

Bed Inspections - Blue Mussel (*Mytilus edulis*) Beds at Lindisfarne 2026

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Summary

Annual surveys of the Lindisfarne Mussel beds at Fenham Flats and Holy Island Sands within the Lindisfarne National Nature Reserve (LNNR) were conducted in late March 2026. The perimeter of the mussel bed has been mapped, and percentage cover of mussels estimated using the Walker Nicholson survey technique. Live mussel samples collected in previous years were not collected again due to the limited number of mussels remaining on the bed. The 2026 survey revealed a continuation of long-term decline.

Key results:

- overall bed area and percentage cover for both beds have reduced again in 2026
- overall bed area for both beds cannot be calculated due to sparsity of live mussel
- average percentage cover at Holy Island fell from 89% to 0.65% from 2015 to 2026
- average percentage cover at Fenham Flats fell from 67.91% to 0.41% from 2015 to 2026
- no evidence of spat was seen at Fenham Flats or Holy Island
- <1% of seed mussel was present at one inspection location at Holy Island (30–45 mm)
- <1% of seed mussel was present at two inspection locations at Fenham Flats (size unknown).

The findings highlight that the mussels beds are still under severe stress, suggesting that reduced adult mussel cover is limiting spat settlement and survival. The original drivers of decline are still unclear but are likely multifactorial. Potential drivers include recruitment failure, biotic pressures such as predation, competition from invasive pacific oysters (*Crassostrea gigas*), and environmental stressors such as pollutants, nutrient loading, and changing sediment dynamics.

Broader regional declines have been documented across the North Atlantic by many experts. Current conditions suggest the Lindisfarne mussel beds may not be self-sustaining and are at risk of local extinction. In their current condition the mussel at Lindisfarne continue to fail the OSPAR habitat definition of an intertidal mussel bed found on mixed and sandy sediments.

Northumberland Inshore Fisheries and Conservation Authority (NIFCA) are reviewing survey plans for 2027, whilst supporting local and national partners to investigate the roles of contaminants, pathogens, and pharmaceuticals in mussel health. Restoration initiatives and collaborative research are underway to address knowledge gaps and explore options for recovery.

Introduction

The blue mussel (*Mytilus edulis*) is a filter-feeding bivalve mollusc consuming phytoplankton, and other particulate organic matter. It is found on a variety of substrata in the intertidal zone of boreal and temperate waters, in both the southern and northern hemispheres (OSPAR, 2014). The blue mussel can accumulate to form beds and is tolerant of a wide variety of environmental conditions including fluctuations in salinity, oxygen, temperature, and desiccation (Andrews et al., 2011). Mussels can form dense beds using byssus threads to attach to the substratum (Babarro et al., 2008) and can be considered a biogenic reef. The dense beds which occur in both fully saline and estuarine waters form natural reefs or biogenic reefs which enhance biodiversity (Gardner, 1996). Mussel beds are included in the OSPAR (Annex V) list of threatened and declining species and habitats and are also listed as a Habitat of Principle Importance under the Natural Environment and Rural Communities Act, 2006. The OSPAR definition for intertidal blue mussel habitats specifies a minimum of 30% percentage cover to be classified as a mussel bed (OSPAR, 2010; Julie Lydia Stounberg et al., 2024).

Blue mussel beds continue to decline in Northumberland and across the UK, but the causes remain unclear and may vary by region with some mussel beds in Teesside doing well in comparison to Northumberland. To address this, the mussel bed restoration network continues to share knowledge, identify research gaps, and further understand the drivers of decline.

Berwick to St Mary's Marine Conservation Zone is adjacent to the Lindisfarne National Nature Reserve (LNNR) and is designated for eider duck, which rely on mussels as a primary food source. As such, these mussel beds are an important supporting habitat, especially in the context of recovering eider populations within the MCZ. Studies are ongoing to assess the use of alternative food sources by eider duck such as shore crab, periwinkle etc, with shore crabs commonly observed in their diet within the Northumberland Inshore Fisheries and Conservation Authority (NIFCA) district.

Lindisfarne

In 2005, the Northumberland Sea Fisheries Committee (NSFC) now NIFCA was approached by Natural England (then English Nature) who requested that NSFC conduct a stock assessment survey of the mussel beds at Fenham Flats, Lindisfarne in order to consider re-opening the mussel beds to commercial harvesting within the LNNR. The beds were harvested for several years, before meat quality was deemed insufficient, and harvesting was discontinued in 2010. NIFCA has continued to conduct annual surveys at the site, providing an annual and unique long-term record of the population dynamics of the mussel bed.

This long-term record shows a decrease in mussel bed density. Further study was deemed essential to determine if the trends discussed are because of recruitment failure, natural temporal variation,

or local factors specific to the Fenham Flats site. NIFCA therefore decided to expand the 2018 mussel surveys to include two additional sites, Holy Island Sands and St Cuthbert's, to compare the results from Fenham Flats with other nearby mussel beds. Only Holy Island Sands was deemed comparable (similar underlying substrate and functionally displaying 'bed' characteristics i.e., aggregated mussels) to Fenham Flats mussel bed, therefore this site has been surveyed annually since 2018.

In 2024 both mussel beds exhibited continued declines, prompting a change in methodology in 2025 to preserve the remaining mussel which now involves a walkover inspection of the bed perimeter and estimated percentage cover. Previous assessments are available on the NIFCA website¹.

Methods

Walkover inspections were conducted at low water during spring tides from the 20th and 21st of March 2026 by NIFCA officers.

Study Sites

Fenham Flats

Fenham Flats is located on extensive mudflats south of Holy Island, within the Lindisfarne National Nature Reserve (NNR) (Figure 1).

Holy Island Sands

Holy Island Sands is located within the shallow, semi-enclosed embayment between the western side of Holy Island and the mainland (Figure 1). This study site is relatively small compared to the neighbouring mussel bed area at Fenham Flats. This site appears to be an important feeding area for a number of nationally important bird species, similar to Fenham Flats, that feed on the mussel beds.



Figure 1 – Lindisfarne mussel beds in 2025

¹ <https://nifca.gov.uk/resource-hub/>

Survey Methods

In previous years mussel samples were collected for analysis for density, total biomass and length frequency (Boon, 2020a; Harvey, 2020; Harvey et al., 2024; Boon, 2020b; Boon et al., 2024). Due to the declines of blue mussel, no samples were collected for such analysis in 2025 (Richardson, 2025).

Percentage cover was estimated using the Walker and Nicholson' survey technique and the estimated bed area was calculated (Walker & Nicholson, 1986).

NIFCA Mussel Inspection Protocol

Perimeter

Two Inshore Fisheries & Conservation Officers (IFCOs), one of whom has previously walked the perimeters of all 3 beds, walk the perimeter with a handheld GPS. Confidence in the accuracy of the area is low as the area of the mussel bed is often difficult to define and is becoming increasingly difficult as the trend of overall decline continues. There is no WFD definition of what constitutes a mussel bed and it can be subjective to define mussel bed area particularly when they have such low percentage cover at Lindisfarne. The information collected was exported as a GPX file from the GPS using the Garmin GPS software Basecamp and then imported into ARCPPro to map and calculate the area of the mussel bed. The bed area estimated in 2025 was used as a guide in the 2026 surveys (Figure 3).

To determine the extent of the bed scattered mussels were included as they are often ignored if their density is greatly below that of the main bed. If an in-situ assessment judges them to contain significant numbers of mussels, and the main bed has a low density, they are included. Similarly with isolated patches, if they are a long way from the bed and contain few mussels they can be ignored. If they are close and contain high numbers of mussels they should be included. If they are distant but contain significant numbers of mussels, they can have their perimeter measured separately.

Percentage cover

Typical transects "zig-zagging" of the bed was conducted to get appropriate coverage of the bed area and percentage cover is estimated using the traditional methods for each bed.

Walker Nicholson technique

Using the GPS tracks of the previous year's mussel bed, a transect is created in a zig zag pattern. One person counts the number of steps until the edge of the bed is reached and the other person counts the number of steps on live mussel. The percentage cover of mussels on the mussel beds were estimated using the 'Walker and Nicholson' survey technique (Walker & Nicholson, 1986). Percentage cover was then calculated using the equation:

$$\text{Percentage Cover} = \frac{\text{Number of footsteps landing on live mussels}}{\text{Total number of footsteps}} \times 100$$

Bed Condition Assessment

The bed condition was assessed during the transects for percentage cover at intervals along each transect, or where the bed conditions changed. Officers noted a waypoint on their GPS, took an image and noted down the bed criteria as detailed below :

- presence of seed mussel
- size of seed mussel (<15 mm, 15-30 mm, 30-45 mm)
- estimated percentage cover of seed mussel
- density of seed mussel
- presence of size mussel
- density of size mussel
- density of size mussel (high/medium/low)
- size of mussels, mixed or uniform
- presence of dead shell
- estimated percentage cover of dead shell.
- ground description

Results

Lindisfarne (Holy Island and Fenham Flats)

A summary of the overall survey results since the mussel beds began being surveyed at Lindisfarne can be seen in Table 1 and 2.

Table 1: Results for the Fenham Flats mussel survey between 2006 and 2026.

Year	Bed area (ha)	Average % cover	Total number of mussels (millions)	Mean shell length (mm)	Mussel density (no./m ²)	Biomass (g/m ²)	Total biomass (tonnes)
2006	41.53	60	133.6	41	321.6	4,480	1,861
2007	37.18	79.81	193.2	45	519.5	8,396	3,122
2008	36.72	78.58	338.5	40	921.7	12,895	4,734
2009	34.43	72.1	288.5	34.5	837.8	9,020	3,105
2010	36.28	78.41	376.4	34.7	1037.3	9,974	3,618
2011	45.65	64.91	243.6	36	533.5	5,498	2,510
2012	43.8	67.9	178.1	43.5	406.7	5,364	2,349
2013	41.3	66.5	128.8	48.2	311.8	5,642	2,330
2014	31.82	54.84	95.6	47.42	300.5	5,776	1,838
2015	40.49	69.01	147.3	49.56	363.6	7,232	2,928
2016	44.9	59.95	115.1	51.2	230.2	5,916	2,654
2017	42.9	58.61	58.4	55.5	145.9	4,822	2,068
2018	39.7	54.8	62.2	50.76	156.61	4,336	1,721
2019	46	41.8	31.0	57.83	67.3	2,503	1,151
2020	52.66	42.9	15.1	59.95	28.74	971	511
2021	46.58	43.47	13.6	44.67	29.12	828	386
2022	46.58*	17.39	2.1*	47.35	4.43*	149	70*
2023	48.10	4.37	0.2	48.32	0.52	19	9
2024	20.81	3.67	0.1	52.89	0.51	20	4
2025	39.03**	1.08	N/A	N/A	N/A	N/A	N/A

2026	39.08**	0.41	N/A	N/A	N/A	N/A	N/A
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*calculated using 2021 bed area

** unable to accurately determine area due to the lack of mussel, this figure is dead mussel shell.

Table 2: Results for the Holy Island mussel survey between 2018 and 2026.

Year	Bed area (ha)	Average % cover	Total number of mussels (millions)	Mean shell length (mm)	Mussel density (no./m ²)	Biomass (g/m ²)	Total biomass (tonnes)
2018	3.11	90	8.58	35.15	276.0	3,749	116.58
2019	4.04	66	5.07	48.08	125.4	2,314	93.48
2020	4.02	75	4.31	48.29	107.25	2,072	83.3
2021	3.59	59	2.52	40.64	70.31	1,188	42.66
2022	3.41	70	0.86	42.02	25.2	496	16.92
2023	3.01	11.5	0.06	46	1.88	40	1
2024	2.53	6.27	0.03	35.79	1.10	17	0.43
2025	1.64**	2.34	N/A	N/A	N/A	N/A	N/A
2026	2.80**	0.65	N/A	N/A	N/A	N/A	N/A

** unable to accurately determine area due to the lack of mussel, this figure is dead mussel shell.

Bed Area

Since surveys commenced in 2006 and 2018 respectively, the overall mussel beds at Fenham Flats and Holy Island Sands have experienced a continuous decline (Figure 1). This has resulted in increased uncertainty regarding the accuracy of bed area estimates due to the patchy distribution of mussels and the amount of dead shell present there. Despite the uncertainty surrounding estimates, there has been a significant and clearly observable reduction in the overall bed area compared to previous years (Figure 2).

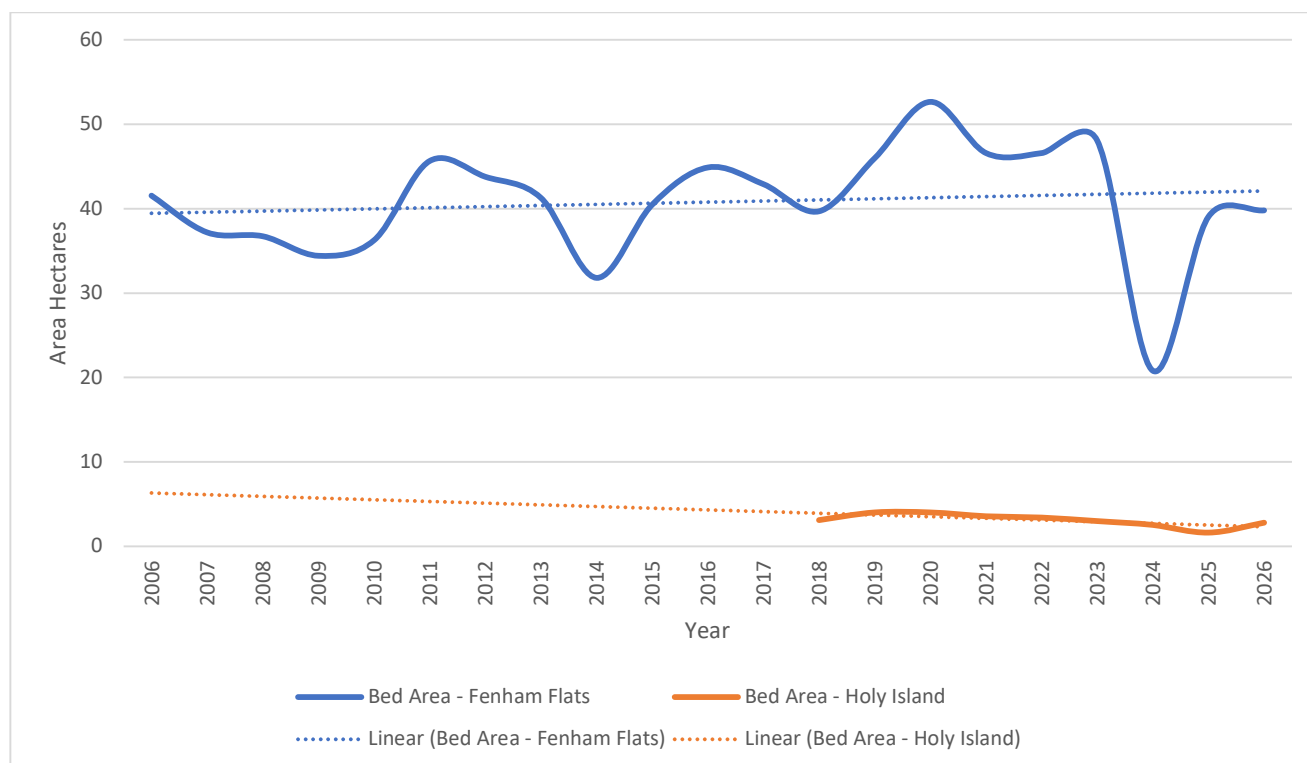


Figure 2 - Overall bed area at Lindisfarne from 2006 to 2026

Overall bed area at Fenham Flats and Holy Island is not accurate. Due to the lack of live mussel the surveyors were following the perimeter of dead shell that had previously been live mussel bed (Figure 3). Due to the sparsity of the live mussel these results should be interpreted with caution.



Figure 3 – Mussel bed perimeters walked in 2025 and 2026

Percentage Cover

From 2006 to 2026 the average overall percentage cover of the mussel bed at Fenham Flats has mostly been in decline from an average of 60% in 2006, with a peak of 79% in 2007 and then a continued decline from 2007 to the current level of 0.41% (Figure 4). The east of the bed has the highest percentage cover of around 0.84%, and the north and mid having 0.32% and 0.2%, respectively. No spat was observed during the bed inspections and only two areas (mid and east) had seed mussel in patches. In 2025, a worst case scenario based on the continuing decline indicated that the mussel bed could potentially lose its viable population by 2026. Although some live individuals remain in 2026.

Holy Island Sands has seen similar declines from a peak of 90% percentage cover in 2018 and a continued decline since with small recoveries in 2020 and 2022 followed by a steep decline in 2024 from 6.27% to 0.64% in 2026. This indicates that the beds do not satisfy the OSPAR habitat definition for mussel beds, as mussel densities are below the required threshold of 30% cover.

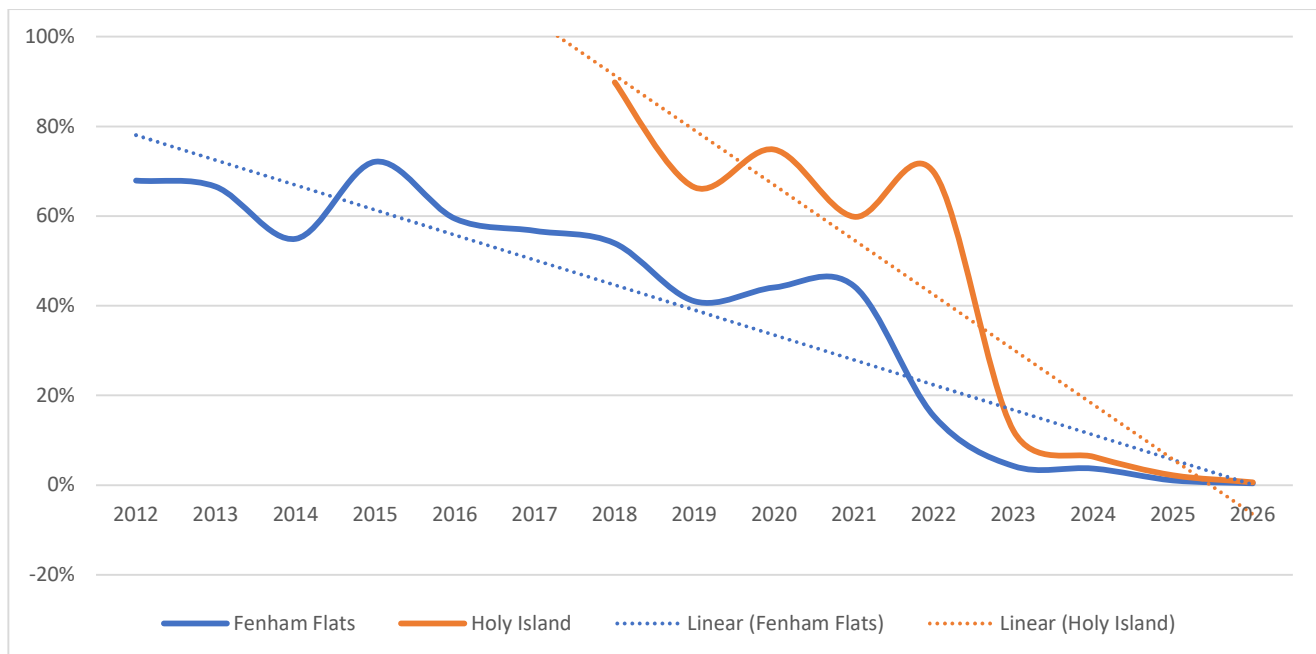


Figure 4 - Average percentage cover estimates Fenham Flats and Holy Island for the years they have been surveyed, with trendlines highlighting their associated declines

Fenham Flats and Holy Island Bed Inspections

Figure 5 provides a summary of the 54 bed inspection locations at Fenham Flats and 18 bed inspection locations for Holy Island in 2026. Annex 1 and 2 detail the results in full. Inspections aimed to cover representative areas of the mussel bed, however, determining an accurate location of the mussel bed at both sites was difficult given the sparsity of live mussel and the issues identifying the perimeter. An overview of the broadscale ground type can be seen in Figure 6.

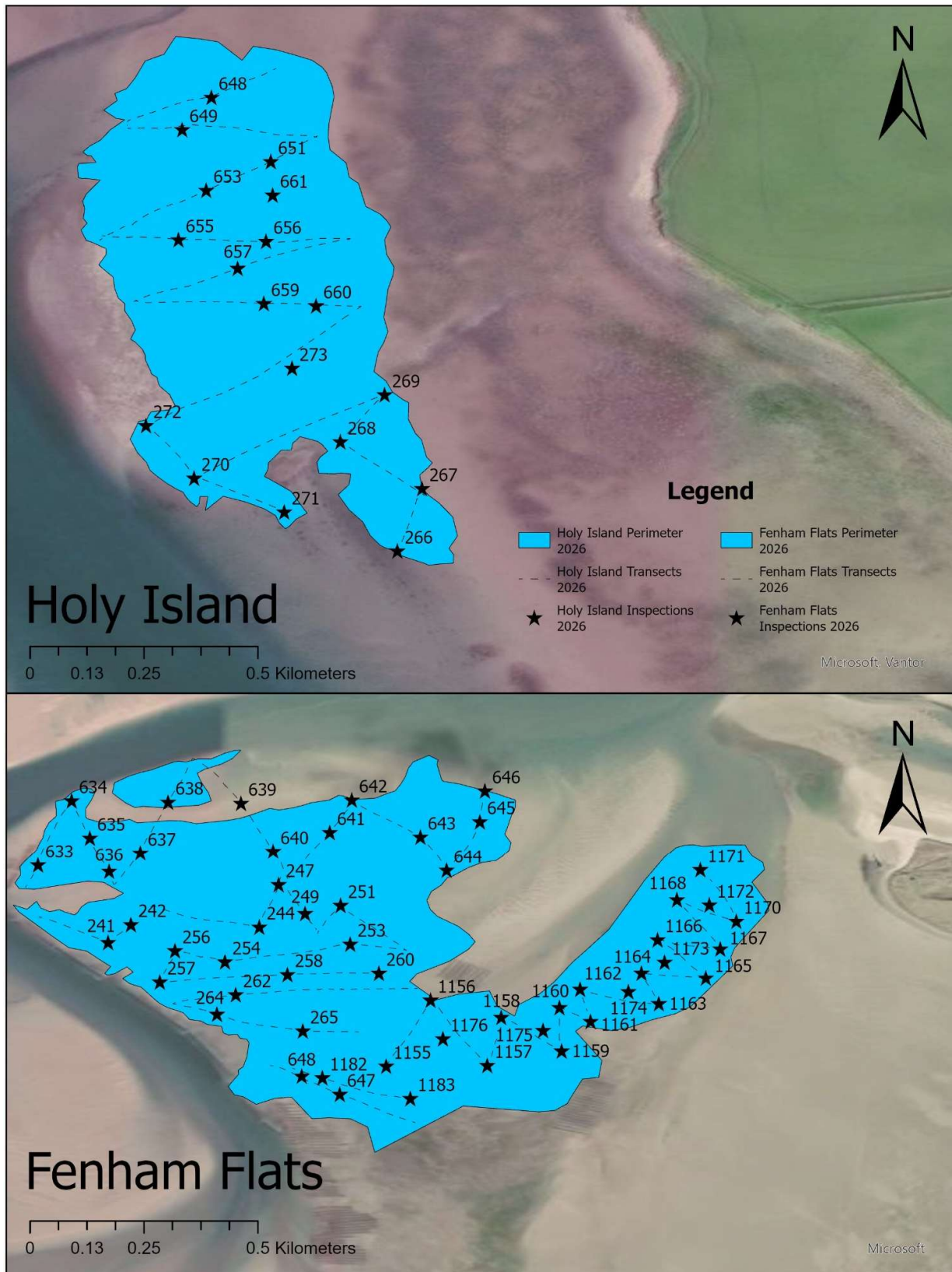


Figure 5 - Map of Fenham Flats and Holy Island Sands perimeter, transects and bed inspection locations

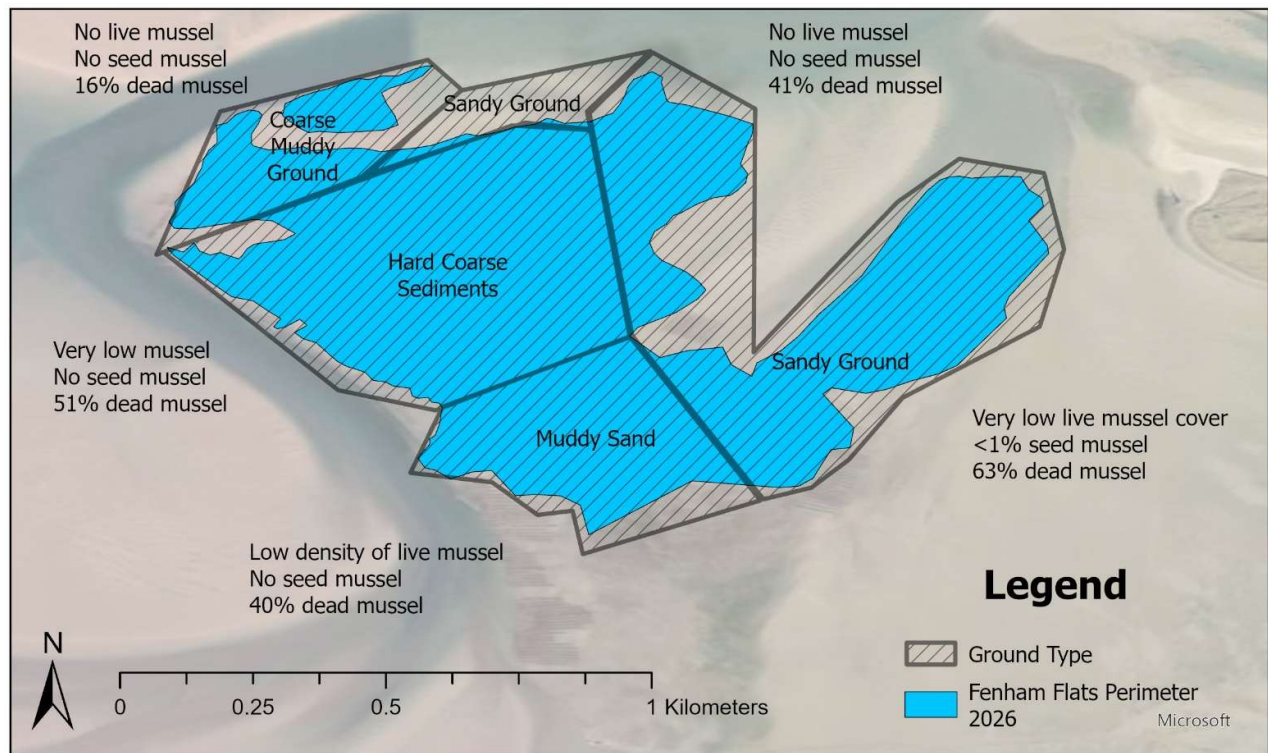


Figure 6 - Bed inspection summary for Fenham Flats mussel bed 2026

Fenham Flats Inspection locations 633 - 639

Transects surveyed in the far northern section of the bed at Fenham Flats showed no seed mussel present or size mussel. Percentage cover of dead shell was low at an average of 16% across these locations similar to 2025. The small, detached section of the bed to the north of the main bed comprises a combination coarse sediment on muddy ground.

Fenham Flats Inspection locations 640 – 646

Transects surveyed in the north eastern area of the bed showed no presence of seed mussel, and no live mussel. Dead shell was present across the area with an average of around 41% dead shell. This area is mostly sandy.

Fenham Flats Inspection locations 647 – 648, 1182 – 1183, and 1155.

Transects surveyed in the southern mid-section of the bed showed no presence of seed mussel, and a low density of live mussel of larger size classes only. Dead shell was present across the area with an average of around 40% dead shell. This area is mostly muddy sand.

Fenham Flats Inspection locations 241 – 265

Transects surveyed at these locations showed no presence of seed mussel and two areas with live an extremely low density of size mussel (40-76 mm). Dead shell was present at an estimated

percentage cover of 51% across this area of the bed. This area, located at the centre of the main bed, contains hard ground with a mixture of coarse mixed sediments.

Fenham Flats inspection locations 1155 – 1168 and 1170 – 1176

Transects surveyed at these locations showed a very low percentage of seed mussel in two areas with a low density of size mussel. Dead shell was present at an estimated percentage cover of 63% across this area of the bed. This area, located to the east of the bed contains mostly sand with very small patches of sandy gravel.

At Fenham Flats live pacific oysters (*C. gigas*) were observed and some surveyors recorded their locations on the beds (Figure 7). These are likely to have originated from the co-located oyster farm which has trestles on Fenham Flats.

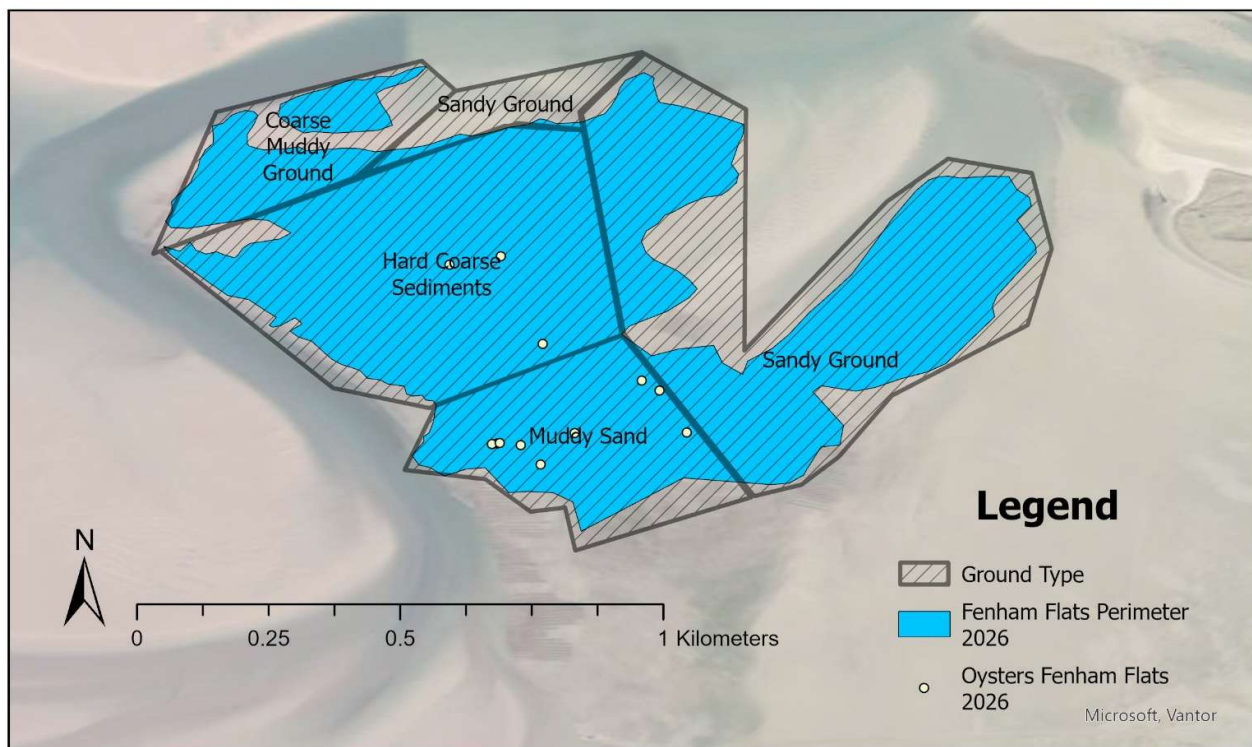


Figure 7 – Ground types and locations of pacific oysters recorded on Fenham Flats Survey 2026



Figure 8 - Live Pacific oysters found on Fenham Flats from the Lindisfarne Oyster Farm in 2026.

Annex 2 provides a summary of the eighteen bed inspection locations for the Holy Island mussel bed in 2026. Inspections covered mussel bed areas from previous years, however, determining a mussel bed on Holy Island Sands was not possible given the sparsity of live mussel this year.

Holy Island Inspection locations

Holy Island is a much smaller area to survey than Fenham Flats and the ground conditions are extremely variable (Figure 9).

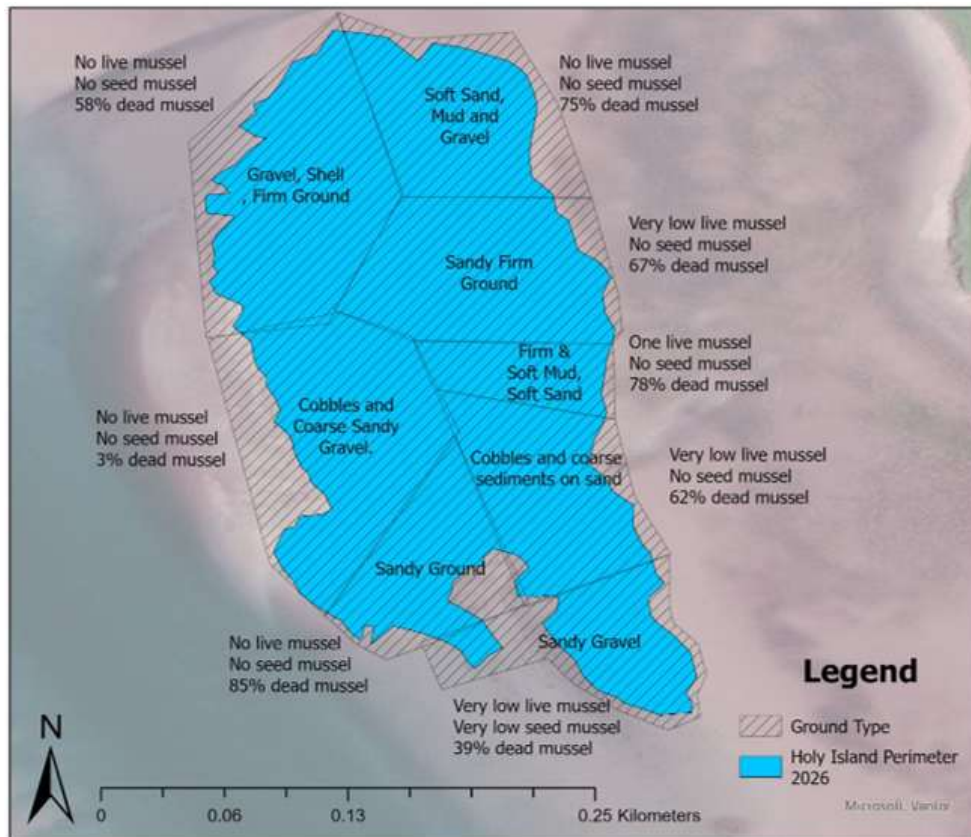


Figure 9 - Bed inspection summary for Holy Island mussel bed 2026

Only one inspection point surveyed showed the presence of seed mussel at <1% percentage cover, one size mussel was found at locations 659 and 661 and a low density of size mussel at location 273. Percentage cover of dead shell varied from 15% in the southern area up to 90% in the centre of the bed with a total average of around 58% across these all locations (Figure 5).

Discussion

The mussel beds at Fenham Flats and Holy Island have continued to decline since surveys began with a steep decline from 2024 to 2026. Surveyors walked the perimeter of the 2025 surveys following the previous area of dead shell, consequently the figures for bed area are not accurate. At Fenham Flats and Holy Island the majority of the bed is dead mussel shell with the occasional live mussel. Both beds fail to meet the OSPAR criteria for classification as intertidal *M. edulis* bed habitats. Given that mussel densities are below 30% cover they have not met the OSPAR criteria since 2021 for Fenham Flats and 2022 for Holy Island. Definitions of intertidal blue mussel beds vary between regions, for example in the Wadden Sea where 5% coverage and $>25\text{m}^2$ constitutes a mussel bed, for Northern Ireland 30% cover and 2m^2 , in Wales 30% cover and 10m^2 is classed as a bed (J.L Stounberg et al., 2024). Considering these definitions, the mussel beds at Lindisfarne would still not meet the classification criteria described above. Potential drivers of decline are discussed below.

Lack of recruitment

Percentage cover was extremely low ($<2\%$) across both mussel beds, percentage cover estimates do not depend on precise bed area measurements, so the figures are considered more reliable. Evidence suggests the decline is indicative of a population that has had poor recruitment in previous years, despite the increase in spat in 2022 at both beds and in 2024 at Fenham Flats there was no seed mussel found in 2025 therefore it was not expected that there would be an increase in mussel stock this year, as the population has been dying at a greater rate than it is being stocked. Over the years at both beds the presence of small size classes of spat $<5\text{ mm}$ mussel has fluctuated and spat mussel has been observed to decline each year to the point where no spat mussel was observed in 2025 and 2026 walkover inspections. This is the fourth consecutive year for Holy Island with no increase in mussel spat and the second consecutive year for Fenham Flats.

Recruitment in mussel populations is known to be sporadic, occurring in unpredictable pulses (Seed & Suchanek, 1992), with higher recruitment occurring roughly every two years and persistent mussel beds are maintained by relatively low levels of this sporadic recruitment which has been observed in recent years at Lindisfarne (Mainwaring Tillin H. & Tyler-Walters H., 2014; McGrorty et al., 1990). In the 2022 surveys, Fenham Flats had 5% cover of small spat mussel at around 1-3 mm, and in 2024 2% of spat mussel at around 2-3 mm. Holy Island sands also had an increase in spat mussel in 2022 sized 1-4 mm but no spat mussel in subsequent years.

Previous reports for this site have highlighted potential issues with spat settlement resulting in a lack of recruitment at the site, resulting in a larger, ageing population as spat mussels are known to preferentially settle among established adult mussel populations, and studies have demonstrated their avoidance of soft substrata (McGrorty et al., 1990). This suggests that juvenile mussels may

not be surviving at Lindisfarne and are unable to grow into mature mussels that would become spawning stock. Recruitment does not appear to be able to counter the causes of decline and sustain the populations of mussel suggesting they may have passed the critical threshold for survival.

Anthropogenic impacts

Declines are observed at both sites, indicating similar impacts and are thought to be multifactorial. The Holy Island survey was intended to compare with Fenham Flats due to concerns about mussel declines there. If Holy Island's mussels had remained healthy, local causes could have been suspected at Fenham Flats. However, declines at both sites, and elsewhere in Northumberland and the UK, indicate broader, more widespread factors are involved. With no human collection pressure at either site due to a prohibition on bait collection in the area under the Lindisfarne National Nature Reserve Byelaw, 1999, biotic factors may be driving the overall decline of the mussel beds.

In addition to lack of recruitment, mussel beds have been found to be highly sensitive to a human induced pressures in a marine environment including introduction or spread of invasive species (including pacific oysters), habitat structural changes (including bait collecting) (Maddock, 2008) and/or physical loss (Mainwaring Tillin H. & Tyler-Walters H., 2014), water quality issues such as eutrophication (Baden et al., 2021), and increased storminess releasing buried contaminants (Richardson, 2021). In recent years there has been questions around the effects of stress upon mussel populations from pathogens and parasites (Chapuis et al., 2025) and the effects of human pharmaceuticals (Maskrey, 2026) potentially stressing mussel populations. These studies have been small scale so far and further work is planned in future.

Another potential driver of the decline may be the proximity to an aquaculture site for pacific oyster which has been in operation since 2007. During the surveys in 2025 and 2026 we noted the presence of pacific oysters living on the sediment at Fenham Flats, something that had not been noted in previous years. In 2026 there appeared to be an increased number of oysters scattered across the flats but more observed near to and under the oyster trestles. The presence of pacific oyster may lead to increased competition for resources, with both *C. gigas* and *M. edulis* being filter feeders. Studies have found that in areas of low flow rates, the presence of oysters has led to a decline in native mussel populations (Joyce et al., 2019). The ecological impacts of invasive species can be severe, but are generally viewed as highly unpredictable, however invasive species are often associated with higher consumption rates than comparative native species, with these higher per capita metrics predicting ecological impacts (Dick et al., 2013). *C. gigas* has previously been reported to consume mussel veligers, which may have caused a decrease in recruitment at these sites (Joyce et al., 2019). The introduction of this factor of resource competition to the site may have led to an increasingly rapid decline in the mussels as the oyster farm has increased in scale. The

potential impact of the presence of pacific oysters could be looked at in more detail given the decreases recorded for both mussel beds, but it is likely that multiple pressures are affecting the mussels here and in Blyth that does not have pacific oyster present in the estuary.

Water quality analysed at this site up to 2020 showed no significant correlation with loss of mussel beds at Lindisfarne. All parameters were within the normal range for a tidal estuary, however finer scale temporal data to monitor the site was recommended (Richardson, 2021).

Environmental impacts

Increased storminess due to climate change may be releasing buried contaminants and a study by Newcastle University in 2021 found that percentage cover of mussel beds in the Lindisfarne area showed a significant negative correlation with PBDE154 a polybrominated diphenyl ether (a banned flame retardant) and dieldrin and endrin (banned pesticides). These biocontaminants may be affecting *M. edulis* populations at Lindisfarne due to increased storm events, but it is unclear if this is seasonal (Richardson, 2021). The Environment Agency as part of the Water Framework Directive monitors Holy Island water quality but there were classification item changes and after 2019 and the above biocontaminants (PDBEs) cannot be analysed temporally. Further investigation of this potential relationship would be beneficial considering the rapid decline of the mussel beds in recent years.

Natural ecological pressures potentially influencing mussel mortality include predation across all size classes by species such as whelks, common periwinkles, crabs, starfish, and eider ducks (Cockrell et al., 2015). However, no targeted studies have been conducted to quantify or assess the impact of these biotic stressors on mussel population dynamics within the site.

A joint study in 2025 by The Roslin Institute, St Abbs Marine Station and Natural England analysed mussel faeces from populations in Teesside, Blyth, Lindisfarne, The Firth of Forth, The Cromarty Firth and Shetland. They were evaluated with eDNA and whole genome sequencing to identify parasites and pathogens potentially affecting mussel health (Chapuis et al., 2025). Results revealed the presence of *Klebsiella quasipneumoniae* in all declining populations of blue mussel. However, there was no indication of its pathogenicity on mussels and may be associated with water quality. Other bacterium found in mussels in Lindisfarne were *Vibrio Splendidus*, *Pshychobacter spp*, *Flammeovirga pectinis*, however little is known about the effects of these bacterium on shellfish.

In September 2025, Natural England and NIFCA collected a small number of mussels from Lindisfarne, the Blyth Estuary (north and south banks), and Royal Quays Marina for Cefas to analyse mussel tissue for human pharmaceuticals. Concentrations of human pharmaceuticals were much lower at Holy Island, which is consistent with the smaller local population and lower inputs of sewage/waste water into the water body with only cocaine being detected in comparison

to Blyth and North Shields where antidepressants were the most frequently identified along with other compounds. Further work is needed to determine whether these compounds have any adverse effects on mussel health or population dynamics (Maskrey, 2026).

Regional and Historical Patterns in Mussel Health

In contrast to the declines in Lindisfarne, blue mussels of all size classes, including spat are abundant at The Royal Quays Marina on the Tyne on hard structure and floating pontoons. This year there has been unverified reports of abundant mussels (again on hard structures) in the north east of the Blyth estuary at Cambois. These reports are promising meaning that there is likely to be larvae in the water column and that the water is suitable to feed the mussels. The fact that they are not settling or growing well on sediment may point to issues with settlement on softer substrata.

Anecdotal evidence, as well as NIFCA survey data, suggests that mussel beds throughout the northeast have seen a decline overall. Historically, northeast beds were more widespread, with a sudden reported decline in 2009, from which they have never fully recovered. This has been seen elsewhere in the UK, for example, populations in the Wash and in Scotland have reportedly decreased in abundance at ~54% of the sites surveyed between 2002-2010 and 2014-2015. This was the largest decline of any intertidal species recorded and 2023 and 2024 saw a biomass increase potentially linked to increased rainfall and sewage input (Burrows et al., 2017).

A 2025 Scottish study has shown the decline of intertidal blue mussels on rocky shores mainly along the southwestern and southeastern coasts, only finding healthy populations on the exposed island coasts of Orkney and Shetland (Burrows et al., 2025). There is another ongoing study in Scotland into the decline of blue mussel beds on muddy sediments that is currently unpublished.

Historically, mussel beds in Northumberland were more widespread and have gradually been lost over the years. A study by Lebour from 1906 showed widespread mussel beds in all of the estuaries in Northumberland including Lindisfarne where abundant beds were found, though there was reported declines due to pea crabs and predation from the dog whelk *Nucella Lapillus*.

Overall there has been a gradual decrease in the population of blue mussels in the North Atlantic region, with considerable variation across different localities (Baden et al., 2021). Declines in extent and biomass of mussel beds has been observed in the Greater North Sea including in Germany, Denmark and the Netherlands (OSPAR, 2023).

The drivers of mussel bed decline at Lindisfarne remain uncertain and survey evidence indicates that juvenile mussels have been unable to settle and/or survive to larger size classes on the intertidal beds, most likely because the remaining patches are now too sparse and provide

insufficient adult mussel matrix for successful settlement and growth. The Lindisfarne mussel beds are functionally extinct on intertidal mixed and sandy sediments, although it is unknown if mussels continue to persist in the subtidal or on hard structures.

Further Study

NIFCA intends to continue annual inspections of the Lindisfarne mussel beds; however, the monitoring approach may need to be reviewed for 2027. An alternative would be an annual walkover of the historic bed areas to assess if any beds have returned in the first instance, with a return to targeted inspections and full surveys should evidence of recovery emerge.

The Mussel Restoration Network expert group in combination with NIFCA are actively working to identify evidence gaps related to blue mussel decline in the UK and explore restoration possibilities.

NIFCA have also been in discussions with Cefas with regards to their coastal health and livelihoods programme with a view to investigating factors contributing to the decline in Northumberland and further afield.

Conclusion

Similar to other mussel beds found within the NIFCA district, the Lindisfarne mussel beds at Fenham Flats and Holy Island have continued to exhibit a pattern of decline all of the metrics that were assessed in 2026. The cause of this decline is still unknown and planned studies locally and nationally are improving understanding of mussel declines and will help guide future investigations.

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Annex 1 – Fenham Flats Bed Inspection Location Summaries

Waypoint	1155	1156	1157	1158	1159
Seed mussel Present	No	Yes	No	No	No
Size of seed mussel	NA	unknown	NA	NA	NA
Estimated % cover of seed mussel	NA	<1%	NA	NA	NA
Density of seed mussel	NA	areas	NA	NA	NA
Presence of size mussel	Yes	No	No	Yes	No
Density of size mussel	Low	NA	NA	Low	NA
Size of mussels	uniform	NA	NA	uniform	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	85-90%	30%	85%	25%	65%
Inspection Images	88 	89 	90 	91 	92 
Description	Sand, gravel	Sand	Muddy sand	Sand	Sandy gravel

Waypoint	1160	1161	1162	1163	1164
Seed mussel Present	No	Yes	No	No	No
Size of seed mussel	NA	unknown	NA	NA	NA
Estimated % cover of seed mussel	NA	>1%	NA	NA	NA
Density of seed mussel	NA	areas	NA	NA	NA
Presence of size mussel	No	No	No	No	Yes
Density of size mussel	NA	NA	NA	NA	Low
Size of mussels	NA	NA	NA	NA	uniform
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	<10%	10%	5%	60%	55%
Inspection Images	93 	94 	95 	96 	97 
Description	Sand	Sand	Sand	Sand	Sand

Waypoint	1165	1166	1167	1168	1170
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	No	Yes	No	No	No
Density of size mussel	NA	Low	NA	NA	NA
Size of mussels	NA	uniform	NA	NA	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	40%	35%	20%	40%	75%
Inspection Image	98 	99 	100 	101 	102 
Description	Sand	Sand	Sand	Sand	Sand

Waypoint	1171	1172	1173	1174	1175
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	No	No	Yes	No	No
Density of size mussel	NA	NA	Low	NA	NA
Size of mussels	NA	NA	uniform	NA	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	85%	<5%	70%	75%	3%
Inspection Image	103 	104 	105 	106 	107 
Description	Sand	Sand	Sandy gravel	Sand	Sand

Waypoint	1176	1182	1183	241	242
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	No	No	No	No	No
Density of size mussel	NA	NA	NA	NA	NA
Size of mussels	NA	NA	NA	NA	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	60%	15%	10%	40%	30%
Inspection Image	108 	109 	110 	3 	4 
Description	Sandy mud	Sand	Cobble, gravel	Sandy, hard ground	Sand, gravel, hard ground

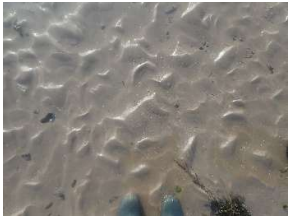
Waypoint	244	247	647	648	249
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	No	No	No	Yes	Yes
Density of size mussel	NA	NA	NA	very low	very low
Size of mussels	NA	NA	NA	mix (large size class)	only one, 76 mm
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	40%	40%	95%	40%	50%
Inspection Image	7 	10 	16 	17 	13-16 
Description	Gravel, hard sand	Gravel, hard sand	Mud	Muddy sand with shell fragments	Sand, gravel, hard ground

Waypoint	251	253	254	256	257
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	No	Yes	No	No	No
Density of size mussel	NA	very low	NA	NA	NA
Size of mussels	NA	40 mm	NA	NA	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	15%	45%	75%	60%	80%
Inspection Image	19&20 	23&24 	29&30 	31&32 	35&36 
Description	Sand	Sand, gravel, hard ground	Sand, gravel and shell	Sand, gravel, hard ground	Sand, gravel, hard ground

Waypoint	258	260	262	264	265
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	No	No	No	No	No
Density of size mussel	NA	NA	NA	NA	NA
Size of mussels	NA	NA	NA	NA	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	70%	70%	80%	5%	60%
Inspection Image	37&38 	41&42 	46&44 	47&48 	49&50 
Description	Sand, gravel, hard ground	Sand, gravel, hard ground	Gravel and sand	Cobbles and pebbles	Sand, gravel, hard ground

Waypoint	633	634	635	636	637
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	Yes	No	No	No	No
Density of size mussel	very low	NA	NA	NA	NA
Size of mussels	only one 45 mm	NA	NA	NA	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	15%	25%	7%	<1%	1%
Inspection Image	1 	2 	4 	5 	6 
Description	Sandy mud, coarse shell fragments and cobbles	Coarse muddy sand, cobbles	Coarse muddy sand, shells and gravel	Coarse muddy sand, gravel, cobbles and seaweed.	Muddy sand and gravel

Waypoint	638	639	640	641	642
Seed mussel Present	No	No	No	No	No
Size of seed mussel	NA	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA	NA
Presence of size mussel	No	No	No	No	No
Density of size mussel	NA	NA	NA	NA	NA
Size of mussels	NA	NA	NA	NA	NA
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	25%	20%	35%	35%	15%
Inspection Image	7 	8 	9 	10 	11 
Description	Muddy sand	Sand	Coarse sediment, gravel and cobbles	Muddy sand, shell and cobbles, sponge	Sand

Waypoint	643	644	645	646
Seed mussel Present	No	No	No	No
Size of seed mussel	NA	NA	NA	NA
Estimated % cover of seed mussel	NA	NA	NA	NA
Density of seed mussel	NA	NA	NA	NA
Presence of size mussel	No	No	No	No
Density of size mussel	NA	NA	NA	NA
Size of mussels	NA	NA	NA	NA
Dead shell present	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	<1%	<1%	80%	<1%
Inspection Image	12 	13 	14 	15 
Description	Sand	Sand, shell fragments	Sand, shell fragments	Sand, seaweed

Annex 2 - Holy Island Bed Inspection Location Summaries

Waypoint	266	267	268	269	270
Seed mussel Present	No	No	No	No	No
Size of seed mussel	N/A	N/A	N/A	N/A	N/A
Estimated % cover of seed mussel	N/A	N/A	N/A	N/A	N/A
Density of seed mussel	N/A	N/A	N/A	N/A	N/A
Presence of size mussel	No	Yes	No	No	No
Density of size mussel	N/A	Very low	N/A	N/A	N/A
Size of mussels	N/A	50-60 mm	N/A	N/A	N/A
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	15-20%	40%	70%	15%	85%
Image					
Description	Sandy gravel	Sandy gravel	Cobbles, pebbles, gravel	Cobbles, pebbles, sandy gravel	Sand

Waypoint	271	272	273	648	649
Seed mussel Present	Yes	No	No	No	No
Size of seed mussel	30-45 mm	N/A	N/A	N/A	N/A
Estimated % cover of seed mussel	<1%	N/A	N/A	N/A	N/A
Density of seed mussel	Areas	N/A	N/A	N/A	N/A
Presence of size mussel	No	No	Yes	No	No
Density of size mussel	N/A	N/A	Low	N/A	N/A
Size of mussels	N/A	N/A	50 mm	N/A	N/A
Dead shell present	Yes	Yes	Yes	N/A	N/A
Estimated % cover of dead shell	60%	3%	95%	80%	40%
Image					
Description	Sandy gravel	Cobbles, pebbles, sandy gravel	Gravel, sand	Sandy, gravelly, soft ground	Mix of shells, firm ground

Waypoint	651	653	655	656
Seed mussel Present	No	No	No	No
Size of seed mussel	N/A	N/A	N/A	N/A
Estimated % cover of seed mussel	N/A	N/A	N/A	N/A
Density of seed mussel	N/A	N/A	N/A	N/A
Presence of size mussel	No	No	No	No
Density of size mussel	N/A	N/A	N/A	N/A
Size of mussels	N/A	N/A	N/A	N/A
Dead shell present	N/A	Yes	Yes	Yes
Estimated % cover of dead shell	70%	35%	65%	50%
Image				
Description	Sandy gravel, very soft and soft mud	Textured, raised mud	Gravelly, firm ground	Sandy, gravelly, firm ground

Waypoint	657	659	660	661
Seed mussel Present	No	No	No	No
Size of seed mussel	N/A	N/A	N/A	N/A
Estimated % cover of seed mussel	N/A	N/A	N/A	N/A
Density of seed mussel	N/A	N/A	N/A	N/A
Presence of size mussel	No	Yes	No	Yes
Density of size mussel	N/A	Only one mussel	N/A	Only one mussel
Size of mussels	N/A	73 mm	N/A	45 mm
Dead shell present	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	90%	75%	80%	60%
Image				
Description	variable ground, some firm, some soft, sandy	variable ground, some firm and soft mud	Sandy and soft	Very firm sandy ground