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Information on the species and habitats around the coasts and sea of the British Isles

Musculus discors beds on moderately exposed circalittoral rock

MarLIN – Marine Life Information Network
Marine Evidence–based Sensitivity Assessment (MarESA) Review

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Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/habitats/detail/90]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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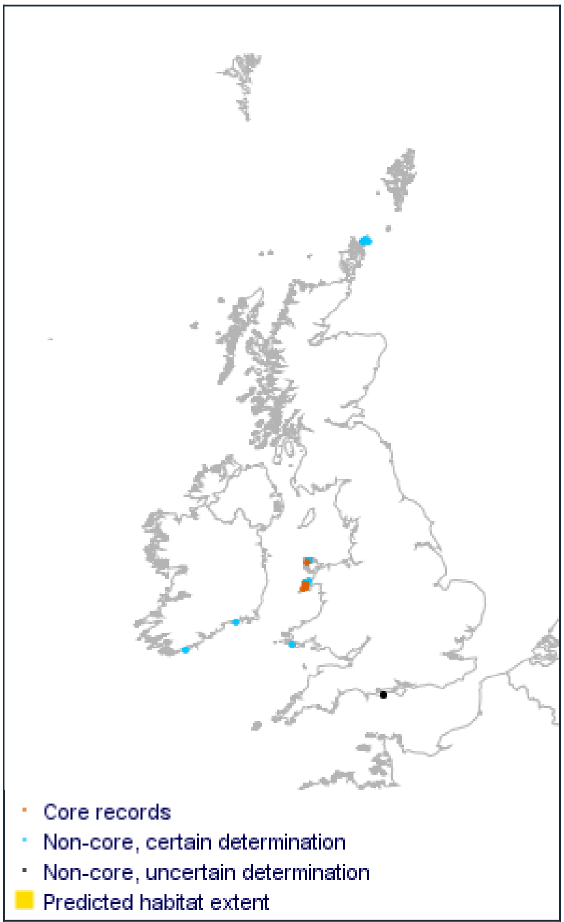

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Harvey Tyler-Walters **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A4.242	*Musculus discors* beds on moderately exposed circalittoral rock
JNCC 2015	CR.MCR.CMus.Mdis	*Musculus discors* beds on moderately exposed circalittoral rock
JNCC 2004	CR.MCR.CMus.Mdis	Musculus discors beds on moderately exposed circalittoral rock
1997 Biotope	CR.MCR.M.Mus	Musculus discors beds on moderately exposed circalittoral rock

Description

This biotope typically occurs on the upper faces of moderately exposed, moderately tide-swept bedrock, boulders and cobbles in slightly silty conditions. The mussel *Musculus discors* occurs in dense mats and occasionally completely coats all available surfaces. There is also often a layer of pseudofaeces, forming a thick, silty matrix. A relatively diverse fauna of cushion and branching sponges is often present on rocky outcrops and other hard substrata that is free of mussels. These include *Tethya aurantium*, *Scypha ciliata*, *Pachymatisma johnstonia*, *Dysidea fragilis*, *Cliona celata* and *Stelligera stuposa*. There may be isolated clumps of silt-tolerant bryozoans such as *Flustra foliacea* and *Crisularia plumosa*. Various species may be observed on top of the mussels, including *Asterias rubens*, *Crossaster papposus* and the brittlestar *Ophiura albida*. Occasional *Alcyonium digitatum* and clumps of the hydroid *Nemertesia antennina* are found attached to rocky outcrops and boulders whilst the anemone *Urticina felina* may be seen in crevices in the rock or on gravely patches between boulders. Colonial ascidians such as *Clavelina lepadiformis* and didemnids may occasionally be present. A wide range of seaweeds may be present, including *Dictyota dichotoma*, *Plocamium cartliagineum*, *Dictyopteris membranacea*, *Cryptopleura ramosa* and *Heterosiphonia plumosa*. The crab *Cancer pagurus* may be observed in crevices. (Information taken from the Marine Biotope Classification for Britain and Ireland, Connor et al., 2004).

Depth range

10-20 m

Additional information

Although several surveys of this biotope are available (for example Cabioch, 1968; Hiscock, 1984; Könnecker & Keegan, 1983; Baldock *et al.*, 1998; JNCC, 1999, Connor *et al.*, 2004), little information on the ecology of the biotope was found.

Listed By

- none -

Further information sources

Search on:

G G JNCC

Habitat review

Ecology

Ecological and functional relationships

This biotope is dominated by suspension feeding species. Little information on the ecology of this biotope was found.

- *Musculus discors* is an active suspension feeder on phytoplankton, bacteria, detritus and dissolved organic matter.
- In this biotope, the *Musculus discors* carpet excludes and may smother other epifauna (Cartlidge & Hiscock, 1980).
- Other suspension feeders include the sponges, hydroids, bryozoans, ascidians and small crustaceans found within the community. When present brittlestars (e.g. *Ophiura* spp.) or *Henricia oculata* may also suspension feed.
- Kelp (e.g. *Laminaria hyperborea*) and foliose red algae (e.g. *Delesseria sanguinea* or *Phycodrys rubens*) probably provide primary production in the form of detritus and dissolved organic matter or grazing by gastropods (e.g. *Gibbula cineria* or *Calliostoma zizyphinum*).
- The faunal turf of hydroids and bryozoans are probably grazed by echinoderms such as *Henricia oculata* and *Echinus esculentus*.
- Mobile predators include crabs such as *Cancer pagurus* and *Necora puber*, which probably take some *Musculus discors* and gastropods. The starfish *Asterias rubens* probably also preys on *Musculus discors*, although Hiscock (1984) noted that *Asterias rubens* was common on areas dominated by *Mytilus edulis* but only occasional on *Musculus discors* beds.
- *Asterias rubens*, *Henricia oculata* and crabs probably also act as scavengers within this biotope.

Seasonal and longer term change

Where foliose algae or kelp are present the algae may be expected to show seasonal changes in growth and development of the lamina, for examples see *Delesseria sanguinea* and *Laminaria hyperborea* reviews. Strings of the eggs of *Musculus discors* may be visible within the nest or byssal mass of the carpet. Eggs strings are laid in the summer months in Greenland and Denmark but no information on spawning times was available for Britain and Ireland. No further information regarding seasonal or temporal changes was found.

Habitat structure and complexity

- Habitat complexity is not high because of the 'blanketing' effect of *Musculus discors* which forms dense carpets covering upward facing hard substrata (including kelp holdfasts and stipes when present) in the infralittoral kelp zone and below. For example, in Kilkiernan Bay, Ireland *Musculus discors* formed a mat of up to 25mm thick over every horizontal surface over many square metres of seabed, reaching an estimated density of 22,000 individuals per square metre (Könnecker & Keegan, 1983).
- At other sites, below the kelp zone, *Musculus discors* formed a carpet covered by a mucous-congealed mat of silt or pseudofaeces bound by fine byssus threads, through which its siphons protruded when feeding (Hiscock, 1984; Brazier *et al.*, 1999).
- The byssus nests and interstices between individual *Musculus discors* probably support meiofauna and small crustaceans, scavenging flatworms and polychaetes.

- The *Musculus discors* carpet may also support scattered individuals of *Mytilus edulis* (Könnecker & Keegan, 1983).
- The carpet is interspersed or punctuated by epifauna such as ascidians (e.g. *Polycarpa pomeria*, *Morchelium argus*, and *Clavelina lepadiformis*), sponges (e.g. *Hemimycale columella* and *Polymastia boletiformis*), hydroids (e.g. *Nemertesia antennina* and *Sertularia* spp.), bryozoans (e.g. *Flustra foliacea* and *Pentapora foliacea*), Anthozoa (e.g. *Alcyonium digitatum*, *Urticina felina* and *Sagartia* sp.), by red foliose seaweeds (e.g. *Delesseria sanguinea*, *Phycodrys rubens* and *Hypoglossum hypoglossoides*) and by kelps when present (Hiscock, 1984; Connor *et al.*, 1997; Baldock *et al.*, 1998).
- The surrounding rocks, vertical surfaces and probably to a lesser extent the *Musculus discors* carpet, supports a rich epifauna of hydroids, bryozoans, ascidians and sponges (Cabioch, 1968; Könnecker, 1977; Könnecker & Keegan, 1983; Baldock *et al.*, 1998). The species composition of the epifauna and associated species varies with depth, light availability (especially the flora), siltation and current flow, and probably reflects the epifauna and flora of the open coast in the local area rather than the presence of the *Musculus discors* carpet itself (Merrill & Turner, 1963; Cabioch, 1968; Cartlidge & Hiscock, 1980; Connor *et al.*, 1997; Baldock *et al.*, 1998). Cartlidge & Hiscock (1980) suggested that *Musculus discors* had a smothering effect over other epifauna.

Productivity

Little information on productivity was found. However, kelps and other macroalgae probably make an important contribution to primary productivity where abundant. Dame (1996) suggested that dense beds of bivalve suspension feeders increase turnover of nutrients and organic carbon in estuarine (and presumably coastal) environments by effectively transferring pelagic phytoplanktonic primary production to secondary production in the sediments (pelagic-benthic coupling). The *Musculus discors* beds probably also provide secondary productivity in the form of tissue, faeces and pseudofaeces, however, probably not to the same magnitude as common or horse mussel beds.

Recruitment processes

Little information concerning recruitment in *Musculus discors* was found. *Musculus discors* is a protandrous hermaphrodite (Ockelmann, 1958). One year old individuals are functionally male. Eggs develop in thier second year, and they pass through a hermaphroditic phase before becoming functional females at the end of their third year (Ockelmann, 1958). They lay large eggs (ca 300x200 µm) in strings within the nest of the parent. The embyos develope witihin the gelatinous egg-string without any pelagic phase. The embyonic shell was found to be ca 400 µm in length, while still within the string (Thorson, 1935, 1936 as cited in Thorson, 1946 and Ockelmann, 1958). Eggs strings are laid in the summer months in north east Greenland and Denmark (Thortson, 1946; Ockelmann, 1958). No information on spawning times was found for Britain and Ireland.

Musculus discors produces relatively few offspring; tens of eggs and offspring rather than hundreds of thousands of eggs in the spawning mytilids such as *Mytilus edulis*. However, direct development withn the nest of the parent probably results in relatively lower levels of juvenile mortality. Therefore, recruitment within populations is likely to be good.

Martel & Chia (1991) reported that juvenile *Musculus discors* (<1 mm) were caught in off-bottom intertidal collectors and one specimen in offshore collectors. Juvenile *Musculus discors* are probably capable of drifting on fine byssal threads (bysso-pelagic transport) and may be carried considerable distances. Therefore, local recruitment in *Musculus discors* may be rapid, depending on the hydrographic regime. Hence, within a population or between adjacent populations recruitment is probably fairly rapid. However, recruitment from distant populations may take longer.

For many hydroids and bryozoans in the biotope, Holt *et al.* (1995) suggested that they were rapid colonizers, able to settle rapidly, mature and reproduce quickly. Many species have a short lived planktonic phase, resulting in relatively local recruitment, however, fecundity is high and most species are widespread, so that recruitment is likely to be rapid from surrounding populations.

Most sponge species in the biotope produce short lived, planktonic larvae so that recruitment is localized, depending on the hydrographic regime. However, some species (e.g. *Polymastia robusta*) produce benthic crawling larvae that probably settle close to the parent (see Fell, 1989 for review).

Ascidians in the biotope have external fertilisation but short lived larvae, so that dispersal is probably limited. Where neighbouring populations are present recruitment may be rapid but recruitment from distant populations may take a long time.

In strong water flow associated with this biotope, most pelagic larvae are probably transported away from the biotope, so that most recruits of species with pelagic life stages come from outside the community. However, direct development in *Musculus discors* probably ensures a relatively good, local recruitment in the vicinty of adults.

Time for community to reach maturity

No information concerning population or community development in *Musculus discors* was found.

Additional information

No text entered.

Preferences & Distribution

Habitat preferences

Depth Range	10-20 m
Water clarity preferences	
Limiting Nutrients	Data deficient
Salinity preferences	Full (30-40 psu)
Physiographic preferences	Open coast
Biological zone preferences	Upper circalittoral
Substratum/habitat preferences	Bedrock, Large to very large boulders
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.)
Wave exposure preferences	Moderately exposed, Sheltered
Other preferences	

Additional Information

Könnecker (1977) suggested that the *Musculus discors* association in Kilkieran Bay, Ireland was an example of an eurythermal and eurysaline community. The MNCR biotope classification (Conner *et al.*, 1997a) suggested that this biotope was associated with moderate wave exposure and weak to moderately strong tidal streams. However, the *Musculus discors* communities described by Cabioch (1968) occurred in areas subject to strong currents, and the *Musculus discors* communities in Kilkieran Bay were associated with currents greater than 2.5m/sec (5 knots) (Könnecker, 1977; 1983).

Species composition

Species found especially in this biotope

- *Clavelina lepadiformis*
- *Hemimycale columella*
- *Henricia oculata*
- *Musculus discors*
- *Nemertesia antennina*
- *Polymastia boletiformis*
- *Stelligera stuposa*

Rare or scarce species associated with this biotope

-

Additional information

The epifauna may be exceptionally rich (Könnecker, 1977; Könnecker & Keegan, 1983). The MNCR recorded 323 species within this biotope, although not all species were present in all records of the biotope. Dominant species were detailed in other surveys by Cabioch (1968), Baldock *et al.* (1998) and JNCC (1999).

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

Musculus discors is the dominant space occupying species within this biotope, and may smother other species. The other species in the community are widespread and characteristic of the open coast, in which the *Musculus discors* beds are found. Therefore, the associated species vary with location and have little significant association with the *Musculus discors* bed itself. Reference has been made to *Nemertesia ramosa* to represent hydroids, *Pentapora foliacea* to represent bryozoans and *Clavelina lepadiformis* to represent ascidians and *Urticina felina* and *Alcyonium digitata* to represent anthozoans occurring within the biotope. However, the biotope is characterized by the *Musculus discors* bed. A reduction in *Musculus discors* density or loss of the bed would result in a significant change in the character of the community in the loss of the biotope. Therefore, the sensitivity of this biotope is dependent on the sensitivity of the *Musculus discors* bed.

Resilience and recovery rates of habitat

Life history and recruitment characteristics of the dominant species groups are presented under 'recruitment processes' above. Direct development in eggs strings, within the adult nest, in *Musculus discors*, probably results in relatively low levels of juvenile mortality and good local recruitment. In addition, direct development and the high energetic investment in relatively few offspring (compared with broadcast spawners) may allow rapid colonization of suitable habitat but restrict long range dispersal. However, Martel & Chia (1991) suggested that in species that brood their offspring or have direct development (such as *Musculus discors*) bysso-pelagic drifting probably contributed to rapid local dispersal and recruitment, depending on the hydrographic regime.

Holt *et al.* (1995) suggested that many hydroids and bryozoans were rapid colonizers, able to settle rapidly, mature and reproduce quickly. Many species have a short lived planktonic phase, resulting in relatively local recruitment, however, fecundity is high and most species are widespread so that recruitment is likely to be rapid from surrounding populations. Ascidians have external fertilisation but short lived larvae, so that dispersal is probably limited. Where neighbouring populations are present recruitment may be rapid but recruitment from distant populations may take a long time. Most sponge species produce short lived, planktonic larvae so that recruitment is localized, depending on the hydrographic regime. Some species (e.g. *Polymastia robusta*) produce benthic crawling larvae that probably settle close to the parent (see Fell, 1989 for review). Growth rate varies between and within species, so that time to reach maturity is also variable and large colonies may take several years to develop. However, little information was found.

In strong water flow associated with this biotope, most pelagic larvae are probably transported away form the biotope, so that most recruits of species with pelagic life stages come from outside the community. However, direct development within the adult nest would avoid the loss of juveniles from the population while allowing bysso-pelagic transport of a proportion of the juveniles, that may themselves colonize suitable habitat elsewhere.

There is no direct evidence of recovery within populations of *Musculus discors* or their beds. The epifaunal community described within this biotope is primarily dependent on the *Musculus discors* bed.

Resilience assessment. Recruitment within a population or between adjacent populations and recovery of *Musculus discors* is probably fairly rapid. Therefore, where some fo the population is lost or its abundance reduced (e.g. 'Medium' resistance) it is suggested that prior abundance may recover within up to two years, and resilience assessed as '**High**'. However, where the bed is significantly or severely damaged (e.g. resistance in 'Low') and recovery is dependant on recruitment from distant populations recruitment may take longer. If a population is removed (resistance is 'None') recovery will depend on recruitment from nearby populations by drifting, followed by subsequent expansion of the population. The species is widespread so that a ready supply of juveniles will probably be present, albeit in small numbers. Therefore, it is suggested that recovery after removal or significant damage to a population may take about up to 10 years so that resilience would be assessed as '**Medium**'. However, confidence in this assessment is '**Low**'. The associated epifaunal community will probably develop within less than 5 years although slow growing sponges may take many years to develop.

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	High Q: Medium A: Low C: Medium	High Q: High A: High C: High	Not sensitive Q: Medium A: Low C: Medium

Musculus discors has a wide distribution extending from the Arctic Circle to the Mediterranean in western Europe. It is, therefore, unlikely to be affected by increases in temperature in British waters. Könnecker (1977) also suggested that *Musculus discors* associations were eurythermal. Similarly, many epifaunal species found in the biotope have a widespread distribution and are unlikely to be adversely affected by long-term change within British waters. Short-term acute change may have adverse effects, for example, reproduction in *Clavelina lepadiformis*, *Delesseria sanguinea* and hydroids is temperature dependent. However, loss of a few epifaunal or epifloral species will not significantly affect the biotope, and are likely to recover quickly. Therefore, a resistance of **High** has been recorded. Hence, resilience is **High** (by default) and the biotope is recorded as **Not sensitive** at the benchmark level.

Temperature decrease (local)	High Q: Medium A: Low C: Medium	High Q: High A: High C: High	Not sensitive Q: Medium A: Low C: Medium

Musculus discors has a wide distribution extending from the Arctic Circle to the Mediterranean in western Europe. It is, therefore, unlikely to be affected by increases in temperature in British waters. Könnecker (1977) also suggested that *Musculus discors* associations were eurythermal. Similarly, many epifaunal species found in the biotope have a widespread distribution and are unlikely to be adversely affected by long-term change within British waters. Short-term acute change may have adverse effects, for example, reproduction in *Clavelina lepadiformis*, *Delesseria sanguinea* and hydroids is temperature dependent. However, loss of a few epifaunal or epifloral species will not significantly affect the biotope, and are likely to recover quickly. Therefore, a resistance of **High** has been recorded. Hence, resilience is **High** (by default) and the biotope is recorded as **Not sensitive** at the benchmark level.

Salinity increase (local)	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Könnecker (1977) classified *Musculus discors* associations as euryhaline but without explanation.

Musculus discors was recorded from fjordic waters in East Greenland that varied between 25-30 psu (Ockelmann, 1958) and from Loch Strom, Shetland that varied between 18-35psu (Thorpe, 1998). However, no evidence was found on the effect of hypersaline (>40 psu) conditions.

Salinity decrease (local)	Low Q: Medium A: Low C: Medium	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

Könnecker (1977) classified *Musculus discors* associations as euryhaline but without explanation. *Musculus discors* was recorded from fjordic waters in East Greenland that varied between 25-30 psu (Ockelmann, 1958) and from Loch Strom, Shetland that varied between 18-35psu (Thorpe, 1998). Intertidal populations of *Musculus discors* are probably exposed to freshwater runoff and rainfall. Therefore, *Musculus discors* itself is probably tolerant of a reduction in salinity from full to variable or even reduced for a year. However, Connor *et al.* (2004) noted that Musculus discors occurred in the lagoonal biotope R.LIR.Lag.AscSpAs at reduced salinity but at lower densities than occurred in this biotope. Hence, a decrease in salinity from 'full' to 'reduced' for a year may result in a reduction in the abundance *Musculus discors* and possibly extent of the bed. Most species or hydroids, ascidians, sponges and bryozoans are stenohaline, occurring only in full salinity waters, although some species are euryhaline. Therefore, a reduction in salinity is likely to result in a decline in species richness of epifaunal species.

Overall, a reduction in salinity from 'full' to 'reduced' is likely to have adverse effects, reducing the extent of the *Musculus discors* populations and significantly reducing the richness of the associated epifauna. Therefore, a resistance of **Low** is recorded, so that resilience is probably **Medium** and a sensitivity of **Medium** is recorded.

Water flow (tidal current) changes (local)	High Q: Medium A: Low C: Medium	High Q: High A: High C: High	Not sensitive Q: Medium A: Low C: Medium

The *Musculus discors* bed biotope is recorded in areas subject to moderately strong tidal streams (0.5-1.5 m/s) (Connor *et al.*, 2004). However, the *Musculus discors* communities described by Cabioch (1968) occurred in areas subject to strong currents, and the *Musculus discors* communities in Kilkieran Bay were associated with currents greater than 2.5 m/sec (5 knots, strong tidal streams) (Könnecker, 1977; 1983). Water flow is probably important for this epifaunal community, in order to provide food (as particulates and plankton), oxygenate the water column and keep the habitat free of excessive silt. Therefore, a decrease in water flow to e.g. weak would probably be detrimental to the biotope. Similarly, and increase in water flow to e.g very strong may be detrimental if the resultant water flow removed or destabilised the bed. However, no direct evidence of disturbance due to changes in water flow or storms was found. Nevertheless, a change in water flow of 0.1-0.2 m/s (the benchmark) is within the normal range experienced by the biotope. Therefore, the biotope is considered to be **Not sensitive** at the benchmark level.

Emergence regime changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant to circalittoral habitats below 5m.

Wave exposure changes (local)	High Q: Medium A: Low C: Medium	High Q: High A: High C: High	Not sensitive Q: Medium A: Low C: Medium

The *Musculus discors* bed biotope is recorded from moderately wave exposed and wave sheltered conditions (Connor *et al.*, 2004), whereas *Musculus discors* has been reported from wave exposed to extremely wave sheltered habitats and is, therefore, probably relatively insensitive to changes in wave exposure within this range. Should the wave exposure increase from exposed to extremely exposed, *Musculus discors* may be removed, even in the shallow subtidal, where the oscillatory water flow generated by wave action is likely to dislodge and remove at least a proportion of the population. Similarly, a proportion of the associated epifaunal species is also likely to be removed, being replaced by more wave tolerant species, e.g. *Tubularia indivisa*. A decrease in wave exposure, e.g. from moderately exposed to very sheltered is likely to increase siltation and increase the risk of deoxygenated conditions (see below). The species composition of the epifauna is likely to change, favouring species resistant of reduced wave action or water movement, e.g. the hydroid *Nemertesia* spp. but the biotope is likely to be little affected. Nevertheless, a 3-5% change in significant wave height is unlikely to adversely affect the biotope, which occurs below 10 m where wave action in attenuated. Therefore, the biotope is considered to be **Not sensitive** at the benchmark level.

Chemical Pressures

	Resistance	Resilience	Sensitivity
Transition elements & organo-metal contamination	Not Assessed (NA)	Not assessed (NA)	Not assessed (NA)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

No information concerning the effects of heavy metals on *Musculus discors* was found. However,

- Bryan (1984) stated that Hg was the most toxic metal to bivalve molluscs while Cu, Cd and Zn seemed to be most problematic in the field. In bivalve molluscs Hg was reported to have the highest toxicity, decreasing from Hg > Cu and Cd > Zn > Pb and As > Cr (in bivalve larvae, Hg and Cu > Zn > Cd, Pb, As, and Ni > to Cr). Crompton (1997) reported that adult bivalve mortalities occurred after 4-14 day exposure to 0.1-1 µg/l Hg, 1-10 µg/l Cu and Cd, 10-100 µg/l Zn but 1-10 mg/l for Pb and Ni.
- Boero (1984) noted that Cu and Cd affected a general control mechanisms, resulting in an increase in growth, while high Cu concentrations increased production of gonozooids, i.e. sexual reproduction of pelagic larvae in the hydroid *Laomedea flexuosa*, possibly a response to unfavourable conditions. Bryan (1984) also reported morphological abnormalities in the hydroid *Eirene viridula* induced by low levels of Hg, Cd PB and Zn, while *Clava multicornis* showed sublethal effects after 6 weeks exposure to 200ppb Cd. *Tubularia* sp. was reported to be resistant to pollution, including Cu (Boero, 1984).
- Bryozoans may accumulate trace metals to a certain extent and freshwater bryozoans were more intolerant of low concentrations of Cu than other freshwater organisms (Holt *et al.*, 1995).
- Bryan (1984) suggested that the general order for heavy metal toxicity in seaweeds is: organic Hg > inorganic Hg > Cu > Ag > Zn > Cd > Pb. Cole *et al.* (1999) reported that Hg was very toxic to macrophytes.

Overall, there was insufficient evidence to assess resistance to heavy metals in *Musculus discors*, although the above evidence for hydroids suggests that they will display sublethal effects at least.

Hydrocarbon & PAH contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

Subtidal populations are protected from the direct effects of oil spills by their depth but are likely to be exposed to the water soluble fraction of oils and hydrocarbons, or hydrocarbons adsorbed onto particulates.

- Suchanek (1993) noted that sub-lethal levels of oil or oil fractions reduce feeding rates, reduce respiration and hence growth, and may disrupt gametogenesis in bivalve molluscs. Widdows *et al.* (1995) noted that the accumulation of PAHs contributed to a reduced scope for growth in *Mytilus edulis*.
- *Musculus discors* may exhibit a similar response to hydrocarbon contamination but no information was found.
- Suchanek (1993) reported that the anemones *Anthopleura* spp. and *Actinia* spp. survived in waters exposures to spills and chronic inputs of oils. Similarly, one month after the *Torrey Canyon* oil spill the dahlia anemone, *Urticina felina*, was found to be one of the most resistant animals on the shore, being commonly found alive in pools between the tide-marks which appeared to be devoid of all other animals (Smith, 1968). However, the hydroid *Tubularia* sp. experienced significant mortality when exposed to low concentrations of crude oil (Suchanek, 1993).
- Laboratory studies of the effects of oil and dispersants on several red algae species, including *Delesseria sanguinea* (Grandy 1984 cited in Holt *et al.* 1995) concluded that they were all sensitive to oil/ dispersant mixtures, with little differences between adults, sporelings, diploid or haploid life stages. O'Brien & Dixon (1976) suggested that red algae were the most sensitive group of algae to oil or dispersant contamination.

No direct evidence on the effects of hydrocarbon contamination on *Musculus discors* was found. The intolerance of the epifaunal species within the community is probably variable so that some species may be lost while others survive, so that species richness is likely to be reduced.

Synthetic compound contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available. No information concerning the effects of contaminants on *Musculus discors* was found. However,

- PAHs contributed to a reduced scope for growth in *Mytilus edulis* (Widdows *et al.*, 1995) and may have a similar effect on other members of the Mytilidae family but to an unknown degree.
- Similarly, Tri butyl-tin (TBT) was reported to affect bivalve molluscs as follows: reduced spat fall in *Pecten maximus*, *Musculus marmoratus* and *Limaria hians*; inhibition of growth in *Mytilus edulis* larvae, and inhibition of growth and metamorphosis in *Mercenaria mercenaria* larvae (Bryan & Gibbs, 1991).
- TBT is an endocrine disrupter and may adversely affect the normal transition from male to female in the protandrous development of *Musculus discors*, however, no evidence to this effect was found. It is possible, therefore, that *Musculus discors* is likely to be adversely affected and even killed by synthetic chemical contamination.

- Bryan & Gibbs (1991) suggested that some hydroids were intolerant of TBT levels between 100-500ng/l. Some hydroids appear to tolerate noxious conditions e.g. *Tubularia* sp., however, hydroid species richness is reduced in polluted conditions and hydroids may be excluded in highly polluted waters (Boero, 1984; Holt *et al.*, 1995).
- Rees *et al.* (2001) suggested that the intolerance of ascidian larvae to TBT may explain their recent recorded increases in abundance in the Crouch Estuary following a decline in TBT concentrations since 1988.
- Laboratory studies of the effects of oil and dispersants on several red algae species, including *Delesseria sanguinea* (Grandy 1984 cited in Holt *et al.* 1995) concluded that they were all sensitive to oil/ dispersant mixtures, with little differences between adults, sporelings, diploid or haploid life stages. O'Brien & Dixon (1976) suggested that red algae were the most sensitive group of algae to oil or dispersant contamination. Cole *et al.* (1999) suggested that herbicides, such as simazina and atrazine were very toxic to macrophytes.
- Cole *et al.* (1999) suggested that herbicides, insecticides, chlorophenols and dichlorophenols were very to highly toxic to marine organisms, especially algae, crustaceans and other invertebrates.
- Smith (1968) reported that *Alcyonium digitatum* was killed by exposure to dispersant (BP 1002) used to clean up the *Torrey Canyon* oil spill, whereas *Urticina felina* was found to be one of the most resistant species on the shore. Similarly, Hoare & Hiscock (1974) found that *Urticina felina* survived fairly near to an acidified halogenated effluent discharge in a 'transition' zone where many other species were unable to survive, suggesting a tolerance to chemical contamination.

Overall, *Musculus discors* may be adversely affected by synthetic chemical contamination, resulting in a loss of a proportion of the population. The associated epifaunal species, especially red algae, hydroids and ascidians, are intolerant of varying degrees and may be lost, reducing species richness.

Radionuclide contamination	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found.

Introduction of other substances	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed**.

De-oxygenation	Medium Q: Medium A: Low C: Medium	High Q: Low A: NR C: NR	Low Q: Low A: Low C: Low

De Zwaan & Mathieu (1992) suggested that members of the family Mytilidae were facultative anaerobes (capable of anaerobic respiration but preferring aerobic respiration) and were tolerant of a wide range of oxygen concentrations (euryoxic). The majority of evidence is derived from the study of *Mytilus* spp. and no information was found on *Musculus* spp. Hydroids inhabit mainly environments in which the oxygen concentration exceeds 5ml/l and respiration is aerobic (Gili & Hughes, 1995). *Delesseria sanguinea* was reported to be very intolerant of anaerobic conditions; at

15°C death occurs within 24hrs and no recovery takes place although specimens survived at 5°C. (Hammer 1972).

Overall, *Musculus discors* probably exhibits facultative anaerobiosis and is probably tolerant of a degree of hypoxia, whereas some members of the associated epifauna are probably highly intolerant. A reduction in oxygen levels below 2 mg/l for a week would probably be detrimental, but the effects would be limited in the strong to moderately strong water flow typical of this biotope. Therefore, a resistance of **Medium** is suggested. Resilience is probably **High** so that sensitivity is recorded as **Low**.

Nutrient enrichment	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not sensitive Q: NR A: NR C: NR

Moderate increases in nutrient levels may benefit *Musculus discors* by increasing macroalgal and phytoplankton productivity, increasing the proportion of organic particulates and hence increasing the food supply. Similarly, increased availability of organic particulates may benefit the other suspension feeding members of the community, e.g. hydroids, bryozoans, sponges and ascidians. However, Shumway (1990) reported the toxic effects of algal blooms on commercially important bivalves. This would suggest that prolonged or acute nutrient enrichment may have adverse effects on suspension feeding bivalves such as *Musculus discors*. Nutrient enrichment may also lead to increased turbidity (see suspended sediments above) and decreased oxygen levels due to bacterial decomposition of organic material (see above). The species composition of the epifaunal community may also change as a result. However, this biotope is considered to be **'Not sensitive'** at the pressure benchmark that assumes compliance with good status as defined by the WFD.

Organic enrichment	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Dense beds of *Musculus discors* in the north of the Llyn Peninsula and Holy Island, Anglesey were reported to be covered by a thick layer of mucous congealed fine silt and their own pseudofaeces (Hiscock, 1984; Brazier et al., 1999). The presence of pseudofaeces suggests a resistance to localised organic enrichment, although strong to moderately strong water flow would probably prevent build up of the products of decomposition (e.g. hydrogen sulphide). In their meta-analysis, Johnston & Roberts (2009) concluded that contaminants such a sewage and nutrients resulted in a loss of species diversity.

Therefore, it is possible that an increase in organic carbon may result in a loss of species richness, and an increase in siltation and suspended solids depending on the nutrient status of the receiving waters (i.e. oligotrophic or eutrophic). However, in the absence of any direct evidence, no assessment has been made.

Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

All marine habitats and benthic species are considered to have a resistance of '**None**' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is '**Very Low**'). Sensitivity within the direct spatial footprint of this pressure is, therefore '**High**'. Although no specific evidence is described confidence in this assessment is '**High**', due to the incontrovertible nature of this pressure.

Physical change (to another seabed type)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

Musculus discors requires hard substrata for attachment with byssal threads, as do the majority of the other epifauna and flora in the biotope. Therefore, a change in substratum from hard rock to sediment would result in loss of the biotope. Resistance to the pressure is considered '**None**', and resilience '**Very low**' or 'None'. The sensitivity of this biotope to change from hard rock or artificial substrata to sedimentary or soft rock substrata is assessed as '**High'**.

Physical change (to another sediment type)	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant on hard rock substrata.

Habitat structure changes - removal of substratum (extraction)	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant on hard rock substrata.

Abrasion/disturbance of the surface of the substratum or seabed	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

Erect epifaunal species are particularly vulnerable to physical disturbance. Veale *et al.* (2000) reported that the abundance, biomass and production of epifaunal assemblages decreased with increasing fishing effort. Hydroids and bryozoans are likely to be uprooted or damaged by bottom trawling or dredging and bryozoans repair damage slowly (Holt *et al.*, 1995). Physical abrasion would probably physically remove some *Musculus discors* individuals from their substratum and break the shells of some individuals, depending on their size. Disturbance of the cohesive mat of individuals may strip away tracts of the biotope or create gaps or 'edges' that may allow peeling away of the *Musculus discors* mat by tidal streams or wave action. Musculus discors may be affected indirectly by physical disturbance that removes macroalgae to which they are attached.

Sensitivity assessment. Physical abrasion may remove or damage a proportion of the *Musculus discors* bed and its associated epifauna. Therefore, a resistance of **Low** has been recorded. Resilience is probably **Medium**, so that sensitivity is recorded as **Medium**.

Penetration or disturbance of the substratum subsurface	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant on hard rock biotopes. However, penetrative activities may also cause abrasion as above.

Changes in suspended solids (water clarity)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Dense beds of *Musculus discors* in the north of the Llyn Peninsula and Holy Island, Anglesey were reported to be covered by a thick layer of mucous congealed fine silt and their own pseudofaeces (Hiscock, 1984; Brazier *et al.*, 1999). Brazier *et al.* (1999) reported that the waters around Holy Island where the *Musculus discors* beds were found, were highly turbid, and restricted kelps to the level of chart datum and red algae to depths of only 3-4 m. Other dense aggregations of *Musculus discors* were reported from areas of strong tidal streams and presumably low levels of suspended sediment and siltation.

Increased suspended sediment concentrations may clog suspension feeding apparatus, lead to the smothering of epifauna and cover the leaves of foliose algae, resulting in reduced photosynthesis. Therefore, the epifaunal community, especially of hydroids, bryozoans and ascidians, is likely to change, with intolerant species replaced by sediment tolerant species. However, although the species richness will decline, the *Musculus discors* populations will probably be little affected. A decrease in suspended sediment may reduce the food supply for suspension feeding epifauna but otherwise have limited effect on the biotope.

Sensitivity assessment. *Musculus discors* is probably tolerant of a wide range of suspended sediment levels based on the evidence above. Therefore, a resistance of **High** is recorded, so that resistance is also **High** (by default) and the biotope is considered to be **Not sensitive** at the benchmark level.

Smothering and siltation rate changes (light)	Medium Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Low Q: Low A: Low C: Low

Musculus discors lives in fixed nests of byssus threads on the surface of the substratum. The byssal mat collects silt and pseudofaeces (Hiscock, 1984; Brazier *et al.*, 1999), however, individual byssal nests within the mat open and the siphons of *Musculus discors* protrude out of the surface of the mat while feeding (Merrill & Turner, 1963; Baldock *et al.*, 1998). While the nest will protect the bivalve from the direct effects of smothering, deposited spoil will smother the surface of the mat. Individual *Musculus discors* are unlikely to be able to burrow up through deposited fine spoil. Smothered individuals will probably succumb to the effects of anoxia. Although, individuals on raised substrata such as the stipe of kelps may escape the effects of smothering, *Musculus discors* within the bed (or mat) are unlikely to be resistant. Large epifauna such as *Alcyonium digitatum*, *Nemertesia antennina*, large branching or globose sponges and anemones (e.g. *Urticina felina*) are unlikely to be adversely affected by smothering with 5 cm of sediment. However, smaller or encrusting forms and some ascidians (e.g. *Clavelina lepadiformis*) are likely to be smothered.

Sensitivity assessment. The effects of smothering will depend on duration. In moderately strong tidal streams or moderate wave exposure, 5 cm of fine sediment may not remain over the biotope for more than few tidal cycles. As most bivalve molluscs can respire anaerobically for short periods, it is possible that most of the population of *Musculus discors* would survive. Therefore, a resistance of **Medium** is suggested. Resilience is probably **High** so that a sensitivity of **Low** is recorded.

	Resistance	Resilience	Sensitivity
Smothering and siltation rate changes (heavy)	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

Musculus discors lives in fixed nests of byssus threads on the surface of the substratum. The byssal mat collects silt and pseudofaeces (Hiscock, 1984; Brazier *et al*., 1999), however, individual byssal nests within the mat open and the siphons of *Musculus discors* protrude out of the surface of the mat while feeding (Merrill & Turner, 1963; Baldock *et al*., 1998). While the nest will protect the bivalve from the direct effects of smothering, deposited spoil will smother the surface of the mat. Individual *Musculus discors* are unlikely to be able to burrow up through deposited fine spoil. Smothered individuals will probably succumb to the effects of anoxia. Although, individuals on raised substrata such as the stipe of kelps may escape the effects of smothering, *Musculus discors* within the bed (or mat) are unlikely to be resistant. Large epifauna such as *Alcyonium digitatum*, *Nemertesia antennina*, large branching or globose sponges and anemones (e.g. *Urticina felina*) are unlikely to be adversely affected by smothering with 5 cm of sediment. However, smaller or encrusting forms and some ascidians (e.g. *Clavelina lepadiformis*) are likely to be smothered.

Sensitivity assessment. The effects of smothering will depend on duration. In moderately strong tidal streams or moderate wave exposure, 30 cm of fine sediment may remain over the biotope for several tidal cycles. It is possible that a proportion of the *Musculus discors* population would succumb to anoxia in this period. Therefore, a resistance of **Low** is suggested. Resilience is probably **Medium**, so that a sensitivity of **Medium** is recorded.

Litter	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

Not assessed.

Electromagnetic changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found

Underwater noise changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Musculus discors is unlikely to respond to underwater noise and is sedentary.

Introduction of light or shading	High Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Not sensitive Q: Low A: Low C: Low

Circalittoral biotopes occur below the influence of light (by definition). Therefore, artificial light could potentially increase the depth to which red algae can colonize the biotope, assuming the light sources were strong enough to penetrate the water column. Similarly, shading may reduce red algal abundance within the biotope. Otherwise the biotope is unlikely to be adversely affected. Resistance and resilience are considered to be **High** and the biotope is recorded as **Not sensitive** to this pressure.

Barrier to species movement	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Musculus discors beds probably exhibit good local recruitment, so that barriers to larval transport are probably not significant (see resilience and recovery rates). However, if a bed was damaged significantly, then barriers to larval transport may prolong recovery.

Death or injury by collision	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant to seabed habitats. NB. Collision by grounding vessels is addressed under 'surface abrasion'.

Visual disturbance	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Musculus discors probably responds to shading by closing its values but its visual acuity is probably very limited. . However, visual disturbance as defined under the pressure benchmark is unlikely to be relevant.

Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Musculus discors is not subject to translocation nor genetic manipulation via breeding programmes or genetic modification. Therefore, this pressure is not relevant.

Introduction or spread of invasive non-indigenous species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Rapid colonizing and carpeting species such as *Didemnum vexillum*, *Botrylloides violaceus*, have been reported to smother mussels (*Mytilus* spp.) (GBNNSIP, 2012a&b). *Didemnum vexillum* may also smother epifauna and substrata in the shallow sublittoral. Therefore, both species could potentially smother *Musculus discors* beds. However, they are yet to be reported growing in the vicinity of *Musculus discors* beds. Therefore, in the absence of direct evidence no assessment has been made, but may be subject to reassessment as new evidence comes to light.

Introduction of microbial pathogens	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Musculus discors was reported to host the ciliate *Hypocomides musculus*, which was either parasitic or commensal. The metacercariae of the trematode *Gymnophallus* spp. were also reported to use

Musculus discors as a secondary host (Lauckner, 1983). However, no effects were given. It is likely that any parasitic infestation will result in at least sub-lethal effects, therefore, a resistance of **High** has been recorded. Hence, resilience is **High** and **Not sensitive** is recorded.

Removal of target species	Medium Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Low Q: Low A: Low C: Low

Musculus discors is not known to be subject to extraction or harvesting. Laminarians are subject to harvesting and aquaculture (see *Laminaria hyperborea* for example). Therefore, removal of the macroalgae will result in removal of substratum and attached *Musculus discors* when they are abundant within the biotope (see Baldock *et al*., 1998 for example). However, members of the population on the surrounding rocky substratum may be unaffected, and removal of macroalgae may provide new substratum for colonization. Therefore, a resistance of **Medium** has been recorded at the benchmark level. Resilience is probably **High** so that a sensitivity of **Low** has been recorded.

Removal of non-target species	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

The incidental removal of *Musculus discors* bed (or mat) by passing bottom fishing gear is addressed under abrasion above. However, the dense *Musculus discors* bed provides a unique habitat, attachment for other epifauna and macroalgae (e.g. red algae), and support infauna of other species within the nests and byssal mat. Loss of the mat would result in a loss of species diversity. Therefore, a resistance of **Low** is recorded. Resilience is probably **Medium** so that a sensitivity of **Medium** is recorded.

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