# Intertidal *Mytilus edulis* beds on mixed and sandy sediments

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*Mytilus edulis* beds are composed of layers of living and dead mussels at high densities, bound together by the byssus threads secreted by the mussels and sometimes overlaying a great deal of accumulated sediment. The three main components are a physical matrix of living and dead shells; a bottom layer of accumulated sediments, mussel faeces and pseudofaeces, organic detritus and shell debris; and an assemblage of associated flora and fauna (Suchanek, 1979).

**Definition for habitat mapping**
Sediment shores characterised by beds of the mussel *Mytilus edulis* occur principally on mid and lower shore mixed substrata (mainly cobbles and pebbles on muddy sediments) but also on sands and muds. In high densities (at least 30% cover) the mussels bind the substratum and provide a habitat for many infaunal and epibiota species. This habitat is also found in lower shore tide-swept areas, such as in the tidal narrows of sealochs. A fauna of dense juvenile mussels may be found in sheltered firths, attached to algae on shores of pebbles, gravel, sand, mud and shell debris with a strandline of fucoids. Mussel beds on intertidal sediments have been reported all along the coast of Europe, particularly in UK, France, Netherlands and Germany.

**Geographical extent**

OSPAR Regions: All
Biogeographic zones Azores shelf, Lusitanean (Cold/Warm), Lusitanean-boreal, Cold-temperate pelagic waters, Boreal-lusitanean, Boreal, Norwegian Coast (Finnmark), Norwegian Coast (Westnorwegian), Norwegian Coast (Skagerrak), South Iceland - Faroe Shelf
Regions specified for decline and/or threat: II, III

The distribution of *Mytilus edulis* species complex is circumpolar in boreal and temperate waters, in both the southern and northern hemispheres extending from the Arctic to the Mediterranean in the north-east Atlantic (Soot-Ryen, 1955). Intertidal beds of the blue mussel *Mytilus edulis* are specific to the OSPAR area. The majority are found in the Waddensea (Netherlands, Germany and Denmark) where a 2007 inventory reported an estimated 1865ha in the Dutch sector (Goudswaard *et al.*, 2007). There are also presentin British coastal waters. TIreland (Jones *et al.*, 2000) and there is a large bed (covering approximately 200ha) in southern Brittany (Rollet *et al.,* 2005).

The species occurs in intertidal and sometimes subtidal habitats, under conditions ranging from fully saline to highly estuarine, and is capable of forming dense beds over much of its range. *Mytilus edulis* is found in a wide range of wave exposures, from all but the very most exposed shores to extremely sheltered habitats. It forms clumps and dense beds on a variety of sediment types, usually in more wave-sheltered conditions. These areas provide increased oxygen and food supplies, and may also help to prevent 'mussel mud' (silt, faeces and pseudofaeces) from building up too quickly.

**Application of the Texel-Faial criteria**
Nomination of intertidal mussel beds to be placed on the OSPAR list cited global and regional importance, rarity, sensitivity, ecological significance and keystone role, with information also provided on threat.

Decline
Significant declines in the extent and biomass of intertidal mussel beds have been reported in the OSPAR Maritime Area and particularly in Region II.

In Germany, a series of surveys covering the whole littoral of Niedersachsen revealed a decrease in the extent of beds and, more drastically, in biomass from roughly 5,000ha in extent in the late 1950s (100,000t fresh weight), 2,700ha in 1989/91, 1,300ha (10,000t) in 1994 to 170ha (1,000t) in 1996. Following some good spatfalls an area of 1,280ha survived the severe winter of 1996/7 (Michaelis *et al* 1996*;* Herlyn & Michaelis 1996; Zen *et al* 1997). Beds in the Ameland region are also reported to have disappeared after intensive fisheries (Dankers 1993).

Details on the mussel populations of Schleswig-Holstein for a period of nine years are also available and a decrease in biomass of approximately 50% was reported between 1989 and 1990 (Ruth, 1994; Dankers *et al.* 1999).

In the Netherlands, Higler *et al*. (1998) observed a serious decline in the populations of mussels between 1988 and 1990, mainly caused by fisheries. The extent of mussel beds decreased from the 1970s to the 1990s. In Denmark, intensive fisheries during 1984 to 1987 almost led to a complete disappearance of the mussel population (Kristensen, 1994, 1995).

Rarity

Intertidal beds are now rare in some parts of their former range in the Waddensea due to fisheries in a period with low spatfall, when mature beds were destroyed. In some areas they are returning very slowly and in others there has been no recovery at all in the last 12 years. Less than 10% of the original area in the Wadden Sea is now present (de Jong, 1999).

Sensitivity

*M. edulis* is widely recognised as being tolerant of a wide variety of environmental variables including salinity, oxygen, temperature and desiccation (Seed & Suchanek, 1992). It is capable of responding to wide fluctuations in food quantity and quality, including variations in inorganic particle content of the water, with a range of morphological, behavioural and physiological responses but is not necessarily particularly tolerant of anthropogenic chemicals (Hawkins & Bayne, 1992; Holt *et al.,* 1998).

Excessive levels of silt and inorganic detritus are thought to be damaging to *Mytilus* once they accumulate too heavily within the reef matrix (Seed & Suchanek, 1992), although the degree to which this might be influenced directly by water quality rather than production of faeces and pseudofaeces is unclear. *Mytilus* is capable of re-surfacing through a shallow covering of sediment and, in general, is considered to have a strong ability to recover from disturbance (Seed & Suchanek, 1992). Dense phytoplankton blooms can, on occasion, be detrimental to *Mytilus edulis*, although serious effects at the population level have only occasionally been reported (Holt *et al.,* 1998)

Ecological significance

Mussel beds are important in sediment dynamics of coastal systems. They collect sediment and are able to keep up with sea level rise. They protrude from the surrounding mudflats and are important as food source for birds. In the Waddensea 25% of the bird numbers used to occur on mussel beds which only occupied 3% of the area (Zwarts, 1991). The morphological structure of littoral areas is also enhanced by the mussel beds even where absent, as remnants are visible as elevations of clay banks or shell layers. In the Waddensea these are often a good basis for new spatfall. Very old beds may also stabilise creek patterns because clay and shell layers are relatively erosion resistant.

Mussel beds provide shelter for a large number of species and form an often rare area of hard substrata in areas of soft sediment. Asmus (1987) and Dittmann (1990) found respectively, 41 and 96 allied species. For some species such as sea anemones, hydroids and eelgrass, the bed provides shelter or permanent water in the tidal pools between the ridges. Others, especially deposit feeding worms, profit from the organic matter that is deposited as pseudofaeces (de Jong *et al.,* 1999).

Threat

Although intertidal mussel beds occur in most of the OSPAR area, the majority of *Mytilus* beds under threat occur in the Waddensea and southern British coastal waters.

The extensive, heavily exploited mussel fisheries (especially spat collecting for aquaculture) removed close to the entire stock in the Waddensea between 1988 and 1990 (Dankers *et al*., 1999), as well as having knock on effects such as an increased mortality for seabirds (e.g., eider ducks) (Kaiser *et al*., 1998) and affecting the benthic diversity. Jones *et al.* (2000), Dankers *et al.* (1999), and others consider that this habitat is under pressure from fisheries activities especially when settlement of spatfall is low.

Another threat is from alien species. The introduced Pacific Oyster (*Crassostrea gigas*) has increased significantly in the Wadden Sea since the beginning of the 21st century and one of the preferred settlement structures for the larvae are existing mussel beds. The result has been a conversion of a large parts of mussel beds into oyster beds. In the Lower Saxony part of the Wadden Sea, for example, every intertidal mussel bed holds at least some oysters (Schieffarth *et al.,* 2007)

Phytoplankton blooms, produced by nutrient enrichment (e.g., industrial and residential sewage discharge, agriculture), are another potential threat to mussel beds (de Jonge, 1997) and Jones *et al.* (1999) have suggested that mussel beds could also have intermediate sensitivity to anti-fouling substances and heavy metal contaminants. The decrease of mussel beds has profound effects on predators such as eider ducks and oystercatchers (Kaiser *et al*., 1998).

**Relevant additional considerations**

Sufficiency of data

Because of its widespread distribution, intertidal habit, its abundance and ecological importance in many places, its use as a bio-indicator, its commercial importance, and the relative ease with which it can be kept alive in the laboratory, *Mytilus edulis* has been extremely widely studied. There are also good records of the locality and size of mussel beds especially in the Waddensea, where they have been mapped since the 1950s or even earlier.

Changes in relation to natural variability

There can be significant variability in the occurrence and persistence of mussel beds as a result of natural factors. The presence and scale of the mussel bed mounds is governed by the interplay of factors that cause them to build up or break them down. Stock density is influenced by recruitment, predation and density dependent mortality, together with factors that affect feeding; the production of faeces and growth all build up the mounds. Waves, currents, predation and sometimes ice scour or sand burial, limit, erode or carry away the mounds.

Many mussel beds are subject to total destruction by storms and tidal surges and on occasion, this may involve hundreds of hectares. The number of mussel beds in the Schleswig-Holstein part of the Wadden Sea mapped by aerial survey decreased from 94 in 1989 to 49 in 1991 as a result of severe storms in early 1990 (Nehls & Thiel, 1993). Using data from 1994-2003 it was determined that almost 40% of all mussel bed area in the Dutch Wadden Sea disappeared due to storms and predation. Of all newly formed beds, 50% did not survive their first winter (Steenbergen *et al.,* 2006)

Ice flows can sweep away beds in the Wash and the Wadden Sea in the most severe winters and sand burial of *Mytilus* reefs occurs occasionally in Morecambe Bay (Dare, pers. comm. in Holt *et al.,* 1998). Large scale sand movements are also common in other places, such as parts of the Cumbrian Coast and Solway Firth (e.g. Perkins, 1967; 1968; 1970; 1971; Perkins et al., 1980), and can be expected to bury *Mytilus* beds on occasion.

Spatfall and recruitment in some beds of mussels is very variable year on year. Recruitment is favoured by cold preceding winters caused by decreases in predator populations and delays in the arrival of newly settled crabs and shrimps on the flats which allows the spat to reach a larger size before the onset of predation. Although a bed as a whole may be a persistent feature, the formation of patches within it is a dynamic process (Svane & Ompi, 1993). Those on the outside of patches tend to be larger and there are complex density dependent influences on a small scale on recruitment, growth and mortality.

Predation is an important influence on all mussel populations. However, Nehls & Thiel (1993) considered that bird predation was less important in causing losses of entire adult mussel populations than factors such as storm damage.

Over time, beds in particular places may for natural reasons vary in the positions they occupy on the continuum between thin, patchy beds and well developed reefs. Because mussel mud is highly cohesive, once it has consolidated, the deposits may last for years after the mussels have largely gone.

Expert judgement

There is good evidence of the threat to mussel beds from fisheries, especially when this coincides with periods of low spatfall. The detailed records of the decline of extensive beds in the Waddensea provide scientific evidence of the threat to this habitat and its decline along southern North Sea coasts. Further evidence of the link to fisheries, which can also inhibit recovery, can be found in the work of Herlyn & Millat (1999) who reported that on 12 non-fished beds, none had disappeared in the year after settling, whereas

7 out of the 8 fished beds had almost or completely disappeared.

ICES evaluation
OSPAR (2001) considered this habitat to be threatened and/or in decline across the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline and threat of intertidal mussel beds was “strong” across the whole OSPAR area. ICES found sufficient evidence for the decline and threat of this habitat over the whole OSPAR area (ICES 2002).

**Threat and link to human activities**
Cross-reference to checklist of human activities in OSPAR MPA Guidelines

*Relevant human activity:* Fishing, hunting & harvesting, land-based activities, aquaculture/mariculture. *Category of effect of human activity;* Physical – substratum change, substratum change, increased siltation, turbidity changes, emergence regime changes, water flow rate, temperature and wave exposure changes. Chemical – Contamination by synthetic compounds, heavy metals and hydrocarbons, nutrient changes. Biological – physical damage to the species, removal of target and non-target species.

There is clear evidence for a decline of mussel beds in areas of intensive fisheries, especially when associated with low recruitment events (Dankers *et al.,* 1999; Jones *et al*., 2000). The best reported example is of the extensive, heavily exploited mussel fisheries (especially spat collecting for aquaculture), in the Waddensea, which removed close to the entire stock between 1988 and 1990 (Dankers *et al*., 1999). The decrease of mussel beds was also reported to have profound effects on predators such as eider ducks and oystercatchers (Kaiser *et al.,* 1998).

**Management considerations**
The main management measures which would assist the conservation of this habitat are the regulation of fisheries (including spat collection for aquaculture) and protection from physical damage.

Intertidal mussel beds have been placed on the red list of biotopes and biotope complexes of the Waddensea. In some locations the beds are also a key feature within some of the Annex I habitats listed in the EC Habitats Directive and therefore given protection through the designation of Special Areas of Conservation.

**Further information**

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