Multi-rig Trawl on Submarine Structures Made by Leaking Gases

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 Submarine Structures Made by Leaking Gases
2. Risk Level	Purple (High risk)
3. Description of Feature	Submarine structures made by leaking gases consist of sandstone slabs, pavements, and pillars up to 4m high, formed by aggregation of sediment by carbonate cement resulting from microbial oxidation of gas emissions, mainly methane. The formations are interspersed with gas vents that intermittently release gas. The methane most likely originates from the microbial decomposition of fossil plant materials (EC, 2007). There are two types of submarine structures. The first type of submarine structures are known as “bubbling reefs”. These formations support a zonation of diverse benthic communities consisting of algae and/or invertebrate specialists of hard marine substrates different to that of the surrounding habitat. A variety of sublittoral topographic features are included in this habitat such as: overhangs, vertical pillars and stratified leaf-like structures with numerous caves. Animals seeking shelter in the numerous caves further enhance the biodiversity (EC, 2007). Fauna found in “Bubbling reefs” consist of a large diversity of invertebrates from the phyla Porifera, Anthozoa, Polychaeta, Gastropoda, Decapoda and Echinodermata as well as a number of fish species. The polychaete *Polycirrus norwegicus* and the bivalve *Kellia suborbicularis* are typically associated with the habitat and rare

	elsewhere in the region (EC, 2007). Flora found in photic zone “Bubbling reefs” may consist of marine macroalgae such as Laminariales, other foliose and filamentous brown and red algae (EC, 2007). The second type are carbonate structures within “pockmarks” formed by leaking gases. Pockmarks are depressions in soft sediment seabed areas, they can be up to 45m deep and a few hundred meters wide. Methane gas escapes the seabed leaving a circular depression. It is suspected that pockmarks form by sudden “catastrophic” gas or porewater eruption and that they periodically have short outbursts followed by long periods of quiescence or micro seepage (Hovland *et al*, 2005). Pockmarks comprise benthic communities of invertebrate specialists, some preferring hard marine substrata which differs from the communities comprising the surrounding (usually) muddy habitat. Invertebrate specialists of hard substrate include Hydrozoa, Anthozoa, Ophiuroidea and Gastropoda. The diversity of the infauna community in the muddy slope surrounding the “pockmark” may be high (EC, 2007). One species has been recognised as endemic to pockmarks, the beard worm *Siboglinum poseidoni*. The worm lives in the surrounding soft sediment, not on the carbonate structures (Seffel, 2010). In the soft sediment surrounding the pockmark Nematodae, Polychaeta and Crustacea are also present (EC, 2007). No flora is usually found in “Pockmarks” (EC, 2007) There are thought to be several submarine structures (“bubbling reefs”) in Welsh waters, the main one is called Holden’s reef, it is described as: nodular boulders and consolidated carbonate-bound sand forming a low-lying reef surrounded by a sand plain. Filamentous and foliose red and brown algae covered the upward-facing surfaces with patches of the sea squirt *Molgula manhattensis,* bryozoans, hydroids, sponges, the soft coral *Alcyonium digitatum* and barnacles

	also present. Rock-boring fauna were apparent in most of the hard substrata including *Hiatella arctica* and the sponge *Cliona celata*. The rugged nature of the reef provided many holes and crevices for mobile crustacea, fish and echinoderms (JNCC).
4. Description of Gear	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 *et al*, 2004). 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 and into the net. 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’ shapped 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 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 species. 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 *et al*, 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).

	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 *et al*, 2011). 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).
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 multi-rig trawling on submarine structures; therefore it is necessary to widen the reseach parameters to include other comparable bottom contacting mobile gear. **1.** Otter trawling can cause physical and biological degradation of benthic habitats (Sanchez-Lizaso *et al*, 1990). Fishing equipment like bottom trawling nets are known to tear off pieces of the carbonate structures, thus destroying or damaging the habitat (Seffel, 2010). JNCC[1] (2008) report on the Scanner pockmark site states that 'Bottom trawling could have modified the structure of the pockmark, causing burial of some of the submarine structures, as well as breaking and displacement of carbonate pieces and some fishing nets were observed caught on the structures. However, the feature appears to be largely undamaged. Bottom trawl gears effect the environment in both direct and indirect ways. Direct effects include scraping and ploughing of the substrate, sediment resuspension and destruction of benthos. Indirect effects include post-fishing mortality and long-term trawl-induced changes to the benthos (Jones, 1992).

	Little is understood of the recoverability or growth rates of the submarine structures caused by leaking gases. Crocker *et al* (2005), however, do make a correlation between the seepage rates and migration pathways of leaking gases and growth, although no rate of growth is mentioned. In their report, “Gas-Related Seabed Structures in the Western Irish Sea”, they discuss echosounder profiles of the 30 mound structures identified. Some of which are made by actively seeping gas, although the exact mode of formation of the mounds was unclear. They conclude that simple cementation of the sands by Methan-derived Authigenic Carbonate (MDAC) doesn’t explain how they grow to become features with vertical relief of some 5-10m above the seabed. Following direct contact causing damage, recoverability is not measurable or predictable. The carbonate structures created in the seabed are dependant on erosion of the surrounding sediments to become exposed. High sedimentation rates may counteract the erosion and cover the structures (Seffel, 2010). Trawling and dredging can re-suspend large amounts of sediments (Pilskaln *et al*, 1998) and this sediment could settle on the carbonate structure. In areas of low tidal influence, the sediment disturbed by bottom contacting gears may settle and smother low-lying carbonate structures. In areas of high tidal influence, sedimentation may be removed on the following tide. **In conclusion**, direct interaction between multi-rig trawls and submarine structures made by leaking gases could cause structural damage through ploughing and scraping of the clump weight and ground rope, rockhopper or discs and tearing and fragmenting by the trailing nets. The increase in sediment disturbance from the interaction of the bottom contacting gear with the seabed, in areas of low tidal influence, could cause a settling of sediment, covering the structure which could slow the rate of recovery.

		2. Otter trawls can cause direct mortality to non-target organisms through door, chain or groundrope impact on the seabed (Bergman & van Santbrink, 2000). Fishing equipment like bottom trawling nets are known to tear off pieces of the carbonate structures, thus destroying or damaging the habitat (Seffel, 2010). The direct effects of trawling on a submarine structure could include the loss of erect and sessile epifauna, smoothing of sedimentary bedforms and removal of taxa that produce structure. Trawl gear can crush, bury or expose marine flora or fauna and reduce structural diversity (Auster & Langton, 1999). The structural complexity of a carbonate reef structure is thought to provide spaces for animals like crustacea and fish to inhabit. Physical damage to the reef would lead to a loss of structural complexity and therefore a consequent loss in fauna might be expected. Collie *et al* (2000) undertook an analysis of published research into fishing activity impacts on the seabed, based on 39 research projects undertaken previously. They found an average of 46% decrease in total number of species individuals within study sites that were disturbed with bottom towed gear. Eutrophication changes the light reaching the structures and decrease the cover (and biomass) of macroalgae. Eutrophication also increases the amount of plankton production, increasing the amount of sedimentation, which also is a threat. High sedimentation rates may create an anoxic environment near the seafloor, making it hard for most flora and fauna to survive (Seffel, 2010) **In conclusion**, multi-rig trawling on submarine structures can damage and/or remove flora and fauna, reducing structural taxa. The increase in sedimentation by bottom contacting gears can create an anoxic environment, making it hard for flora and fauna to survive.
6. MPAs where feature exists	**Pen Llyn A'r Sarnau SAC**	There is only one area of carbonate reef in Welsh territorial waters. This comprises several Bubbling reefs and it is found within this SAC within 2Nm of the coast between Barmouth and Dyffryn Ardudwy.

		The sediments surrounding Holden's Reef are medium to coarse sands and unlikely to cause an anoxic environment if increased sedimentation occurs.

7. Conclusion

The information presented above indicates that the action of fishing with multi-rig trawl gear directly on submarine structures made by leaking gases could cause damage to the structure and associated species through ploughing and scraping. An increase in sedimentation and eutrophication through seabed disturbance by the gear could influence gas seepage rates and cause smothering of structure, flora and fauna in an area of low tidal influence. Little is understood about growth rates of these structures, therefore recoverability is unknown.

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
- 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
- Collie, J.S., Hall, S.J., Kaiser, M.J. & Poiner, I.R. (2000). A quantitative analysis of fishing impacts shelf-sea benthos. Journal of Animal Ecology, 69(5), 785–798.
- Croker, P.F., Kozachenko, M. & Wheeler, A.J. (2005). Gas-Related Seabed Structures in the Western Irish Sea (IRL-SEA6). Technical report produced for Strategic Environmental Assessment – SEA6
- EC. (2007). European Councill DG Environment. Interpretation manual of European Union Habitats (EUR27) Page 16.
- 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)
- 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.
- Holst, R., Revill, A. (2009). A simple statistical method for catch comparison studies. Fisheries Research 95. 254-259 Barbera, C., C. Bordehore, Joseph A. Borg, M. Glémarec, J. Grall, J. M. Hall-Spencer, C. H. De La Huz et al. "Conservation and management of northeast Atlantic and Mediterranean maerl beds." Aquatic conservation: marine and freshwater ecosystems 13, no. S1 (2003): S65-S76.
- Hovland, M., Svensen, H., Forsberg, C.H., Johansen, H., Fichler, C., Fosså, J.H., Jonsson, R. & Rueslåtten, H. (2005). – *Complex pockmarks with carbonate-ridges of mid- Norway: Products of sediment degassing,* Marine Geology 218, 191-206

- 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.
- JNCC. Joint Nature Conservation Committee – Marine Recorder. http://jncc.defra.gov.uk/page-1599 (viewed 06-02-2017)
- JNCC[1]. (2008). Scanner Pockmark SAC Selection Assessment: http://jncc.defra.gov.uk/PDF/ScannerPockmark_SelectionAssessment_4.0.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,
- 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).
- Pilskaln, C.H., Churchill, J.H., Mayer, L.M. (1998). Frequency of bottom trawling in the Gulf of Maine and speculations on the geochemical consequences. Conservation Biology 12: 1223-1229
- 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).
- Seffel, A. (2010). Present knowledge of Submarine structures made by leaking gases in European waters, and steps towards a monitoring strategy for the habitat. Report written by Ekologigruppen AB. University of Rostock, Rostock, Germany. 150 pp.