and temporally with fishing pressure (Torrogolsa and Gimenez, 2010; Fahy et al., 1995). Whelks do not reach sexual maturity for several years, have limited dispersal potential (Martel et al., 1986a) and display little adult movement (Pálsson et al., 2014; Weetman et al., 2006). Therefore, populations are inherently vulnerable to high *F* and are particularly susceptible to recruitment overfishing (Shrives et al., 2015) and severe localised depletion (Nicholson and Evans, 1997). Environmental parameters have been shown to influence the biological characteristics of populations, with size-at-maturity being negatively correlated to bottom-temperature but positively correlated with depth (McIntyre et al., 2015; Haig et al., 2015). This is unsurprising given that the common whelk is a boreal species, although no clear latitudinal relationship has been observed (McIntyre et al., 2015) and local factors such as food availability and fishing pressure are likely to have an influence in maturation and growth (Martel et al., 1986b).

There is presently little scientific evidence to suggest that the current MLS of 45 mm used as the baseline throughout the EU is an adequate fisheries threshold for sustainable exploitation. Shelmerdine et al. (2007) suggests that management measures should be considered on a regional basis after demonstrating significant differences in the biology of whelk populations sampled in Shetland and the south-coast of England. Haig et al. (2015) shows that the size at maturity (L_{50}) can vary considerably between populations over distances as small as 10 km (although application of management measures at this spatial scale are acknowledged to be impractical). Complications arise when trying to compare research on size-at-maturity, as there is not currently a standard scientific methodology to determine this metric (Haig et al., 2015).

This study combines published data (Haig et al., 2015) from Welsh waters with data collected in the Isle of Man territorial sea. The aim was to compare spatial variation in size-at-maturity and also to determine reproductive response to spatial, temporal and environmental parameters.

2. Materials and methods

2.1. Field materials (fisheries dependent data)

Nine fishers, registered in Wales (3), England (1) and the Isle of Man (5), each fished two identical whelk pots once a month within the ICES area VIIa (Irish Sea). The fishers retained the entire pot contents, including undersized bycatch and non-target species. The pots supplied to fishers were 36 l Fish-tec™ 'WHELKER' pots, described by fishers as being 'stand-up' pots due to their orientation (Haig et al., 2015). The pots are made of thick plastic and are weighted with lead. The drainage holes in the base of the pot measure 30 mm in diameter and the entrance to the pot is covered with a purse-pull mesh netting.

Fishers completed data-forms with details on the location (latitude and longitude), date, soak-time and bait used. Isle of Man (Manx)