

## A5.62: Mussel beds *Modiolus modiolus* on Atlantic sublittoral sediment

### Summary

*Modiolus* beds form when horse mussels (*Modiolus modiolus*) aggregate together by attaching to each other and the substratum with byssal threads. The degree of aggregation at which individuals are considered to be sufficiently dense to constitute a “bed” has been determined to be >30% cover. The depth range over which *M. modiolus* forms beds is unknown, but they typically occur at depths from the lower shore to about 70 m. The majority of beds are located in current- swept fully-saline locations, in the open coast as well as sheltered bays, fjords or lochs. They develop on a range of substrata, most often on cobbles through to muddy gravels, but have also been found on bedrock.

Beds are often persistent features which build up through accumulating faecal pellets, shell and trapped sand, so that they may become de-coupled from the substratum on which they were originally founded. Communities associated with *M. modiolus* beds are diverse, with a wide range of epibiota and infauna being recorded, including hydroids, red seaweeds, solitary ascidians and bivalves such as *Aequipecten opercularis* and *Chlamys varia*. The dominant species and main components vary depending on the biotope, four of which have been described for this habitat. Where they occur *M. modiolus* beds contribute significantly to benthic productivity. They support associated communities of high biodiversity and may be locally important in providing both refugia and feeding opportunities for young fish.

Bottom-towed fishing gear currently represents the greatest pressure for *Modiolus* beds, while climate change, specifically sea temperature rise, may also be a considerable future threat to the maintenance of the range of *M. modiolus*, which is a strictly cold-water species. *Modiolus* beds are best protected by regulation of fisheries and shell fisheries including exclusion of bottom contact fishing gear from areas where this habitat occurs.

### Synthesis

*Modiolus modiolus* is an Arctic-Boreal species, with a distribution ranging from the seas around Scandinavia (including Skagerrak & Kattegat) and Iceland south to the Bay of Biscay. Beds of *M. modiolus* occur with a patchy distribution in the colder waters of the North East Atlantic, with a range that extends from Russia in the southern parts of the Barents and White Seas, off Norway and down to Sweden (the Sound and Kattegat) and off the UK, in the southern North Sea and Irish Sea. Beds are also known to occur around Iceland and the Faeroes.

While some beds are well known previously unknown small beds of *M. modiolus* continue to be found even in areas where the distribution of coarse-scale benthic habitats is considered to be well documented. Maps have been produced for several countries and regions, but there remains uncertainty over the extent and occurrence of this habitat. Available evidence indicates that fully developed “beds”, where the mussels cover most of the sea floor creating biogenic reef structures, are scarce.

Very few individual beds have been studied over decadal time periods, so there is little firm evidence for decline across the entire habitat range. There are, however, clear instances where severe local declines have been caused by physical damage from trawling. There is also some evidence to suggest that the quality of *Modiolus* beds have declined over both historical and shorter timescales and that they continue to be vulnerable to human activities, particularly demersal fishing activity, but there are insufficient reliable data to quantify trends. OSPAR have identified this habitat as being under threat and/or declining in the all parts of the OSPAR area where it occurs and *Modiolus modiolus* is assessed as Vulnerable under the HELCOM species red list.

This habitat has been assessed as Near Threatened in both the EU 28 and EU 28+ because of recent and future threats.

Overall Category & Criteria			
EU 28		EU 28+	
Red List Category	Red List Criteria	Red List Category	Red List Criteria
Near Threatened	A2b, C/D2.	Near Threatened	A2b, C/D2.

### Sub-habitat types that may require further examination

None.

## Habitat Type

### Code and name

A5.62: Mussel beds *Modiolus modiolus* on Atlantic sublittoral sediment



*Modiolus modiolus* bed on sandy mud in the Upper Basin of Loch Creran, Scotland (© G. Saunders).



*Modiolus modiolus* bed on muddy sediment. Loch Linnhe, Scotland (© G. Saunders).

### Habitat description

*Modiolus modiolus* is an Arctic-Boreal species, with a distribution ranging from the seas around Scandinavia (including Skagerrak & Kattegat) and Iceland south to the Bay of Biscay. Beds of *M. modiolus* occur with a patchy distribution in the colder waters of the North-East Atlantic, with a range that extends from Russia in the southern parts of the Barents and White Seas, off Norway and down to Sweden (the Sound and Kattegat) and off the UK, in the southern North Sea and Irish Sea. Beds are also known to occur around Iceland and the Faeroes.

*Modiolus* beds form when horse mussels (*Modiolus modiolus*) aggregate together by attaching to each other and the substratum with byssal threads. The degree of aggregation at which individuals are considered to be sufficiently dense to constitute a “bed” has been determined to be >30% cover. The depth range over which *M. modiolus* forms beds is unknown, but they typically occur from the lower shore to about 70 m, with clumps found below 100 m in the Irish Sea. Off the Faeroes, they occur to about 200m depth, being most dense between 65-95 m. The majority of beds are located in current- swept fully-saline locations, although some can be found in sheltered bays, fjords or lochs, with some beds restricted to depths below haloclines.

*Modiolus* beds occur on a range of substrata, most often on cobbles through to muddy gravels but have also been found on bedrock. Beds are often persistent features which build up through accumulating faecal pellets, shell and trapped sand, so that they may become de-coupled from the substratum on which they were originally founded. They can be self-sustaining to the extent that spat survival is greatest in the crevices amongst the byssal threads of the mature clumps. A diverse range of epibiota and infauna often

exists in these communities including hydroids, red seaweeds, solitary ascidians and bivalves such as *Aequipecten opercularis* and *Chlamys varia*. The clumping of the byssus threads of the *M. modiolus* creates a stable habitat that also attracts a very rich infaunal community including areas with a high density of polychaete species.

Indicators of quality:

The condition of *Modiolus* beds may be judged in several different ways:

- Spatial integrity, such as whether fishing gear tracks cut across a bed.
- Topographic integrity, such as the continued presence of ridges, mounds and other biogenic relief.
- The size distributions of the mussels and whether the populations are being adequately renewed by successful spat settlement and juvenile survival through the first years when they are most vulnerable to predation.
- The abundance, composition, condition and diversity of the associated biota.

For physical disturbance impacts, changes in soft epifauna are more likely. Some of the vagile epifauna, such as brittlestars (e.g. *Ophiothrix fragilis*) are known to fluctuate markedly in abundance, so caution is needed when interpreting change. Damage also leads to increased abundance of scavengers, which are attracted to disturbed areas.

Characteristic species:

The dominant species and main components vary depending on the associated biotope, four of which have been described for this habitat: In areas of open coast and tide-swept channels an abundance of hydroids and red seaweeds characterises a biotope with *Ophiothrix fragilis* often common, along with the calcareous tubes of *Spirobranchus triqueter*, anemones such as *Alcyonium digitatum* and *Urticina felina* and hydroids such as *Abietinaria abietina* and *Sertularia argentea*. *Buccinum undatum* may also be important and in some areas the clam *Chlamys varia* may be frequent. Where there is a rich infaunal community this can comprise a high density of polychaete species including *Glycera lapidum*, *Paradoneis lyra*, *Aonides paucibranchiata*, *Laonice bahusiensis*, *Protomystides bidentata*, *Lumbrineris* spp., *Mediomastus fragilis* and syllids such as *Exogone* spp. and *Sphaerosyllis* spp. Bivalves such as *Spisula elliptica*, *Timoclea ovata* and other venerid species are also common and brittlestars such as *Amphipholis squamata*.

Where the conditions are very sheltered brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra*, as well as *Ophiopholis aculeata* are often frequent, sometimes forming a dense bed. The queen scallop *Aequipecten opercularis* is often present in moderate abundances. Large solitary ascidians (*Asciidiella aspersa*, *Corella parallelogramma*, *Dendrodoa grossularia*) and fine hydroids (e.g. *Kirchenpaueria pinnata*) are present, attached to the mussel shells. Decapods such as hermit crabs (*Pagurus bernhardus*) and spider crabs (*Hyas araneus*) are typically present. Coralline algal crusts may be found on the mussel shells, with some red seaweeds in shallower water such as *Phycodrys rubens*.

In a biotope that develops in tide swept sheltered conditions, the variable scallop (*Chlamys varia*) may be present in large numbers amongst the *Modiolus* shells. Hydroids such as *Halecium* spp. and *Kirchenpaueria pinnata* and ascidians such as *Asciidiella aspersa*, *Corella parallelogramma* and *Ciona intestinalis* may be found attached to pebbles or mussel shells. The echinoderms *Ophiothrix fragilis* and *Antedon bifida* are often frequent in this biotope as is the encrusting polychaete *Spirobranchus triqueter*.

## Classification

EUNIS (v1405):

Level 4. A sub-habitat of 'Atlantic circalittoral biogenic habitat' (A5.6).

Annex 1:

1170 Reefs

MAES:

Marine - Marine inlets and transitional waters

Marine - Coastal

MSFD:

Shallow sublittoral rock and biogenic reef

Shallow sublittoral coarse sediment and shallow sublittoral mixed sediment

Shallow sublittoral sand Shallow sublittoral mud

EUSEaMap:

Shallow photic rock or biogenic reef

Shallow aphotic rock or biogenic reef

Shallow sands

Shallow muds

Shallow coarse or mixed sediments

IUCN:

9.5 Subtidal sandy mud

**Does the habitat type present an outstanding example of typical characteristics of one or more biogeographic regions?**

Unknown

Justification

*Modiolus* beds may have been more widespread in the past and could therefore have been historically characteristic of the region.

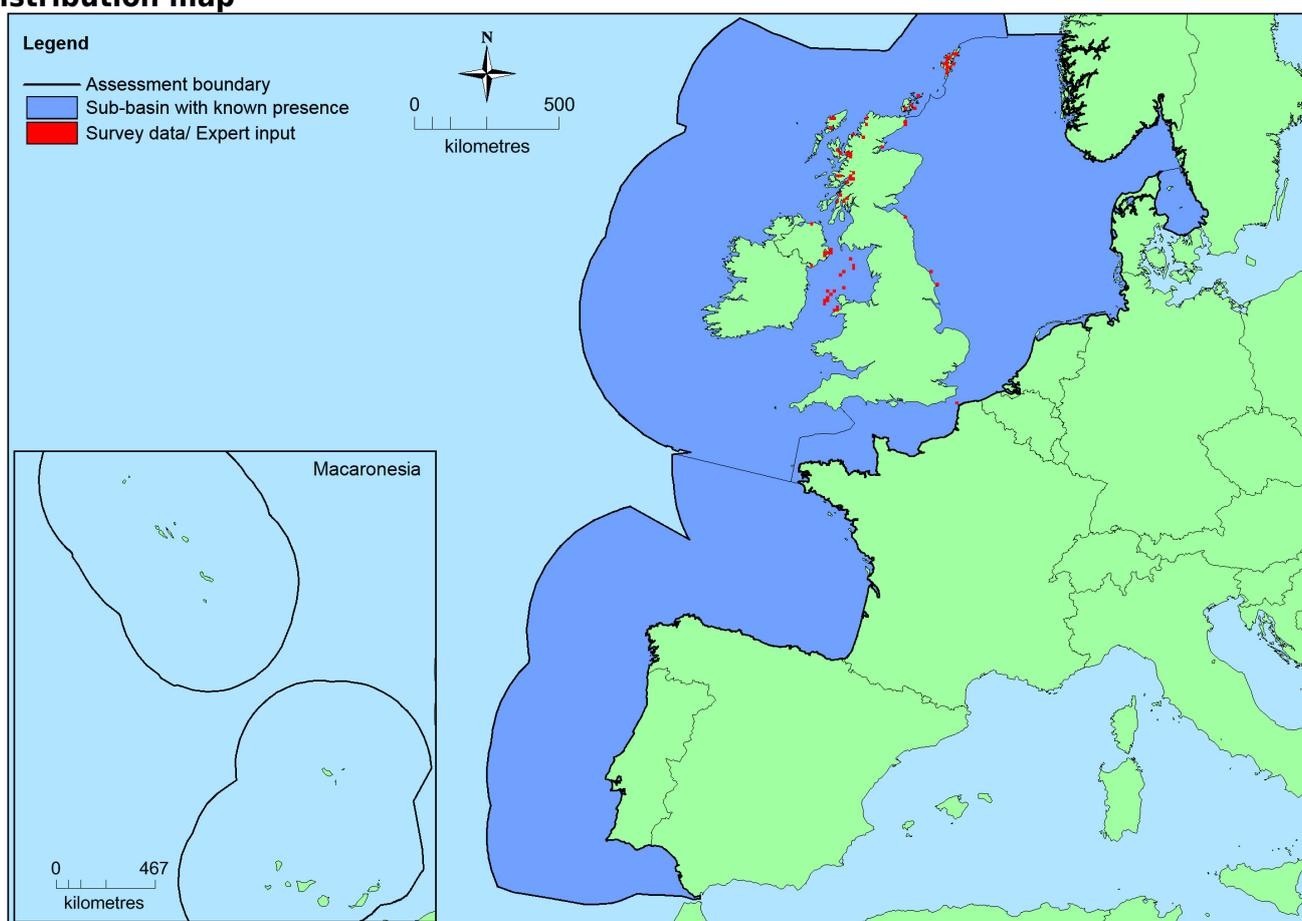
### **Geographic occurrence and trends**

Region	Present or Presence Uncertain	Current area of habitat	Recent trend in quantity (last 50 yrs)	Recent trend in quality (last 50 yrs)
<i>North-East Atlantic</i>	Celtic Seas: Present Kattegat: Present Greater North Sea: Present	Unknown Km <sup>2</sup>	Decreasing	Decreasing

## Extent of Occurrence, Area of Occupancy and habitat area

	Extent of Occurrence (EOO)	Area of Occupancy (AOO)	Current estimated Total Area	Comment
EU 28	365,273 Km <sup>2</sup>	69	Unknown Km <sup>2</sup>	EOO and AOO have been calculated on the available data. Although this data set is known to be incomplete the figures exceed the thresholds for threatened status.
EU 28+	>365,273 Km <sup>2</sup>	>69	Unknown Km <sup>2</sup>	EOO and AOO have been calculated on the available data. Although this data set is known to be incomplete the figures exceed the thresholds for threatened status.

## Distribution map



There are insufficient data to provide a comprehensive and accurate map of the distribution of this habitat. This map has been generated using EMODnet data from modelled/surveyed records for the North East Atlantic (and supplemented with expert opinion where applicable) (EMODnet 2010). EOO and AOO have been calculated on the available data presented in this map however these should be treated with caution as expert opinion is that this is not the full distribution of the habitat.

## How much of the current distribution of the habitat type lies within the EU 28?

Partly as a result of the patchy distribution of this biogenic habitat and uncertainty about whether records refer to individuals or beds, detailed up-to-date information on distribution is lacking over significant parts of the range. Without such information, it is not possible to provide estimates of the area covered by the *M.modiolus* bed habitat or the proportion hosted by EU 28. This habitat does occur in Norway, but there is insufficient information to provide estimates of the area covered.

## Trends in quantity

This habitat is thought to have been decreasing in the Celtic Seas over the last 50 years, but the extent of this decline is unknown. Some notable events have, however, been observed; for example, severe declines or complete losses have been reported for Strangford Lough, Northern Ireland, to the south of the Isle of Man and off North Anglesey, Wales. Under current climate change scenarios, there are considerable concerns for the viability of the habitat, particularly for beds at the southern limit of the range.

- Average current trend in quantity (extent)

EU 28: Decreasing

EU 28+: Decreasing

- Does the habitat type have a small natural range following regression?

No

*Justification*

This habitat does not have a small natural range as EOO > 50,000 km<sup>2</sup>.

- Does the habitat have a small natural range by reason of its intrinsically restricted area?

No

*Justification*

This habitat does not have a small natural range as EOO > 50,000 km<sup>2</sup>.

## Trends in quality

Historic studies have reported severe degradation of beds in the Celtic Seas (e.g. south of Isle of Man, in Strangford Lough, Northern Ireland, and off the Llyn peninsula, Wales). A small number of *M. modiolus* beds occur off the Swedish west coast fronting the Kattegat and there are some indications of degradation of the associated fauna due to eutrophication.

A small number of *M. modiolus* beds occur off the Swedish west coast fronting the Kattegat and there are some indications of degradation of the fauna associated with these beds due to eutrophication. In the UK, although the use of bottom towed fishing gear has been banned in a small number of sites within the last 15 years, there is likely to have been a reduction in the quality of beds exposed to bottom trawling.

The habitat quality of beds exposed to bottom towed fishing gear is predicted to reduce in the future. Under current climate change scenarios, the viability of this habitat, particularly of beds at the southern limit of its range is considered to be under serious threat.

- Average current trend in quality

EU 28: Decreasing

EU 28+: Decreasing

## Pressures and threats

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The threats and impacts on *M. modiolus* beds have been fairly well studied. Bottom-towed fishing gear causes rapid and severe damage to beds, both in terms of quantity and quality. The integrity of the often rich associated communities living on and within the beds may be susceptible to human-induced eutrophication events. Climate change may be a future threat forcing a northward shift in the distribution of *Modiolus modiolus*.

### List of pressures and threats

#### Biological resource use other than agriculture & forestry

Fishing and harvesting aquatic resources

Professional active fishing

Benthic or demersal trawling

Benthic dredging

### **Pollution**

Pollution to surface waters (limnic, terrestrial, marine & brackish)

Diffuse pollution to surface waters due to agricultural and forestry activities

Diffuse pollution to surface waters due to household sewage and waste waters

Nutrient enrichment (N, P, organic matter)

### **Climate change**

Habitat shifting and alteration

## **Conservation and management**

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The most effective conservation and management measure for this habitat is the restriction and control of activities that physically damage the bed structure. This would include regulation of demersal fisheries and shell fisheries, including exclusion of these activities from areas where this habitat occurs, both within and outside marine protected areas. This will also be important to enabling the recovery of this habitat in degraded areas. Mapping as well as long-term monitoring is needed to assess the condition of this habitat.

### **List of conservation and management needs**

#### **Measures related to marine habitats**

Restoring marine habitats

#### **Measures related to spatial planning**

Establish protected areas/sites

Legal protection of habitats and species

#### **Measures related to hunting, taking and fishing and species management**

Regulation/Management of fishery in marine and brackish systems

### **Conservation status**

Annex 1:

1170: MATL U2, MMAC FV

OSPAR threatened and declining habitat

HELCOM have conferred Red List status to the species and assessed it as "Vulnerable", but have not considered the *Modiolus* bed habitat, except as part of a wider "Reefs" habitat (also assessed as "Vulnerable").

### **When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?**

*M.modiolus* is a long-lived species and individuals within beds studied around the UK are frequently 25 or more years old. The species is considered to be highly intolerant to substratum loss, abrasion and physical damage. As recruitment is sporadic, varying with season, annually, with location, and hydrographic regime and is generally of low intensity, it may take many years for a population to recover from damage, if at all. Recovery has not been recorded from any damaged beds that have been studied. Efforts to restore beds through relocation have not been successful to date.

### Effort required

50+ years	200+ years
Naturally	Naturally

### Red List Assessment

#### Criterion A: Reduction in quantity

Criterion A	A1	A2a	A2b	A3
EU 28	decline but unquanti %	decline but unquanti %	decline but unquanti %	unknown %
EU 28+	decline but unquanti %	decline but unquanti %	decline but unquanti %	unknown %

There are data from selected locations that have been well-studied. A single location has reported a 100% loss, while other beds have been observed to be severely damaged. Overall there are insufficient quantitative data for a reliable estimate the historical or recent decline.

Future decline has been predicted due to continuing impact from demersal fisheries, and under various scenarios of climate change where modelling work indicates that the areas suitable for *M.modiolus* beds around the British Isles will decrease and that a loss of 100% of the “most suitable” habitat was likely to occur by 2080. Beds may extend further north but this will be outside the EU28+ area.

OSPAR have identified this habitat as being under threat and/or declining in the all parts of the OSPAR area where it occurs. This habitat has therefore been assessed as Near Threatened under criteria A2.

#### Criterion B: Restricted geographic distribution

Criterion B	B1				B2				B3
	EOO	a	b	c	AOO	a	b	c	
EU 28	>50,000 Km <sup>2</sup>	Yes	Yes	No	>50	Yes	Yes	No	No
EU 28+	>50,000 Km <sup>2</sup>	Yes	Yes	No	>50	Yes	Yes	No	No

This habitat has a large natural range in the North East Atlantic region The precise extent is unknown however as EOO >50,000 km<sup>2</sup> and AOO >50, this exceeds the thresholds for a threatened category on the basis of restricted geographic distribution. Some future decline has been predicted but the distribution of the habitat is such that the identified threats are unlikely to affect all localities at once. This habitat has therefore been assessed as Least Concern under criteria B1, B2 and B3.

#### Criterion C and D: Reduction in abiotic and/or biotic quality

Criteria C/D	C/D1		C/D2		C/D3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	unknown %	may be substantial b %	unknown %	may be substantial b %	unknown %	unknown %
EU 28+	unknown %	may be substantial b %	unknown %	may be substantial b %	unknown %	unknown %

Criterion C	C1		C2		C3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	unknown %	unknown %	unknown %	unknown %	unknown %	unknown %

Criterion C	C1		C2		C3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28+	unknown %	unknown %	unknown %	unknown %	unknown %	unknown %

Criterion D	D1		D2		D3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	unknown %	unknown%	unknown %	Unknown%	unknown %	unknown%
EU 28+	unknown %	unknown%	unknown %	unknown%	unknown %	unknown%

Historic studies have reported severe degradation of beds in the Celtic Seas (e.g. south of Isle of Man, in Strangford Lough, Northern Ireland, and off the Llyn peninsula, Wales). A small number of *M. modiolus* beds occur off the Swedish west coast fronting the Kattegat and there are some indications of degradation of the associated fauna due to eutrophication.

The habitat quality of beds exposed to bottom towed fishing gear is predicted to reduce in the future. Furthermore, under current climate change scenarios, the viability of this habitat, particularly of beds at the southern limit of the range of *M. modiolus*, is considered to be under serious threat. Beds may extend further north but this will be outside the EU28+ area.

OSPAR have identified this habitat as being under threat and/or declining in the all parts of the OSPAR area where it occurs. This habitat has therefore been assessed as Near Threatened under criteria C/D2.

### Criterion E: Quantitative analysis to evaluate risk of habitat collapse

Criterion E	Probability of collapse
EU 28	unknown
EU 28+	unknown

Maxent modelling and GIS environmental envelope analysis of *Modiolus modiolus* beds was carried out by Gormley et al (2013) The extent of “most suitable”, “less suitable” and “unsuitable” habitat was calculated for UK waters for the baseline year (2009) and for projected increased ocean temperature scenarios extending to 2030, 2050, 2080 and 2100. The steepest decline was predicted for between 2050 and 2080 and the authors concluded that a loss of 100% of the “most suitable” habitat was likely to occur by 2080.

### Overall assessment "Balance sheet" for EU 28 and EU 28+

	A1	A2a	A2b	A3	B1	B2	B3	C/D1	C/D2	C/D3	C1	C2	C3	D1	D2	D3	E
EU28	DD	DD	NT	DD	LC	LC	LC	DD	NT	DD	DD	DD	DD	DD	DD	DD	DD
EU28+	DD	DD	NT	DD	LC	LC	LC	DD	NT	DD	DD	DD	DD	DD	DD	DD	DD

Overall Category & Criteria			
EU 28		EU 28+	
Red List Category	Red List Criteria	Red List Category	Red List Criteria
Near Threatened	A2b, C/D2.	Near Threatened	A2b, C/D2.

### Confidence in the assessment

Low (mainly based on uncertain or indirect information, inferred and suspected data values, and/or limited expert knowledge)

## Assessors

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## Contributors

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## Reviewers

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## Date of assessment

27/11/2015

## Date of review

12/01/2016

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