Beam Trawl on Subtidal Boulder and Cobble Reef

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	Beam Trawl on Subtidal Boulder and Cobble Reef
2. Risk Level	Purple (High risk)
3. Description of Feature: (see Annex 1 for further information on description)	‘Boulder and cobble’ reef has been split apart from ‘Bedrock reef’ for the purposes of the Assessing Welsh Fishing Activities project. A full set of biotopes that have been assosciated with the boulder and cobble reef habitiat are listed in Annex 2. Subtidal boulder and cobble reefs are areas of predominantly cobbles and boulders ranging in size from 64mm upwards (Irving, 2009). They can be surrounded by a matrix of smaller sized material and are often dominated by epifaunal species (JNCC). By its nature, boulder and cobble reef is more vulnerable to being moved than bedrock reef due to its smaller particle size, although large boulders will be more similar to bedrock. Due to the interstitial spaces and hard surfaces of coarse particles, this type of reef is capable of harbouring a rich variety of species including corals, anemones and sponges (Irving, 2009) and encompass a wide range of biological communities. The larger boulders support a fauna and flora that is much the same as bedrock reef (Tillin & Tyler-Walters, 2016; Readman, 2016; Tillin & Hiscock, 2016). Shallow areas may be dominated by kelp and other seaweeds, whereas deeper areas are dominated by animals (e.g. sponges, anthozoans and bryozoans)

	(JNCC). The biological communities on smaller boulders and cobbles are very much influenced by the degree of mobility and also scour from surrounding sediments (Tillin & Tyler-Walters, 2016; Readman, 2016; Tillin & Hiscock, 2016). In general, the more mobile cobbles and those more influenced by scour will support less life. These areas tend to be dominated by Keel worms (*Pomatoceros spp*.) and encrusting bryozoans (Tillin & Tyler-Walters, 2016). As the stability increases, species like Hornwrack (*Flustra foliacea*) and erect hydroids tend to become more common (Tyler-Walters & Ballerstedt, 2007). In some areas cobbles and boulders become even more consolidated and support seaweeds like Sugar kelp (*Saccharina latissima*) or Sea oak (*Halidrys siliquosa)* in shallow water (Stamp & Tyler-Walters, 2002) and a diverse faunal turf in deeper waters. Other habitats associated with boulder and cobble reefs in Welsh waters include brittlestar beds, a faunal turf dominated by sea squirts and crusts of Ross worm (*Sabellaria spinulosa)*. In north Cardigan Bay, within the Pen Llyn a'r Sarnau SAC, the Sarnau reefs are glacial features that often have extensive algal communities. The communities found on large boulders are generally the same as those found on bedrock (CCW, 2009a). The most commonly occurring biotopes which are found on the 'boulder and cobble' points in Wales are CR.HCR.XFa (Mixed faunal turf communities), SS.SMx.CMx.FluHyd (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment), IR.HIR.KFaR.FoR (Foliose red seaweeds on exposed lower infralittoral rock), SS.SMx.CMx.OphMx (*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment), SS.SCS.CCS.PomB (*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles) and CR.HCR.XFa.ByErSp (Bryozoan turf and erect sponges on tide-swept circalittoral rock).

4. Description of Gear	A beam trawl consists of a cone-shaped body of net ending in a bag or codend, which retains the catch. In these trawls the horizontal opening of the net is provided by a beam, made of wood or metal, attached to two solid metal plates called 'shoes'. These 'shoes' are welded to the end of the beam which slide over the seabed when the beam and net are dragged by the vessel (FAO, 2001). When fishing for flatfish, mainly sole or plaice, the beam trawl is equipped with tickler chains to disturb the fish from the seabed. For operations on rough fishing grounds chain matrices/mats can be used. Chain matrices/mats are rigged between the beam and the ground rope to prevent damage to the net and to prevent boulders/stones from being caught by the trawl. A beam trawl is normally towed on outriggers with one 4m beam trawl on each side of a powerful vessel, the gear can reach a weight of up to 9000kg. A 'Eurocutter' beam trawler with an engine power <221Kw will leave parallel trawl tracks of approximately 4m wide and 11m apart on the seabed (ICES, 2014). The total length of the net used on a 'Eurocutter' should be between 10 and 15m. Inshore vessels may use one smaller beam, approximately 2m, off the stern of the vessel. The total length of the net should be about 5m. The penetration depth of a beam trawl ranges from 1 to 8cm but depends on the weight of the gear and the towing speed, as well as on the type of substrate (Paschen *et al,* 2000).
5. Assessment of Impact Pathways: 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.	There is a lack of studies specifically investigating the impacts of beam trawling on the associated biotopes listed in Annex 2; therefore it is necessary to widen the reseach parameters to include other comparable bottom contacting mobile gear. **1.** Demersal beam trawl gear can have a direct physical effect on the seabed wherever the beams, shoes, mats, nets and chains have contact with the seabed. 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). Short-term effects of bottom trawling on a 'hard-bottom' (pebble, cobble, and boulder) seafloor were studied on the outer continental shelf in the eastern Gulf of Alaska. Eight sites were trawled to obtain quantitative data. Boulders were displaced, and large epifaunal invertebrates were removed or damaged by a single trawl pass. These structural components of habitat were the dominant features on the seafloor (Freese *et al*, 1999). On compact substrate (with a greater percentage of cobble), the trawl path was visible as a darker band because the layer of lighter-colored overlying silt was removed. This study demonstrated that a significant number of boulders were displaced, and emergent epifauna were removed or damaged by a single pass of a trawl (Freese *et al*, 1999). Although this study addressed only single tows, areas subjected to multiple, long-term trawling would probably show a greater amount of cobble and boulder displacement. **In conclusion**, direct contact between beam trawl gear and the subtidal boulder and cobble reef could cause boulder and cobble displacement and scours in the underlying sediment caused by dragging of the boulders and cobbles by the gear. **2.** Demersal mobile fishing gear reduces habitat complexity by: removing emergent epifauna, smoothing sedimentary bedforms, and removing or scattering non target taxa that produce structure (Auster & Langton, 1999; Jones, 1992). Subtidal boulder and cobble reef sites are thought to be sensitive to towed demersal gear effects, as they often are abundant in encrusting and erect biota that are easily damaged by bottom trawling (Kaiser *et al*, 2002). Demersal mobile fishing gear has the potential to directly displace, injure, remove, or destroy flora and fauna colonies (Van Dolah *et al*; 1987; Sainsbury *et al*, 1997; Freese *et al*, 1999; Fosså *et al*, 2002; Wassenberg *et al*, 2002). Injuries, which may lead to delayed mortality

	(Freese, 2003), demand costly resources for regeneration, potentially impairing colony growth and sexual reproduction (Rinkevich, 1996; Henry & Kenchington, 2004), and hence may ultimately limit population recruitment. Demersal mobile fishing gear can also alter seabed physical characteristics, such as sediment properties (Schwinghamer *et al*, 1998; Kenchington *et al*, 2001), microtopography (Caddy, 1973; Thrush *et al*, 1995; Currie & Parry, 1996; Schwinghamer *et al*, 1998) and substrate stability (Caddy, 1973; Black & Parry, 1994, 1999; Freese *et al*, 1999), while resuspending sediments (Churchill, 1989; Jennings & Kaiser, 1998). These physical characteristics affect recruitment and community structure of colonial epifauna (e.g. hydroids, (Gili & Hughes, 1995)), hence their modification may also alter the species composition. The solidity of rock and the fractal complexity of its surface provide an abundance of stable, niche habitats exploited by a wide diversity of species, leading to the belief that rocky reef habitats have high biodiversity (Kostylev *et al*, 2005). Exclusive communities live in crevices and often do not protrude above the surface of the rock, they are are not thought to be at risk of damage from towed demersal gear. However, sensitive species that often characterise this feature occur on the surface of the subtidal bedrock reef and have limited protection from abrasion (Connor *et al*, 2004). The Marine Life Information Network (MarLIN) considers the sensitivity of biotopes/components of biotopes to the impacts from general abrasion. In the following analysis the MarLIN sensitivity assessments (Annex 2) are utilised and supported where further scientific literature is available on the specific interactions. Communities of flora and fauna that live in or on caves, overhangs, vertical walls and very large immovable boulders can be sensitive to abrasion. However, the operation of towed demersal gears prevents the gear from interacting with these subtidal bedrock reef habitat types.

	Therefore these features are considered as low sensitivity to abrasion from towed demersal gear. **<u>Sponges</u>** A number of studies have concluded that the effects of a single trawl event from towed demersal gear on sponges led to a significant proportion of sponges being damaged and/or loosened and that recovery was slow (Van Dolah *et al,* 1987; Tilmant, 1979; Freese *et al*, 1999; Freese, 2001; Boulcott & Howell, 2011). Tilmant (1979) recorded that the a recovery was ongoing but not complete 11 months after a trawl event. Freese revisited a site one year after a trawl event and found no signs of sponge regrowth or recovery. Little information on sponge longevity and reslilience exists. Individual sponges are usually hermaphrodites (Hayward & Ryland, 1995) and reproduction can be asexual (e.g. budding) or sexual (Naylor, 2011). Growth and reproduction are generally seasonal (Hayward & Ryland, 1995) with sponge rejuvenation possible from fragments of sponge (Fish & Fish, 1996). Some sponges are known to be highly resilient to physical damage with an ability to survive severe damage, regenerate and reorganize to function fully again, however, this recoverability varies between species (Coleman *et al*, 2013; Wulff, 2006). The majority of the literature agrees that a single trawl could damage or remove 25-75% of sponges. Therefore it can be presumed that multiple trawl events will increase this level of impact. Sponges characterise biotopes such as: CR.HCR.XFa.ByErSp and CR.HCR.XFa.ByErSp.Sag **<u>Anthozoans</u>** *Eunicella verrucosa* is a sessile epifauna species and is likely to be severely damaged by heavy mobile gears, such as scallop dredging (MacDonald *et al*, 1996; Tinsley, 2006; Hinz *et al*, 2011; Hiscock, 2007). *Eunicella* grows very slowly in British waters, approximately 1 cm per year (Bunker, 1986; Picton & Morrow, 2005). Recovery

	following an abrasion event, such as trawling, is likely to take over 4 years (Coma *et al,* 2006; Sheehan *et al,* 2013). Importantly *Eunicella verrucosa* larvae are thought to generally settle near the parent (Hiscock, 2007; Weinberg & Weinberg, 1979), therefore recovery is most likely if fecund mature species are left after a fishing event. Boulcott & Howell (2011) conducted experimental Newhaven scallop dredging (a source of abrasion) over a circalittoral rock habitat in the sound of Jura, Scotland and recorded the damage to the resident community. Damage to circalittoral rock fauna was of an incremental nature, with loss of species such as *Alcyonium digitatum* and faunal turf communities increasing with repeated trawls. *Alcyonium digitatum, Tubularia indivisa* plus the anthozoan community are sedentary species that would likely suffer from the effects of abrasion (Stamp, 2015). The resilience assessments of the CR.HCR.FaT.CTub.Adig biotope are largely based on the time taken for *Alcyonium digitatum* to recover (approximately 5 years). Without the recovery of this species, the biotope would change (Stamp, 2015). *Caryophyllia smithii* is a small (max 3 cm across) solitary coral, common within tide swept sites of the UK (Wood, 2005). Fowler & Laffoley (1993) suggests that *Caryophyllia smithii* is a slow growing species (0.5-1 mm in horizontal dimension of the corallum per year). This suggests that damage from a single trawl, however minor, could be long lasting. *Sagartia elegens*, *Urticina felina, Metridium senile, Actinothoe sphyrodeta* and *Corynactis virdis* can colonize bare surfaces through a-sexual reproduction within 1 year but may take up to 5 years to establish mature populations (Wood, 2005). If after a single trawling event, members of these species remained within the community it is likely they could recolonize without the need for larval recruitment. Some of the anthozoan community could potentially re-cover relatively quickly from damage caused by trawling, however if the assemblage is completely removed from the habitat, recovery would be less likely.

	Re-establishment of typical biomass will be driven by surviving individuals as well as recruitment (Stamp, 2015). Anthozoans characterise biotopes such as: CR.HCR.XFa.ByErSp.Eun, CR.HCR.FaT.CTub.Adig and CR.MCR.EcCr.UrtScr **Bryozoans** Typical bryozoans include *Flustra foliacea,* which although flexible, physical disturbance by passing mobile gear is likely to damage fronds and remove some colonies. Colonies on hard substrata are probably less vulnerable to fishing activity but would probably be damaged or partially removed (Bullimore, 1985; Jennings & Kaiser, 1998). Silén (1981) reported that experimental removal of a notch in the frond of *Flutra foliacea* was repaired within 5 -10 days. The newly formed margin where the notch has been removed grew at normal rates (4-5 zooid lengths per month). Additionally the removal of one layer of the bilaminar frond, experimentally (Silén, 1981) or by predators (Stebbing, 1971) was repaired with similar rapidity. It was noted that the un-damaged layer of the frond stopped growing while the damaged area was being repaired (Silén, 1981). *Bugula spp.* and other bryozoan species exhibit multiple generations per year, that involve good local recruitment, rapid growth and reproduction. Bryozoans are often opportunistic, fouling species that colonize and occupy space rapidly. For example, hydroids would probably colonize within 1-3 months and return to their original cover rapidly; while *Bugula* species have been reported to colonize new habitats within 6 -12 months. However, *Bugula* has been noted to be absent from available habitat even when large populations are nearby (Castric-Frey, 1974; Keough & Chernoff, 1987), suggesting that recruitment may be more sporadic (Tyler-Walters, 2005). The bryozoan community could potentially re-cover relatively quickly from damage caused by a single trawling episode, however if the assemblage is subjected to repeated trawling and/or completely

	removed from the habitat, recovery would take longer relying on re-colonization rates and good local recruitment from surviving communities (Stamp, 2015). Bryozoans characterise biotopes such as: CR.HCR.XFa.FluCoAs and CR.MCR.EcCr.FaAlCr.Flu **<u>Hydrozoans</u>** Hydroids are thought of as early colonizers of bare surfaces (Whomersley & Picken, 2003; Zintzen *et al,* 2008; Hiscock *et al*, 2010) with *Tubularia spp.* opportunistically often the first to colonize and reaching sexual maturity rapidly (Hughes, 1983). *Tubularia indivisa* is a short lived, common athecate hydroid species, and recruitment is seasonally variable with settlement peaking in early spring, however other smaller recruitment events occur within summer and autumn (Hughes, 1983). The hydrozoan community could potentially re-cover relatively quickly from damage caused by a single trawling episode, however if the assemblage is subjected to repeated trawling and/or completely removed from the habitat, recovery would take longer relying on re-colonization rates (which are thought to be high in hydroids) and good local recruitment from surviving communities. Hydrozoans characterise biotopes such as: CR.MCR.CFaVS.CuSpH and CR.HCR.FaT.CTub.Adig **<u>Kelps and Seaweeds</u>** Physical disturbance by towed demersal gear is likely to remove a proportion of macroalgae, such as fucoids and laminarians. The kelps *Laminaria spp.* act as ecosystem engineers (Jones *et al*, 1994; Smale *et al*, 2013) by altering; light levels (Sjøtun *et al*, 2006), physical disturbance (Connell, 2003), sedimentation rates (Eckman *et al*, 1989) and water flow (Smale *et al*, 2013), which can profoundly alter the

	physical environment for fauna and flora in close proximity. *Laminaria hyperborea* biotopes increase the three dimensional complexity of unvegetated rock (Norderhaug, 2004; Norderhaug *et al*, 2007; Norderhaug & Christie, 2011; Gorman *et al*, 2013; Smale *et al*, 2013) and support high local diversity, abundance and biomass of epi/benthic species (Smale *et al*, 2013), and serve as a nursery ground for a number of species. Kelp is also an important species as a primary producer (Kaiser, 2011), food resource (Kaiser, 2011) and provides bird foraging habitat (Iken, 2012). Christie *et al* (1998) suggested that kelp habitats were relatively resistant to the direct disturbance/removal of the *Laminaria hyperborea* canopy. Recruitment of kelps following disturbance can be influenced by the proximity of mature kelp beds producing viable zoospores to the disturbed area (Kain, 1979; Fredriksen *et al,* 1995). Kain (1964) investigated the removal of kelp through trawling and found that the associated holdfast communities recovered in 6 years, however the epiphytic stipe community did not fully recover within the same time period. Even though the associated holdfast and stipe colonies eventually die as the substratum rots, over a few weeks at sea they are likely to shed thousands of larvae, and seaweed rafts are now seen as important dispersal agents (Hayward & Ryland, 2017). Seaweed communities (both red and brown) are likely to be affected by entanglement with the trailing nets of the beam trawl. This can cause tearing of the macroalgae. Recoverability is dependent on the remaining proportion of individuals, if the holdfast and/or stipe remain, regrowth is likely to be rapid in most species. However, if the whole plant is removed, recolonization is reliant on reproduction of nearby colonies. If nearby seaweed communities survive a trawling episode, their fitness (e.g. growth rates and reproductive output) may be compromised by the level of damage sustained during trawling. Therefore, surviving seaweed communities will be less efficient at aiding recolonization of adjacent lost individuals (Iken, 2012). Kelps and seaweeds can recover quickly from superficial tearing however repeated trawling and high impact damage, to the stipe or

	holdfast, could take more than 6 years to recover. Damaged individuals will be less efficient at aiding recolonization. Kelps and seaweeds characterise biotopes such as: IR.HIR.KFaR.LhypR, IR.LIR.K.LhypLsac, IR.MIR.KT.FilRVS and IR.MIR.KT.XKT **Ascidians** The ascidians are epifaunal and physical disturbance is likely to cause damage with mortality likely. Emergent epifauna are generally very intolerant of disturbance from fishing gear (Jennings & Kaiser, 1998). However, studies have shown *Ascidia spp*. to become more abundant following disturbance events (Bradshaw *et al*, 2000). Ascidians are likely to be significantly affected by abrasion caused by towed demersal fishing gear, although, given their high resilience, they are likely to recover quickly (Stamp, 2015). Ascidians characterise biotopes such as: IR.MIR.KT.LdigT and IR.FIR.SG.DenCcor ***Sabellaria spp.*** (Detailed assessments of *Sabellaria spp*. reef have been undertaken separately). Beam trawling can negatively impact on *Sabellaria alevolata* and *Sabellaria spinulosa* reefs through partial or total damage and/or removal of the reef structure through abrasion and ploughing and through removal/damage of typical species. Recovery will be dependant on local factors such as season of impact, larval supply, environmental factors, condition of reef etc. Although there is a potential for rapid recovery of a partially damaged reef, and a much slower recovery for heavily impacted reefs, the conditions to support recovery are not guaranteed (AWFA, 2017a). *Sabellaria spp*. characterise biotopes such as: CR.MCR.CSab

	<u>Mussels</u> (Detailed assessments of Subtidal Mussel Bed on Rock have been undertaken separately). The action of fishing with beam trawl gear directly on subtidal mussel bed (*Mytilus edulis* and *Muculus discors)* on rock features is likely to be directy lethal by crushing or indirectly damaging by weakening or breaking of the byssus threads, making them prone to becoming unattatched. 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 (AWFA, 2017b). Mussels characterise biotopes such as: CR.MCR.Cmus.Mdis, CR.MCR.Cmus.CMyt and IR.LIR.IFaVS.MytRS **<u>Other habitat forming species</u>** The urchin *Echinus esculentus* characterises biotopes such as: IR.MIR.KR.Lhyp.GzPk and IR.MIR.KR.Lhyp.GzFt and fluctuations in their numbers may give foliose seaweeds a chance to re-grow periodically. There may be a change in community structure when grazing pressure decreases, although recoverability is probably high. However, recruitment can be sporadic or annual depending on locality and factors affecting larval pre-settlement and post-settlement survival (Lewis & Nichols, 1980). Brittlestars characterise biotopes such as: CR.MCR.EcCr.CarSp.Bri and CR.MCR.EcCr.FaAlCr.Bri and the removal of the dense brittlestar beds may change the community structure. Brittlestar beds have been assessed under this project separately (AWFA, 2017c). **In conclusion,** beam trawl gear could cause an abrasive pressure upon a number of the subtidal bedrock reef biotopes listed in annex 2. Any activity that physically abrades the faunal crust is likely to result in

		localized damage. Increase in scour or other abrasion events are likely to remove sponge, ascidian and anemone components. Trawling can physically remove or damage much of the macro-epibenthic fauna. Small colonies that may survive a single trawl are unlikely to survive repeated trawls. On a comparison between cold and warm water experiments, impacts of trawling are much more persistent on cold water species due to the slower growth/regeneration rates. Damaged or lost individuals are likely to be replaced by early colonizers, which could change the biotope. Given the slow growth rates and long lifespans of the rich, diverse fauna in Welsh waters, it is likely to take many years for cold water communities to recover if adversely affected by physical damage. Impact from beam trawl gear on flora is likely to include tearing and/or displacement of individuals or communities which, depending on the remaining proportion of the flora, could recover quickly. Recovery is likely to be led by fast colonising individuals such as *Sagartia elegens*, *Urticina felina, Metridium senile, Actinothoe sphyrodeta* and *Corynactis virdis.* The majority of the epifauna species often rely on adjacent colonies for recolonization, however, recovery is likely to be slower if the adjacent colonies are degraded by trawling.
6. MPAs where feature exists	**Pembrokeshire Marine SAC**	Boulder and cobble reefs in this SAC are largely composed of igneous rock but include areas of more friable Old Red Sandstone and some limestone. Extensive areas of sublittoral rocky reef stretch offshore from the west Pembrokeshire coast and between the Pembrokeshire islands and many small rocky islets. Limestone bedrock and boulder reefs occur in the south of the site. Reefs also extend through Milford Haven (although there are few records between South Hook Point and the mouth of Pembroke River) and into the variable salinity conditions of the Daugleddau estuary (CCW, 2009b). There are also other patches of boulder and cobble reefs along the North and South coasts of St Bride’s Bay.

	Pen Llyn a'r Sarnau SAC	This SAC encompasses a varied range of reef habitats, including an unusual series of submerged and intertidal glacial moraines. Boulder and cobble reefs are common and extensive off the North Llyn Peninsula, around Bardsey Island, between Pen y Cil and Porth Neigwl and within Tremadog Bay. The Sarnau (Sarn Badrig, Sarn-y-Bwch and Cynfelyn Patches) are very unusual shallow subtidal reefs, which extend many kilometres from the coast into Cardigan Bay. The Sarnau are glacial moraines (resulting from the last glaciation) and are composed of boulders, cobbles and pebbles mixed with various grades of sediments (CCW, 2009a).
	Menai Strait and Conwy Bay SAC	The bedrock and boulder reefs of the Menai Strait and Conwy Bay SAC occur mainly within the tidal rapids of the Menai Strait and close to the coast around Puffin Island and along the coast between Penmon Sound and Red Wharf Bay, although there are also other records in shallow areas of the SAC around the Great Orme, North of Red Wharf Bay and in other areas of the Menai Strait. (CCW, 2009c).
	Carmarthen Bay and Estuaries	Bedrock and boulder reefs are not common in this site but there are records within the Large Shallow Inlet and Bay feature around Caldey Island and also off Worm's Head.
	Cardigan Bay SAC	Cardigan Bay SAC supports both rocky and biogenic reef types. Its rocky reefs are widespread and in the subtidal form a mosaic with areas of sand and gravel. There are records of boulder and cobble habitat scattered throughout the SAC. The records of more extensive boulder and cobble reefs tend to occur closer to the coast (within 3nm). Further offshore many of the records tend to consist of relatively low proportions of boulders and cobbles amongst sediment and some of these may not qualify as Annex I reef habitat. The seabed of Cardigan Bay appears to be very patchy, forming a mosaic of seabed types, some of which seem to run parallel to the shore. This heterogeneity is greatest in the east and near shore, becoming more homogeneous offshore in the west. The distribution and extent of reefs within the site is therefore uncertain especially for subtidal areas (CCW, 2009d).

7. Conclusion

The information presented above indicates that the action of fishing with beam trawl gear directly on subtidal boulder and cobble reef can cause boulder and cobble displacement which could lead to habitat restructuring, habitat loss, ploughing of the underlying substrate through dragged boulders and cobbles and destabilisation of the habitat. The effect of beam trawl gear during the initial interaction or from prolonged fishing is likely to cause damage, which can be long-lasting and lethal, to the species which occupy the habitat. While rapid recovery is possible for some species, this is reliant on adjacent communities for recolonization. Recovery of damaged or removed individuals is likely to be led by fast colonizers such as *Sagartia elegans*, *Urticina felina, Metridium senile, Actinothoe sphyrodeta* and *Corynactis virdis,* but this could change the biotope.

8. References

- 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
- AWFA. (2017a). Beam Trawl on *Sabellaria spp*. reef. Assessing Welsh Fishing Activities project assessments.
- AWFA. (2017b). Beam Trawl on Subtidal Mussel Bed on Rock. Assessing Welsh Fishing Activities project assessments.
- AWFA. (2017c). Beam Trawl on Brittlestar Beds. Assessing Welsh Fishing Activities project assessments.
- Black, K.P. & Parry, G.D. (1994). Sediment transport rates and sediment disturbance due to scallop dredging in Port Phillip Bay. Mem Qld Mus 36:327–341
- Black, K.P. & Parry, G.D. (1999). Entrainment, dispersal and settlement of scallop dredge sediment plumes: Field measurements and numerical modelling. Can J Fish Aquat Sci 56: 2271–2281
- Boulcott, P. & Howell, T.R.W. (2011). The impact of scallop dredging on rocky-reef substrata. Fisheries Research (Amsterdam), 110 (3), 415-420.
- Bradshaw, C., Veale, L.O., Hill, A.S. & Brand, A.R. (2000). The effects of scallop dredging on gravelly seabed communities. In: Effects of fishing on non-target species and habitats (ed. M.J. Kaiser & de S.J. Groot), pp. 83-104. Oxford: Blackwell Science.
- Bullimore, B. (1985). An investigation into the effects of scallop dredging within the Skomer Marine Reserve. *Report to the Nature Conservancy Council by the Skomer Marine Reserve Subtidal Monitoring Project, S.M.R.S.M.P. Report,* no 3., Nature Conservancy Council.
- Bunker, F. (1986). Survey of the Broad sea fan *Eunicella verrucosa* around Skomer Marine Reserve in 1985 and a review of its importance (together with notes on some other species of interest and data concerning previously unsurveyed or poorly documented areas). Volume I. *Report to the NCC by the Field Studies Council.*
- Caddy, J.F. (1973). Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. J Fish Res Board Can 30:173–180

- Castric-Fey, A. (1974). *Les peuplements sessiles du benthos rocheux de l'archipel de Glenan (Sud-Bretagne). Ecologie descriptive and experimentale.* , Ph. D. thesis, Université de Bretagne Occidentale, L' Université Paris, Paris, France.
- CCW. (2009a). Countryside Council for Wales. Lleyn Peninsula and the Sarnau European Marine Site – Advice in fulfilment of regulation 33 of the conservation (natural habitats, &c.) regulations 1994.
- CCW. (2009b). Countryside Council for Wales. Pembrokeshire Marine European Marine Site – Advice in fulfilment of regulation 33 of the conservation (natural habitats, &c.) regulations 1994.
- CCW. (2009c). Countryside Council for Wales. Menai Strait and Conwy Bay European Marine Site – Advice in fulfilment of regulation 33 of the conservation (natural habitats, &c.) regulations 1994.
- CCW. (2009d). Countryside Council for Wales. Cardigan Bay European Marine Site – Advice in fulfilment of regulation 33 of the conservation (natural habitats, &c.) regulations 1994.
- Christie, H., Fredriksen, S. & Rinde, E. (1998). Regrowth of kelp and colonization of epiphyte and fauna community after kelp trawling at the coast of Norway. *Hydrobiologia*, **375/376**, 49-58.
- Churchill, J.H. (1989). The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. Cont Shelf Res 9:841–864
- Coleman, R.A., Hoskin, M.G., von Carlshausen, E. & Davis, C.M. (2013). Using a no-take zone to assess the impacts of fishing: Sessile epifauna appear insensitive to environmental disturbances from commercial potting. *Journal of Experimental Marine Biology and Ecology*, **440**, 100-107.
- Coma, R., Linares, C., Ribes, M., Diaz, D., Garrabou, J. & Ballesteros, E. (2006). Consequences of a mass mortality in populations of *Eunicella singularis* (Cnidaria: Octorallia) in Menorca (NW Mediterranean). *Marine Ecology Progress Series*, **331**, 51-60.
- Connell, S.D. (2003). Negative effects overpower the positive of kelp to exclude invertebrates from the understorey community. *Oecologia*, *137*(1), pp.97-103.
- Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. & Reker, J.B. (2004). The Marine Habitat Classification for Britain and Ireland. Version 04.05. Joint Nature Conservation Committee, Peterborough. www.jncc.gov.uk/MarineHabitatClassification.
- Currie, D.R., Parry, G.D. (1996). Effects of scallop dredging on a soft sediment community: a large-scale experimental study. Mar Ecol Prog Ser 134:131–150
- Eckman, J.E., Duggins, D.O. & Sewell, A.T. (1989). Ecology of under story kelp environments. I. Effects of kelps on flow and particle transport near the bottom. *Journal of Experimental Marine Biology and Ecology*, *129*(2), pp.173-187.
- FAO. (2001). Fishing Gear types. Beam trawls. Technology Fact Sheets. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 13 September 2001. [Cited 10 January 2017]. http://www.fao.org/fishery/geartype/305/en
- Fish, J.D. & Fish, S. (1996). *A student's guide to the seashore.* Cambridge: Cambridge University Press.
- Fosså, J.H., Mortensen, P.B., Furevik, D.M. (2002). The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. Hydrobiologia 471:1–12
- Fowler, S. & Laffoley, D. (1993). Stability in Mediterranean-Atlantic sessile epifaunal communities at the northern limits of their range. Journal of Experimental Marine Biology and Ecology, 172 (1), 109-127.

- Fredriksen, S., Sjøtun, K., Lein, T.E. & Rueness, J. (1995). Spore dispersal in *Laminaria hyperborea* (Laminariales, Phaeophyceae). *Sarsia*, **80** (1), 47-53.
- Freese, J.L. (2001). Trawl-induced damage to sponges observed from a research submersible. *Marine Fisheries Review*, **63** (3), 7-13.
- Freese, J.L. & Wing, B.L. (2003). Trawl-induced damage to sponges observed from a research submersible. *Marine Fisheries Review*, **63** (3), 7-13
- Freese, L., Auster, P.J., Heifetz, J. & Wing, B.L. (1999). Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. *Marine Ecology Progress Series*, **182**, 119-126.
- Gili, J.M. & Hughes, R.G. (1995). The ecology of marine benthic hydroids. Oceanogr Mar Biol Annu Rev 33:351–426
- Gorman, D., Bajjouk, T., Populus, J., Vasquez, M. & Ehrhold, A. (2013). Modeling kelp forest distribution and biomass along temperate rocky coastlines. *Marine Biology*, **160** (2), 309-325.
- Hayward, P.J. & Ryland, J.S. (ed.) (1995). *Handbook of the marine fauna of North-West Europe.* Oxford: Oxford University Press.
- Hayward, P.J. & Ryland, J.S. (ed.) (2017). *Handbook of the marine fauna of North-West Europe.* Oxford: Oxford University Press.
- Henry, L.A. & Kenchington, E.L. (2004). Ecological and genetic evidence for impaired sexual reproduction and induced clonality in the hydroid *Sertularia cupressina* (Cnidaria: Hydrozoa) on commercial scallop grounds in Atlantic Canada. Mar Biol 145:1107–1118
- Hinz, H., Tarrant, D., Ridgeway, A., Kaiser, M.J. & Hiddink, J.G. (2011). Effects of scallop dredging on temperate reef fauna. *Marine Ecology Progress Series*, **432**, 91-102.
- Hiscock, K. (2007). *Eunicella verrucosa* Pink sea fan. 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/species/detail/1121
- Hiscock, K., Sharrock, S., Highfield, J. & Snelling, D. (2010). Colonization of an artificial reef in south-west England—ex-HMS 'Scylla'. Journal of the Marine Biological Association of the United Kingdom, 90 (1), 69-94.
- Hughes, R. (1983). The life-history of Tubularia indivisa (Hydrozoa: Tubulariidae) with observations on the status of T. ceratogyne. Journal of the Marine Biological Association of the United Kingdom, 63 (02), 467-479.
- ICES. (2014). Second Interim Report of the Working Group on Spatial Fisheries Data (WGSFD), 10–13 June 2014, ICES Headquarters, Copenhagen, Denmark . ICES CM 2014/SSGSUE:05. 102 pp.
- Iken, K. (2012). Grazers On Benthic Seaweeds. *Seaweed Biology: Novel Insights into Ecophysiology, Ecology and Utilization*. 157-177.
- Irving, R. (2009). The identification of the main characteristics of stony reef habitats under the Habitats Directive. Summary report of an inter-agency workshop 26-27 March 2008. *JNCC Report* No. 432
- Jennings, S. & Kaiser, M.J. (1998). The effects of fishing on marine ecosystems. *Advances in Marine Biology*, **34**, 201-352.
- JNCC. http://jncc.defra.gov.uk/ProtectedSites/SACselection/habitat.asp?FeatureIntCode=H1170
- Jones, B. (1992). Environmental impact of trawling on the seabed: A review, New Zealand Journal of Marine and Freshwater Research, 26:1, 59-67
- Jones, C.G., Lawton, J.H. & Shackak, M. (1994). Organisms as ecosystem engineers. *Oikos*, **69**, 373-386.

- Jones, L.A., Hiscock, K. & Connor, D.W. (2000). Marine habitat reviews. A summary of ecological requirements and sensitivity characteristics for the conservation and management of marine SACs. *Joint Nature Conservation Committee, Peterborough. (UK Marine SACs Project report.)*. Available from: http://www.ukmarinesac.org.uk/pdfs/marine-habitats-review.pdf
- Kain, J.M. (1964). Aspects of the biology of *Laminaria hyperborea* III. Survival and growth of gametophytes. *Journal of the Marine Biological Association of the United Kingdom*, **44** (2), 415-433.
- Kain, J.M. (1979). A view of the genus *Laminaria*. *Oceanography and Marine Biology: an Annual Review*, **17**, 101-161.
- Kaiser, M.J. (2011). *Marine ecology: processes, systems, and impacts*. Oxford University Press.
- Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S., Poiner, I.R. (2002). Modification of marine habitats by trawling activities: prognosis and solutions. Fish Fish. 3, 114–136.
- Kenchington, E.L.R., Prena, J., Gilkinson, K.D., Gordon, D.C. Jr. MacIsaac, K., Bourbonnais, C., Schwinghamer, P.J., Rowell, T.W., McKeown, D.L., Vass, W.P. (2001). Effects of experimental otter trawling on the macrofauna of a sandy bottom ecosystem on the Grand Banks of Newfoundland. Can J Fish Aquat Sci 58: 1043–1057
- Keough, M.J. & Chernoff, H. (1987). Dispersal and population variation in the bryozoan *Bugula neritina*. *Ecology*, **68**, 199 - 210.
- Kostylev, V.E., Erlandsson, J., Ming, M.Y., Williams, G.A. (2005). The relative importance of habitat complexity and surface area in assessing biodiversity: fractal application on rocky shores. Ecological Complexity 2, 272–286.
- Lewis, G.A. & Nichols, D. (1980). Geotactic movement following disturbance in the European sea-urchin, *Echinus esculentus* (Echinodermata: Echinoidea). *Progress in Underwater Science*, **5**, 171-186.
- MacDonald, D.S., Little, M., Eno, N.C. & Hiscock, K. (1996). Disturbance of benthic species by fishing activities: a sensitivity index. Aquatic Conservation: Marine and Freshwater Ecosystems, 6 (4), 257-268.
- Naylor, P. (2011). *Great British Marine Animals, 3rd Edition.* Plymouth. Sound Diving Publications
- Norderhaug, K.M. (2004). Use of red algae as hosts by kelp-associated amphipods. *Marine Biology*, **144** (2), 225-230.
- Norderhaug, K.M. & Christie, H. (2011). Secondary production in a Laminaria hyperborea kelp forest and variation according to wave exposure. *Estuarine, Coastal and Shelf Science*, *95*(1), pp.135-144.
- Norderhaug, K.M., Christie, H. & Fredriksen, S. (2007). Is habitat size an important factor for faunal abundances on kelp (*Laminaria hyperborea*)? *Journal of Sea Research*, **58** (2), 120-124.
- Paschen, M., Richter, U. & Ko¨pnick, W. (2000). Trawl Penetration in the Seabed (TRAPESE). Final report Contract No. 96–006.
- Picton, B.E. & Morrow C.C. (2005). *Encyclopedia of Marine Life of Britain and Ireland* http://www.habitas.org.uk/marinelife/species.asp?item=D10920, 2008-01-08
- Readman, J.A.J. (2016). *Flustra foliacea* on slightly scoured silty 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/24
- Rinkevich, B. (1996). Do reproduction and regeneration in damaged corals compete for energy allocation? Mar Ecol Prog Ser 143:297–302

- Sainsbury, K.J., Campbell, R.A., Lindholm, R., Whitelaw, A.W. (1997). Experimental management of an Australian multispecies fishery: examining the possibility of trawl-induced habitat modification. In: Pikitch EK, Huppert DD, Sissenwine MP (eds) Global trends: fisheries management. American Fisheries Society, Bethesda, MD
- Schwinghamer, P., Gordon, D.C., Rowell, T.W., Prena, J., McKeown, D.J., Sonnichshen, G., Guigné, J.Y. (1998). Effects of experimental otter trawling on surficial sediment properties of a sandy-bottom ecosystem on the Grand Banks of Newfoundland. Conserv Biol 12:1215–1222
- Sheehan, E.V., Stevens, T.F., Gall, S.C., Cousens, S.L. & Attrill, M.J. (2013). Recovery of a temperate reef assemblage in a marine protected area following the exclusion of towed demersal fishing. *Plos One*, **8** (12), e83883.
- Silén, L. (1981). Colony structure in *Flustra foliacea* (Linnaeus) (Bryozoa, Cheilostomata). *Acta Zoologica (Stockholm.)*, **62**, 219-232.
- Sjøtun, K., Christie, H. & Helge Fosså, J. (2006). The combined effect of canopy shading and sea urchin grazing on recruitment in kelp forest (*Laminaria hyperborea*). *Marine Biology Research*, **2** (1), 24-32.
- Smale, D.A., Burrows, M.T., Moore, P., O'Connor, N. & Hawkins, S.J. (2013). Threats and knowledge gaps for ecosystem services provided by kelp forests: a northeast Atlantic perspective. *Ecology and evolution*, **3** (11), 4016-4038.
- Stamp, T.E. (2015). *Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept 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/1053
- Stamp, T.E. & Tyler-Walters, H. (2002). *Halidrys siliquosa* and mixed kelps on tide-swept infralittoral rock with coarse sediment. 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/258
- Stebbing, A.R.D. (1971). Growth of *Flustra foliacea* (Bryozoa). *Marine Biology*, **9**, 267-273.
- Thrush, S.F., Hewitt, J.E., Cummings, V.J., Dayton, P.K. (1995). The impact of habitat disturbance by scallop dredging on marine benthic communities: What can be predicted from the results of experiments? Mar Ecol Prog Ser 129:141–150
- Tillin, H.M. & Hiscock, K. (2016). *Urticina felina* and sand-tolerant fauna on sand-scoured or covered 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/290
- Tillin, H.M. & Tyler-Walters, H. (2016). *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. 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/177
- Tilmant, J.T. (1979). Observations on the impact of shrimp roller frame trawls operated over hard-bottom communities, Biscayne Bay, Florida: *National Park Service*.
- Tinsley, P. (2006). Worbarrow Reefs Sea Fan Project, 2003-2005 *Dorset Wildlife Trust Report*
- Tyler-Walters, H. (2005). *Bugula turbinata* An erect bryozoan. 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/species/detail/1715

- Tyler-Walters, H. & Ballerstedt, S. (2007). *Flustra foliacea* Hornwrack. 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/species/detail/1609
- Van Dolah, R.F., Wendt, P.H. & Nicholson, N. (1987). Effects of a research trawl on a hard-bottom assemblage of sponges and corals. *Fisheries Research*, **5** (1), 39-54.
- Wassenberg, T.J., Dews, G., Cook, S.D. (2002). The impact of fish trawls on megabenthos (sponges) on the north-west shelf of Australia. Fish Res 58:141–151
- Weinberg, S. & Weinberg, F. (1979). The life cycle of a gorgonian: *Eunicella singularis* (Esper, 1794). *Bijdragen tot de Dierkunde*, **48** (2), 127-137.
- Whomersley, P. & Picken, G. (2003). Long-term dynamics of fouling communities found on offshore installations in the North Sea. Journal of the Marine Biological Association of the UK, 83 (5), 897-901.
- Wood. C. (2005). Seasearch guide to sea anemones and corals of Britain and Ireland. Ross-on-Wye: Marine Conservation Society.
- Wulff, J. (2006). Resistance vs recovery: morphological strategies of coral reef sponges. *Functional Ecology*, **20** (4), 699-708.
- Zintzen, V., Norro, A., Massin, C. & Mallefet, J. (2008). Temporal variation of Tubularia indivisa (Cnidaria, Tubulariidae) and associated epizoites on artificial habitat communities in the North Sea. Marine Biology, 153 (3), 405-420.

Annex 1
Data manipulation

‘Boulder and cobble’ reef has been split apart from ‘Bedrock reef’ for the purposes of the Assessing Welsh Fishing Activities project so it aligns with the approach taken by Natural England for a related piece of work. This is the first time that this has been attempted for Welsh data.

The first stage of this process is to ascertain whether the habitat/data point is classified as ‘reef’. For a habitat to be ‘stony reef’ it requires 10% or more of the seabed substratum at that location to be particles greater than 64mm across (i.e. cobbles). The figure of 10% is taken from a report determining the characteristics of stony reef (Irving 2009). The remaining supporting ‘matrix’ could be of smaller sized material. The reef may be consistent in its coverage or it may form patches with intervening areas of finer sediment.

Boulder and Cobble reef, for the purposes of this exercise, is substratum which meets two conditions:

1. There is over 10% hard substratum (i.e. particles > 64mm) in a finer sediment matrix, as described above.
2. The *proportion* of bedrock (to the total hard substratum in that location) should be recorded as <50% bedrock. (We acknowledge this means that the substratum could comprises of up to 49% bedrock and this would still class as Subtidal Boulder and Cobble reef, but the line has to be drawn somewhere if we are to split these reef types).

As the habitat type is specified as *subtidal* reef, only those biotopes which are subtidal have been included in the definition of Subtidal Boulder and Cobble reef. Those which contain Littoral Rock or Littoral Sediment have been omitted.

The data for Welsh waters includes many records where there is >10% hard substratum but the biotope recorded is a sediment one. This will happen where the dominant biotope was considered to be a sediment one. These have been removed from the list of biotopes below. Higher biotope codes were also removed from the list (e.g. high energy circalittoral rock), as these are at too coarse a level of detail to provide useful biological information.

Annex 2

Biotopes that have been assosciated with the boulder and cobble reef habitiat (version 15.03) (JNCC - http://jncc.defra.gov.uk/marine/biotopes/hierarchy.aspx?level=5)

CR.FCR.Cv	High	CR.MCR.EcCr.FaAlCr.Flu	Low	IR.LIR.K.Sar	Low	SS.SMx.CMx.OphMx	Medium
CR.HCR.FaT.BalTub	Low	CR.MCR.EcCr.FaAlCr.Pom	Low	IR.MIR.KR.HiaSw	Medium	SS.SMx.IMx.CreAsAn	Low
CR.HCR.FaT.CTub.Adig	Low	CR.MCR.EcCr.UrtScr	Low	IR.MIR.KR.Ldig.Bo	Medium	SS.SMx.IMx.SpavSpAn	Medium
CR.HCR.XFa.ByErSp	Medium	CR.MCR.SfR.Pol	Medium	IR.MIR.KR.Ldig.Ldig	Low		
CR.HCR.XFa.ByErSp.DysAct	Medium	IR.FIR.SG.CC	Low	IR.MIR.KR.Lhyp	Medium		
CR.HCR.XFa.ByErSp.Eun	Medium	IR.FIR.SG.CrSpAsDenB	Low	IR.MIR.KR.Lhyp.Ft	Medium		
CR.HCR.XFa.ByErSp.Sag	Medium	IR.FIR.SG.DenCcor	Low	IR.MIR.KR.Lhyp.GzPk	Medium		
CR.HCR.XFa.CvirCri	Low	IR.FIR.SG.FoSwCC	Low	IR.MIR.KR.Lhyp.Pk	Medium		
CR.HCR.XFa.FluCoAs	Low	IR.HIR.KFaR.Ala	Low	IR.MIR.KR.LhypT	Medium		
CR.HCR.XFa.FluCoAs.SmAs	Low	IR.HIR.KFaR.Ala.Ldig	Low	IR.MIR.KR.LhypT.Ft	Medium		
CR.HCR.XFa.FluCoAs.X	Low	IR.HIR.KFaR.Ala.Myt	Low	IR.MIR.KR.LhypT.Pk	Medium		
CR.HCR.XFa.FluHocu	Low	IR.HIR.KFaR.FoR	Low	IR.MIR.KR.LhypTX	Medium		
CR.HCR.XFa.Mol	Low	IR.HIR.KFaR.LhypFa	Medium	IR.MIR.KR.LhypTX.Ft	Medium		
CR.HCR.XFa.SpAnVt	Medium	IR.HIR.KFaR.LhypR	Medium	IR.MIR.KR.LhypTX.Pk	Medium		
CR.HCR.XFa.SpNemAdia	Medium	IR.HIR.KFaR.LhypR.Ft	Medium	IR.MIR.KR.XFoR	Low		
CR.HCR.XFa.SubCriTf	Medium	IR.HIR.KFaR.LhypR.Pk	Medium	IR.MIR.KT.FilRVS	Low		
CR.MCR.CFaVS	Medium	IR.HIR.KFaR.LhypRVt	Medium	IR.MIR.KT.LdigT	Medium		
CR.MCR.CFaVS.CuSpH	Medium	IR.HIR.KSed.DesFilR	Medium	IR.MIR.KT.XKT	Medium		
CR.MCR.CMus.CMyt	Medium	IR.HIR.KSed.LsacChoR	Medium	IR.MIR.KT.XKTX	Medium		
CR.MCR.CMus.Mdis	Medium	IR.HIR.KSed.LsacSac	Medium	SS.SCS.CCS.PomB	Low		
CR.MCR.CSab	Medium	IR.HIR.KSed.ProtAhn	Low	SS.SCS.ICS.HchrEdw	Not sensitive		
CR.MCR.EcCr.AdigVt	Low	IR.HIR.KSed.Sac	Medium	SS.SCS.ICS.SSh	Not sensitive		
CR.MCR.EcCr.CarSp	Low	IR.HIR.KSed.XKHal	Medium	SS.SCS.SCSVS	Not sensitive		
CR.MCR.EcCr.CarSp.Bri	Medium	IR.HIR.KSed.XKScrR	Medium	SS.SMp.KSwSS.LsacGraFS	Medium		
CR.MCR.EcCr.CarSp.PenPcom	Low	IR.LIR.K.LhypLsac	Medium	SS.SMp.KSwSS.LsacGraVS	Medium		
CR.MCR.EcCr.FaAlCr	Low	IR.LIR.K.LhypLsac.Pk	Medium	SS.SMp.KSwSS.LsacR	Medium		
CR.MCR.EcCr.FaAlCr.Adig	Low	IR.LIR.K.Lsac.Ft	Low	SS.SMp.KSwSS.LsacR.CbPb	Medium		
CR.MCR.EcCr.FaAlCr.Bri	Medium	IR.LIR.K.Lsac.Ldig	Low	SS.SMp.KSwSS.LsacR.Gv	Medium		
CR.MCR.EcCr.FaAlCr.Car	Low	IR.LIR.K.Lsac.Pk	Low	SS.SMx.CMx.FluHyd	Medium		