

Bed Inspections - Blue Mussel (*Mytilus edulis*) Beds at Lindisfarne 2025

Sarah Richardson, Vicky Rae, Andrew Boon and Alex Aitken

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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 were conducted late March/early April 2025. 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 this year for the first time due to concerns regarding the limited number of mussels remaining on the bed. Therefore it was not possible to determine density, biomass, or length frequency of mussel, however the 2025 survey revealed a continuation of long-term decline.

Key results:

- overall bed area and percentage cover for both beds have reduced again in 2025
- overall bed area at Holy Island decreased from 3.11 hectares (ha) to 1.64 ha from 2018 to 2025
- overall bed area at Fenham Flats decreased from 41.53 ha to 39.03 ha from 2006 to 2025
- average percentage cover at Holy Island fell from 89% to 2.9% from 2015 to 2025
- average percentage cover at Fenham Flats fell from 67.91% to 1.08% from 2015 to 2025
- no evidence of recruitment was seen at Fenham Flats (no spat or seed mussel)
- one seed mussel (30–45 mm) was observed at Holy Island with no evidence of spat.

The findings highlight that the mussels beds are 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 would not meet the OSPAR habitat definition of an intertidal mussel bed found on mixed and sandy sediments.

NIFCA will continue annual inspections, along with 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; Stounberg et al., 2024).

Blue mussel beds are declining 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, a mussel bed restoration network has been established to share knowledge, identify research gaps, and understand the drivers of decline.

Lindisfarne

In 2005, the Northumberland Sea Fisheries Committee (NSFC) now Northumberland Inshore Fisheries and Conservation Authority (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 Lindisfarne National Nature Reserve. The beds were harvested for several years, before meat quality was deemed insufficient, and harvesting was discontinued in 2010. NIFCA has continued to carry out annual surveys at the site, providing an annual and unique long-term record of the population dynamics of the mussel bed.

NIFCA has a long-term record of the population dynamics of the mussel bed at Fenham Flats and the results from recent years have shown 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. Due to significant biomass reduction, stock assessment 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 30th of March to the 1st of April 2025 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.

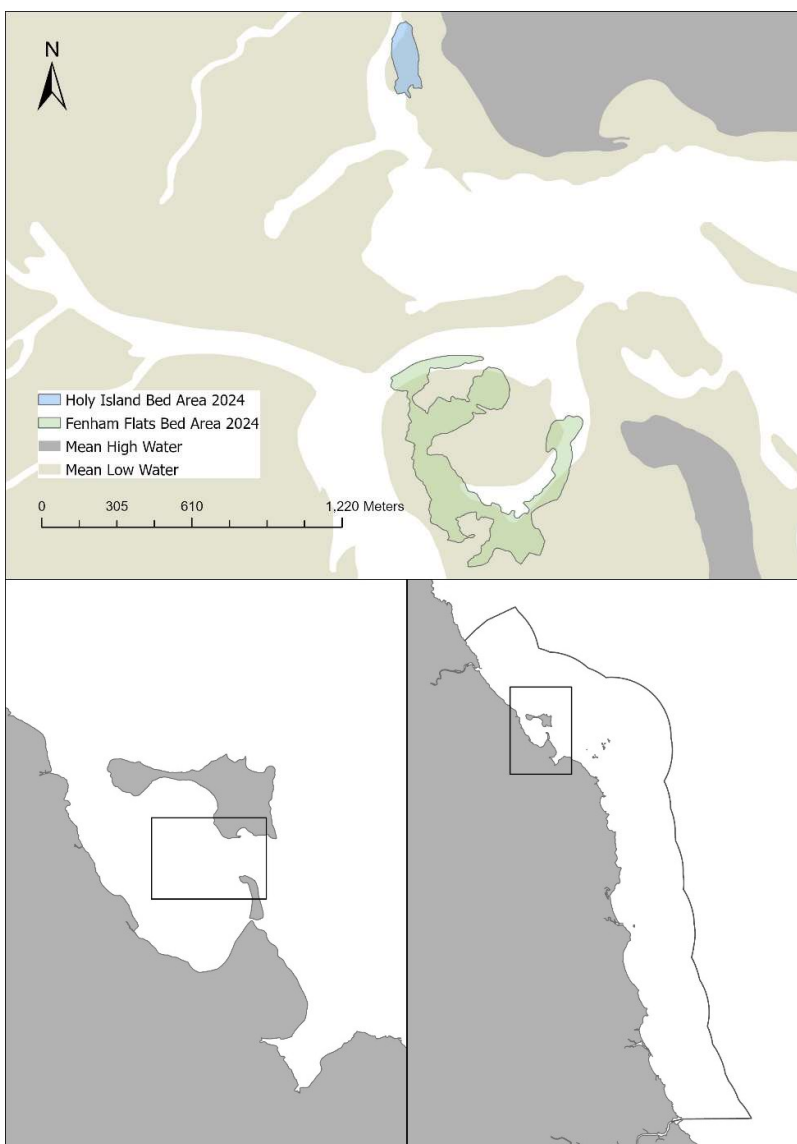


Figure 1 Fenham Flats and Holy Island mussel beds in 2024

¹ <https://nifca.gov.uk/about-us/publications/>

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. 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 2024 was used as a guide in the 2025 surveys (Figure 1).

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.

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 2025.

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

*calculated using 2021 bed area

Table 2: Results for the Holy Island mussel survey between 2018 and 2025.

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

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 2). 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.

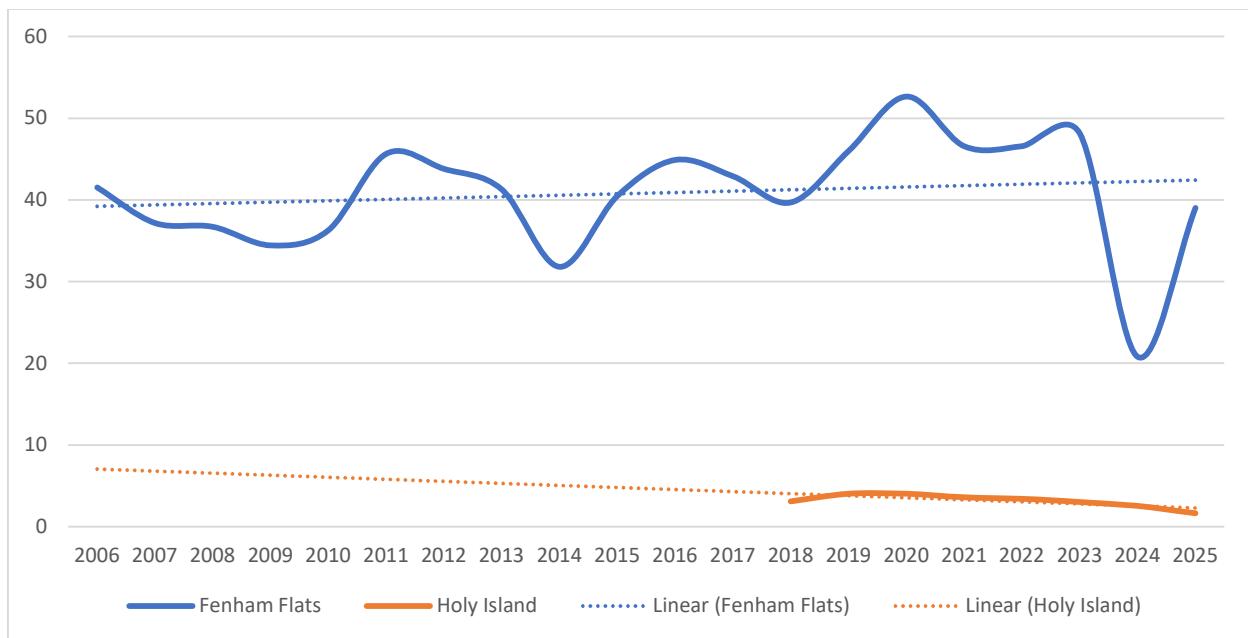


Figure 2 Overall bed area at Lindisfarne from 2006 to 2025

Overall bed area at Fenham Flats appears to have increased since 2024 from 21.81ha to 39.03ha in 2025 (Figure 3). This should be interpreted with caution. Due to the lack of live mussel the surveyors were following the perimeter of dead shell as a guide and it is possible that the dead shells have scattered further across the area giving the appearance of a larger bed.

Overall bed area at Holy Island sands has decreased since 2024 from 2.3ha to 1.64ha in 2025. This bed is smaller than Fenham Flats, so it was simpler to define its perimeters, but again due to the lack of live mussel this figure should be interpreted with caution.

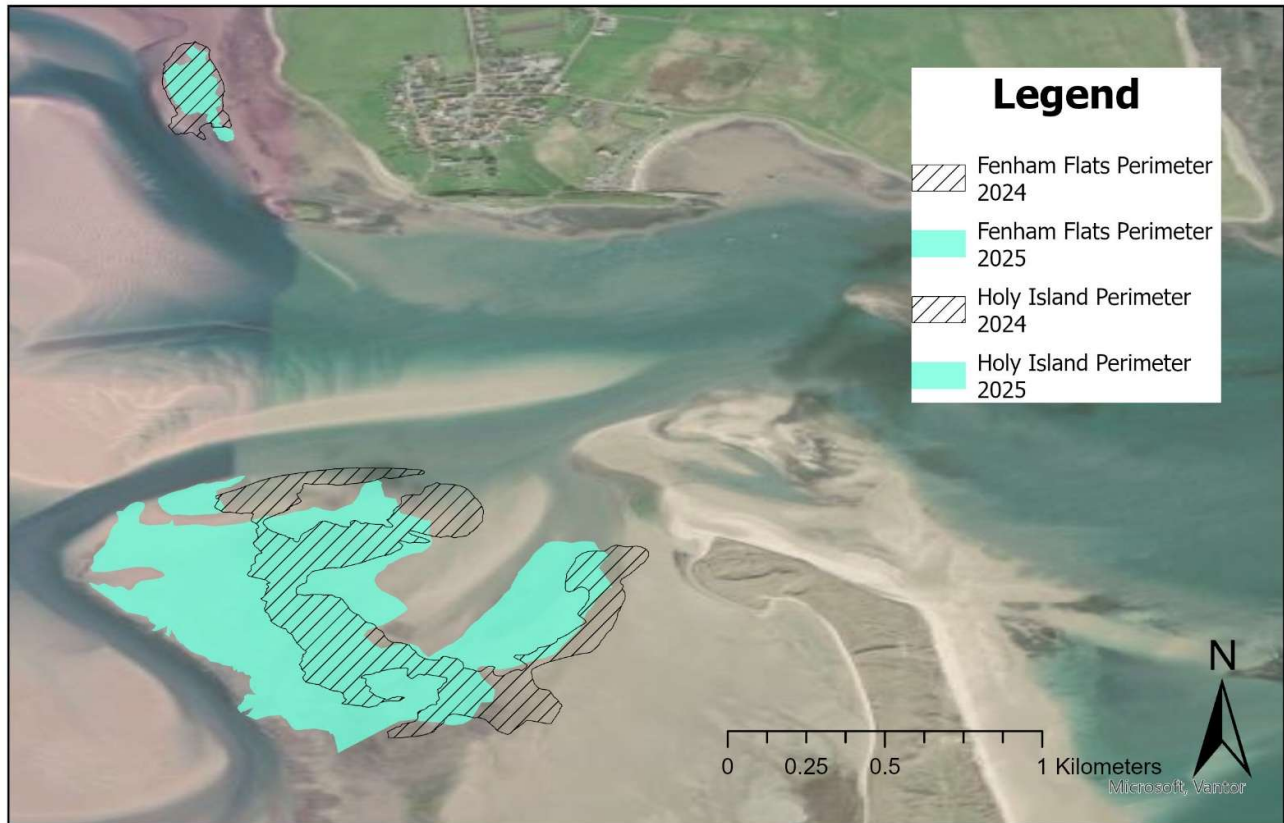


Figure 3 Comparison of the Lindisfarne mussel bed area and perimeters in 2024 and 2025

Percentage Cover

From 2006 to 2025 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 1.08% (Figure 4). The middle of the bed has the highest percentage cover of around 2.2% in comparison to the eastern part of the bed which has only 0.4% and the northern part of the bed 1.2%. No seed mussel, or spat was observed during the bed inspections. In a worst case scenario following the current trend of decline, the bed could potentially have no viable mussel population by 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 6.34% to 2.19% in 2025. In a worst case scenario following the current trend of decline, the bed would have no viable mussel population by 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.

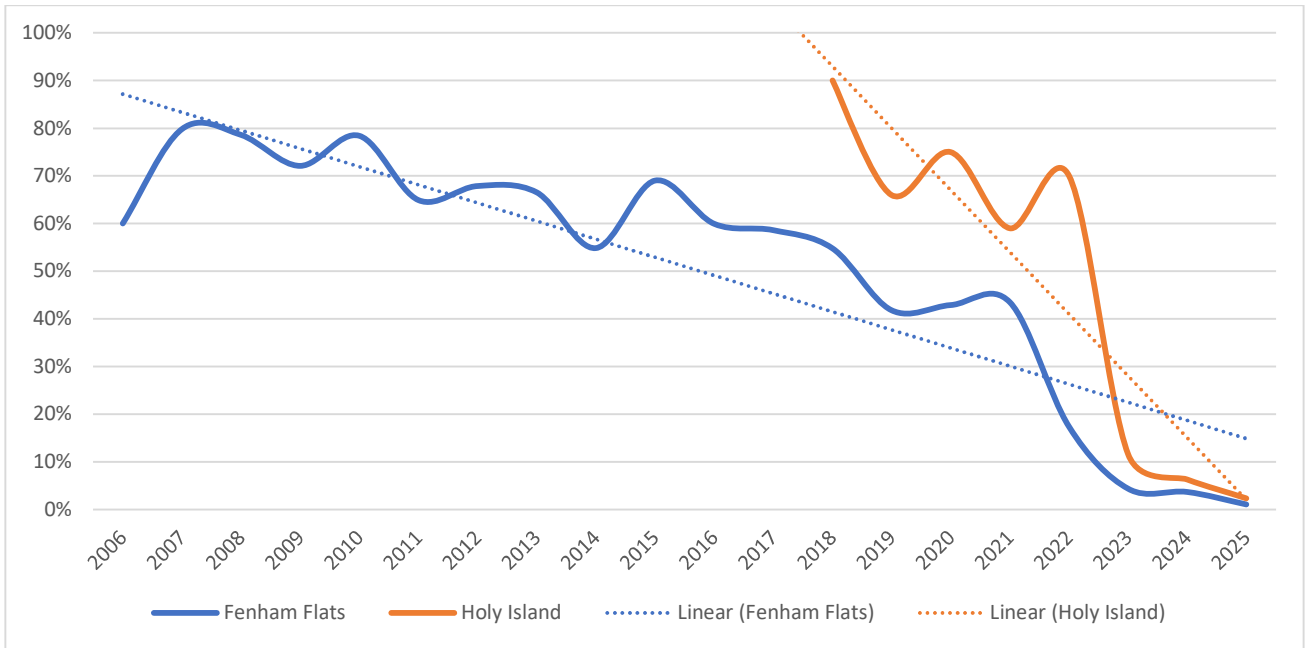


Figure 4 Average percentage cover estimates Fenham Flats and Holy Island for the years they have been surveyed, with trendlines highlighting their associated declines

Fenham Flats and Holy Island Bed Inspections

Figure 5 shows the perimeter of both mussel beds at Lindisfarne and their respective transects and bed inspection locations. At Fenham Flats, the bed area is very large and as the dead shell was used to determine the perimeter it appeared that it had been further spread to the west since 2024.

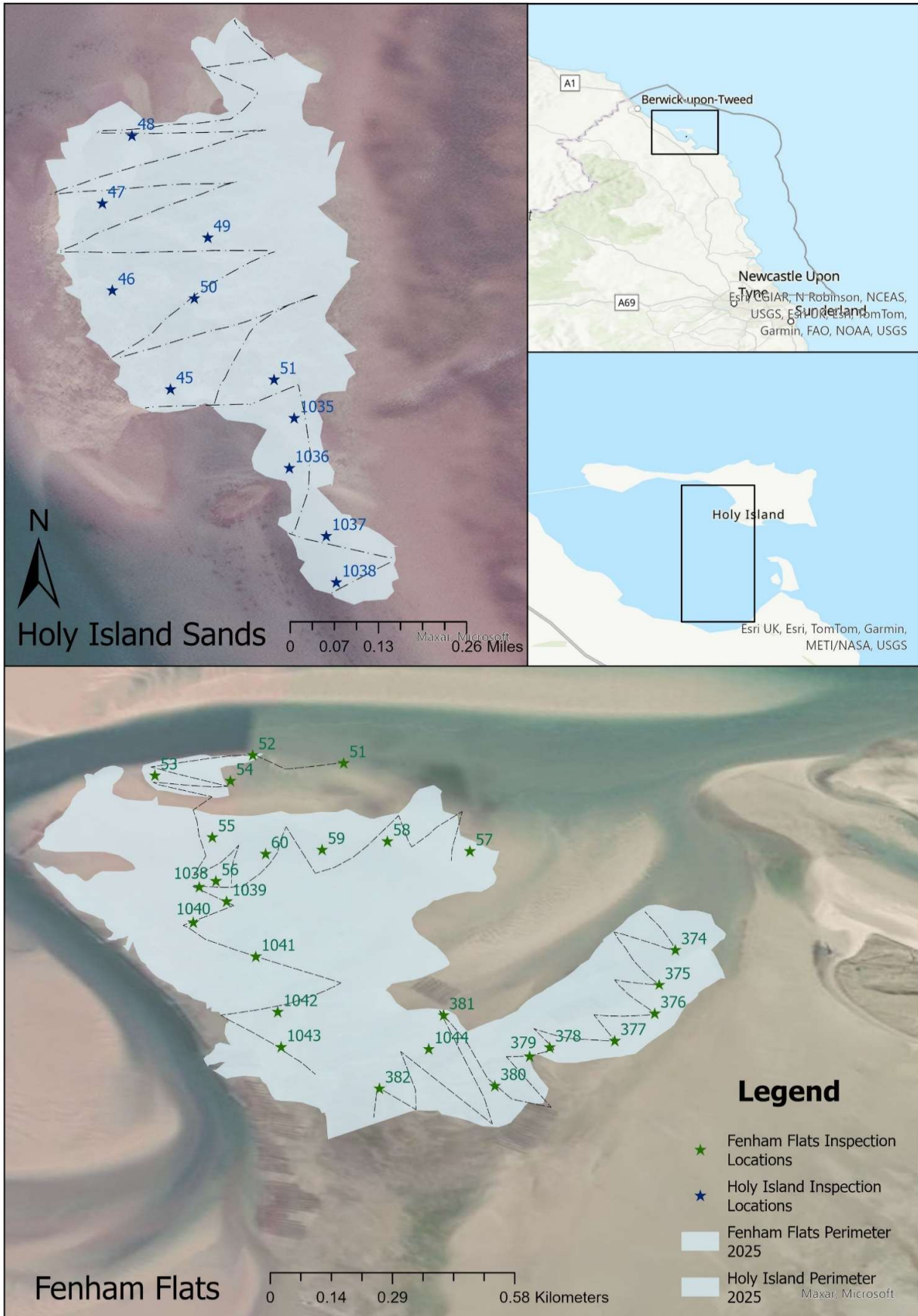


Figure 5 Map of Fenham Flats and Holy Island Sands perimeter, transects and bed inspection locations.

Annex 1 and Figure 6 provide a summary of the 24 bed inspection locations and for Fenham Flats mussel bed in 2025. Inspections aimed to cover representative areas of the mussel bed, however, determining an accurate location of the mussel bed on Fenham Flats was difficult given the sparsity of live mussel and the issues identifying the 2024 perimeter. Summaries below have been split into smaller areas based on inspection locations.

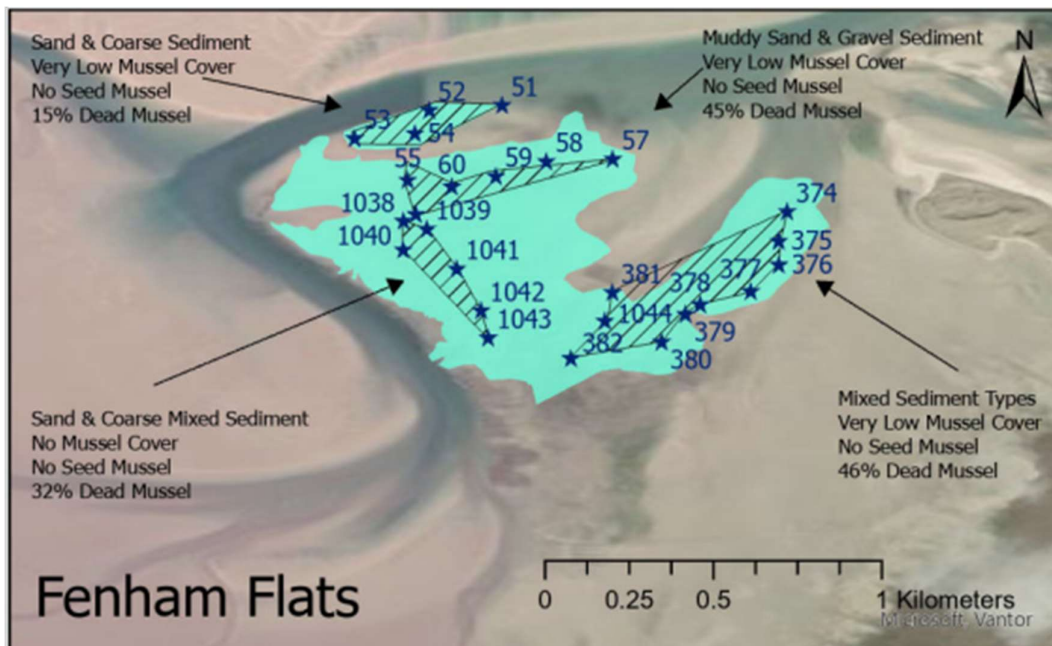


Figure 6 Bed inspection summary for Fenham Flats mussel bed

Fenham Flats Inspection locations 51 – 54

Transects surveyed in the far northern section of the bed at Fenham Flats showed no seed mussel present and a very low density of live mussel which was of uniform size class. Percentage cover of dead shell was low at an average of 15% across these locations. The section of the bed, which is somewhat separated now from the northern part of the main bed and comprises a combination of sandy and coarse sediments with pebbles.

Fenham Flats Inspection locations 55 – 60

Transects surveyed at these locations showed no presence of seed mussel and no live mussel. Dead shell was present at an estimated percentage cover of 32% across this area of the bed. This area, located at the northern end of the main bed, contains a mixture of coarse and sandy materials as well as coarse mixed sediments.

Fenham Flats Inspection locations 1038 – 1043

Transects surveyed in this western area of the bed showed no presence of seed mussel, and only some live mussel in the southern part of the bed which was of uniform size class. Dead shell was

present across the area with an average of around 45% dead shell. This area which is on the western side of the bed has mainly muddy sand and gravel sediment.

Fenham Flats Inspection locations 1044 and 374 – 382

Transects surveyed in this area of the bed showed no presence of seed mussel, uniform size mussel was only found at locations 374 and 380. Dead shell was present across the area at an average of around 46% across these locations, though this ranges from 10% up to 75% in areas. This area which is on the eastern side of the bed has a mix of sediment types.

At Fenham Flats occasional live Pacific oysters (*Crassostrea gigas*) were observed on the beds (Figure 7). These are likely to have originated from the co-located oyster farm which has cages placed on Fenham Flats.



Figure 7 Live Pacific Oysters found on Fenham Flats from the Lindisfarne Oyster Farm.

Annex 2 and Figure 8 provide a summary of the eleven bed inspection locations for the Holy Island mussel bed in 2025. Inspections aimed to cover representative areas of the mussel bed, however, determining an accurate location of the mussel bed on Holy Island Sands was again difficult given the sparsity of live mussel and the issues identifying the 2024 perimeter.

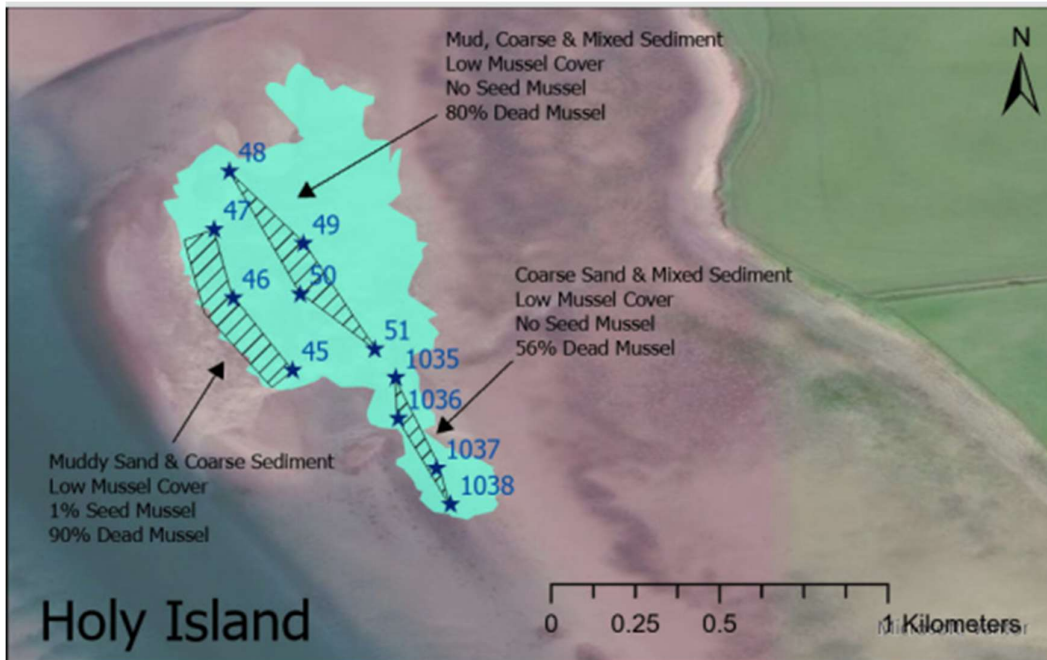


Figure 8 Bed Inspection summary for Holy Island Mussel Bed

Holy Island Inspection locations 45 – 47

Transects surveyed in this area of the bed showed presence of seed mussel at approximately 1% percentage cover, one size mussel was also found at location 46. A very high percentage cover of dead shell was present across the area at an average of around 90% across these three locations. This area which is in the western part of the bed is mostly muddy sand and coarse sediment.

Holy Island Inspection locations 48 – 51

Transects surveyed in this area of the bed did not record any seed mussel, but live mussels were found at locations 48, 50, and 51. The density of live mussels was low, with only one individual observed at location 50. Dead shell coverage was high on this part of the bed with an estimated average of 80% across these four locations. This area which is in the centre of the bed is mostly mud and coarse and mixed sediments.

Holy Island Inspection locations 1035 – 1038

No seed mussels were observed along the transects surveyed in this area of the bed; however, a single live mussel was recorded at location 1037. Dead shell coverage varied from 10% to 90% with an average of 56% across all four locations. This area which is in the southern part of the bed is mostly coarse sand and mixed sediments.

Discussion

The mussel beds at Fenham Flats and Holy Island have continued to decline since surveys began with a steep decline from 2022 to 2023 and continuing steady decline until these surveys in 2025. Both mussel beds have become increasingly sparse, consequently at Fenham Flats particularly it is difficult to accurately determine the extent of the mussel bed as the majority of the bed area appears to be dead shell. Surveyors walked the perimeter of the 2024 survey following the area of dead shell which may have been scattered further across the flats in the past year as the area appears much larger and has shifted to the west of the area surveyed in 2024. The extent of the mussel bed at Holy Island was simpler to estimate due to its smaller size and again the majority of the bed area is dead shell, consequently the figures for bed area should be interpreted with caution.

This demonstrates that the beds fail to meet the OSPAR criteria for classification as intertidal *M. edulis* bed habitats, given that mussel densities are below 30% cover on the beds. This means that the mussel at Lindisfarne has not met the OSPAR criteria since 2021 for Fenham Flats and 2022 for Holy Island.

Lack of recruitment

Percentage cover varied greatly across both mussel beds, but since the percentage cover estimates do not depend on precise bed area measurements, they are considered more reliable. Evidence suggests that mussels are declining at Lindisfarne and any 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 2024 at Fenham Flats, this has not translated into an increase in mussel stock in the subsequent years, and as such it appears that the population is dying at a greater rate than it is being stocked. Over the years at both beds the presence of small size classes of spat <5mm mussel has fluctuated and spat mussel has been observed to decline each year to the point where no spat mussel was observed in 2025 in the walkover inspections. This is the third consecutive year for Holy Island with no increase in mussel spat and the first for Fenham Flats. Due to the lack of live mussel and the need to conserve the remaining mussel beds, data on mussel stock, length frequency and mussel density will no longer be collected.

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 thought to be 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 2022 surveys, Fenham Flats had 5% cover of small spat mussel at around 1-3mm and in 2024 2% of spat around 2-3mm. Holy Island sands also had an increase in spat mussel in 2022 sized 1-4mm but no spat mussel in subsequent years. In 2025 no seed mussel was

observed on Fenham Flats at all and only one inspection location on Holy Island Sands had had 30-45mm seed mussel present at around 1% cover. No spat was observed on either of the beds.

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. 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).

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 we noted the presence of pacific oysters living on the sediment at Fenham Flats, something that has not been noted in previous years. The presence of pacific oyster may lead to increased competition for resources, with both *Crassostrea 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 at the site.

At Lindisfarne there are ongoing issues with water quality that have caused macroalgal blooms, this change in nutrient loading at the site was not seen as a significant to the mussel bed but only four years of data was used, water quality data monitoring should continue into the future to increase confidence in this initial conclusion. In addition, water quality analysed at this site 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 bio contaminants 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.

Preliminary results were shared from a joint study in 2025 by The Roslin Institute, St Abbs Marine Station and Natural England, where mussel faeces from populations in Teesside, Blyth, Lindisfarne, The Firth of Forth, The Cromarty Firth and Shetland 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.

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, growing well on the floating pontoons and hard structures present there. The marina is controlled by a lock gate so it may act as more of an enclosed system for the mussel larvae to circulate in. It has some freshwater input from two outfall pipes that may be providing additional nutrient rich water for the mussels.

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 reason for the decline of the mussel beds at Lindisfarne are still unknown and likely to be multifactorial, however it is clear that juvenile mussels have been unable to settle and grow successfully on the beds, most likely due to their sparse nature and lack of adult mussel. It is possible that the remaining mussel beds could be lost altogether in the coming years.

Further Study

NIFCA intends to continue the annual inspections of the mussel beds at Lindisfarne. Future mussel surveys looking at factors such as biomass, length frequency and density are unlikely to resume unless there is a substantial increase in the mussel populations.

A national expert group, led by The Tees River Trust, is working to identify evidence gaps related to blue mussel decline in the UK and explore restoration possibilities. These efforts are hoped to benefit the Lindisfarne and Blyth mussel beds.

In September 2025, Natural England and NIFCA collected a small sample of mussels from The Lindisfarne, Blyth and the Royal Quays Marina to analyse tissue for the presence of selected pharmaceuticals with results expected in 2026.

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 2025. The cause of this decline is still unknown, however future surveys will aim to continue to monitor these trends and will guide further investigation into the driver of this decline.






References






- Andrews, J.W., Brand, A.R. & Maar, M. (2011) 'MSC Assessment Report for Isefjord and East Jutland Danish Blue Shell Mussel Fishery.', MSC,
- Babarro, J.M.F., Fernández Reiriz, M.J. & Labarta, U. (2008) 'Secretion of byssal threads and attachment strength of *Mytilus galloprovincialis*: the influence of size and food availability', *Journal of the Marine Biological Association of the United Kingdom*, 88(4), pp. 783–791.
- Baden, S., Hernroth, B. & Lindahl, O. (2021) 'Declining Populations of *Mytilus* spp. in North Atlantic Coastal Waters—A Swedish Perspective', *Journal of Shellfish Research*, 40(2), pp. 269–296.
- Boon, A. (2020a) *Holy Island Mussel Survey Northumberland Inshore Fisheries and Conservation Authority* (ed.).
- Boon, A. (2020b) *Stock Assessment of the Edible Mussel (*Mytilus edulis*) Beds in Blyth Estuary*.
- Boon, A., Smart, K. & Aitken, A. (2024) *Stock Assessment of the Blue Mussel (*Mytilus edulis*) Beds at Lindisfarne 2024*.
- Burrows, M.T., Brook, T. & Twigg, G. (2025) *Marine Biodiversity and Climate Change (MarClim): Scotland 2020-2022*.
- Burrows, M.T., Twigg, G. & Mieszkowska, N. (2017) *Marine Biodiversity and Climate Change (MarClim): Scotland 2014/15*.
- Chapuis, A., Harsányi, P., Scott, C. & Regan, T. (2025) *Pathogens and Parasite Investigations in Mussels Using eDNA from Faeces: A Pilot Study Across the East Coast of Britain (2024-2025)*.
- Dick, J.T.A., Gallagher, K., Avlijas, S., Clarke, H.C., Lewis, S.E., Leung, S., Minchin, D., Caffrey, J., Alexander, M.E., Maguire, C., Harrod, C., Reid, N., Haddaway, N.R., Farnsworth, K.D., Penk, M. & Ricciardi, A. (2013) 'Ecological impacts of an invasive predator explained and predicted by comparative functional responses', *Biological Invasions*, 15(4), pp. 837–846.
- 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(2), pp. 385–399.
- Harvey, B. (2020) *Blue mussel declines in the Blyth estuary*.





- Harvey, B., Smart, K., Rae, V. & Aitken, A. (2024) *Stock assessment of the blue mussel (Mytilus edulis) beds in the Blyth estuary-2024*.
- Joyce, P.W.S., Kregting, L. & Dick, J.T.A. (2019) 'Relative impacts of the invasive Pacific oyster, *Crassostrea gigas*, over the native blue mussel, *Mytilus edulis*, are mediated by flow velocity and food concentration', *NeoBiota*, 45pp. 19–37.
- Maddock (2008) *UK Biodiversity Action Plan Priority Habitat Descriptions - Blue mussel beds on sediment*.
- Mainwaring Tillin H. & Tyler-Walters H., K. (2014) *Assessing the sensitivity of blue mussel beds to pressures associated with human activities*. JNCC Report No. 506.
- McGrorty, S., Clarke, R., Reading, C. & Goss-Custard, J. (1990) 'Population Dynamics of the Mussel *Mytilus edulis*: Density Changes and Regulation of the Population in the Exe Estuary, Devon', *Marine Ecology-progress Series - MAR ECOL-PROGR SER*, 67pp. 157–169.
- OSPAR (2014) 'Intertidal *Mytilus edulis* beds on mixed and sandy sediments'. QUALITY STATUS REPORT, Case Reports for the OSPAR List of threatened and/or declining species and habitats
- OSPAR (2010) *Quality Status Report - Intertidal Mytilus edulis beds on mixed and sandy sediments*.
- OSPAR (2023) *Status Assessment 2023 - Intertidal Mytilus Edulis Beds on Mixed and Sandy Sediments*. [Online] [online]. Available from: <https://oap.ospar.org/en/ospar-assessments/committee-assessments/biodiversity-committee/status-assesments/mytilus-edulis-beds/> (Accessed 4 August 2025).
- Richardson, S.-S. (2021) *An investigation into the drivers of Mytilus edulis decline within Northumberland Marine Special Protection Area*.
- Seed, R. & Suchanek, T. (1992) *Population and community ecology of Mytilus*, in [Online]. pp. 87–169.
- Stounberg, J.L., Timmerman, K., Dahl, K., Pinna, M. & Svendsen, J.C. (2024) 'Comparing biogenic blue mussel (*Mytilus edulis*) reef definitions in Northern Europe: Implications for management and conservation', *Environmental Science & Policy*, 151p. 103622.
- Walker, M.D. & Nicholson, P. (1986) 'The precision of estimates of mussel biomass by zig-zag survey.' Fisheries and Food Ministry of Agriculture Directorate of Fisheries Research (ed.). ICES





Annex 1 – Fenham Flats Bed Inspection Location Summaries

Waypoint	51	52	53	54	55
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	Yes	Yes	Yes	No	No
Density of size mussel	Low	Low	Low	N/A	N/A
Size of mussels	Uniform	Uniform	Uniform	N/A	N/A
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	5%	35%	15%	3%	6%
Inspection Images					
Description	Sand with pebbles and occasional dead mussel. Some size mussel, with common periwinkle, barnacles, keel worms and encrusting coralline algae on pebbles.	Coarse sand and pebbles with dead mussel shells and few size mussel. Top shells, flat periwinkles and common periwinkle.	Coarse sand and pebbles with dead mussel shells and few size mussel. Barnacles, flat periwinkles and common periwinkle.	Sandy ground, very few dead mussel shells and some seaweed. No live mussel present. Common and flat periwinkle attached to seaweed and dead shell.	Coarse mixed sediment. No live mussel present and very few dead mussel shells. Common periwinkle and barnacles attached to pebbles.




Waypoint	56	57	58	59	60
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	No	No	No	No
Density of size mussel	N/A	N/A	N/A	N/A	N/A
Size of mussels	N/A	N/A	N/A	N/A	N/A
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	60%	47%	14%	46%	21%
Inspection Images					
Description	Coarse mixed sediment with dead mussel shells and no live mussel. Limpets, barnacles, flat and common periwinkle.	Coarse and sandy sediment with dead mussel shells and no live mussel. Common cockle and barnacles.	Sandy sediment with no live mussel and some dead mussel shells. Limpets, common cockle, flat and common periwinkle.	Coarse and sandy sediment with good cover of dead mussel shells and no live mussel. Keel worms, common and flat periwinkle, and barnacles.	Coarse and sandy sediment with dead mussel shells and no live mussel. Keel worms, common and flat periwinkle, and barnacles.





Waypoint	374	375	376	378	380
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	Yes	No	No	No	No
Density of size mussel	Low	N/A	N/A	N/A	N/A
Size of mussels	only 1 mussel recorded	N/A	N/A	N/A	N/A
Dead shell present	Yes	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	60%	50%	40%	10%	70%
Inspection Image					
Description	Coarse and sandy sediment with good cover of dead mussel shells and few live mussel. Keel worms, common and flat periwinkle, common cockle, top shells and barnacles.	Coarse sandy sediment with good cover of dead shells, no live mussel. Barnacles, common cockles and limpets present.	Sandy sediment and pebbles. Dead shells present but no live mussel and few other species.	Sandy sediment. Few dead mussel shells present and no live mussel. Few other species present.	Coarse and sandy sediment with good cover of dead mussel shells and barnacles. No live mussel. Common cockle present.





Waypoint	381	382	1038	1039
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	Yes	No	No	No
Density of size mussel	Low	N/A	N/A	N/A
Size of mussels	Uniform	N/A	N/A	N/A
Dead shell present	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	40%	75%	50%	55%
Inspection Image				
Description	Muddy sand and pebbles, some live mussel and dead mussels. Common periwinkle, common cockle, barnacles and keel worms.	Coarse mixed sediment, no live mussel present but high numbers of dead shells. Barnacles, common cockle and flat periwinkle.	Muddy sand and gravel, no live mussel, some dead shells. Common periwinkle abundant, barnacles, keel worm, topshell and pink encrusting algae.	Muddy sand and gravel, no live mussel, some dead mussel shell. Barnacles and common periwinkle.

Waypoint	1041	1042	1043	1044
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	Yes	Yes
Density of size mussel	N/A	N/A	Low	Low
Size of mussels	N/A	N/A	Uniform	Uniform
Dead shell present	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	55%	30%	30%	25%
Inspection Image				
Description	Coarse mixed sediment, no live mussel, some dead shell. Common periwinkle and topshell present.	Sand and coarse mixed sediment. No live mussel, some dead mussel. Pink encrusting algae on pebbles. Barnacles, keel worms, topshell and common periwinkle present.	Muddy sand and gravel, some live mussel and dead mussel shell. Barnacles, common periwinkle, topshell, keel worm and dog whelk.	Muddy sand and gravel, some live mussel and dead mussel shell. Barnacles, common periwinkle, top shell, keel worm and common cockle.

Annex 2 - Holy Island Bed Inspection Location Summaries

Waypoint	45	46	47
Seed mussel Present	No	Yes	No
Size of seed mussel	N/A	30-45mm	N/A
Estimated % cover of seed mussel	N/A	1%	N/A
Density of seed mussel	N/A	Only 1	N/A
Presence of size mussel	No	Yes	Yes
Density of size mussel	N/A	Low	Low
Size of mussels	N/A	Only 1 mussel recorded	Uniform
Dead shell present	Yes	Yes	Yes
Estimated % cover of dead shell	85%	96%	90%
Image			
Description	Mixed and sandy sediments. Size mussel present, high coverage of dead shells. Abundant common periwinkle. Keel worm and barnacles.	Mixed and sandy sediments. Size mussel present, high coverage of dead shells. Abundant common periwinkle. Keel worm and barnacles.	Mixed and sandy sediments. Size mussel present, high coverage of dead shells. Abundant common periwinkle and barnacles.

Waypoint	48	49	50	51
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	Yes	No	Yes	Yes
Density of size mussel	Low	N/A	Very low	Low
Size of mussels	Uniform	N/A	Only 1 mussel recorded	Uniform
Dead shell present	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	80%	65%	95%	80%
Image				
Description	Muddy sand and coarse sediments with pebbles. Presence of live mussel at low density. High coverage of dead mussel shell. Common periwinkle, common cockle and barnacles.	Mud and coarse sediments with pebbles. No live mussel, High coverage of dead mussel shell. Common periwinkle, common cockle and barnacles.	Mud and coarse sediments with pebbles. Live mussel present at a very low density, Very high coverage of dead mussel shell. Common periwinkle and barnacles.	Muddy sand and coarse sediments with pebbles. Live mussel present at low density. High coverage of dead mussel shell. Common periwinkle, common cockle and barnacles.

Waypoint	1035	1036	1037	1038
Seed mussel Present	No	No	No	No
Size of seed mussel	N/A	N/A	N/A	NA
Estimated % cover of seed mussel	N/A	N/A	N/A	NA
Density of seed mussel	N/A	N/A	N/A	NA
Presence of size mussel	No	Yes	Yes	No
Density of size mussel	N/A	Low	Low	N/A
Size of mussels	N/A	Uniform	Only 1 mussel recorded	NA
Dead shell present	Yes	Yes	Yes	Yes
Estimated % cover of dead shell	90%	80%	45%	10%
Image				
Description	Coarse sandy sediments with shell fragments pebbles, no size mussel present. Very high coverage of dead shells. Common periwinkle, flat periwinkle and limpets, encrusting coralline algae.	Coarse mixed sediments and cobbles, size mussel present. High coverage of dead shells. Abundant common periwinkle, flat periwinkle, cockles, and barnacles, encrusting coralline algae.	Coarse mixed sediments and cobbles, size mussel present. medium coverage of dead shells. Abundant common periwinkle, barnacles and encrusting coralline algae.	Coarse mixed sediments and cobbles, no size mussel present. Very low coverage of dead shells. Abundant common periwinkle, cockles, one dead oyster shell, and encrusting coralline algae on cobbles.