Multi-rig Trawl on Seagrass (SACs)

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 Seagrass (SACs)
2. Risk Level	Purple (High risk)
3. Description of Feature	Seagrass beds are comprised of several relevant biotopes (see annex 1 for full biotope descriptions). Intertidal seagrass beds biotope LS.LMp.LSgr (and its sub-biotope LS.LMp.LSgr.Znol) are typically dominated by *Zostera nolteii*. Subtidal seagrass beds biotope SS.SMp.SSgr has sub-biotopes SS.SMp.SSgr.Zmar (dominated by *Zostera marina/angustifolia* (Note: the taxonomic status of *Z. angustifolia* is currently under consideration, currently *Z. angustifolia* is considered a synonym of *Z. marina*) and SS.SMp.SSgr.Rup (featuring *Ruppia maritima*). Seagrass beds develop in intertidal and shallow subtidal areas on sands and muds. They may be found in marine inlets and bays but also in other areas, such as lagoons and channels, which are sheltered from significant wave action (BRIG, 2008). The *Zostera* species that occur in the UK all are considered to be scarce. Dwarf eelgrass *Zostera nolteii* is found highest on the shore, often adjacent to lower saltmarsh communities. Narrow-leaved eelgrass *Zostera marina* is found on the mid to lower shore and in the sublittoral. The plants stabilise the substratum, are an important

	source of organic matter and provide shelter and a surface for attachment by other species. Eelgrass is an important source of food for wildfowl which feed on intertidal beds. Where this habitat is well developed the leaves of eelgrass plants may be colonised by diatoms and algae such as *Ulva spp*., *Cladophora ssp*., Red Seagrass Crust *Rhodophysema georgii*, *Ceramium virgatum*, stalked jellyfish and anemones. The soft sediment infauna may include amphipods, polychaete worms, bivalves and echinoderms. The shelter provided by seagrass beds makes them important nursery areas for flatfish and, in some areas, for cephalopods. Adult fish frequently seen in *Zostera* beds include pollack *Pollachius pollachius*, two-spotted goby *Gobiusculus flavescens* and various wrasse species (BRIG, 2008; Bertelli & Unsworth, 2014). Two species of pipefish, *Entelurus aequoraeus* and *Syngnathus typhie* are almost totally restricted to seagrass beds while the red algae *Polysiphonia harveyi* which has only recently been recorded from the British Isles is often associated with eelgrass beds (BRIG, 2008). The diversity of species associated with the seagrass bed will depend on environmental factors such as salinity and tidal exposure and the density of microhabitats, but it is potentially highest in the perennial fully marine subtidal communities and may be lowest in intertidal, estuarine, annual beds (BRIG, 2008). *Zostera* beds are naturally dynamic and may show marked seasonal changes. Leaves are shed in winter, although *Zostera noltii* retains its leaves longer than *Zostera marina*. Leaf growth stops in September/October (Brown, 1990). Although a wide range of species are associated with seagrass beds which provide habitat and food resources, these species occur in a range of other biotopes and were therefore not considered to characterize the sensitivity of this biotope (D'Avack *et al*, 2014).

	Seagrass species are fast-growing and relatively short-lived, they can take a considerable time to recover from damaging events, if recovery does occur at all (D'Avack *et al*, 2014). Boese *et al* (2009) found that natural seedling production was not of significance in the recovery of seagrass beds but that recovery was due exclusively to rhizome growth from adjacent perennial beds. All *Zostra* plants have a similar type of structure and they are restricted to horizontal growth of roots and, hence, unable to grow rhizomes vertically.
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 used mainly on 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.	**1.** Demersal mobile fishing gear reduces habitat complexity by: removing emergent epifauna, smoothing sedimentary bedforms, and removing taxa that produce structure (Auster & Langton, 1999). Demersal otter trawl gear has a direct physical effect on the seabed wherever the ground rope, chains and bobbins, sweeps, doors and any chaffing mats or parts of the net bag 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). As a sensitive marine habitat, seagrass meadows are highly susceptible to physical impacts and disturbance of the habitat (Short & Wyllie-Echeverria, 1996). Most seagrass species, including *Zostera marina* and *Zostera noltii*, grow over sandy to muddy sediments, which are easily penetrated by seagrass roots. The direct ploughing

and scraping of the otter trawl gear on seagrass could cause mortality from a single pass of an otter trawl. The penetration depth of multi-rig trawl gear components range from 2-10cm in sand sediments and 2-35cm in muddier sediment (Eigaard *et al*, 2016), and could remove the upper layers of sediment on which the seagrasses are reliant for anchoring and nutrient uptake. A single pass of multi-rig trawl gear could remove the feature and its root structures and further passes could remove the nutrient rich sediment, reducing the likelihood of recolonisation.

Unsworth and Cullen-Unsworth (2015) investigated the effects of physical disturbance on seagrass meadows in Porthdinllaen, within the Pen Llyn a’r Sarnau Special Areas of Conservation. They conclude that the chains and anchors associated to various types of moorings drag over the seagrass and repeatedly tear the plants, eventually ripping up their roots and rhizomes and reducing the capacity for recovery to occur. The effects of towed demersal gear, such as multi-rig trawl gear, on seagrasses is likely to be greater than the damage caused by anchoring and moorings.

A depression of the seabed caused by disturbance of the sediment can restrict the expansion of the seagrass bed. The size and shape of impacted areas will have a considerable effect on resilience rates (Creed *et al*, 1999). Larger denuded areas (such as those caused by towed demersal fishing gear) are likely to take longer to recover than smaller scars, for example seagrass beds likely to be more resilient to physical damage resulting from narrow furrows left after anchoring because of large edge-to-area ration and related availability of plants for recolonisation.

Neckles *et al* (2005) investigated the effects of trawling for the blue mussels *Mytilus edulis* on *Zostera marina* beds in Maquoit Bay, USA. Impacted sites ranged from 3.4 to 31.8ha in size and were characterized by the removal of above and belowground plant material from the majority of the seabed. The study found that one year after the last trawl, *Zostera marina* shoot density, shoot height and total biomass averaged respectively to 2-3%, 46-61% and < 1%

to that of the reference sites. Substantial differences in *Zostera marina* biomass persisted between disturbed and reference sites up to 7 years after trawling. Rates of recovery depended on initial fishing intensity but the authors estimated that an average of 10.6 years was required for *Zostera marina* shoot density to match pre-trawling standards.

The effects of dredging for scallops on *Zostera marina* beds were investigated by Fonseca *et al* (1984) in Nova Scotia, USA. Dredging was carried out when *Zostera marina* was in its vegetative stage on hard sand and on soft mud substrata. Damage was assessed by analysing the effects of scallop harvesting on seagrass foliar dry weight and on the number of shoots. Lower levels of dredging (15 dredges) had a different impact depending on substrata, with the hard bottom retaining a significantly greater overall biomass than soft bottom. However, an increase in dredging effort (30 dredges) led to a significant reduction in *Zostera marina* biomass and shoot number on both hard and soft bottoms. Solway Firth is a British example for the detrimental effects of dredging on seagrass habitats. In the area, where harvesting for cockles by hand is a traditional practice, suction dredging was introduced in the 1980s to increase the yield. A study by Perkins (1988) found that where suction dredging occurred, the sediment was smoothened and characterized by a total absence of *Zostera* plants. The study concluded that the fishery was causing widespread damage and could even completely eradicated *Zostera* from affected areas. Due to concerns over the sustainability of this fishing activity, the impacts on cockle and *Zostera* stocks, and the effects on overwintering wildfowl, the fishery was closed to all forms of mechanical harvesting in 1994.

Most seagrass species grow over sandy to muddy sediments, which are easily penetrated by seagrass roots. However, highly mobile, but otherwise suitable, sandy sediments may be bare of seagrass (Hemminga & Duarte, 2000). Processes that cause sand ripples and waves can cause successive burial and erosion, which may cause seagrass mortality, depending on the size and frequency of these events. Sediment disturbance caused by multi-rig trawling is likely to cause a greater intensity of burial and erosion in a single pass of the gear than caused by current and wave energy. Below ground rizomes and root structures are dependant on the upper few centimeters of sediment for nutrients. Continued multi-rig trawling events could reduce the nutrient levels within sediments and make recovery difficult. The depth limit of seagrasses is set by the compensation irradiance for growth, or the irradiance required to provide sufficient carbon gains to compensate for carbon losses.

The light requirement for seagrass growth is typically defined as the percentage of surface irradiance that needs to be received by the plants to grow, which ranges between 4% and 29% (Dennison *et al*, 1993), with an average of about 11% of the irradiance incident just below the water surface (Duarte, 1991). These light requirements are greater than those generally observed for other marine phototrophs, such as macroalgae and microalgae (Duarte, 1995). These extremely high light requirements mean that seagrasses are acutely responsive to environmental changes, especially those that alter water clarity (Orth *et al*, 2006).

Duarte *et al* (2007) sought to test seagrass depth limit models from test data comprising 424 reports of seagrass colonisation depth limits. Most (86%) of the reports in the validation set assembled pertained to observations of colonisations depth of *Zostera marina*. The results showed that *Zostera marina* has a colonisation depth range of between 0.5-10m. This data has taken into account varying levels of turbidity. Duarte *et al* (2007) does however make the argument that clear water could allow seagrasses to grow at a depth of 30m. At these depths, the contribution of absorption of water filters out irrandiance at red wavelengths while allowing high-energy blue light to penetrate and promote photosynthesis.

Trawling and dredging re-suspend large amounts of sediments (Pilskaln *et al*, 1998). The increase in turbidity through sediment re-suspension caused by multi-rig trawling would influence the photosynthesis of seagrasses, which could cause mortality. Riemann and Hoffmann (1991) found short-term increased suspended sediment loads of 960-1361%.

In conclusion, the direct physical impact, changes in light caused by sediment re-suspension or sediment removal by, multi-rig trawl gear gear can cause seagrass mortality, without guarantee of recolonisation or recovery.

2. Dermersal trawls cause direct mortality to non-target organisms through impact on the seabed (Bergman & van Santbrink, 2000).

There is growing evidence that seagrass meadows are presently experiencing worldwide decline primarily because of human disturbance, such as direct physical damage and deterioration of water quality (Short and Wyllie-Echeverria, 1996; Hemminga and Duarte, 2000). There is, therefore, concern that the functions seagrasses perform in the marine ecosystem will be reduced or, in some places, lost altogether (Duarte, 2002). Fisheries operations, particularly shallow trawling (Pascualini *et al*, 1999) causes disturbance and damage to seagrass communities.

Seagrass meadows can serve as a nursery ground, often to juvenile stages of economically important species of finfish and shellfish, although the species vary by region and climate (Beck *et al*, 2001; Heck *et al*, 2003). The loss of seagrasses, through physical disturbance from multi-rig trawl gear, would therefore impact on the typical species in which it supports.

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 individuals of a species in study sites that were disturbed with bottom towed gear

In conclusion, seagrass loss through multi-rig trawling could cause a detrimental impact on typical species through loss of food and removal of nursery areas for juvenile finfish and shellfish species.

		Multi-rig trawling could also directly remove typical species from the feature. Typical species recolonisation of this habitat would be dependant on the quality of habitat which remained following a trawling episode. Where there is damage to the habitat, mobile species would be quick to recolonise. If there is the total removal of seagrasses, recolonisation will not occur.
6. MPAs where feature exists	**Menai Strait and Conwy Bay SAC**	Intertidally between Llanfairfechan and Bangor, at Moel-y-Don opp Felinheli and within Y Foryd.
	Lleyn Peninsular and Sarnau SAC	Intertidal and Subtidal beds at Porth Dinllaen, Llanbedrog, intertidally at Pen y chain, subtidally off Criccieth (within 1Nm).
	Pembrokeshire Marine SAC	Subtidally within North Haven at Skomer, intertidally and subtidally within the Milford Haven at Sandy Haven Bay, intertidally on Dale Flats, subtidally and intertidally between South Hook Point and Milford Docks, Sprinkle Pill, Garron Pill, Cresswell River, Carew River, Cosheston Pill, West Llanion Pill, Pembroke River, Pwllcrochan Flats, Angle Bay, off Ellen's Well and the Lifeboat station.
	Carmarthen Bay and Estuaries SAC	River Towy (between Salmon Point and Ferryside), within the Burry Inlet at Llanridian Sands and Penrhyn Gwyn.
	Severn Estuary SAC	Located between Summerleaze and the M4 Severn Crossing.

7. Conclusion

The information presented above indicates that the action of fishing with multi-rig trawl gear directly on seagrass (SACs) is likely to initially cause lethal damage to the seagrass and associated species, while recovery is possible (up to 10.6 years) this would be less likely if the upper centimeters of sediment was also removed during initial interaction or prolonged fishing. Additionally, fishing with multi-rig trawl gear adjacent to seagrass beds could have a negative impact from short or long term sediment re-suspension causing an increase in turbidity, thus affecting photosynthesis; this impact would depend on the extent and frequency of the activity and the tidal and environmental conditions in the area of the habitat.

8. References

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Annex 1

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

SS.SMp.SSgr - Sublittoral seagrass beds.

Beds of seagrass (*Zostera marina* or *Ruppia* spp.) in shallow sublittoral sediments. These communities are generally found in extremely sheltered embayments, marine inlets, estuaries and lagoons, with very weak tidal currents. They may inhabit low, variable and full salinity marine habitats. Whilst generally found on muds and muddy sands they may also occur in coarser sediments, particularly marine examples of *Zostera* communities.

SS.SMp.SSgr.Zmar - *Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand

Expanses of clean or muddy fine sand and sandy mud in shallow water and on the lower shore (typically to about 5 m depth) can have dense stands of *Zostera marina/angustifolia.* In Zmar the community composition may be dominated by these *Zostera* species and therefore characterised by the associated biota. Other biota present can be closely related to that of areas of sediment not containing *Zostera marina*, for example, *Laminaria saccharina, Chorda filum* and infaunal species such as *Ensis* spp. and *Echinocardium cordatum*. From the available data it would appear that a number of sub-biotopes may be found within this biotope dependant on the nature of the substratum and it should be noted that sparse beds of *Zostera marina* may be more readily characterised by their infaunal community. For example, coarse marine sands with seagrass have associated communities similar to MoeVen, SLan or Glap whilst muddy sands may have infaunal populations related to EcorEns, AreISa and FfabMag. Muddy examples of this biotope may show similarities to SundAasp, PhiVir, Are or AfilMysAnit. At present the data does not permit a detailed description of these sub-biotopes but it is likely that with further study the relationships between these assemblages will be clarified. Furthermore, whilst the *Zostera* biotope may be considered an epibiotic overlay of established sedimentary communities it is likely that the presence of *Zostera* will modify the underlying community to some extent. For example, beds of this biotope in the south-west of Britain may contain conspicuous and distinctive assemblages of Lusitanian fauna such as *Laomedea angulata, Hippocampus* spp. and *Stauromedusae*.

SS.SMp.SSgr.Rup - *Ruppia maritima* in reduced salinity infralittoral muddy sand

In sheltered brackish muddy sand and mud, beds of *Ruppia maritima* and more rarely *Ruppia spiralis* may occur. These beds may be populated by fish such *as Gasterosteus aculeatus* which is less common on filamentous algal-dominated sediments. Seaweeds such as *Chaetomorpha* spp., *Enteromorpha* spp., *Cladophora* spp., and *Chorda filum* are also often present in addition to occasional fucoids. In some cases the stoneworts *Lamprothamnium papulosum* and *Chara aspera* occur. Infaunal and epifaunal species may include mysid crustacea, the polychaete *Arenicola marina*, the gastropod *Hydrobia ulvae*, the amphipod *Corophium volutator* and oligochaetes such as *Heterochaeta costata*. In some areas *Zostera marina* may also be interspersed with the *Ruppia* beds.