

Multi-rig Trawl on Subtidal Mussel Bed on Rock

Introduction

The Assessing Welsh Fisheries Activities Project is a structured approach to determine the impacts from current and potential fishing activities, from licensed and registered commercial fishing vessels, on the features of Marine Protected Areas.

1. Gear and Feature	Multi-rig Trawl on Subtidal Mussel Bed on Rock
2. Risk Level	Purple (High risk)
3. Description of Feature	<p>Subtidal mussel bed on rock habitats are comprised of three relevant biotopes (see annex 1 for full biotope descriptions).</p> <p>1. IR.LIR.IFaVS.MytRS are shallow, tide swept, reduced salinity infralittoral rock with dense beds of <i>Mytilus edulis</i>.</p> <p>2. CR.MCR.CMus.CMyt typically occurs on the upper faces of tide-swept circalittoral bedrock, boulders and mixed substrata exposed to varying amounts of wave action.</p> <p>3. CR.MCR.CMus.Mdis (<i>Musculus discors</i>) beds with cushion and branching sponges on moderately tide-swept and exposed bedrock, boulders and cobbles.</p> <p>The biotope IR.LIR.IFaVS.MytRS occurs in shallow, often tide-swept, reduced salinity conditions, comprising dense beds of the mussel <i>Mytilus edulis</i> with the occasional barnacle <i>Balanus crenatus</i>. Mussels appear to provide the predominant substratum in this biotope. The mussel shells are colonized by epibiota - species that can survive reduced (but not necessarily 'low') salinity. Most species are suspension feeders and so do not interact but the predatory starfish <i>Asterias rubens</i> can be very common in this biotope and can have a major effect on survival of the mussels.</p>

The dominant species in the biotope can be present throughout the year except for filamentous brown and any other algae which most likely show seasonal change related to light levels. It is possible that some species in the biotope will be killed by low salinity during heavy rain in the winter.

The mussels provide hard substratum for a range of algae and invertebrates to settle and interstices for polychaete worms and other mobile biota to live. If sediments are present amongst the mussels, infaunal burrowing species will be supported (Tillin & Mainwaring, 2015).

The biotope **CR.MCR.CMus.CMyt** occurs in strong tides on a variety of substrata. Although a wide range of species are associated with *Mytilus edulis* reef or bed biotopes these characterizing species occur in a range of other biotopes and are therefore not considered to be obligate associates.

Species richness is not particularly high, *Asterias* sp. are usually common, as are crabs such as *Cancer pagurus*, *Carcinus maenas* and *Necora puber*. Hydroids such as *Kirchenpaueria pinnata* and those characteristic of strong tides and a little scour are also often present such as *Sertularia argentea* and *Tubularia indivisa*. Ascidians such as *Molgula manhattensis* and *Polycarpa* spp. and *Flustra foliacea* may be present, particularly in silty conditions, although not often on the mussels themselves (Tyler-Walters, 2016a).

The gaps between interconnected mussels form numerous interstices for a variety of organisms. In the intertidal *Mytilus* sp. beds the species richness and diversity increases with the age and size of the bed (Suchanek, 1985; Tsuchiya & Nishihira, 1985, 1986; Seed & Suchanek, 1992). The mussel matrix may support sea cucumbers, anemones, boring clionid sponges, ascidians, crabs, nemerteans, errant polychaetes and flatworms (Suchanek, 1985; Tsuchiya & Nishihira, 1985, 1986). Epifloral/faunal grazers, such as limpets, chitons and sea urchins (e.g. *Echinus esculentus*), may use the

	<p>mussel bed as a refuge. Their grazing reduces epiflora/faunal fouling of <i>Mytilus edulis</i> shells, hence reducing the potential for dislodgement of the mussels due to strong water flow or storm surges (Suchanek, 1985).</p> <p>The biotope CR.MCR.CMus.Mdis: The mussel <i>Musculus discors</i> occurs in dense mats (around 60,000 individuals per m²) and occasionally completely coats all available surfaces. There is 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 substratum that is free of mussels. An investigation into the infauna associated with <i>Musculus</i> beds found 88 infaunal species (Hopkinson, 2011). The majority of the UK records for this biotope are from the Llyn Peninsula (JNCC).</p>
<p>4. Description of Gear</p>	<p>Otter/stern trawlers range in size from small, undecked boats, powered by outboard engines up to large vessels with up to 8,000HP engines (Galbraith <i>et al</i>, 2004).</p> <p>An otter trawl is a cone-shaped net that is towed over and remains in contact with the seabed. The net is usually towed from the stern of a vessel and comprises: a codend (which retains the catch), the body of the net, the mouth of the net with two lateral wings extending forward from the mouth of the net and connected to the boat via warps. The trawl mouth is kept open vertically by a headline with floats, it also has a ground rope (sweep/bridle) equipped with rubber discs, bobbins, spacers etc. to protect the trawl from damage. Tickler chains can be attached to the ground rope in certain fisheries to disturb the target species from the seabed into the net.</p> <p>The mouth of the net is kept open horizontally by two otter boards or 'doors'. These can be made of wood or steel and can be shaped differently depending on the type of vessel, water depth and target species. The 'flat' or 'v' shaped doors are mainly used by inshore vessels. The weight of the doors vary depending on the size of the net and the power of the vessel. During fishing operations the doors and the ground rope/chain are in constant contact with the seabed as this</p>

helps to disturb the fish and send them upwards into the mouth of the net.

The door size will vary depending on the power and size of the vessel and the net being used. The weight of the doors will depend on the material used in their construction e.g wooden doors are usually made from hardwood planks over an inch thick, these doors will be heavier than softwood construction but lighter than steel construction (SEAFISH).

The area of seabed impacted by the doors will depend on the angle of the doors to the net. When a door is 4m long, the width of the track is about 2m with a door angle of 30 degrees. The track can be made narrower by reducing the angle of the door to the net or by altering the height/length ratio of the door (FAO). The penetration depth of otter trawl gear components range from 2-10cm in sand sediments and 2-35cm in muddier sediment (Eigaard *et al*, 2016).

On very rough seabed special rock hopper gear can be used. The rockhopper gear is simply the heavy fibre ground rope furnished with rubber discs or rubber wheel rollers (bobbins) and spacers which roll over small obstructions or rough ground.

Otter trawls generally cover a greater area of ground than beam trawls (MMO, 2014). The ground rope will have the most extensive contact with the seabed, with the length of the ground rope depending on the size of the gear.

Multi-rig trawling is the method of towing two or more otter trawls side-by-side by one vessel. Multi-rig trawls can be towed with either a 2 or 3 warp system depending upon the capabilities of the vessel's winch. The basic rig is, similar to a single net rig, with trawl doors on each outside warp to spread the gear and a clump weight on the tail of the centre warp to keep the gear in contact with the seabed. Between the doors and clump weight the two nets are towed side by side. The amount of bridle (sweep) between the net and doors and net and weight depends on the type of seabed worked and the target

	<p>species.</p> <p>The centre weight can range from a simple clump of heavy chain to a specialist depressor style weight and is usually about 25%-50% heavier than one door. The multi-rig clump can have a penetration depth of between 3-15cm in both sand and mud sediments (Eigaard <i>et al</i>, 2016). To keep both nets square and in their most efficient mode, the centre wire has to be shortened slightly. The amount depends on the length of wire between the doors and the vessel and the door spread (Seafish, 2011).</p> <p>The demersal trawl door is designed to hydrodynamically spread the mouth of a trawl and to have sufficient weight to ensure that the trawl gear maintains contact with the seabed. The roller clump is designed to distribute the towing force of the central warp between the two gears of a twin trawl and again have sufficient weight to ensure that the gears maintain contact with the seabed. These are the heaviest individual components of a trawl gear and are expected to have the greatest physical impact on the seabed (Ivanovic <i>et al</i>, 2011).</p> <p>A multi-rig designed for catching prawns covers a smaller area than a single trawl due to the low headline (~ 0.5 fathom) and reduced sweep length (Holst & Revill, 2009).</p>
<p>5. Assessment of Impact Pathways:</p> <ol style="list-style-type: none"> 1. Damage to a designated habitat feature (including through direct physical impact, pollution, changes in thermal regime, hydrodynamics, light etc.). 2. Damage to a designated habitat feature via removal of, or other detrimental impact on, typical species. 	<p>There are a lack of studies specifically investigating the impacts of multi-rig trawl gear on subtidal mussel bed on rock communities; therefore it is necessary to widen the research parameters to include other comparable bottom contacting mobile gear.</p> <p>1. Demersal mobile fishing gear reduces habitat complexity by: removing emergent epifauna, smoothing sedimentary bedforms, and removing taxa that produce structure (Auster & Langton, 1999). Otter trawling can cause physical and biological degradation of benthic habitats (Sanchez-Lizaso <i>et al</i>, 1990). Ways in which gear affects the seabed can be classified as: scraping and ploughing; sediment resuspension; and physical destruction, removal, or scattering of non-target benthos (Jones, 1992).</p>

Mytilus edulis lives on the surface of the seabed held by byssus threads attached to either the substratum or to other mussels in the bed. Activities resulting in abrasion and disturbance can either directly affect the mussel by crushing them or indirectly affect them by the weakening or breaking of their byssus threads making them vulnerable to displacement (Denny, 1987). Once the beds are fragmented they are vulnerable to being displaced where they are unlikely to survive (Dare, 1976). Disturbed or displaced mussels can also be affected by lower tolerances (24–28% lower) to toxic compounds and increased risk of predation, compared to byssally attached mussels (Rajagopal *et al*, 2005).

The Scottish MPA Project Fisheries Management Guidance (JNCC, 2013) suggests that scallop dredges and other demersal towed gear are likely to result in the removal of a proportion of the bed along with its associated fauna and flora.

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.

Mainwaring *et al.* (2014) reviewed the evidence for recovery of *Mytilus edulis* beds from disturbance and an earlier study by Seed & Suchanek (1992) reviewed studies on the recovery of 'gaps' in *Mytilus* spp. beds. It was concluded that beds occurring on less exposed sites took longer to recover after a disturbance event than beds found at more exposed sites. However, the slowest recovering sites are at the least risk of natural disturbance and often considered more 'stable' (Lewis, 1964) as they are less vulnerable to removal by wave action. Death or disturbance of underlying individuals may detach the mussel bed from the substratum, leaving the bed

vulnerable to tidal scour and wave action (Seed & Suchanek, 1992).

Blue mussels, *Mytilus edulis*, are sessile, attached organisms that are unable to repair significant damage to individuals. Mussels do not reproduce asexually and therefore the only mechanism for recovery from significant impacts is larval recruitment to the bed or the area where previously a bed existed (Tyler-Walters 2016a).

The resilience and the ability to recover from human induced pressures is a combination of the environmental conditions of the site, the frequency (repeated disturbances versus a one off event) and the intensity of the disturbance. Recovery of impacted populations will always be mediated by random events and processes acting over different scales including, but not limited to, local habitat conditions, further impacts and processes such as larval-supply and recruitment between populations (Tillin & Mainwaring, 2015).

Larval settlement and recruitment of many invertebrates are strongly influenced by substrate structure (Botero & Atema 1982; Bourget *et al*, 1994; Jacobi & Langevin, 1996; Lemire & Bourget, 1996; Lapointe & Bourget, 1999; Linnane *et al*, 2000). Compared with a smooth substrate such as mud or sand, the roughness of solid elements also increases turbulence above the seabed, which in turn will increase the amount of organisms and no-living matter available to the benthic suspension feeders (Fréchette *et al*, 1989; Butman *et al*, 1994; Lenihan, 1999). Moreover, the solid elements serve as attachment sites and increase substrate heterogeneity and complexity, providing refuges for prey and predators (Revelas, 1982; Arnold, 1984; Orth *et al*, 1984; Sponaugle & Lawton, 1990; Lee & Kneib, 1994; Hedvall *et al*, 1998). The altered composition of the seabed induced by bottom contacting mobile gears thereby interferes with recruitment, growth and survival of the associated fauna.

Recruitment within a population or between adjacent populations and recovery of *Musculus discors* is probably fairly rapid. Therefore, where some of the population is lost or its abundance reduced it is suggested that prior abundance may recover within up to two years.

However, where the bed is significantly or severely damaged and recovery is dependant on recruitment from distant populations recruitment may take longer. If a population is removed 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 (Tyler-Walters, 2016b).

In conclusion, direct contact between multi-rig trawl gear and subtidal mussel beds could cause structural damage to the mussel beds through the ploughing and scraping of the beam which would result in the removal and loosening of mussel matrices. Those individuals which have been loosened are at a greater risk, in tidal influenced areas, of being removed by natural disturbances. Recovery is possible although dependant on local environmental factors.

2. Demersal trawls can cause direct mortality to non-target organisms through shoe, tickler chain or chain mat impact on the seabed (Bergman & van Santbrink, 2000). The use of dredges, beam trawls, otter trawls and the development of heavier and more powerful fishing gear has increased concern about the impact on benthic communities (Jennings & Kaiser, 1998; Hall, 1999).

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 (Holt *et al*, 1995).

In Limfjorden, Denmark, observations on commercial dredge tracks and field experiments with controlled dredging have demonstrated a significant short-term effect on the infauna. In particular, the polychaetes associated with mussel beds had a reduced density after dredging, and gastropods and bivalves were also reduced in number

		<p>after dredging (Dolmer <i>et al</i>, 2002).</p> <p><i>Mytilus edulis</i> beds are not dependent on associated species to create or modify habitat, provide food or other resources, although their loss would represent a loss of diversity. For attached organisms the sensitivity of the <i>Mytilus edulis</i> biotope would be of primary concern as removal of the reef would also lead to removal of the attached species.</p> <p>The associated epifaunal community of <i>Muculus discors</i> will probably develop within less than 5 years of removal although slow growing sponges may take many years to develop (Tyler-Walters, 2016b).</p> <p>In conclusion, multi-rig trawl gear on subtidal mussel beds can damage and/or remove flora and fauna, reducing biodiversity. Recovery, although possible is dependent on local environmental factors.</p>
<p>6. MPAs where feature exists</p>	<p>Menai Strait & Conwy Bay SAC</p>	<p>There are records of subtidal <i>Mytilus</i> Mussel Beds on rock within the Menai Strait between the Britannia Bridge and Menai Bridge</p>
	<p>Lleyn Peninsula and the Sarnau SAC</p>	<p>There are records of subtidal <i>Mytilus</i> Mussel Beds on rock along the North Llyn coast between Nefyn and Uwchmynydd and also off Cadlan and off Cilan head.</p> <p>Subtidal <i>Musculus discors</i> beds have been recorded off shore along the North Llyn coast from Trevor to Uwchmynydd.</p>
	<p>Cardigan Bay SAC</p>	<p>There are records of subtidal <i>Mytilus</i> Mussel Beds on rock westwards of Cardigan Island.</p>
	<p>Pembrokeshire Marine SAC</p>	<p>There are records of subtidal <i>Mytilus</i> Mussel Beds on rock between Strumble Head and Ynys Deullyn; within St Bride's Bay; around Skomer Island; between the 'Falls' rocks and Grasholm; around Skokholm Island and off St Govan's Head.</p>

		Subtidal <i>Musculus discors</i> beds on rock have been recorded off shore near St Anne's Head and between 'Griffiths rocks' and 'Monkey rocks'.
	Carmarthen Bay & Estuaries SAC	There are records of subtidal <i>Mytilus</i> Mussel Beds on rock around Caldy Island; off Worms Head and between Worms Head and Port Eynon

7. Conclusion

The information presented above indicates that the action of fishing with multi rig trawl gear directly on subtidal mussel bed on rock features is likely to be lethal by crushing or be indirectly damaging by weakening or breaking of the byssus threads, making them prone to becoming unattached. While recovery is possible this is dependant on local environmental factors such as larval availability, tidal influence and the extent of the remaining bed. Recovery would also be less likely in periods of prolonged fishing. The damage or removal of a mussel bed would also result in the damage or removal of attached species.

8. References

- Arnold, W.S. (1984). The effects of prey size, predator size, and sediment composition on the rate of predation of the blue crab, *Callinectes sapidus* Rathbun, on the hard clam, *Mercenaria mercenaria* (Linné). J Exp Mar Biol Ecol 80:207–219
- Auster, P.J. & Langton, R.W. (1999). The effects of fishing on fish habitat. In: Benaka L (ed) Fish habitat essential fish habitat (EFH) and rehabilitation. Am Fish Soc 22:150-187
- Bergman, M.J.N. & Santbrink, J.van. (2000). Mortality in megafaunal benthic populations caused by trawl fisheries on the Dutch continental shelf in the North Sea in 1994 ICES J. Mar. Sci. 57 (5): 1321-1331
- Botero, L. & Atema, J. (1982). Behavior and substrate selection during larval settling in the lobster *Homarus americanus*. J Crust Biol 2:59-69
- Bourget, E., DeGuise, J., Daigle, G. (1994). Scales of substratum heterogeneity, structural complexity, and the early establishment of a marine epibenthic community. J Exp Mar Biol Ecol 181:31–51
- Butman, C.A., Fréchette, M., Geyer, W.R., Starczak, V.R. (1994). Flume experiments on food supply to the blue mussel *Mytilus edulis* L as a function of boundary-layer flow. Limnol Oceanogr 39:1755–1768
- Dare, P.J. (1976). Settlement, growth and production of the mussel, *Mytilus edulis* L., in Morecambe Bay, England. *Fishery Investigations, Ministry of Agriculture, Fisheries and Food, Series II, 28* , 25pp.
- Denny, M.W. (1987). Lift as a mechanism of patch initiation in mussel beds. *Journal of Experimental Marine Biology and Ecology*, 113, 231-45

- Dolmer, P., Kristensen, T., Christiansen, M.L., Petersen, M.F., Kristensen, P.S., Hoffmann, E. (2002). Short-term impact of blue mussel dredging (*Mytilus edulis* L) on a benthic community. *Hydrobiologia*
- Eigaard, O.R., Bastardie, F., Breen, M., Dinesen, G.E., Hintzen, N.T., Laffargue, P., Mortensen, L.O., Nielsen, J.R., Nilsson, Hans. C., O'Neill, F.G., Polet, H., Reid, D.G., Sala, A., Sko'ld, M., Smith, C., Sorensen, T.K., Tully, O., Zengin, M. & Rijnsdorp, A.D. (2016). Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. – *ICES Journal of Marine Science*, 73: i27–i43.
- FAO. Dragged gears – Food and Agriculture Organisation of the United Nations, Fisheries and Aquaculture Department. <ftp://ftp.fao.org/docrep/fao/010/a1466e/a1466e02.pdf> (viewed 25/01/2017)
- Fréchet, M., Butman, C.A., Geyer, W.R. (1989). The importance of boundary-layer flows in supplying phytoplankton to the benthic suspension feeder, *Mytilus edulis* L. *Limnol Oceanogr* 34:19–36
- Galbraith, R.D. & Rice, A. after Strange, E.S. (2004). An introduction to Commercial Fishing gear and methods used in Scotland. Scottish Fisheries Information Pamphlet No. 25. Fisheries Research Services.
- Hall, S.J. (1999). The effects of fishing on marine ecosystems and communities. Blackwell, Oxford
- Hedvall, O., Moksnes, P.O., Pihl, L. (1998). Active habitat selection by megalopae and juvenile shore crabs *Carcinus maenas*: a laboratory study in an annular flume. *Hydrobiologia* 375:89–100
- Holst, R. & Revill, A. (2009). A simple statistical method for catch comparison studies. *Fisheries Research* 95. 254-259
- Holt, T.J., Jones, D.R., Hawkins, S.J. & Hartnoll, R.G. (1995). The sensitivity of marine communities to man induced change - a scoping report. *Countryside Council for Wales, Bangor, Contract Science Report*, no. 65.
- Hopkinson, L. (2011). Investigation into *Musculus discors* beds in the Llyn Peninsula. MSc thesis
- Ivanović, A., Neilson, R.D. & O'Neill, F.G. (2011). Modelling the physical impact of trawl components on the seabed and comparison with sea trials. *Ocean Engineering*, 38(7), 925-933.
- Jacobi, C.M. & Langevin, R. (1996). Habitat geometry of benthic substrata: effects on arrival and settlement of mobile epifauna. *J Exp Mar Biol Ecol* 206:39–54
- Jennings, S. & Kaiser, M.J. (1998). The effects of fishery on marine ecosystems. *Adv Mar Biol* 34:201–352
- JNCC. <http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002165> (viewed 06/03/2017)
- JNCC. (2013). Blue Mussel Beds. Scottish MPA Project Fisheries Management Guidance, *Joint Nature Conservation Committee, Peterborough*, http://jncc.defra.gov.uk/pdf/SMPA_fisheries_management_guidance_blue_mussel_beds_July_2013.pdf
- Jones, B. (1992). Environmental impact of trawling on the seabed: A review, *New Zealand Journal of Marine and Freshwater Research*, 26:1, 59-67
- Lapointe, L. & Bourget, E. (1999). Influence of substratum heterogeneity scales and complexity on a temperate epibenthic marine community. *J Exp Mar Biol Ecol* 189:159–170 19
- Lee, S.Y. & Kneib, R.T. (1994). Effects of biogenic structure on prey consumption by the xanthid crabs *Eurytium limosum* and *Panopeus herbstii* in a salt marsh. *J Exp Mar Biol Ecol* 104:39–47
- Lemire, M. & Bourget, E. (1996). Substratum heterogeneity and complexity influence micro-habitat selection of *Balanus* sp and *Tubularia crocea* larvae. *J Exp Mar Biol Ecol* 135:77–87

- Lenihan, H.S. (1999). Physical-biological coupling on oyster reefs: how habitat structure influences individual performance. *Ecol Monogr* 69:251–275
- Lewis, J.R. (1964). *The ecology of rocky shores*. English University Press, London
- Linnane, A., Mazzoni, D., Mercer, J.P. (2000). A long-term mesocosm study on the settlement and survival of juvenile European lobster *Homarus gammarus* L in four natural substrata. *J Exp Mar Biol Ecol* 249:51–64
- Mainwaring, K., Tillin, H. & Tyler-Walters, H. (2014). Assessing the sensitivity of blue mussel beds to pressures associated with human activities. *Joint Nature Conservation Committee, JNCC Report No. 506.*, Peterborough, 96 pp.
- MMO. (2014). Fishing gear glossary for the matrix (by gear type). Management of fisheries in European marine sites implementation group. Marine Management Organisation.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/314315/gearglossary_gear.pdf (viewed 18-01-2017)
- Orth, R.J., Heck, K.L., Montfrans, J van. (1984). Faunal communities in seagrass beds: a review of the influence of plant structure and prey characteristics on predator-prey relationships. *Estuaries* 7:339–350
- Rajagopal, S., Van der Velde, G., Van der Gaag, M. & Jenner, H.A. (2005). Byssal detachment underestimates tolerance of mussels to toxic compounds. *Marine pollution bulletin*, 50(1), pp.20-29.
- Revelas, E.C. (1982). The effect of habitat structure on the predator–prey relationship between the green crab, *Carcinus maenas*, and the blue mussel, *Mytilus edulis*. *Biol Bull* 163:367–368
- Sanchez-Lizaso, J.L., Guillen, J.E., Ramos-Espla, A.A. (1990). The regression of *Posidonia oceanica* meadows in El Campello. *Rapports C.I.E.S.M.* 32(1): 7.
- SEAFISH. Guidelines for the construction of Small Flat wooden trawl doors.
http://www.seafish.org/media/Publications/Guidelines_for_Construction_of_Small_Flat_Wooden_Trawl_Doors.pdf (viewed 25-01-2017)
- SEAFISH. (2011). Gear Technology Note – Towed Gear.
http://www.seafish.org/media/Publications/SeafishGuidanceNote_TowedGear_201102.pdf (viewed 01/02/17).
- Seed, R. & Suchanek, T.H. (1992). Population and community ecology of *Mytilus*. In *The mussel Mytilus: ecology, physiology, genetics and culture*, (ed. E.M. Gosling), pp. 87-169. Amsterdam: Elsevier Science Publ. [Developments in Aquaculture and Fisheries Science, no. 25.]
- Sponaugle, S. & Lawton, P. (1990). Portunid crab predation on juvenile hard clams: effects of substrate type and prey density. *Mar Ecol Prog Ser* 67:43–53
- Suchanek, T.H. (1985). Mussels and their role in structuring rocky shore communities. In *The Ecology of Rocky Coasts: essays presented to J.R. Lewis, D.Sc.*, (ed. P.G. Moore & R. Seed), pp. 70-96.
- Tillin, H.M. & Mainwaring, K. (2015). *Mytilus edulis* beds on reduced salinity tide-swept infralittoral rock. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: <http://www.marlin.ac.uk/habitat/detail/259>
- Tsuchiya, M. & Nishihira, M. (1985). Islands of *Mytilus* as a habitat for small intertidal animals: effect of island size on community structure. *Marine Ecology Progress Series*, 25, 71-81.
- Tsuchiya, M. & Nishihira, M. (1986). Islands of *Mytilus edulis* as a habitat for small intertidal animals: effect of *Mytilus* age structure on the species composition of the associated fauna and community organization. *Marine Ecology Progress Series*, 31, 171-178.

- Tyler-Walters, H. (2016a). *Mytilus edulis* beds with hydroids and ascidians on tide-swept exposed to moderately wave-exposed circalittoral rock. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: <http://www.marlin.ac.uk/habitat/detail/208>
- Tyler-Walters, H. (2016b). *Musculus discors* beds on moderately exposed circalittoral rock. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: <http://www.marlin.ac.uk/habitat/detail/90>
- Veale, L.O., Hill, A.S., Hawkins, S.J. & Brand, A.R. (2000). Effects of long term physical disturbance by scallop fishing on subtidal epifaunal assemblages and habitats. *Marine Biology*, 137, 325-337.

Annex 1

Biotope descriptions (version 15.03) (JNCC - <http://jncc.defra.gov.uk/marine/biotopes/hierarchy.aspx?level=5>)

IR.LIR.IFaVS.MytRS - *Mytilus edulis* beds on reduced salinity infralittoral rock

This biotope occur in shallow, often tide-swept, reduced salinity conditions. Dense beds of the mussel *Mytilus edulis* with the occasional barnacle *Balanus crenatus*. A wide variety of epifaunal colonisers on the mussel valves, including seaweeds, hydroids and bryozoans can be present. Predatory starfish *Asterias rubens* can be very common in this biotope. This biotope generally appears to lack large kelp plants, although transitional examples containing mussels and kelps plants may also occur. More information needed to validate this description.

CR.MCR.CMus.CMyt - *Mytilus edulis* beds with hydroids and ascidians on tide-swept exposed to moderately wave-exposed circalittoral rock

This biotope typically occurs on the upper faces of tide-swept circalittoral bedrock, boulders and mixed substrata exposed to varying amounts of wave action. The mussel *Mytilus edulis* forms dense beds, to the exclusion of other species. The starfish *Asterias rubens* is frequently recorded, and it predares heavily on the mussels. Occasionally, the anemone *Urticina felina* may be seen within crevices in the rock or on gravel patches. Crabs such as *Necora puber* and *Carcinus maenas* may be seen on the rock or mussels whilst fauna observed in crevices typically consists of the lobster *Homarus gammarus* and the crab *Cancer pagurus*. The anemone *Sargatia elegans* can be seen attached to bedrock and cobbles, whereas the barnacle *Balanus crenatus* may be seen attached to the mussels themselves.

CR.MCR.CMus.Mdis - *Musculus discors* beds on moderately exposed circalittoral rock

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 substratum 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 *Bugula 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 gravelly 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 cartilagineum*, *Dictyopteris membranacea*, *Cryptopleura ramosa* and *Heterosiphonia plumosa*. The crab *Cancer pagurus* may be observed in crevices.