Exe Estuary
Mussel Stock Assessment 2016

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1. Introduction

1.1 The Exe Estuary

The Exe Estuary is the most highly designated nature conservation site in Devon; it is a Ramsar Site, a Special Protection Area (SPA), and a Site of Special Scientific Interest (SSSI). It encompasses over 3,000 hectares of diverse aquatic and terrestrial habitats (EEMP, 2014). The Exe Estuary SPA includes both marine areas (i.e. land covered continuously or intermittently by tidal waters) and land which is not subject to tidal influence (Figure 1). Sub-features have been identified which describe the key habitats within the European Marine Site necessary to support the birds that qualify within the SPA. Bird usage of the site varies seasonally, with different areas being favoured over others at certain times of the year. The mussel beds in particular are important in supporting the wintering wader and wildfowl assemblages to enable them to acquire sufficient energy reserves to ensure population survival (Natural England, 2015). Oystercatchers are the main bird species to use the mussel beds, along with Redshank, Curlew, Turnstone and Greenshank. Several thousand Oystercatchers overwinter on the Exe Estuary and predominantly feed on the mussels, a few will also feed on cockles, winkles and ragworms (Goss-Custard & Verboven, 1993).

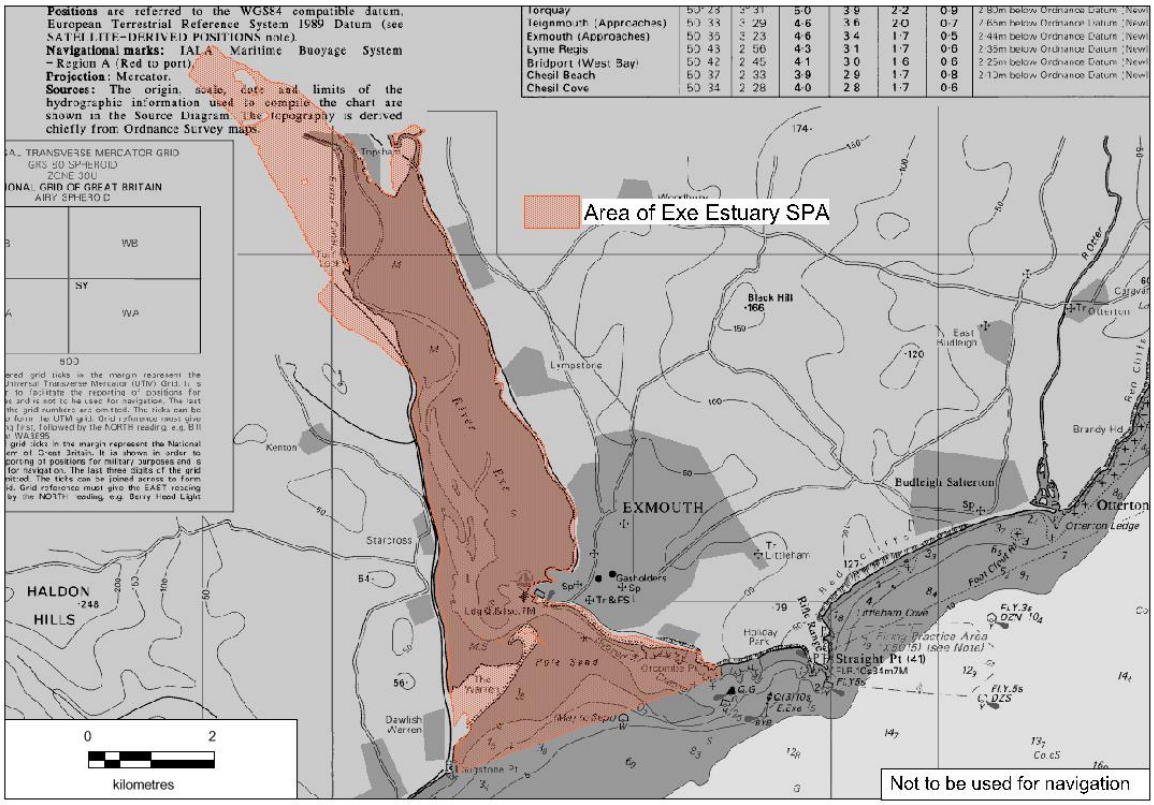

Figure 1 Area of the Exe Estuary SPA

The main commercial fishing activity occurring within the Exe Estuary SPA is the mussel fishery, worked by the Exmouth Mussels Limited. Exmouth Mussels Ltd. collect up to 2000 tonnes of mussel seed per year, from sites at the mouth of the estuary. The seed mussel is then re-laid onto land that Exmouth Mussels Ltd. leases, and therefore has rights to. Seed is re-laid at a ratio of 3:1, subtidal:intertidal. Once the seed has grown to marketable size, it is harvested using a “hydraulic jet elevator”, which uses water jets to dislodge the mussels from the bed onto a conveyor belt, which brings them up onto the fishing vessel for sorting. The main fishing activity occurs in the summer, when most wintering bird populations are absent, however some activity takes place all year round.

Commercial mussel harvesting can only take place on classified beds (Figure 2). Devon & Severn IFCA's stock assessments focus on the public fishery beds of Bull Hill and Starcross. These areas are popular for recreational shellfish collection.

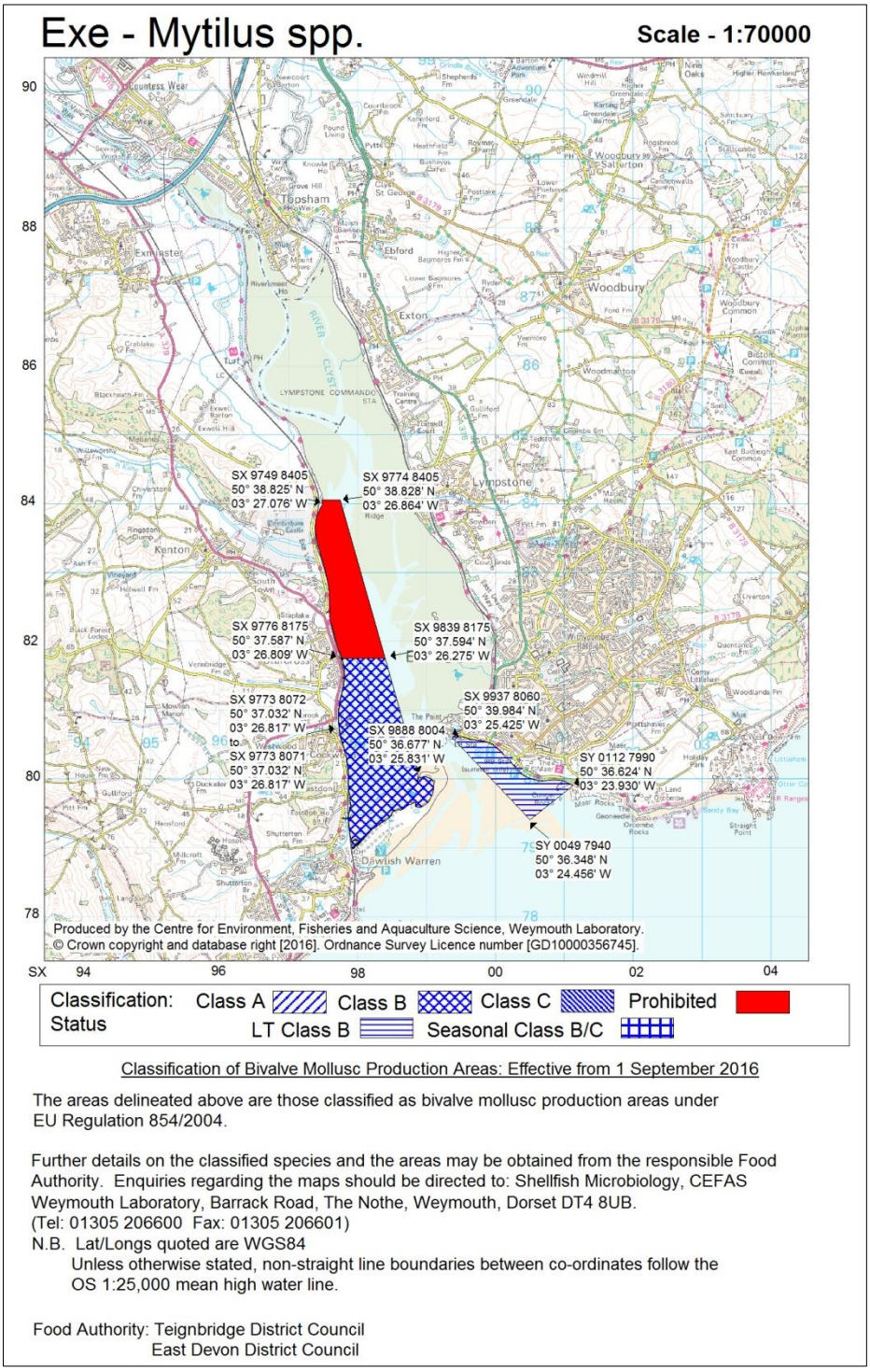

Figure 2 Classified mussel harvesting areas on the Exe Estuary (Cefas, 2016)

1.2 *Mytilus edulis*

Blue mussels, *Mytilus edulis*, are cold-water mussels which can occur in brackish water (Gardner, 1996). They are found on the north Atlantic and north Pacific coast of North America, Europe and in other temperate and polar waters. Blue mussels can occur intertidally and subtidally, and on a

variety of substrates, from rocks to sediments, and in a range of conditions. “Blue mussel beds on sediment” are listed as a UK Biodiversity Action Plan (BAP) Priority Habitat (Maddock, 2008). This includes a range of sediments, such as sand, cobbles, pebbles, muddy sand and mud. *M. edulis'* ability to occupy such a range of habitats results from its ability to withstand wide variation in salinity, desiccation, temperature and oxygen concentration (Andrews et al., 2011).

M. edulis beds play an important role in the healthy functioning of marine ecosystems; having a role in coastal sediment dynamics, acting as a food source to wading birds, and providing an enhanced area of biodiversity in an otherwise sediment-dominated environment (Maddock, 2008). Mussel beds support their own diverse communities as the mussel matrix, composed of interconnected mussels and accumulated sediments and debris, provides numerous microhabitats and an organically enriched environment (Andrews et al., 2011). Blue mussels are filter feeders, feeding primarily on micro-algae, suspended debris and zooplankton, and play a vital role in estuaries by removing bacteria and toxins.

The reproductive strategy of *M. edulis* is to deploy a large number of gametes, approximately three million eggs, into the surrounding water where fertilisation takes place (Andrews et al., 2011). Following fertilisation the zygotes, as planktonic larvae, undergo six stages of metamorphosis before settlement. Mussels can adapt their reproductive strategy depending on environmental conditions. For example, the release of gametes can be timed to complement favourable environmental conditions, and the planktonic phase can last between two and four weeks depending on temperature, food supply and availability of a suitable substrate to settle on (Andrews et al., 2011). Depending on temperature and nutrient levels, spawning may occur just once or several times per year (Bayne & Worrall, 1980).

Current threats to *M. edulis* beds include commercial fishing, water quality, coastal developments, anchoring and bait digging (Maddock, 2008).

1.3 Objectives

The objective of this project is to carry out annual surveys of the public mussel beds on the Exe Estuary, to define where the mussel beds are and accurately map, using GIS, and the overall extent of each of the mussel beds. Devon and Severn IFCA will undertake a stock assessment on each of the beds to estimate the density of mussels on the beds and the total stock of marketable mussels. Results of these surveys can be compared on an annual basis. This will help inform future management of the mussel beds on the Exe and the development of shellfisheries in this part of the Devon & Severn IFCA District.

2. Methodology

2.1 Equipment

1 x 4’ cane, with 11cm ring attached to one end
1 x 11cm corer
2 x GPS units
2 x buckets
Plastic bags
Sieve
Digital scales
Survey forms
Callipers

2.2 Method

The area of the bed is recorded by walking its perimeter and marking points with a handheld GPS, which are then plotted onto MapInfo GIS software.

To determine coverage and patch density transects are walked in a zig-zag across the bed, right up to the perimeter, to provide optimum coverage through the bed. The start and end point of each transect is recorded using a handheld GPS, to be mapped later using MapInfo GIS software (Figure 3). A 4’ bamboo cane with an 11cm ring attached to the end, so that the ring sits flat on the ground when held out to one side, is used to determine the mussel coverage for each transect. Every three paces along each transect the cane is flicked out to one side and it is recorded whether it is a “hit” if the ring contains live mussel, or a “miss” if the ring doesn’t contain live mussel. On every fifth hit the contents of the ring is taken as a sample, using an 11cm diameter corer. All mussel samples from the same transect are collected together in one bag, but kept separate from those of other transects.

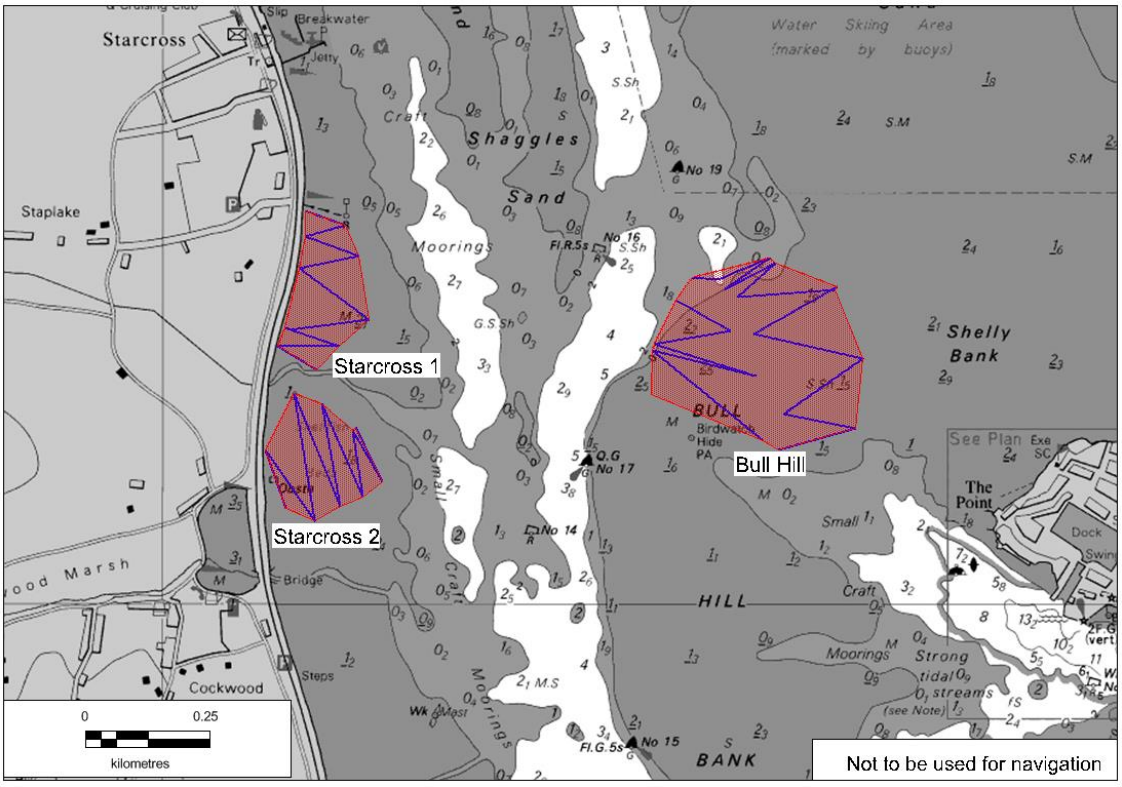

Figure 3 Transects walked (blue) and area of each mussel bed (red).

Once all transects are complete the mussel samples are sieved and cleaned. For each transect the number of samples taken is recorded, all mussels are measured recording sizes on the survey form, and divided into size groups; 1-10mm, 11-20mm, 21-30mm, 31-40mm, 41-50mm, 51-60mm, 61-70mm, 70+mm. Each size group is weighed separately and the total weight of each group is recorded. The data collected are used to calculate the coverage, density and area of the mussel bed (Figure 4), which are then used to estimate the mussel tonnage on each bed. Size distribution is obtained from the length measurements of mussels in the retained samples. The hit/miss data is also pooled, to calculate the average coverage and patch density for the whole bed, compensating for the possibility of some transects being longer than others.

$$\%\ \text{cover} = \frac{\text{no. hits}}{\text{no. hits + no. misses}}$$

$$\text{Density across bed} = \frac{\text{total mussel weight/surface area sampled}}{\%\ \text{cover}}$$

Figure 4 Calculations used for mussel coverage on bed, and density of mussels across bed.

The survey method used is a procedure developed by MarinX, Dutch marine consultants. This method was chosen in place of the method which uses footfall to determine hits/misses and the throwing of a quadrat to determine coverage, as it is deemed to be more accurate. Using a pre-determined ring size for hits/misses, removes the potential for inaccuracies caused by surveyors having different sized feet. It is also easier to see whether the ring contains live mussel instead of looking at a footprint. The flicking of the ring at the end of the cane provides a random sample which is not subject to human error by trying to select a "representative" quadrat.

3. Results

3.1 Bull Hill

- Area: 11.2ha
- Coverage: 5%
- Mean density: 0.16kg/m^2
- Total stock: 18 tonnes
- Stock ≥50mm: 8 tonnes

Bull Hill was surveyed on 7th April 2016. Samples were taken from every fifth "hit", producing three samples from 17 transects. The stock of marketable sized mussels was estimated to be 8 tonnes out of a total 18 tonnes on the bed, i.e. 44%. Table 1 shows the difference in stock composition relative to previous surveys. Figures 5 and 6 show the total stock and the stock for each size class, respectively, for each year.

Table 1 Summary of Bull Hill stock composition from 2013 to 2016.

	2013	**2014**	**2016**	Difference since last survey
Area (ha)	10.9	11.1*	11.2*	+0.9%
Density (kg/m^2)	11.25	0.14	0.16	+14%
Total stock (tonnes)	1222	16	18	+12.5%
Stock 1-10mm	0	0	0	=
Stock 11-20mm	1	0	0	=
Stock 21-30mm	13	0	0	=
Stock 31-40mm	142	3	0	-100%
Stock 41-50mm	504	13	10	-23%
Stock 51-60mm	478	0	8	+ 8 tonnes
Stock 61-70mm	84	0	0	=

* This refers to the area where mussel was found, as it would probably no longer be considered a mussel "bed".

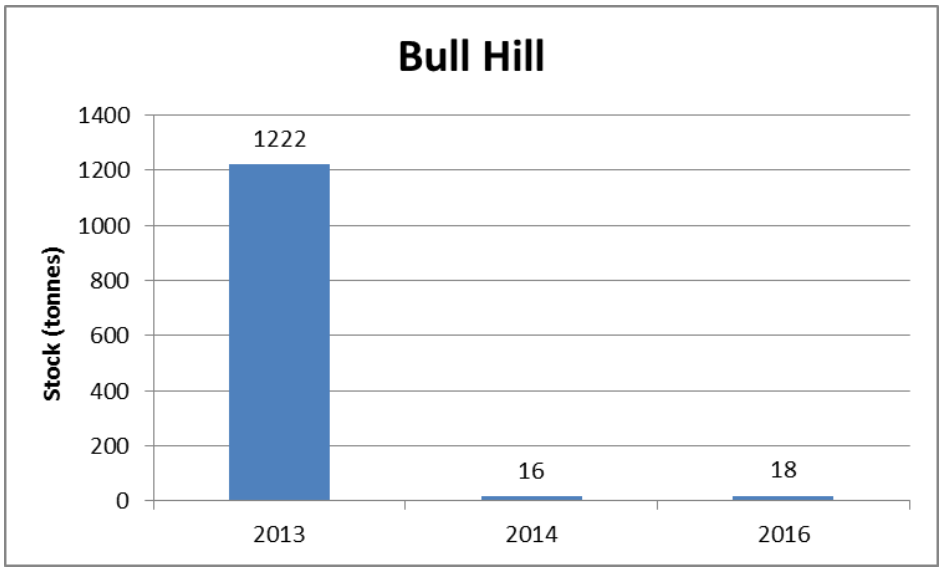

Figure 5 Bull Hill total stock, 2013-2016.

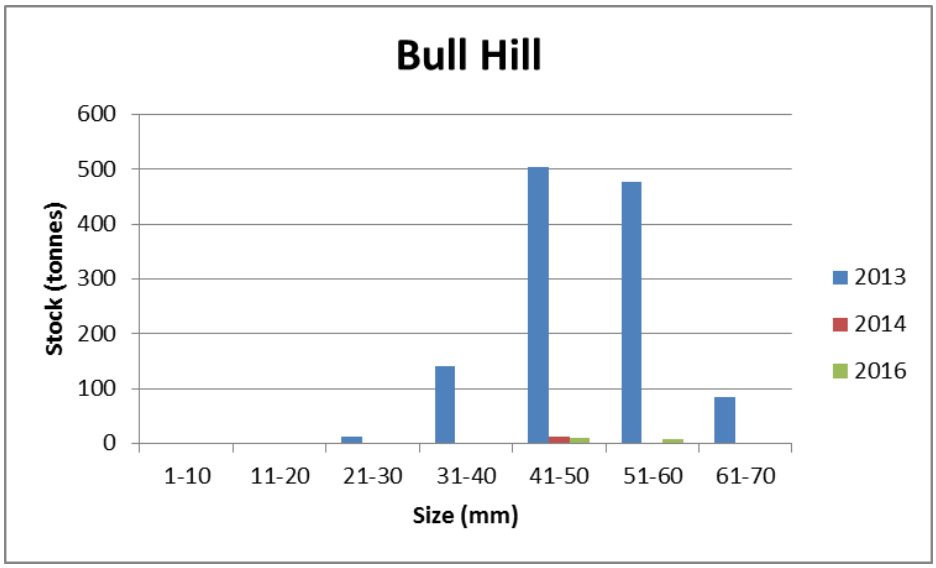

Figure 6 Bull Hill stock per size class, 2013-2016.

3.2 Starcross 1

- Area: 3.6 ha
- Coverage: 15%
- Mean density: 0.8kg/m^2
- Total stock: 29 tonnes
- Stock ≥50mm: 28 tonnes

Starcross 1 was surveyed on 8th April 2016. Samples were taken from every fifth "hit", producing seven samples from nine transects. The stock of marketable sized mussels was estimated to be 28 tonnes out of a total 29 tonnes on the bed, i.e. 96%. Table 2 shows the difference in stock composition relative to previous surveys. Figures 7 and 8 show the total stock and the stock for each size class, respectively, for each year.

Table 2 Summary of Starcross 1 stock composition from 2013 to 2016.

	2013	**2014**	**2016**	Difference since last survey
Area (ha)	4.4	5.1	3.6	-29%
Density (kg/m^2)	3.06	1.00	0.8	-20%
Total stock (tonnes)	136	50	29	-42%
Stock 1-10mm	0	0	0	=
Stock 11-20mm	0	0	0	=
Stock 21-30mm	0	0	0	=
Stock 31-40mm	0	1	0	-100%
Stock 41-50mm	9	0	1	+ 1 tonne
Stock 51-60mm	62	42	15	-64%
Stock 61-70mm	65	7	13	+85%

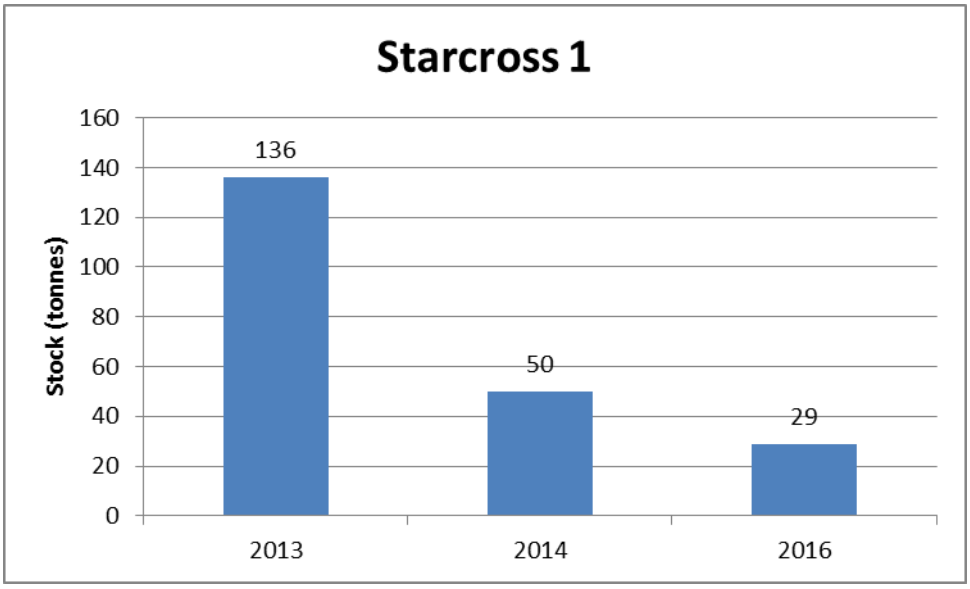

Figure 7 Starcross 1 total stock, 2013-2016.

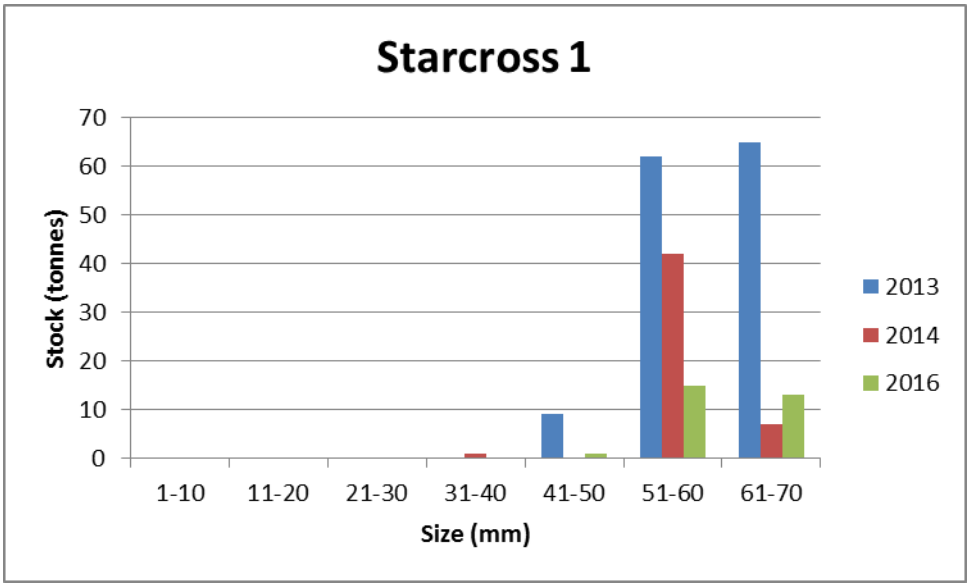

Figure 8 Starcross 1 stock per size class, 2013-2016.

3.3 Starcross 2

- Area: 3.7ha
- Coverage: 11%
- Mean density: 0.57kg/m^2
- Total stock: 21 tonnes
- Stock ≥50mm: 16 tonnes

Starcross 2 was surveyed on 8th April 2016. Samples were taken from every fifth "hit", producing four samples from nine transects. The stock of marketable sized mussels was estimated to be 16 tonnes out of a total 21 tonnes on the bed, i.e. 76%. Table 3 shows the difference in stock composition relative to previous surveys. Figures 9 and 10 show the total stock and the stock for each size class, respectively, for each year.

Table 3 Summary of Starcross 2 stock composition from 2013 to 2016.

	2013	**2014**	**2016**	Difference since last survey
Area (ha)	3.0	2.3	3.7	+60%
Density (kg/m^2)	3.72	1.45	0.57	-60%
Total stock (tonnes)	113	33	21	-36%
Stock 1-10mm	0	0	0	=
Stock 11-20mm	0	3	0	-100%
Stock 21-30mm	2	2	0	-100%
Stock 31-40mm	2	5	1	-80%
Stock 41-50mm	9	11	4	-63%
Stock 51-60mm	82	11	3	-73%
Stock 61-70mm	18	2	13	+550%

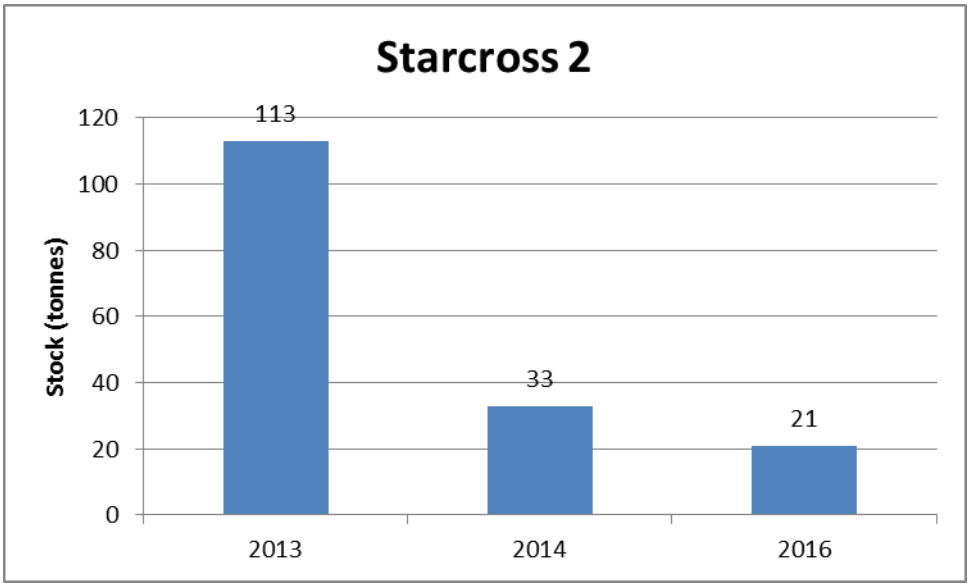

Figure 9 Starcross 2 total stock, 2013-2016.

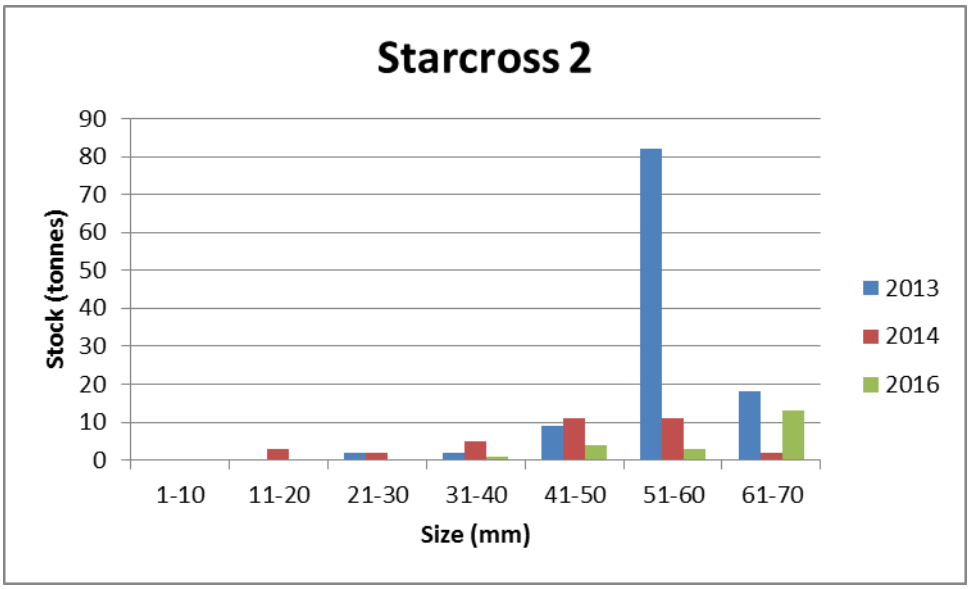

Figure 10 Starcross 2 stock per size class, 2013-2016.

4. Discussion

During the winter of 2014 there was a dramatic loss of mussel from Bull Hill (approximately 99%). Starcross 1 and Starcross 2 both suffered mussel loss over the same period, although not to the same extent (63% and 71%, respectively). This extreme loss of mussel stock is not unique to the Exe Estuary, the Taw-Torridge and Teign estuaries, also in the Devon & Severn IFCA District, have suffered similar losses (D&S IFCA observations). Large mussel loss has also been reported around the UK for a similar time period, such as in Wales and in estuaries on the east coast. It is widely believed that these declines in mussel stock are the result of poor spat settlement over the last few years (local mussel fishers, pers. comms.) which has resulted in aging beds. When this factor was coupled with the increased water flow and wave action through estuaries during the storms of 2014 the mussel was scoured away. The results of the 2013 Devon & Severn IFCA stock assessments demonstrate that the beds were largely composed of mature mussel with little younger mussel present; 89% of the combined stock from the three beds was over 40mm in length.

The total stock on Bull Hill has increased by two tonnes since 2014, however there was less stock in the 31-40mm and 41-50mm size groupings, with only the weight of mussel in the 51-60mm size class showing an increase. Therefore it is likely that the overall increase in stock is due to mussel growth rather than new settlement. The Starcross beds both experienced a decrease in total stock since 2014, but still follow the pattern of losing stock in the smaller size classes while gaining weight at the larger end of the scale. The reduction in total stock could be due to continued loss by natural scour, removal by humans (this area is popular among recreational hand-gatherers), or removal by birds feeding on the mussel. Birds choose to feed on mussels of a medium size, which is a compromise between minimising shell ingestion and maximising energy gain (Hamilton et al., 1999 and Nagarajan et al., 2002).

The decline of Bull Hill is concerning to all those who manage the estuary as it acts as an important food source for overwintering birds, as well as being a hydrographical feature. There is concern about the stability of the existing flow patterns in the Exe as Bull Hill is now a flatter, lower bank. "Intertidal biogenic reefs: mussel beds" is listed as a supporting habitat of the SPA, with the Conservation Objectives to "maintain or restore the structure and function of the habitats of the qualifying feature" and "maintain or restore the supporting processes on which the habitats of the qualifying features rely" (Natural England, 2015). It is therefore all the more important that any mussel spat available in the estuary is able to settle on Bull Hill, to enable the bed to re-establish. However, conditions on the Exe make this very difficult. The estuary is particularly fast flowing making it difficult for spat to settle, also without the existing mature mussel bed there is very little hard substrate for any spat to attach to, and any spat which is able to settle is more exposed to predation. McGrorty et al. (1990) found that on the Exe there was a strong positive correlation between densities of spat settlement and adult densities on the mussel beds, with spat rarely occurring at other sites on the estuary than in the byssal threads of adults. Spat seem only able to protect themselves by settling deep within the byssal threads of already established adults. Mussel beds do have naturally cyclical lives, with periods of loss and periods of recovery, so it is likely that Bull Hill will recover naturally over time. However, given the importance of this bed within the estuary it was decided between Natural England, Devon & Severn IFCA and Exmouth Mussels Ltd. that anything which could speed up the recovery of the bed would be of benefit. Therefore, in the summer of 2015 Exmouth Mussels Ltd. installed an experimental seed recovery system of approximately 1000 square metres of "hairy rope" to try to capture larval mussels as they float by, which could then be harvested and spread across the bank (Exmouth Mussels Ltd., pers. comms.). Unfortunately this project proved unsuccessful at capturing spat. However, Exmouth Mussels Ltd. continue to spread a culch of shell across the bank to provide a substrate on which mussel might settle.

It is recommended that the stock assessments continue to be carried out on an annual basis, to monitor any future changes to the stock of the beds and particularly to detect any signs of recovery. This will help to inform any future management Devon & Severn IFCA may bring in for the collection of mussel, as part of their review of existing byelaws.

References

Andrews, J.W., Brand, A.R., and Maar, M. (2011) *MSC Assessment Report for Isefjord and East Jutland Danish Blue Shell Mussel Fishery* [online: msc.org] Moody Marine Ltd. Derby UK

Bayne, B. L., and Worrall, C. M. (1980) Growth and production of *Mytilus edulis* from two populations. *Marine Ecology – Progress Series* **1**: 317-328

Cefas (2016) Shellfish harvesting classification zone maps www.cefas.co.uk/cefas-data-hub/food-safety/classification-and-microbiological-monitoring/england-and-wales-classification-and-monitoring/classification-zone-maps/

EEMP (2014) Exe Estuary Management Partnership: State of the Exe Estuary.

Gardner, J.P.A. (1996) The *Mytilus edulis* species complex in southwest England: effects of hybridization and introgression upon interlocus associations and morphometric variation. *Marine Biology* **125**: 385-399

Goss-Custard, J. D. and Verboven, N (1993) Disturbance and feeding shorebirds on the Exe estuary. *Wader Study Group Bulletin* **68:** 59-66

Hamilton, D. J., Nudds, T. D., and Neate, J. (1999) Size-selective predation of Blue Mussels (*Mytilus edulis*) by Common Eiders (*Somateria mollissima*) under controlled field conditions. *The Auk* **116 (2)**: 403-416

Maddock, A. (2008) *UK Biodiversity Action Plan; Priority Habitat Descriptions*. BRIG.

McGrorty, S., Clarke, R.T., Reading, C.J., and Goss-Custard, J.D. (1990) Population dynamics of the mussel *Mytulis edulis*: density changes and regulation of the population in the Exe estuary, Devon. *Marine Ecology Progress Series* **67**: 157-169

Nagarajan, R., Lea, S.E.G., and Goss-Custard, J.D. (2002) Reevaluation of patterns of mussel (*Mytilus edulis*) selection by European Oystercatchers (*Haematopus ostralegus*). *Canadian Journal of Zoology* **80**: 846-853

Natural England (2015) Marine conservation advice for Special Protection Area: Exe Estuary (UK9010081)