Taw-Torridge
Mussel Stock Assessment 2017

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1. Introduction

1.1 The Taw-Torridge Estuary

The Taw Torridge estuary is located on the North Devon coast, within the Area of Outstanding Natural Beauty (AONB) and the North Devon UNESCO Biosphere Reserve (Figure 1).

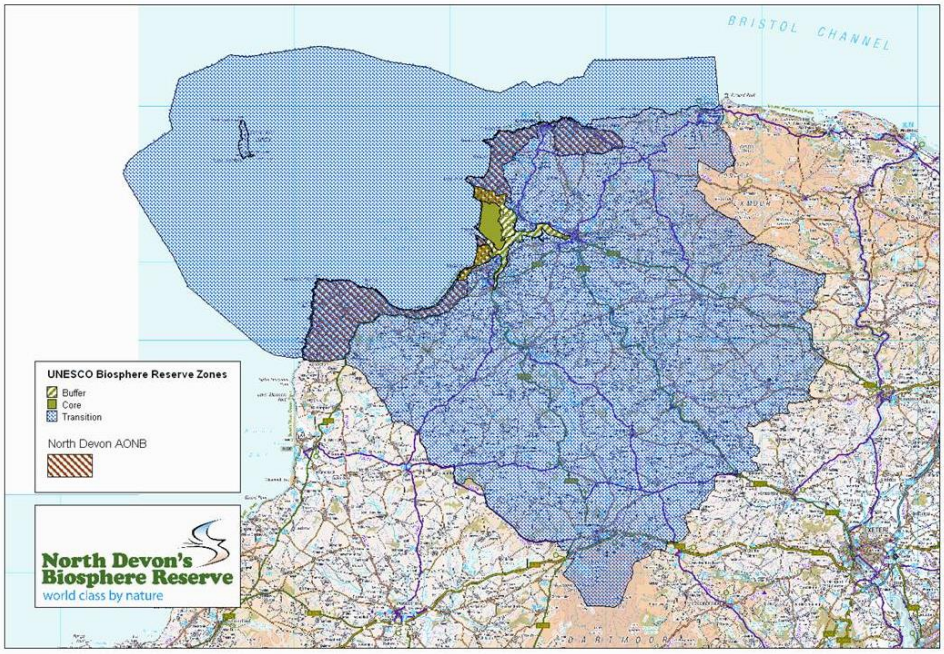

Figure 1 The location of the Taw Torridge Estuary (shown in yellow) within the North Devon Biosphere Reserve and the North Devon Coast AONB. (Taw Torridge Estuary Management Plan, 2010)

The estuary is an important site for wildlife and has been designated a Site of Special Scientific Interest (SSSI) (Figure 2) for over-wintering and migratory populations of wading birds, and for the rare plants found on its shores. Parts of the estuary have also been put forward as a recommended Marine Conservation Zone (rMCZ) by Finding Sanctuary (Figure 3). The site was proposed for six Broad Scale Habitats; Subtidal mud, subtidal sand, coastal saltmarshes and saline reed beds, intertidal coarse sediment, intertidal sand and muddy sand, low energy intertidal rock, and one FOCI species the European eel (*Anguilla anguilla*).

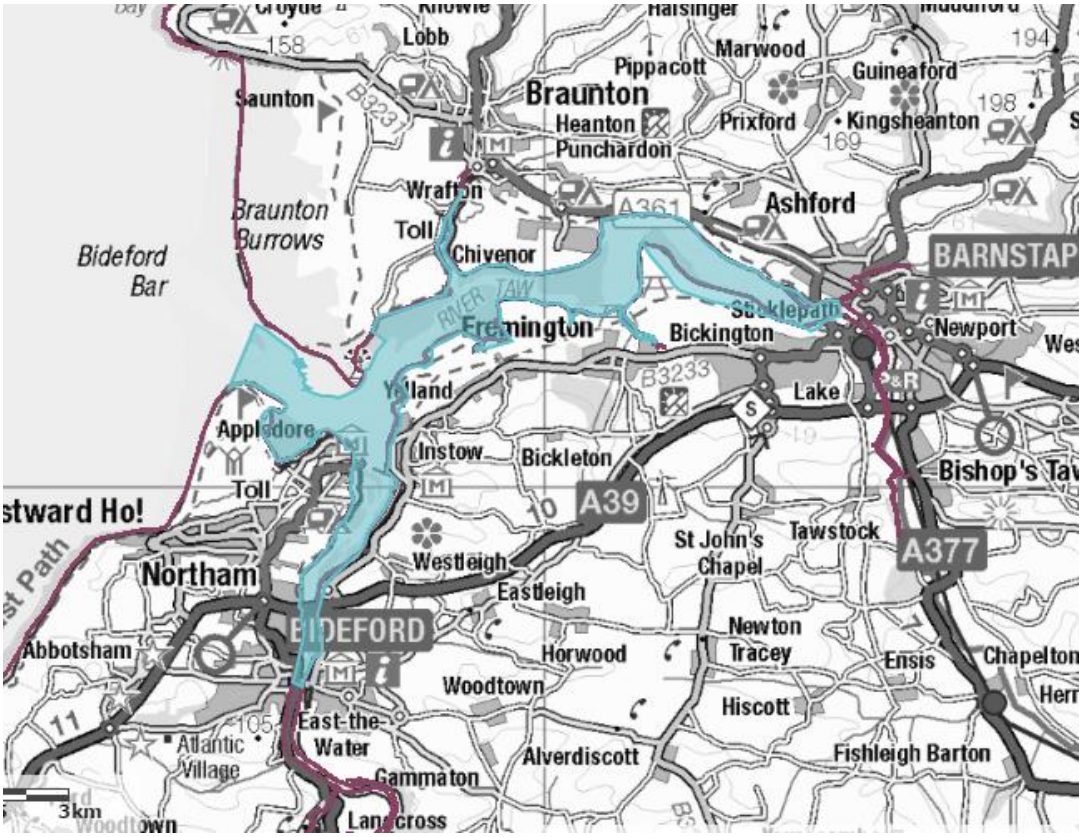

Figure 2 Taw-Torridge Estuary SSSI, shown in blue (Defra, 2016)

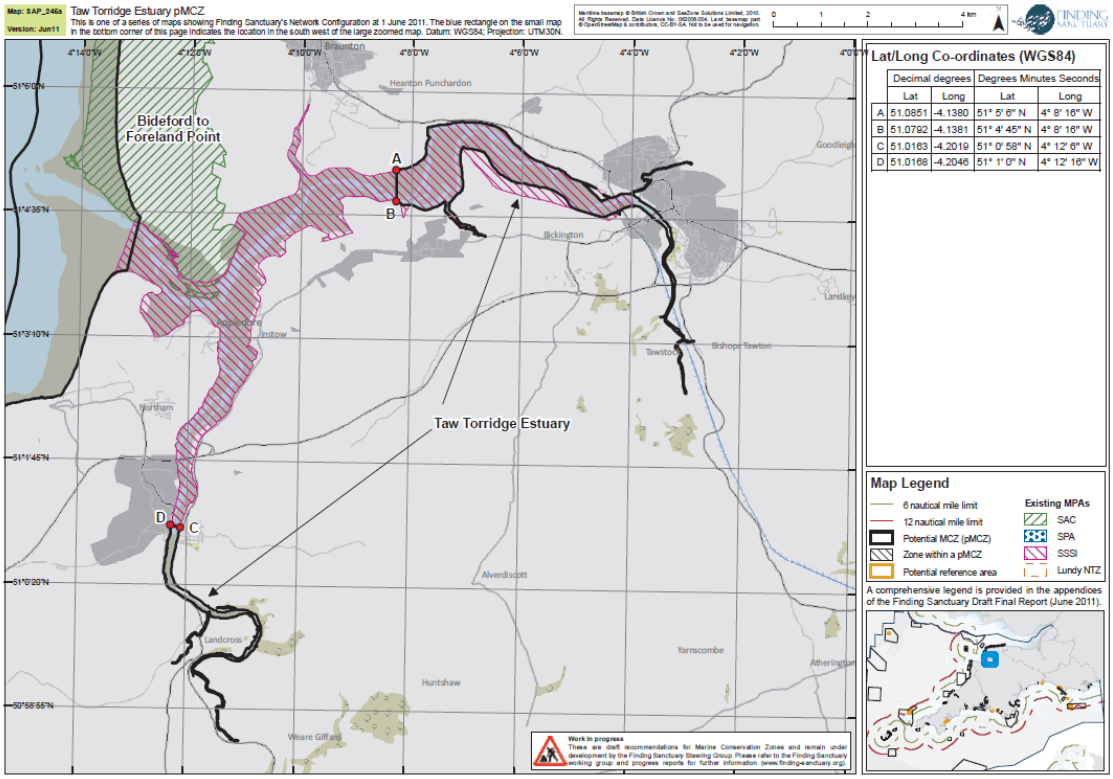

Figure 3 Area of rMCZ, outlined in black. Area of SSSI shown in red hatching, and area of SAC shown by green hatching. (Finding Sanctuary, 2011)

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 Taw-Torridge Estuary, to define where the mussel beds are and accurately map, using GIS, and the overall extent of each of the mussel beds. Devon & 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 Taw-Torridge and the development of shellfisheries in this part of the Devon & Severn IFCA District.

2. Methodology

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 4). 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.

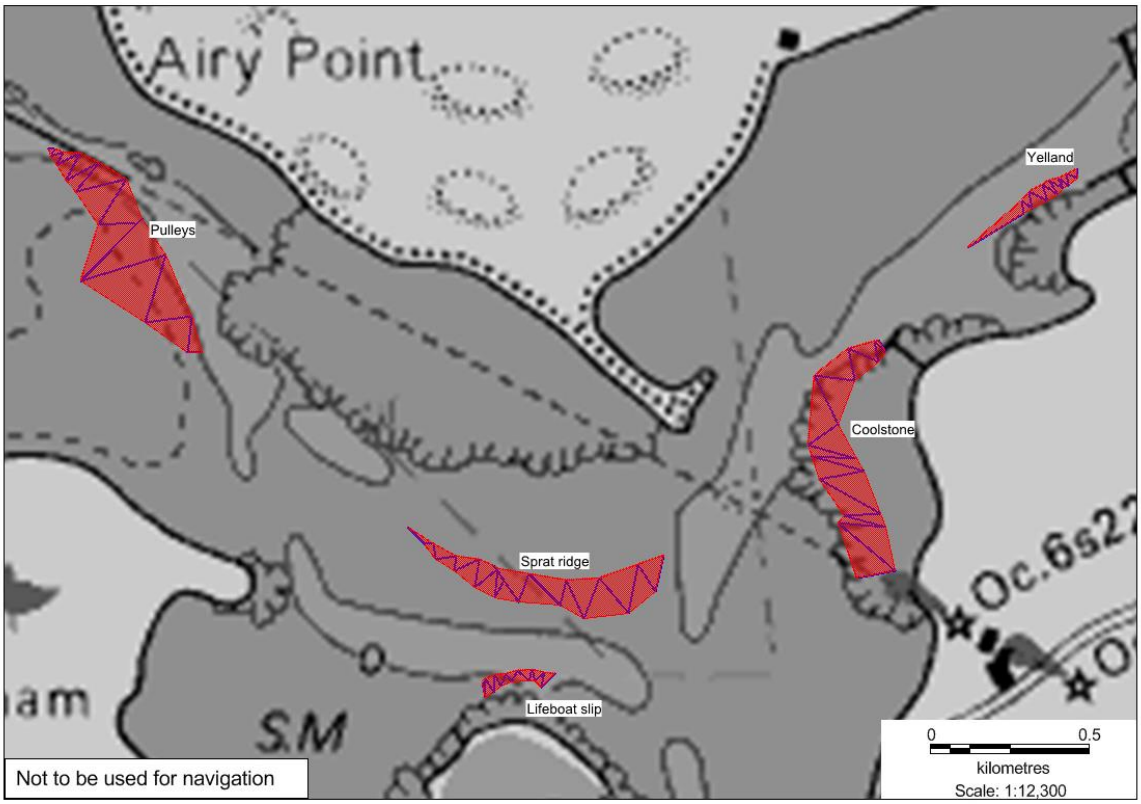

Figure 4 Transects walked (blue) and area of each mussel bed (red).

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; ≤25mm, 26-49mm, ≥50mm. 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 5), 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 5 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 Coolstone

- Area: 7.6 hectares
- Coverage: 31%
- Mean Density: 2.19 kg/m^2
- Total Stock: 167 tonnes
- Stock ≥50mm: 105 tonnes

Coolstone was surveyed on 30th March 2017. Samples were taken from every fifth "hit", producing 20 samples from 14 transects. The stock of marketable sized mussels was estimated to be 113 tonnes out a total 164 tonnes on the bed, i.e. 63%. Table 1 shows the difference in stock composition relative to previous surveys. Figures 6 and 7 show the total stock and the stock for each size class, respectively, for each year.

Table 1 Summary of Coolstone stock composition from 2012 to 2017.

	Coolstone 1						Coolstone 2				Coolstone 3		Difference since last survey
Year	2012	2013	2014	2015	2016**	2017**	2012	2013	2014*	2015	2012	2013	
Area (ha)	7.4	8.2	4.7	3.3	9.3	7.6	0.5	0.4	0.3	4.2	0.6	0.2	-18%
Stock ≤25mm (tonnes)	6	0	2	0	1	0	0	0	0	0	0	0	-100%
Stock 26-49mm (tonnes)	280	218	99	35	50	61	17	12	4	55	11	3	+22%
Stock ≥50mm (tonnes)	78	87	94	10	113	105	8	9	2	19	1	0	-7%
Total Stock (tonnes)	364	306	194	46	164	167	26	21	6	73	12	3	+2%

*Coolstone 2 & 3 merged to one bed (2013-2014)

**Coolstone 1 & 2 merged to one bed (2015-2016, 2016-2017)

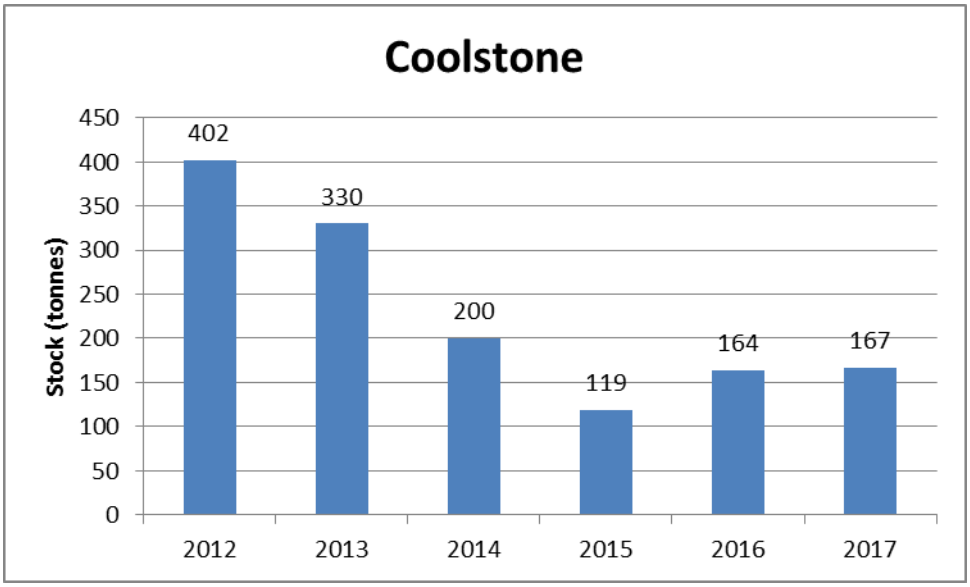

Figure 6 Coolstone total stock, 2012-2017 (combined totals for Beds 1-3, in year where they were separate).

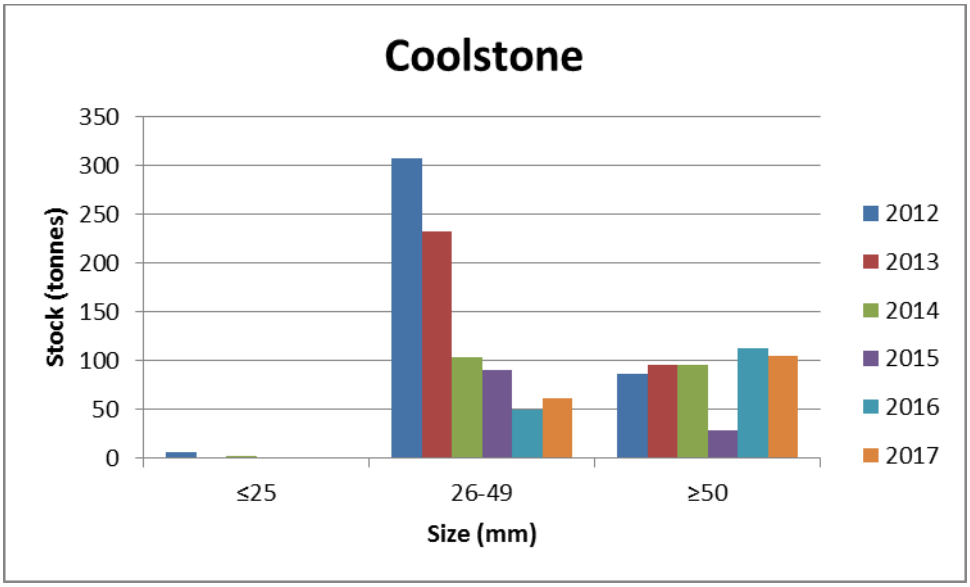

Figure 7 Coolstone stock per size class, 2012-2017 (combined totals for Beds 1-3, in year where they were separate).

3.2 Lifeboat Slip

- Area: 1.5 hectares
- Coverage: 23%
- Mean Density: 2.15 kg/m^2
- Total Stock: 32 tonnes
- Stock ≥50mm: 14 tonnes

Lifeboat Slip was surveyed on 28th March 2017. Samples were taken from every fifth "hit", producing 8 samples from 12 transects. The stock of marketable sized mussels was estimated to be 14 tonnes out a total 32 tonnes on the bed, i.e. 44%. Table 2 shows the difference in stock composition relative to previous surveys. Figures 8 and 9 show the total stock and the stock for each size class, respectively, for each year.

Table 2 Summary of Lifeboat Slip stock composition from 2012 to 2017.

Year	2012	2013	2014	2015	2016	2017	Difference since last survey
Area (ha)	1.0	0.7	0.6	0.6	1	1.5	+50%
Stock ≤25mm (tonnes)	1	0	0	0	0	0	=
Stock 26-49mm (tonnes)	45	14	24	11	18	17	-6%
Stock ≥50mm (tonnes)	7	16	11	26	17	14	-18%
Total Stock (tonnes)	53	30	35	37	36	32	-11%

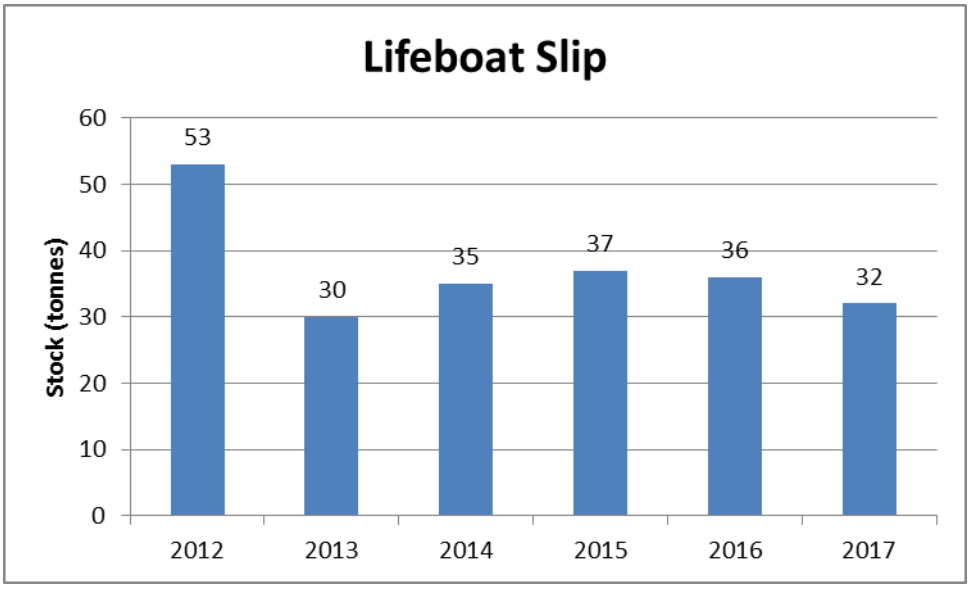

Figure 8 Lifeboat Slip total stock, 2012-2017

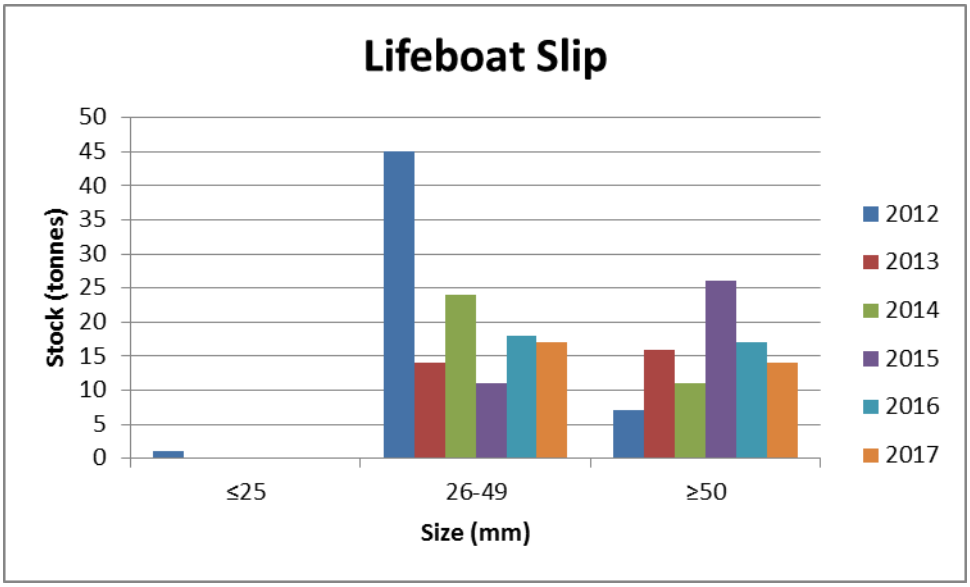

Figure 9 Lifeboat Slip stock per size class, 2012-2017

3.3 Sprat Ridge

- Area: 6.6 hectares
- Coverage: 45%
- Mean Density: 4.17 kg/m^2
- Total Stock: 275 tonnes
- Stock ≥50mm: 108 tonnes

Sprat Ridge was surveyed on 29th March 2017. Samples were taken from every fifth "hit", producing 36 samples from 22 transects. The stock of marketable sized mussels was estimated to be 108 tonnes out a total 275 tonnes on the bed, i.e. 39%. Table 3 shows the difference in stock composition relative to previous surveys. Figures 10 and 11 show the total stock and the stock for each size class, respectively, for each year.

Table 3 Summary of Sprat Ridge stock composition from 2012 to 2017.

Year	2012	2013	2014	2015	2016	2017	Difference since last survey
Area (ha)	7.4	8.7	6.7	8.7	7.6	6.6	-13%
Stock ≤25mm (tonnes)	16	2	2	0	23	5	-78%
Stock 26-49mm (tonnes)	550	534	267	203	139	162	+17%
Stock ≥50mm (tonnes)	210	310	209	162	220	108	-51%
Total Stock (tonnes)	776	846	478	365	383	275	-28%

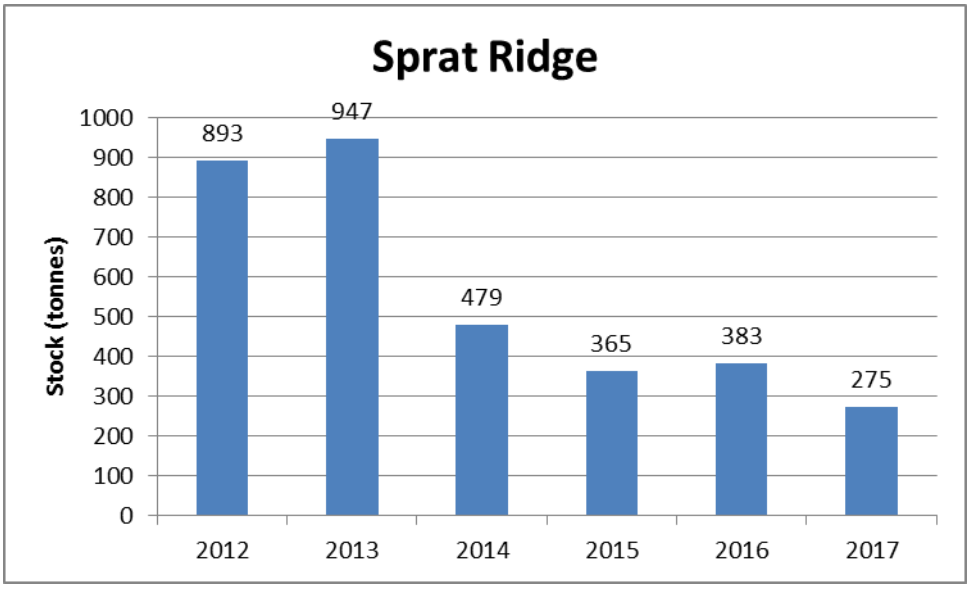

Figure 10 Sprat Ridge total stock, 2012-2017

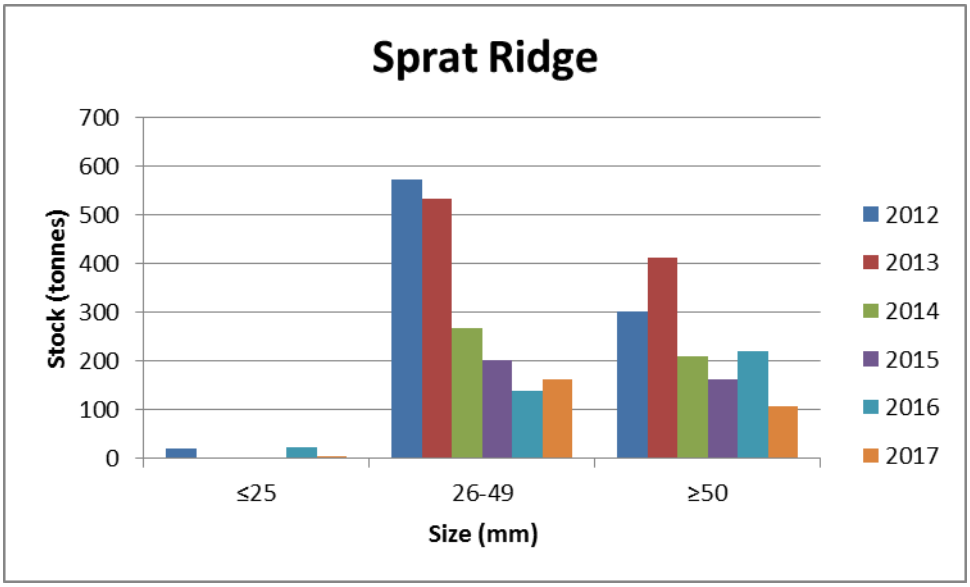

Figure 11 Sprat Ridge stock per size class, 2012-2017

3.4 Pulleys

- Area: 10.8 hectares
- Coverage: 65%
- Mean Density: 5.40 kg/m^2
- Total Stock: 581 tonnes
- Stock ≥50mm: 0 tonnes

Pulleys was surveyed on 28th March 2017. Samples were taken from every fifth "hit", producing 85 samples from 17 transects. There was no stock of marketable size, out of a total 581 tonnes. Table 4 shows the difference in stock composition relative to previous surveys. Figures 12 and 13 show the total stock and the stock for each size class, respectively, for each year.

Table 4 Summary of Pulleys stock composition from 2012 to 2017.

Year	2012	2013	2014	2015	2016	2017	Difference since last survey
Area (ha)	13	12.5	4.8	13.9	11.8	10.8	-8%
Stock ≤25mm (tonnes)	59	5	2	0	143	14	-90%
Stock 26-49mm (tonnes)	718	392	31	19	24	567	+2263%
Stock ≥50mm (tonnes)	159	266	15	8	0	0	=
Total Stock (tonnes)	936	663	48	28	168	581	+246%

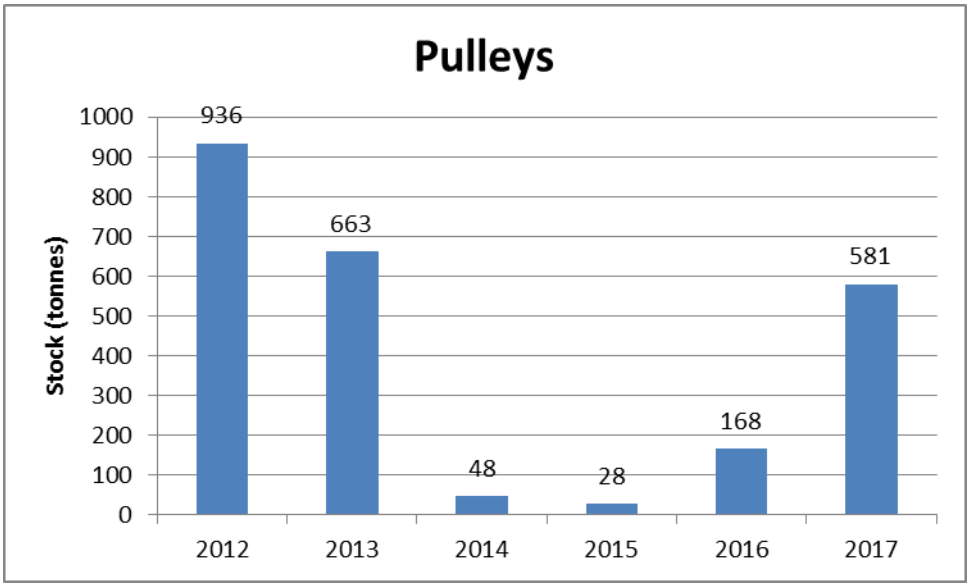

Figure 12 Pulleys total stock, 2012-2017

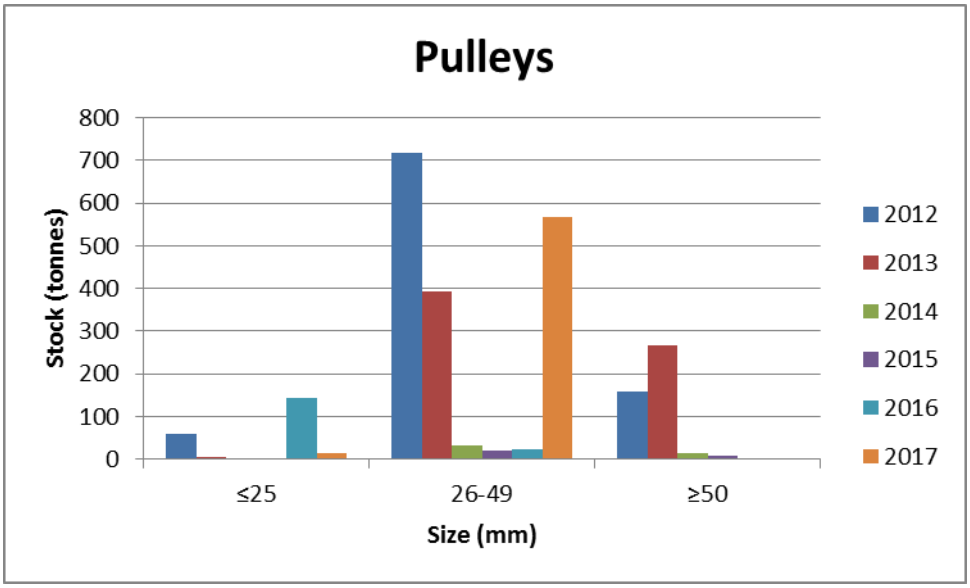

Figure 13 Pulleys stock per size class, 2012-2017

3.5 Yelland

- Area: 1 hectares
- Coverage: 32%
- Mean Density: 2.67 kg/m^2
- Total Stock: 26 tonnes
- Stock ≥50mm: 17 tonnes

Yelland was surveyed on 27th March 2017. Samples were taken from every fifth "hit", producing 8 samples from 14 transects. The stock of marketable sized mussels was estimated to be 17 tonnes out a total 26 tonnes on the bed, i.e. 65%. Table 5 shows the difference in stock composition relative to previous surveys. Figures 14 and 15 show the total stock and the stock for each size class, respectively, for each year.

Table 5 Summary of Yelland stock composition from 2012 to 2017.

Year	2012	2013	2014	2015	2016	2017	Difference since last survey
Area (ha)	1.5	0.8	0.4	2	0.9	1	+11%
Stock ≤25mm (tonnes)	2	0	0	0	1	1	=
Stock 26-49mm (tonnes)	16	7	2	3	11	9	-18%
Stock ≥50mm (tonnes)	46	45	23	36	23	17	-26%
Total Stock (tonnes)	63	52	25	39	35	26	-26%

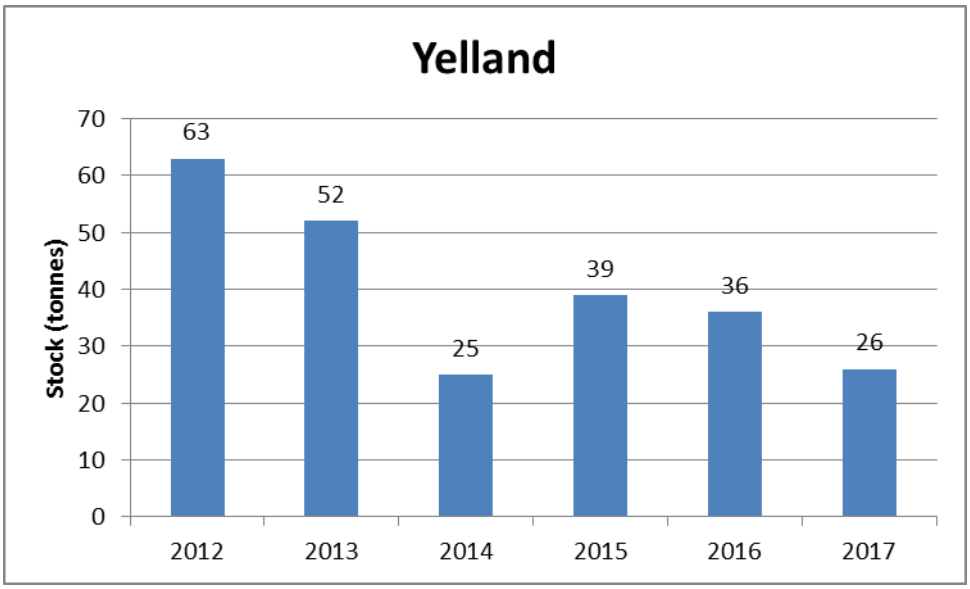

Figure 14 Yelland total stock, 2012-2017

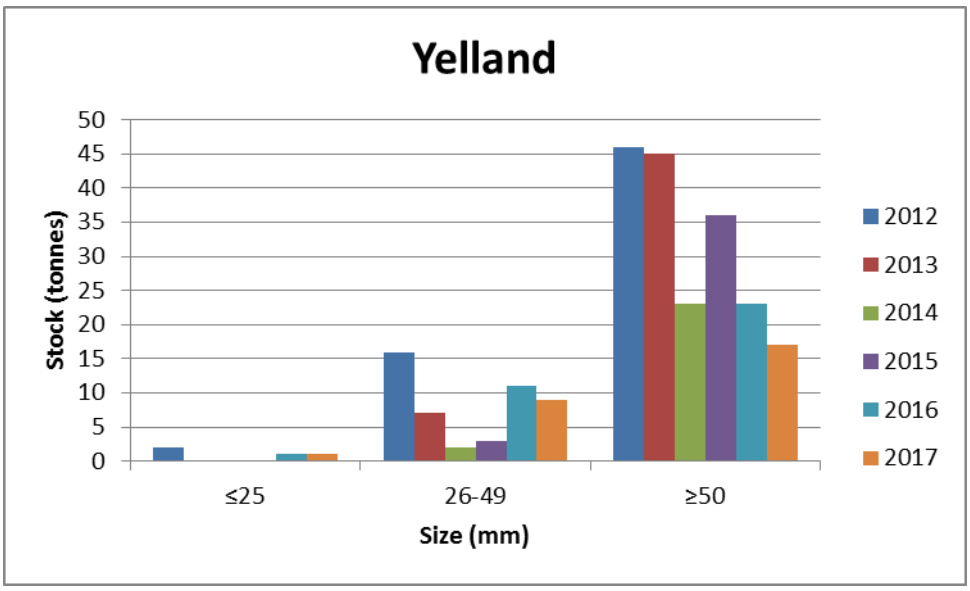

Figure 15 Yelland stock per size class, 2012-2017

4. Discussion

Between the 2013 and 2014 surveys all the beds, apart from Lifeboat Slip, suffered a severe loss of mussel stock. This loss is most apparent on Sprat Ridge and Pulleys. This extreme loss of mussel stock is not unique to the Taw-Torridge Estuary, the Exe 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.

By last year's survey 3 out of the 5 beds were showing signs of recovery, with increases in total mussel stock. Coolstone increased by 38% in 2016 compared to 2% this year and Sprat gained 5% in tonnage in 2016 compared to a 28% decrease this year, new spat settlement was found on both these beds. However last year, there was also a decline in the 26-49mm size category coupled with an increase in the ≥50mm category, indicating that some of the increase in total stock can be attributed to mussel growth, as well as new settlement. In 2016 the Pulleys bed stock increased in the 26-49mm, with no mussels in the ≥50mm category, but a gain of 413 tonnes of seed mussel. Therefore, the increase in stock in 2016 can almost entirely be attributed to new settlement. Sprat, Lifeboat Slip and Yelland showed a decrease in stock this year, with a reduction of 108, 4 and 9 tonnes respectively. This is likely to reflect older mussel dying off, as there were signs of new settlement but the three beds showed a decline in stock of ≥50mm. This year Pulleys showed a significant increase in stock of 26-49mm which is likely due to the growth of the stock of ≤25mm from 2016.

Following the loss of mussel between 2013 and 2014 Natural England, as the regulatory body for SSSIs, introduced management measures to ensure that enough mussel would be available to provide an adequate food supply for the birds for which the SSSI is designated. No more than 500kg of mussels can be removed from the SSSI per month, and any business wishing to remove mussel must notify Natural England and Devon & Severn IFCA of their intentions to do so by 23rd of the month prior to the month when mussel harvesting is proposed. This allows Natural England and the IFCA to determine if the planned removal will, in combination with other planned activities, be likely to result in the 500kg limit being exceeded. If this is the case, planned removal by all individuals will need to be reduced accordingly. Records of quantity of mussel removed (including location) together with copies of movement documents are submitted to Natural England and the IFCA within 14 days of harvesting.

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, as well as allowing Natural England to ensure the mussel harvesting limit remains suitable to provide enough bird food availability.

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