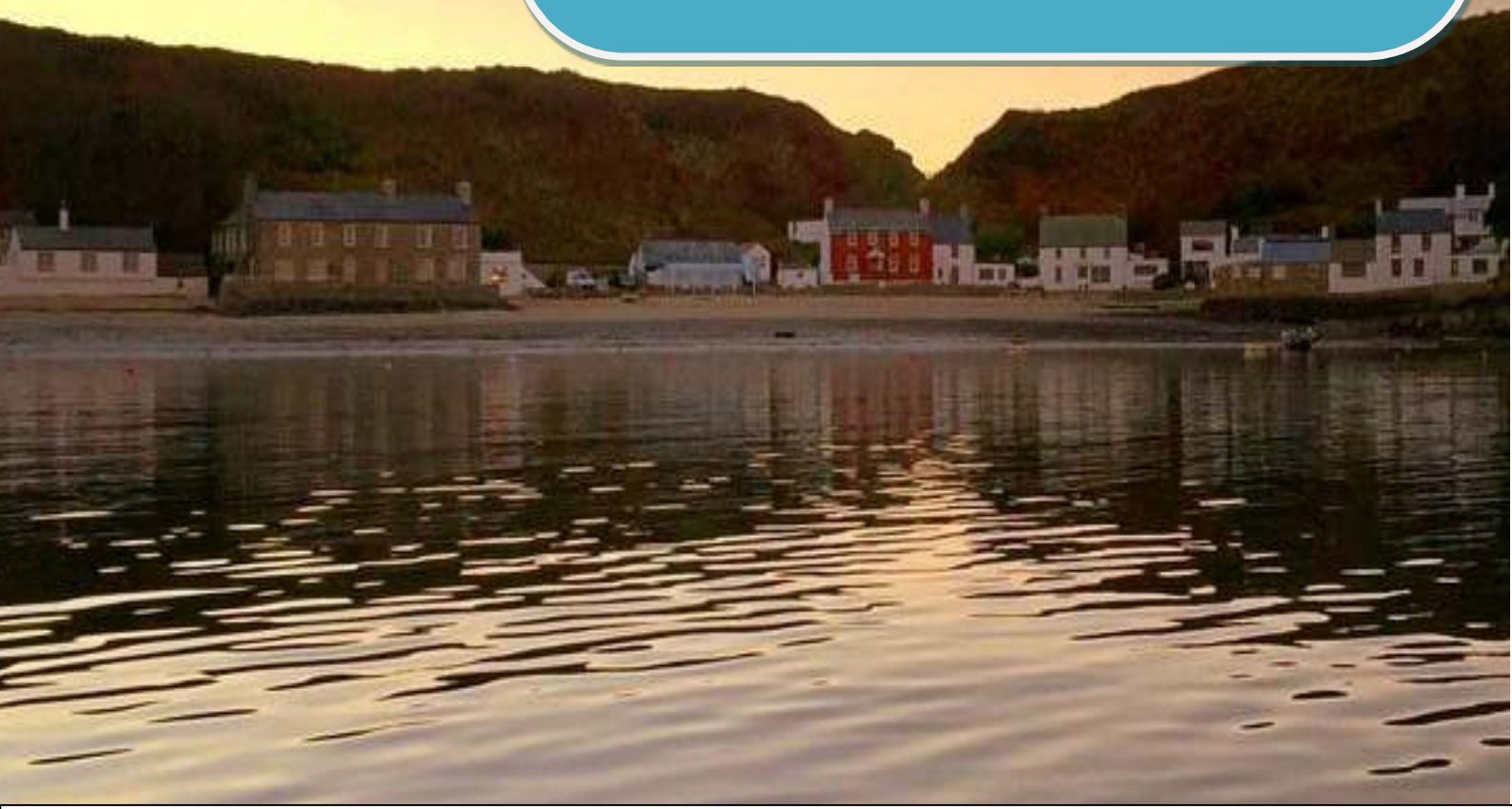
ACA Pen Llŷn a'r Sarnau SAC

Prosiect Morwellt Porthdinllaen Seagrass Project

Mynediad cerbydau ar draws y morwellt rhynglanwol ym Mhorthdinllaen: adolygiad o'r effeithiau posib ac opsiynau rheoli

Vehicular access across the intertidal seagrass bed at Porthdinllaen: review of potential impacts and management options

2017



Lucy Kay and Liz Morris-Webb

Adroddiad wedi darparu ar gyfer ACA Pen Llŷn a'r Sarnau / A report prepared for the Pen Llŷn a'r Sarnau SAC

Pen Llŷn a'r Sarnau SAC
Vehicular access across the intertidal seagrass bed at Porthdinllaen: review of potential impacts and management options

Lucy Kay & Liz Morris-Webb

Final

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A report prepared by Marine EcoSol on behalf of Gwynedd Council and the Pen Llŷn a'r Sarnau SAC for the Porthdinllaen Seagrass Project.

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Mae'r adroddiad hwn yn crynhoi ac yn adolygu'r wybodaeth am effeithiau ffisegol uniongyrchol sy'n deillio o ddefnyddio cerbydau ag olwynion ar welyau morwellt rhynglanwol. Comisiynwyd yr adroddiad hwn gan ACA Pen Llŷn a'r Sarnau i gefnogi'r gwaith sydd ar y gweill gan Brosiect Morwellt Porthdinllaen. Ei fwriad yw cyfrannu tuag at ddulliau y gellid eu defnyddio yn y dyfodol i reoli cerbydau ag olwynion yn ardal y gwely morwellt rhynglanwol ym Mhorthdinllaen.

Cydnabyddir bod gwelyau morwellt yn gynefin morol pwysig a gwerthfawr. Maent yn darparu bwyd a chysgod i lawer o rywogaethau eraill, yn cyflawni swyddogaethau strwythurol, gweithredol ac ecolegol pwysig yn yr amgylchedd morol ac yn darparu nifer o wasanaethau ecosystem. Yn y DU mae nifer o gyfreithiau statudol a pholisïau cenedlaethol a rhyngwladol yn diogelu'r gwelyau morwellt.

Er bod corff sylweddol o wybodaeth yn bodoli am effeithiau amrywiol weithgareddau dynol ar welyau morwellt, ychydig iawn o astudiaethau sy'n ystyried effeithiau cerbydau ar forwellt rhynglanwol. Gan nad oes ymchwil wedi'i ddogfennu ar effeithiau cerbydau ar forwellt, mae'r adroddiad hwn hefyd yn ystyried yr effeithiau ffisegol o sathru gwelyau morwellt ynghyd â'r effeithiau ehangach, ac mae'n darparu nifer o enghreifftiau o effaith cerbydau ar forwellt.

Mae effeithiau cerbydau a sathru ar gynefinoedd gwaddodol morol (gan gynnwys morwellt) yn cynnwys:

- cywasgu'r is-haen. Yn gyffredinol mae hyn yn creu rhigolau a phantiau sy'n gallu aros am flynyddoedd lawer (hyd yn oed o ganlyniad i un digwyddiad), a fydd o bosib yn creu pantiau dwfn a pharhaus. Mae cywasgu yn newid rhinweddau'r gwaddod, a gall newid yr hydroleg leol. Gall yr ardaloedd sydd wedi cywasgu fod â phridd sydd â dwysedd uwch a sy'n anoddach i'w dreiddio, gyda lleihad yn y cynnwys lleithedd a halltedd.
- lleihad ym mhresenoldeb a niferoedd y rhywogaethau cysylltiedig
- difrod i rwydwaith tanddaearol gwreiddiau'r morwellt (*rhizomes*)
- cynnydd yn erydiad y gwaddod
- lleihad yn nwyster y morwellt (dwyster yr egin, llafnau byrrach, lleihad yn nhaldra'r canopi) a gorchudd (maint) y dolydd morwellt.
- darnio'r gwelyau morwellt

Pan fo'r effeithiau yn parhau, gall arwain at ddiflaniad y morwellt. Mae'r gallu i adfer y morwellt yn dibynnu ar nifer o ffactorau, gan gynnwys: math y cerbyd, dwyster y trawiad (e.e. nifer a hyd amser), maint yr ardal a effeithiwyd, dull gyrru'r cerbyd, natur y cynefin a'r llystyfiant, gan gynnwys topograffi, ac amrywiad tymhorol ym maint y gorchudd a'r tyfiant. Ystyrir bod trawiadau ffisegol ar waddodion meddal sy'n cynnwys morwellt yn waeth nag ar waddodion mwy bras, gan ei bod yn fwy tebygol y bydd yr ardrawiad yn treiddio o dan yr haen wyneb ac yn effeithio ar y system wreiddiau tanddaearol bas (*rhizome*).

Mae asesiadau sensitifrwydd yn ystyried bod cynefinoedd morwellt yn hynod o sensitif i weithgareddau sy'n treiddio neu'n aflonyddu'r is-haen o dan yr wyneb neu sy'n achosi newid mecanyddol i'r gwaddod (ac felly'n difrodi'r gwreiddiau a'r dail).

Mae tystiolaeth yn Mhorthdinllaen, sydd wedi deillio o astudiaethau monitro parhaus, bod cerbydau ar y gwelyau morwellt rhynglanwol wedi cael effaith, a bod hyn wedi digwydd ers sawl blwyddyn. Felly, ystyrir bod effaith y cerbydau hyn yn cyfrannu'n rhannol at ddifrodi'r gwely morwellt ac yn effeithio ar ei iechyd a'i wytnwch.

Pysgotwyr yn bennaf sy'n defnyddio cerbydau ym Mhorthdinllaen, gan ddefnyddio tractorau i fynd at eu cychod pysgota ac i gludo offer a'u dalfa o bysgod. Hefyd, mae peth

defnydd o gerbydau gyriant pedair olwyn a *'pick-up'* sy'n gysylltiedig â gwaith cynnal-a-chadw a newid angorfeydd. Mae rhai effeithiau eraill ar y gwelyau morwellt ym Mhorthdinllaen ar wahân i gerbydau.

Disgrifir perchnogaeth y blaendraeth ac ym Mhorthdinllaen, a nodir y gyrwyr deddfwriaethol allweddol sy'n diogelu'r gwely morwellt. Mae gofyniad cyfreithiol i amddiffyn y gwely morwellt ym Mhorthdinllaen, ac amcan Prosiect Morwellt Porthdinllaen yw cyflawni'r gofyn hwn, gan sicrhau iechyd y gwely morwellt i'r dyfodol ynghyd â chefnogi defnydd presennol yr ardal.

Mae nifer o opsiynau y gellid eu hystyried i leihau effaith y cerbydau ar y morwellt, a disgrifir y rhain yn yr adroddiad. Y pwysicaf o'r rhain yw cychwyn trafodaethau gyda'r pysgotwyr lleol ym Mhorthdinllaen i drafod y mater, gan archwilio datrysiadau posib a chytuno ar ffordd ymlaen. Rhaid ystyried y defnydd o gerbydau, a datrysiadau i leihau'r effaith, yng nghyd-destun effeithiau ffisegol uniongyrchol eraill a phwysau eraill ar y gwely morwellt, ynghyd â'r ffordd orau o ymdrin â'r rhain.

Executive summary

This report collates and reviews information about direct physical impacts from wheeled vehicles on intertidal seagrass beds. The report has been commissioned by the Pen Llŷn a'r Sarnau SAC partnership to support work being undertaken through the Porthdinllaen Seagrass Project. It aims to inform any future management approaches that may be implemented for wheeled vehicles operating over the intertidal seagrass bed at Porthdinllaen.

Seagrass beds are recognised as an important and valuable marine habitat. They provide food and shelter for many other species, play an important structural, functional and ecological roles in the marine environment and provide a number of ecosystem services. In the UK seagrass beds are protected under a number of international and national statutory laws and policy drivers.

Whilst there is a substantial body of information about impacts of various human activities on seagrass beds, only a very limited number of studies specifically address impacts caused by vehicles on intertidal seagrass. In the absence of any substantial amount of documented research on vehicle impacts on seagrass, this report also considers physical impacts arising from trampling and the wider implications of this on seagrass beds, and provides a number of known examples of vehicle impact on seagrass.

Vehicle and trampling impacts on marine sediment habitats (including seagrass), include:

- compaction of the substratum. This generally creates ruts and depressions that can persist for many years (even after a single pass event), potentially creating deep persistent ditches. Compaction alters the sediment properties and can affect local hydrology. Compacted areas can exhibit increased soil penetration resistance and bulk density, and decreased moisture content and salinity.
- reduction in presence and abundance of associated species
- damage to the underground network of seagrass roots (rhizomes)
- increased erosion of sediment
- reduction in seagrass density (shoot density, shorter blade length, reductions in canopy height) and cover (extent) of seagrass meadows.
- fragmentation of seagrass beds

Where impacts persist, seagrass may be completely absent. Recovery from impact depends on a number of different factors including: the type of vehicle, the intensity of the impact (e.g. number of passes and duration), the size of the area impacted, how the vehicle is driven, the nature of the habitat and vegetation including the topography, and seasonal variation in plant cover and growth. Physical impacts on softer sediments with seagrass are considered to be more adverse than for coarser sediments, as there is greater potential for the impact to penetrate the surface layer and affect the shallow underground root (rhizome) system.

Sensitivity assessments consider seagrass habitats to be highly sensitive to activities that lead to penetration or disturbance of the substratum below the surface and those that cause mechanical modification of the sediment (and hence damage to roots and leaves).

There is evidence at Porthdinllaen, identified from ongoing monitoring studies, of impacts from vehicles on the intertidal seagrass bed that have been occurring for many years. The impact from vehicles is considered to be contributing, in part, to damage to the seagrass bed and affecting its health and resilience.

Vehicle use at Porthdinllaen is primarily by fishermen using tractors to gain access to and from their fishing vessels and transport equipment and catch. There is also some use of four wheel drive vehicles and pick-ups associated with maintenance and replacement of

moorings. There are other impacts on the seagrass bed at Porthdinllaen in addition to vehicle use.

Ownership of the foreshore and at Porthdinllaen is described and key legislative drivers requiring protection of the seagrass bed are highlighted. There is a legal requirement to protect the seagrass bed at Porthdinllaen and the aim of the Porthdinllaen Seagrass Project is to meet this obligation and ensure the future health of the seagrass bed whilst supporting continued use of the area.

There are a number of options that could be considered to reduce the impact of vehicles on the seagrass and these are described in the report. The most important of these is to initiate a discussion with local fishermen at Porthdinllaen to discuss the issue, explore potential solutions and agree a way forward. Vehicle use, and solutions to reduce its impact, need to be seen in the context of other direct physical impacts and other pressures on the seagrass bed and how these could best be dealt with.

1. Introduction & background to the project

1.1 The Porthdinllaen seagrass project and the aim of this report

Porthdinllaen is a small coastal village on the north coast of Pen Llŷn in north west Wales. The village is nestled within a sheltered bay that provides a valued safe haven and anchorage for recreational boats and a number of small fishing vessels (Figure 1.1).

The conditions in the bay support the development of seagrass, which forms a dense bed in the intertidal and the subtidal areas. The seagrass bed is an important component of both the Pen Llŷn a'r Sarnau Special Area of Conservation (SAC) and the Porthdinllaen i Borth Pistyll Site of Special Scientific Interest which encompass parts of the beach and adjacent sea area at Porthdinllaen.

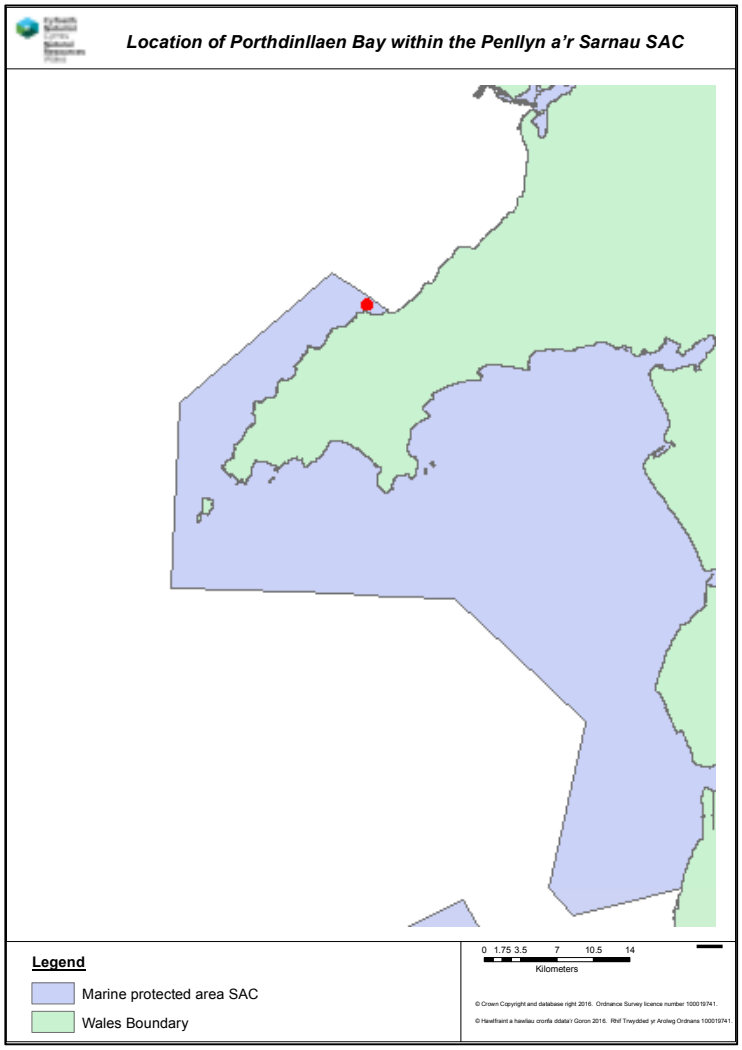

Figure 1.1 Location map of Porthdinllaen bay in the Pen Llŷn a'r Sarnau SAC (from Davies et al., 2017). Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 1000019741. Crown Copyright and Database Right

The management of the Pen Llŷn a'r Sarnau SAC is overseen by a partnership of organisations that work collaboratively to address issues affecting the SAC. The Porthdinllaen Seagrass Project is one of a number of management projects being implement by the SAC partnership and co-ordinated by the SAC Officer. It aims to work

collaboratively with local users and organisations to address issues affecting the seagrass at Porthdinllaen.

This report has been commissioned by the Pen Llŷn a'r Sarnau SAC partnership to support work being undertaken through the Porthdinllaen Seagrass Project. The report collates and reviews information about impacts from (wheeled) vehicles on intertidal seagrass beds. The report presents several management approaches that have been implemented in other locations to address or avoid similar impacts. The report will help inform any future management approaches that may be implemented for wheeled vehicles operating over the intertidal seagrass bed at Porthdinllaen.

More information about the Porthdinllaen Seagrass Project can be found on the Pen Llŷn a'r Sarnau SAC website[1].

1.2 Approach taken to prepare the report

This report focuses specifically on the direct physical impact of vehicles on intertidal seagrass beds. There are other potential associated impacts that can arise from use of vehicles in intertidal seagrass beds such as litter, pollution, introduction of non-native species, noise and visual disturbance. These are not considered within the specification of this report.

A significant proportion of the work to prepare the report involved a desk study and literature review of relevant information relating to vehicle impacts on seagrass. The literature review drew on a number of sources of information including the peer-reviewed literature, web-based resources and contact with marine management practitioners and individuals involved in seagrass research in the UK and further afield.

Whilst there is a substantial body of documented information on impacts of various human activities on seagrass beds (both intertidal and subtidal), only a very limited amount of this specifically addresses the impacts caused by vehicles. Motorised wheeled vehicles were the main focus of the literature searches as this relates most closely to the types of vehicles in use at Porthdinllaen, but references to motorised tracked vehicles or non-motorised wheeled vehicles were also investigated. References and information relevant to both temperate and tropical situations were considered.

Literature searches were undertaken using the following resources:

- Open Grey (http://www.opengrey.eu/search): Information on grey literature in Europe *(searched 'seagrass' and 'vehicle impact', 'beach management of human activities')*
- The Directory of Open Access Journals (https://doaj.org) *(searched 'seagrass' and 'vehicle impact')*
- Bangor University library catalogue *(various searches including 'seagrass' + trampling', 'vehicle', 'damage', 'impact')*
- Google Scholar *(searched 'seagrass' and 'vehicle impact')*
- ResearchGate *(searched 'seagrass' and 'seagrass impact')*
- The Web of Science *(searched 'seagrass + vehicular damage' and 'seagrass + impact')*
- Library and publications catalogues of the Joint Nature Conservation Committee, Natural Resources Wales, Scottish Natural Heritage and Natural England.
- The Seagrass Forum (Seagrass Research Discussion List) *(*http://lists.murdoch.edu.au/mailman/listinfo/seagrass_forum) - a web-based global

[1] www.penllynarsarnau.co.uk

forum to help connect seagrass researchers around the world and facilitate the discussion of all aspects of seagrass biology and ecology.

Practical examples of vehicle impacts and management were provided by marine management practitioners in government and research organisations in UK and further afield.

Information about the use of vehicles at Porthdinllaen was provided by the local National Trust Ranger, SAC Officer and SAC Project Officer from their own knowledge and through discussion with local residents, boat users and fishermen who use the Porthdinllaen area.

Organisations contacted included: Natural Resources Wales, The National Trust (Wales and UK), Scottish Natural Heritage, Natural England, Department of Agriculture, Environment & Rural Affairs Northern Ireland, Environmental Protection Agency Ireland, Project Seagrass and Ministry of Defence (MoD, Defence Infrastructure Organisation Environmental Support & Compliance Team).

2. Seagrass

Seagrasses are marine plants that grow in sheltered intertidal and shallow subtidal sea areas in many parts of the globe. Seagrasses are 'true' plants - marine angiosperms that, in contrast to other marine plants such as seaweeds and algae, have flowers and produce seeds. Seagrasses can grow in sandy, muddy and gravelly substrates and they anchor themselves within this by a network of underground roots (rhizomes) that extend horizontally beneath the substratum surface.

In the UK there are two known species of seagrass: *Zostera marina* and *Zostera noltei*[2] (Kay, 1998). *Zostera marina* is a predominantly subtidal species that can extend into the lower shore, whereas *Z. noltei* is an intertidal species that can be found on wave sheltered mud and sand in bays and estuaries. A third species *Zostera angustifolia* is also often referred to, but the majority consensus is that this is actually a variant of *Z. marina*.

In appropriate environmental conditions seagrasses can flourish and form extensive beds (or meadows), creating a habitat which supports a variety of other species and which has an important structural, functional and ecological role in the marine environment. A number of ecosystem services are provided by seagrass (Jackson *et al.,* 2013; UK National Ecosystem Assessment, 2011; Unsworth & Cullen-Unsworth, 2015).

Plate 2.1 Seagrass Zostera marina habitat (© Paul Kay)

Seagrass beds are an important source of organic matter and they have a role in nutrient cycling, provide oxygen to water and sediment and sequester carbon from the atmosphere. Seagrass beds also help stabilise sediment and increase biodiversity by providing a habitat for many other species both within the substratum and amongst the plants; they are known to provide an important nursery and foraging habitat for a number of different fish (e.g. Bertelli & Unsworth, 2014; Davison & Hughes, 1998; Duarte, 2002; Jackson *et al.,* 2013).

Seagrass presence and growth is determined by a number of environmental parameters including temperature, salinity, light, substrate type, depth, water current, wave action, availability of seeds and vegetative fragments, and competition with other species, all of which will show degrees of variation as part of natural environmental processes.

In addition to natural environmental change, there are a range human activities and human-induced influences that can effect seagrass (directly and indirectly). These influences can

[2] Dwarf eelgrass is often referred to in the scientific literature as *Z.noltii*. The World Register of Marine Species (WoRMS http://www.marinespecies.org) does not accept *Zostera noltii* and instead lists *Zostera noltei* (or, in full, *Zostera (Zosterella)* noltei) as the accepted name. In this report *Z.noltei* is used except where *Z.noltii* is the name used in any cited literature.

change the scale or nature of the biological, chemical and physical parameters essential for the growth of seagrass plants and establishment of seagrass beds.

Recognition of the importance of seagrass beds and seagrass species, together with improved understanding of the nature and scale of global and local declines has led to measures for improved protection and management of seagrass worldwide. In the UK there are a number of statutory and policy drivers (both national and international) supporting protection of seagrass habitats. Jackson *et al. (*2013) provide a summary of the political framework for seagrass protection in the UK at the time of their report, which encompasses measures focusing on specific protection of seagrass as well as requirements to protect the wider ecosystem and biodiversity.

3. Impact of vehicles on seagrass

This section presents the findings of the desk based review of vehicle impacts on seagrass. It draws on a number of reviews relating to seagrass together with more recent publications on impacts of vehicle use over seagrass beds. Additional information was sought from reviews of vehicle impacts on other natural habitats where appropriate. Information has also been provided by statutory conservation and marine management organisations and researchers in the UK, as well as seagrass researchers and managers contacted via the international web-based seagrass forum.

3.1 Use of vehicles over intertidal areas of seagrass

Intertidal seagrass beds generally develop in sheltered coastal areas with sand/mud shores. The sediment is generally quite soft and so these areas tend not to attract vehicles for general recreation or parking as can occur on some firmer sand shores.

The majority of access over intertidal seagrass identified from the literature and information provided by marine managers is associated with maritime development works and related activities, or access related to fisheries. Fisheries related access is either to reach shellfish grounds within or beyond the seagrass bed, or to enable transport of equipment and catch to and from boats moored or beached at low tide. A limited amount of vehicle use is associated with general vehicular traffic (R. Wilkes, *pers. comm.*, 2017) and, at Porthdinllaen, some has been associated with inspection of intertidal moorings (L. Kay, personal observations). Detail of vehicular access across Porthdinllaen seagrass is presented in section 5.

The vehicles used in the vicinity of seagrass beds are generally of a type appropriate for use on softer sediment shores such as tractors, 4WD vehicles, all-terrain vehicles (ATVs) and off-road motorbikes; larger vehicles, such as tractors, may also be used to tow trailers. However, where the sediment is sufficiently firm, ordinary vans or small pick-ups may be used.

3.2 Impacts of vehicles on natural habitats

Impacts from motorised vehicles on natural habitats and species are not a new phenomenon. An example of an early study into the impacts of vehicles on the natural environment is Meinecke (1929), which reported on damage to the roots of redwood trees from vehicles driving over them; the report recommended that vehicles (and intensive foot access tracks) were kept away from the trees because of the severity of impact on their relatively shallow root system.

With increasing use of motorised vehicles, studies of their impact have expanded to look at the effects on different habitats and under different scenarios. The majority of this work has focused on terrestrial habitats. A review of literature undertaken as part of a report into the effect of access for fisheries on intertidal habitats (Tyler-Walters & Arnold, 2008) also found that most of the studies into impacts of vehicles on natural habitats related to terrestrial habitats, although effects on sand dunes were documented. Many of the people contacted as part of the study reported vehicle impacts on saltmarsh habitats.

The impact of vehicles on terrestrial habitats and their recovery varies depending on a number of different factors including: the type of vehicle, the intensity of the impact (e.g. number of passes and duration), the size of the area impacted, how the vehicle is driven, the nature of the habitat and vegetation including the topography, and seasonal variation in plant cover and growth (Buckley, 2004).

Reported impacts of vehicle use on natural habitats (Buckley, 2004; Tyler-Walters & Arnold, 2008) include:

- soil compaction and modifying soil properties (such as decreased porosity and hydraulic conductivity and increased bulk density and penetration resistance)
- creation of ruts and furrows
- destabilising sediment
- soil erosion
- crushing & bruising of individual plants
- reduction in vegetation cover (which can lead to increased soil erosion, nutrient loss and soil surface temperature)
- alteration of dominant vegetation community type
- transport of seeds and fragments of non-native species including introduction of plant pathogens
- reduction in animals populations
- crushing animals, nests & burrows
- collisions with animals and roadkill
- physiological damage due to noise
- noise, vibration and visual impact disturbance leading to displacement, habitat loss and impact on behavioural activity (e.g. ability to feed or presence of prey species)
- barriers to movement from wheel ruts, tracks and dirt roads
- indirect impacts of increased human access, including feral animals, hunting and fires.

There have been fewer studies into the impact of vehicles on intertidal sediment habitats than for terrestrial and coastal systems such as sand dunes, but many of the impacts outlined above also apply to intertidal sediment habitats.

Recorded impacts on sand beach habitats and their infauna (reported in Buckley, 2004 and Davenport & Davenport, 2006) include: creation of ruts and sediment compaction; reductions in ghost crab populations by up to 90%; damage to large bivalve species and sand dollars (an echinoderm) in sediment and impacts on isopod populations. Work in South Africa (van der Merwe, 1988, van der Merwe and van der Merwe, 1991 and Brown, 2000, all cited in Buckley, 2004) identified that the proportion of isopods killed or injured by off road vehicle was directly related to the number of vehicle passes and this was a major factor in the decline of isopod populations. Vehicle impacts on coastal sediment habitats can be very persistent, Martin *et al.* (2008) observed tracks created by off-road vehicles on wind-tidal flats in Mexico that have persisted for at least 38 years.

Saltmarsh

The impacts of vehicles on saltmarsh habitats are more widely reported both within the literature and in observations by conservation and land mangers. The obvious visual impact is the creation of ruts which can persist for many years and, if the impact continues, create deep persistent ditches. Tyler-Walters & Arnold (2008) note a number of incidences of reported impacts by marine managers of vehicle use on saltmarsh in the UK. A single pass of a vehicle has been shown to have a significant impact on saltmarsh causing rutting and loss of saltmarsh plants (Blionis & Woodin, 1999; Broadhead & Godfrey, 1979; and Packham & Willis, 1997, cited in Tyler-Watlers & Arnold, 2008). Vegetation recovery may occur quite quickly or within a few years depending on the intensity of the impact

(Broadhead & Godfrey, 1979). However, the impact may be more persistent such that vegetation within the impacted area does not recover to its original state but instead remains in an earlier successional stage, even after a period of several years following the impact (Blionis & Woodin, 1999). Vehicle impact compacts the substratum, increasing soil penetration resistance and bulk density, and decreasing moisture content and salinity.

The majority of impact studies on vehicle use in saltmarsh habitats have focused on the effects on vegetation cover, plant composition and soil properties. There are fewer studies into the effect on associated fauna, even though a range of specialist saltmarsh organisms depend on the presence of saltmarsh plants for their survival. Trave and Sheaves (2014) recorded a reduction in saltmarsh crab burrow density and crab assemblages in the areas of marsh affected by chronic vehicle use compared with vegetated, un-impacted areas of marsh.

Trampling

Tyler-Walters and Arnold (2008) identified a greater body of referenced literature on the impact of trampling by foot access on intertidal sediment habitats compared with studies into the impact of vehicles, although comparative information on trampling effects in some intertidal habitats was very limited. The findings of trampling studies are, however, useful to help inform understanding of potential impacts from vehicle use. Trampling effects include compaction of the sediment and impacts on the infaunal species. In intertidal muddy sediment, trampling has been shown to have an adverse impact on macrofauna, particularly where sediments are dominated by animals with stable burrows which are crushed when the sediment is compacted. Depending on the habitat and circumstances of the impact, meiofauna communities may recover quite quickly through rapid recruitment from surrounding areas (Tyler-Walters & Arnold, 2008).

In many situations physical impacts on natural habitats, whether these are marine or terrestrial habitats, do not generally occur in isolation but are one aspect of a suite of influences (natural and human-induced) on the natural system.

3.3 Relative impact of different types of vehicle

To help understand the impacts likely to arise from different types of vehicle it is useful to consider the relative impact levels of different vehicles and, also, how these might compare with the impacts from foot access.

Liddle (1997) calculated relative ground pressures exerted by outdoor recreational vehicles, animals and humans in order to compare the relative impact of different recreational activities. He calculated that a person walking in bare feet on hard ground exerted a ground pressure of 297g/cm^2, compared to 416g/m^2 for a human wearing Vibram-soled boots on hard ground, 1,282g/cm^2 for a horse with rider on hard ground (ground pressure of the whole foot) and 1,686g/cm^2 for a 4WD Toyota with four people and gear on hard ground. These ground pressure figures are influenced by a wide variety of different factors in any given situation, such as the softness or hardness of the ground, whether the ground is flat or sloping, different types of footwear, and different types of vehicle tyres. The tangential forces exerted by a vehicle were noted by Liddle (1997) to be much higher than those generated by human feet or horses' hooves.

Another method of assessing relative effects of vehicular impact on vegetation through the calculation of a relative net 'Land Impact' figure was developed by Yorks (2000 & 2009). This again identified vehicles as having a significantly larger net land impact than walkers, cyclists and horses, with a larger land impact arising from heavier and more powerful vehicles.

Yorks developed a general model for understanding the varying impact of different forms of travel where the total amount of impact to vegetation can be understood as a function of the energy transmitted to plant structures by different modes of travel:

Land Impact = (weight + output acceleration) x swath

'Output acceleration' is defined as vehicle power (horsepower) divided by its weight (mass). 'Swath' is the width of the vehicle track (vehicle tyre, foot or track) multiplied by the distanced travelled.

Whilst this provides a relative comparative approach, it does not take into account contributing factors such as habitat type, soil hardness, the specific community impacted, topography of the ground, nor the influence of different types of tyres, tracks or foot ware. The influence of distance travelled within the model has the potential to bias comparisons between different forms of travel to identify those forms of travel that are likely to cover greater distances (e.g. motorised vehicles) as always having the greater impact, when walking and trampling can also have significant negative impacts on natural habitats.

The relative impact of a first pass, or limited number of passes can vary considerably depending on the mode of travel and the nature and sensitivity of the receiving habitat. Repeated or sustained passes of many different modes of travel can, in time, have significant and long-lasting effects. So, whilst the relative impact of a walker, compared to a heavy vehicle, is less for a single pass, sustained impacts from walkers can result in damage to soils, sediment, vegetation and associated fauna.

Tyler-Walters & Arnold (2008), in considering the comparative impact of different types of vehicles, considered that Yorks' (2000) model represented the best comparative study available at the time. However, his relative calculation of ground impact for large vehicles was considered an over-estimate for short distance journeys, and therefore Tyler-Walters & Arnold (2008) used the general estimate by others (Liddle, 1997; Buckley, 2004) that off-road vehicles could create 5-30 times the damage of a walker.

Based on Yorks' work and other studies, Tyler-Walters & Arnold (2008) ranked the potential relative impact of different vehicles types as follows: the potential relative impact of a semi-truck is greater than that of a 4x4 (SUV, pick-up or tractor), which is greater than an ATV or trail-bike, which has a greater impact than a walker.

Using available information on the potential relative impact of vehicles and levels of access activity for fishing reported by representatives of relevant organisations, Tyler-Walters and Arnold (2008) suggested intensity definitions for vehicle access to fishing areas (Table 3.1). The intensity definitions do not take into account differences in the weight of vehicles if loaded and/or pulling trailers.

Table 3.1. Intensity definitions for access to fishing areas assisted by vehicles (from Tyler-Walters & Arnold, 2008)

Intensity	Definition
Heavy	Access by more than two 4x4s (or SUVs) or a mixture of SUV and ATVs per hectare per day. Several vehicles access the areas as a group.
Moderate	Access by a single 4x4 (or SUV) or several ATVs per hectare per day
Light	Access by one/two trail bikes or ATVs per hectare per day
Single	Access on a single occasion

3.4. Impact of vehicles on intertidal seagrass

There are a considerable number of studies and reports documenting the impact of a range of human activities on seagrass beds (e.g. d'Avack *et al.,* 2014; Duarte, 2002; Duarte *et al.,* 2004; Holt *et al.,* 1997; Jackson *et al.,* 2013; Short & Wyllie-Echeverria, 1996). Direct physical disturbance to seagrass can be caused by a variety of activities including trampling, dredging, use of mobile fishing gear, land claim, coastal development, boat propellers, anchoring, mooring, boat hulls during shore landings and vehicles. Many of these impacts are considered in the available literature but, as detailed in section 3.2, very few peer reviewed papers focus specifically on the effects of vehicles on intertidal seagrass.

As a result, this section considers the peer reviewed literature together with documented studies and incidental observations relating to particular vehicle impacts on seagrass in the UK and Ireland. Given limited research on vehicular damage and recovery, documented evidence of the impacts of trampling on seagrass is also taken into account. Trampling on sediment shores and saltmarsh (discussed in section 3.2) is a direct physical compression impact on sediment habitat and it is therefore helpful to consider in building a picture of the impact of vehicles on intertidal seagrass, and the factors that affect the nature and scale of those impacts.

a) Angle Bay, Pembrokeshire, Wales

Angle Bay in Milford Haven, Pembrokeshire has been the location for two studies into the impact of vehicles on intertidal seagrass.

The earlier study undertaken between 1996-2001 (Hodges & Howe, 1997 & 2005; Moore, 2006) investigated the impact of the Sea Empress oil spill (1996) on intertidal seagrass *Zostera angustifolia*[3] in three locations in Milford Haven contaminated by oil. In Angle Bay, the study also looked at the impact on the seagrass of the vehicles used in the clean-up operation. Ruts from the vehicles were clearly visible immediately after the clean-up, and oil from the spill that was present on the beach and over the intertidal seagrass had been pressed into the sediment by the vehicles. The vehicle tracks remained visible for up to 4 years.

The second study at Angle Bay (Pauls *et al.,* 2017) undertaken over 4 years (2007-2011), looked at the effect of vehicle tracks on *Zostera noltei* as part of an investigation of the recovery of seagrass subject to typical human disturbance. This is the only reference to a study specifically set up to look at vehicle impacts on seagrass that has been found. The experiment was set up to look at the impact of a single event vehicle impact on the seagrass using a four wheel drive (4WD, or 4x4) pick up with a tyre width of 20cm. The immediate impact was a clear decrease in the presence of *Z. noltei* in the area directly impacted by

[3] This is now identified as *Zostera noltei* in Angle Bay

the vehicle tyres, with a decrease of 80-90% seagrass blade frequency observed (blade frequency measured as percentage presences /absence of seagrass blades along a 2m tape measure). Adjacent areas 50-75cm to either side of the tyre track did not show a similar reduction in the presence of *Z. noltei* indicating a localised immediate impact. Much of the seagrass had been squashed down into the surface of the tyre track.

Plate 3.1 Tyre track impact created for the experimental study at Angle Bay (Pauls et al., 2017. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved).

Over the first 9 months the tyre tracks caused deep ruts and compression of the sediment which led to local changes in hydrology. The ruts were observed to act as small streams channelling water from the surrounding sediments which, in places, washed some seagrass away. After 9 months this water-channelling effect had diminished although the tracks were still visible. Seagrass presence in the impact site took 2 years to recover to a similar level as at the control site, showing a slow recovery time for a single pass event.

Pauls *et al.* (2017) also observed a distinct seasonal variation in seagrass frequency in both the impact and control sites with the greatest density in July, slightly decreasing in October and then a sharp decrease during the winter months of January and February. Most seagrass growth occurred between April and September. The seasonal growth pattern shown in the Angle Bay study illustrates the effect of a short growing season available to seagrass in temperate regions. This can make the impacts more pronounced with a greater impact during periods of low growth, which may be attributed to insufficient rhizome reserves due to the seasonal variation (Valentine & Heck, 1991; Heck & Valentine, 1995 and Valentine *et al.*, 1997, cited in Eckrich & Holmquist, 2000).

b) Traeth Melynog, Anglesey, Wales

Traeth Melynog is a sheltered bay on the Anglesey coast at the west end of the Menai Strait, North Wales. Cockles are hand collected from intertidal sediments here and the fishery is managed through a permit system administered by Welsh Government under a Statutory Instrument. All permit holders are required to comply with specific access arrangements specified by Natural Resources Wales in order to avoid impact on the seagrass bed (*Zostera noltei*) present at Traeth Melynog. The cockle bed at Traeth Melynog is within the Newborough Warren-Ynys Llanddwyn National Nature Reserve (NNR). Under the NNR byelaws, Natural Resources Wales issues a permit annually which gives permission to cocklers to follow an access route that is not damaging, including allowing vehicle access up to a specific point, but not across the seagrass bed.

In 2015, ATVs were used outside of the permitted route by some cocklers accessing the cockle bed. Photographs of the vehicle tracks have been taken by Natural Resources Wales during a survey of the impact in 2015 and subsequently in 2016 and 2017. The impact assessment focused on the extent of the vehicle tracks over the seagrass bed using photographs and GPS mapping to document and measure the extent. Specific fixed-

monitoring photo points were not established, but the three images in Plate 3.2 below show the continued evidence of tracks from the initial impact in 2015 to 2017.

Plate 3.2 Tracks created by ATV's within a seagrass bed at Traeth Melynog in 2015, and photographed in 2016 and 2017 (photographs by Rowland Sharp; contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

(a) 2015 ***(b) 2016*** ***(c) 2017***

c) Solway Firth, Scotland

In the Solway Firth, ATV's used by fishermen accessing cockle grounds were reported to have caused damage to *Zostera noltei* seagrass beds by leaving deep tracks across the bed and intertidal sediment, although the long-term impact of this is not investigated (Lancaster & Smith, 2004, cited in Sewell & Hiscock, 2005).

d) Ireland - Water Framework Directive Monitoring

In Ireland, Water Framework Directive (WFD) monitoring undertaken by the Environmental Protection Agency includes intertidal seagrass beds (Wilkes, 2014; Wilkes *et al.* 2017). Vehicle impacts, whilst not a specific indicator in the WFD monitoring, are noted during the surveys as part of the observations on potential threats and impacts. Vehicle impacts have been observed as aquaculture-related traffic (generally tractors accessing oyster trestles in the lower intertidal), recreational traffic (people driving cars on the beach), and other forms of recreation or access such as horse riding or dog walking. Plate 3.3 shows some example of vehicle tracks over seagrass recorded during the WFD monitoring. The scale and impacts from these activities varies and there have not been any formal studies into specific impacts and the sources of traffic over the beds. In some cases where impacts are repeated and vehicular pressure prolonged, seagrass beds have been bisected with seagrass absent within the impacted area (Wilkes *et al.* 2017). In areas that only experience occasional pressures the impacts are observed as short-lived.

Plate 3.3 Examples of vehicle tracks over seagrass recorded during WFD monitoring of intertidal seagrass in Ireland (images provided by Environmental Protection Agency, Ireland, © Robert Wilkes

(a) General traffic ***(b) Aquaculture-related traffic*** ***(c) Sustained traffic***



e) Strangford Lough, Northern Ireland

An extreme example of impact from vehicles on intertidal seagrass occurred in an incident of ploughing on the foreshore of Strangford Lough in Northern Ireland in 2004 that resulted in damage to 5.3Ha of intertidal seagrass bed and loss of the seagrass from the affected area (Portig & Jackson, 2005). The effect of the ploughing was more severe than just the impact of vehicles crossing the bed as it turned over the top 20cm of sediment, uprooting the seagrass rhizomes and burying the plants and seeds that would have been present in the upper layer of the seagrass bed. Sediment areas were compacted by the vehicles used to tow the ploughs, but the focus of the impact study was on the ploughed area as this was by far the more significant impact. Recovery time for the seagrass was considered to be in excess of 5 years, possibly a lot longer, as the sediment conditions had to stabilise and seagrass recovery would be predominantly by vegetative growth into the affected area. The damaged areas was allowed to recover naturally.

An intertidal seagrass survey of Northern Ireland seagrass beds in 2009-2010 (Beer & McQuaid, 2011) did not report impacts from vehicles on the seagrass beds studied, but vehicular impacts were not part of the specific parameters being measured. The *Zostera* in Strangford Lough is monitored under the programme of WFD monitoring; it was last surveyed in 2016 and was found to be of high status (Wilkes, *et al.,* 2017).

f) Effects of trampling on seagrass

Trampling is a relatively common source of direct physical impact on intertidal seagrass as it occurs with all forms of visitor and user access. The nature and scale of the impact depends on a number of factors as outlined in section 3.2. Like other sources of physical weights on sediment substrate there is a compression impact.

Trampling can have a significant detrimental impact on seagrass species resulting in reductions in seagrass density (shoot density, shorter blade length, reductions in canopy height) and cover of seagrass meadows, with the amount of damage being relatively proportional to the intensity and duration of the impact (Eckrich & Holmquist, 2000; Garmendia *et al.,* 2017; Travaille *et al.,* 2015).

Eckrich & Holmquist (2000) recorded up to 72% loss of root (rhizome) biomass and up to 81% loss of standing crop of plant material as a result of trampling. The reduced seagrass cover in heavily trampled sample areas (trampled 50 times per month for four months) was still visually distinguishable from the surrounding seagrass 14 months after the trampling ended. Trampling may be considered to be a low impact activity but can give rise to

significant negative effects on sensitive habitats within Marine Protected Areas (as shown by Travaille *et al.,* 2015). The impact of trampling increases if people are moving slowly or standing as they tend to sink more into the sediment and cause greater physical alteration of the substratum and damage to the submerged root system of the seagrass plants.

Greater physical damage has been recorded where seagrass are growing in softer substrates (Eckrich & Holmquist 2000; Major *et al.,* 2004). Substrates saturated with water are generally more easily penetrated than dry substrates, therefore trampling and other physical pressures in these situations is more likely to lead to greater penetration. Impacts that penetrate through to the underground rhizomes, causing damage or disturbance at root level, will prolong recovery. Pickett & White (1985), cited in Eckrich & Holmquist (2000) suggest that for root-based systems such as seagrass meadows, the plants may be relatively resistant to above-substrate disturbances but damage to the underground root system can result in substantial changes. If the rhizomes remain intact and the impact is not persistent, seagrass can exhibit a reasonable level of recoverability although this can be slow, even for low intensity impacts

There has been very little work on the effect of compression impact on the physical and chemical properties of the sediment. Compaction reduces the pore space in sediment and, as a result, reduces the space available for infaunal organisms to live in (Robertson & Campanella, 1983, cited in Hsu *et al.,* 2009). The compression effects arising from use of vehicles over intertidal seagrass beds persist for some time as can be seen in the documented examples, with ruts remaining visible on the surface for over a year from only single pass events. Compression of sediment may lead to build of sulphide in the compacted sediment which may have consequences for root health of seagrass plants (R. Unsworth, pers. comm., 2017)

3.5 Summary of the sensitivity of seagrass beds to vehicle impact and recoverability

Whilst there are only a few specific studies into the impact of vehicles on intertidal seagrass, there is a significant body of evidence that highlights the sensitivity of seagrass plants to physical impacts. Holt *et al.* (1997) identified *Zostera* beds particularly sensitivity to physical damage, disturbance and pollution.

Seagrasses have a shallow root system of rhizomes that is within the top 20cm of sediment, making them vulnerable to direct physical impact and uprooting (Fonesca, 1992, cited in Holt *et al.,* 1997). Physical impact, such as from vehicle use and trampling, particularly in softer sediment, has been shown to have a negative effect on both seagrass plant rhizomes beneath the surface and the abundance and condition of the standing crop of plant material (Eckrich & Holmquist 2000; Major *et al.,* 2004; Pauls *et al.,* 2017). Physical impacts can compress the sediment, altering the sediment structure (observed as persistent ruts and furrows in the case of vehicle impact), and physically impact the rhizomes within the sediment resulting in a reduction in seagrass biomass and, in extreme cases, complete loss of seagrass in the impacted area. The rhizomes of *Zostera* only run horizontally which means that changes in sediment depth, such as in depressions caused by physical disturbance, can be sufficient to inhibit recovery of the seagrass resulting in bare patches, or fragmentation, within a bed (Jackson *et al.,* 2013). Some researchers suggest that mechanical damage may cause fragmentation of habitat which may initiate a large-scale decline (Short & Wyllie-Echeverria, 1996).

Recoverability of seagrass and its resilience to impacts is variable depending on the nature, scale (area affected) and intensity (severity and duration) of the impact, as well as the environmental conditions present, season and growth rates of the seagrass. The papers and case studies referred to above show that seagrass beds can recover from physical

impacts from vehicles and trampling but that recovery can be slow, even from single event impacts and, that where the impact is persistent, seagrass cover may be completely lost even when the impact is intermittent.

Tyler-Walters & Arnold (2008) prepared a sensitivity matrix for the impact on intertidal habitats of access to fishing grounds by foot or vehicle. The sensitivities were determined from available information and expert judgement, taking a precautionary approach given the limited amount of information available. The particular lack of evidence available about the sensitivity of intertidal communities to vehicle use led them to apply the premise, explained in section 3.3 above, that vehicles exert between 5-30 times the level of damage as walkers in terrestrial and coastal habitats. Using the vehicle intensities in Table 1, seagrass beds were ranked as highly sensitive to high, medium and low intensity vehicle use and of medium sensitivity to a single pass event.

Further work on the sensitivity of seagrass beds to human pressure (d'Avack *et al.,* 2014) concluded the beds to be highly sensitive to activities that led to penetration or disturbance of the substratum below the surface and those that cause mechanical modification of the sediment (and hence damage to roots and blades). Seagrass beds were assessed as having medium sensitivity to physical abrasion/disturbance of the substrate on the surface of the sediment. d'Avack *et al.* (2014) reviewed the effect of a range of human activities and noted that impacts can act in combination (synergistically and/or cumulatively) although the assessments they present are based on consideration of evidence relating to single pressure impacts.

The Marine Evidence based Sensitivity Assessment (MarESA) for '*Zostera* (*Zostera*) *marina* beds on lower shore or infralittoral clean or muddy sand' and '*Zostera* (*Zosterella*) *noltei* beds in littoral muddy sand', assesses both types of seagrass bed as medium sensitivity in relation to physical disturbance from abrasion/disturbance of the surface of the substratum or seabed, and of high sensitivity to physical disturbance from penetration or disturbance of the substratum subsurface (d'Avack *et al.,* 2015).

4. Management approaches to reduce vehicle impact on seagrass

There is a substantial body of literature and other relevant information relating to management of human activities on natural habitats. It is not possible to provide a comprehensive review of this information within the scope of this report. Instead, this section provides an overview of the legal considerations regarding use of vehicles on the shore in the context of Wales, and summarises management measures applied in response to (i) the legal conservation and biodiversity framework and (ii) those that take a less formally prescribed approach.

4.1. Legal considerations relating to vehicular access on the shore

It is not intended to give a full review of the legal framework and requirements relating to public use of the foreshore in this section of the report. However, some relevant points regarding vehicle use, foreshore ownership and public rights are presented to provide some context for the situation at Porthdinllaen.

Bean & Appleby (2014) provide a review of legal considerations relating to the collection of bait and seaweed from the intertidal and associated activities. The legalities relating to the use of vehicles for such activities is relevant in the context of vehicle use and impact on seagrass and other intertidal habitats. Most of the information presented in this section is summarised from Bean & Appleby.

The legal position of any particular activity on the foreshore[4] is complex and can vary from site to site depending on any agreements between the landowner and users of the foreshore, the existence of relevant public rights and the presence of regulatory legislation that affects the activity taking place (e.g. byelaws).

Land ownership of the coast of Wales generally extends seawards to mean high water. Seaward of this, the foreshore area from mean high water to low water is most commonly owned by the Crown Estate (The Crown Estate Estuary and Foreshore Map[5]), although large parts of this are leased to third parties such as local authorities, National Parks and the National Trust. Other, non-Crown Estate foreshore land is also owned by other bodies (such as port authorities, local authorities, government departments, statutory bodies) as well as some private individuals and estates. Below mean low water the seabed (which includes lower parts of intertidal shore seaward of mean low water) is generally in Crown ownership although again, areas may be leased or assigned in some way to others (e.g. fishery Several Orders) and/or may in part come under the governance of other organisations such as harbour authorities.

An owner of the foreshore has the same rights as an owner of any other piece of land. However, the foreshore owner's rights are subject to various rights (in favour of the general public, and/or specific parties) that are peculiar to the foreshore. This includes the public 'right to fish' for personal consumption (or sustenance, including collection of bait for personal use for angling) and the public right of navigation. Any fishing or removal of

[4] In England & Wales the foreshore is the area between mean high water and mean low water ordinary tides, although case law has concluded that the lower limit of the foreshore also includes the part of the shore seaward of low water that is exposed on low spring tides.

[5] https://www.thecrownestate.co.uk/rural-and-coastal/coastal/metal-detecting/the-crown-estate-foreshore-and-estuary-map/

resources from the foreshore itself for monetary gain must seek permission of the landowner via a '*profit a prendre*' or be defended as a 'customary right'[6].

There is no general right for the public to access the foreshore or to go over the foreshore to access tidal waters. However, it has been determined that access across the foreshore for the purposes of exercising the public right of fishery is a necessary accompaniment to this right. Access by the public over the foreshore for other purposes, whilst not a strict right, is frequently permitted or tolerated by the landowner.

There is no public right to use a vehicle on land that is not forming part of a road. Under Section 34 of the Road Traffic Act 1988[7] (as amended by Schedule 7 of the Countryside and Rights of Way Act 2000) it is an offence to drive a vehicle off-road without specific authorisation from the landowner. Under the Road Traffic Act, driving a vehicle on the foreshore without express authorisation is illegal. Such authorisation could be granted through byelaws or specific permission from the landowner.

Use of vehicles on the intertidal in relation to fisheries is complicated and there are ongoing discussions about localised cases (R. Sharp, pers. comm. 2017). It may be that different factors contributing to the legal framework in different areas need to be resolved on a case-by-case basis.

In relation to customary rights, this refers to rights that have existed actually or presumably from time immemorial and which have obtained the force of law in a particular locality. Time immemorial is taken to mean since before 1189 and continuing without interruption. Customary rights also need to satisfy other legal requirements (Bean & Appleby, 2014).

4.2 Management measures / approaches in use and their effectiveness

4.2.1 Management measures driven by legislative requirements

The policy and legislative framework for the protection of seagrass in the UK operates from an international to a local level (e.g. Jackson *et al.,* 2013) with requirements to protect seagrass habitat both as a protected habitat as well as through measures to maintain and restore wider ecosystem function and biodiversity. The suite of drivers within this framework requires various actions by governments, statutory organisations, developers, landowners and others that will result in a collective management (co-management) approach that safeguards (and, where necessary, restores) seagrass habitat.

The most commonly used approach in the UK to manage vehicle use over seagrass is driven by European and national conservation and biodiversity legislation that requires assessment of activities that may impact designated features of conservation sites and/or priority biodiversity habitats or species. Licensing and permission-granting procedures, such as planning permission and marine licences are required to comply with this legislation through assessment and consenting procedures relevant to the legislation.

The legal and policy framework for seagrass protection in the UK is complex with a variety of legislative and policy drivers; Jackson *et al.* (2013) provide a summary of the political framework for seagrass protection in the UK at the time of their report and the relevance of

[6] Customary rights refer to rights that have existed actually or presumably from time immemorial and which have obtained the force of law in a particular locality. Time immemorial is taken to mean since before 1189 and continuing without interruption. Customary rights also need to satisfy other legal requirements (Bean & Appleby, 2014).

[7] Road Traffic Act 1988.[1] http://www.legislation.gov.uk/ukpga/1988/52/contents. Accessed 08/10/2017. Revisited 26/10/17.

different drivers to seagrass protection. The key biodiversity-related legislative drivers for protection of seagrass in Wales are:

- The EU Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitat and of wild fauna and flora[8]). *Zostera* spp. may be protected as a component of specific Annex I habitats within Special Areas of Conservation designated under the Directive. Relevant Annex I habitats are Sandbanks, Large shallow inlets and bays, Estuaries, Mudflats and sandflats[9].
- The EC Birds Directive (Directive 2009/147/EC on the conservation of wild birds[10]). Seagrass may be protected within designated Special Areas of Conservation (SPAs) where it provides a recognised food resource for bird species that are a designated feature of the site.
- The Wildlife and Countryside Act 1981, as amended[11]. This Act enables the notification of Sites of Special Scientific Interest which are established to conserve and protect the best examples of wildlife, geological and physiographical heritage[12]. Seagrass beds (*Zostera* spp.) may be protected as part of the special interest of a SSSI, but only in the intertidal since SSSI do not cover sub tidal areas (except in some estuaries where the low water channel is included within the site). Landowners and occupiers of an SSSI are required to manage the land (including the intertidal where relevant) in a way that helps conserve its special features. Landowners and occupiers are required to seek permission (in Wales, from Natural Resources Wales) to undertake any operations likely to damage the scientific interest of part of all or a SSSI; a list of such operations forms part of the SSSI notification documents and is provided to land owners and occupiers as well as public bodies at the time of notification. There are also provisions for the protection of the designated features of a SSSI from damage by third parties.

  The Wildlife and Countryside Act 1981, as amended, may afford protection to seagrass beds where they provide a habitat for seahorse species listed under Schedule 5 of the Act (long snouted seahorse *Hippocampus guttulatus* and short snouted seahorses *Hippocampus hippocampus*). Schedule 5 of the Act makes it an offence (subject to exceptions) to intentionally kill, injure or take any wild animals listed under the Schedule, and prohibits interference with places used for their shelter or protection, or intentionally disturbing the animals occupying such places.
- Marine and Coastal Access Act 2009[13] includes powers that enable the designation of Marine Conservation Zones (MCZs) in the territorial waters adjacent to England and Wales and UK offshore waters. MCZs are established to protect a range of nationally important marine wildlife, habitats, geology and geomorphology. Skomer MCZ is currently the only Marine Conservation Zone in Welsh territorial waters. Seagrass beds are one of the features of the Skomer MCZ.

[8] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
[9] Interpretation Manual of European Union Habitats, EUR28 April 2013. European Commission DG Environment, Nature ENV B.3.
http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf
[10] http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm
[11] https://www.legislation.gov.uk/ukpga/1981/69
[12] https://naturalresources.wales/guidance-and-advice/environmental-topics/wildlife-and-biodiversity/find-protected-areas-of-land-and-seas/sites-of-special-scientific-interest-sssis/?lang=en
[13] https://www.legislation.gov.uk/ukpga/2009/23/contents

- The Environment (Wales) Act 2016[14]. Section 7 of this Act requires Welsh Ministers to publish, review and revise lists of living organisms and types of habitat in Wales which they consider are of key significant to sustain and improve biodiversity in relation to Wales[15]. Under the Act, Welsh Ministers must take all reasonable steps to maintain and enhance the living organisms and types of habitat included in the list, and encourage others to take such steps. Seagrass beds are listed under Section 7 as one of the habitats of principal importance for the purpose of maintaining and enhancing biodiversity in relation to Wales.

The above Directives and Acts are not the only legislative drivers relevant to protection of seagrass beds in Wales. However, at the time of preparing this report, they are the main pieces of legislation that place requirements on government, public bodies, land owners and occupiers, and others in Wales to assess the impact of activities and operations that may affect seagrass beds, and to protected designated features of marine protected areas in Wales.

Marine managers from around the UK who were contacted as part of this review highlighted the EU Habitats Directive and the EU Birds Directive and relevant national legislation relating to marine protected areas as being the main measures used to prevent damage by vehicles on intertidal seagrass[16]. No current known examples of vehicle impacts on intertidal seagrass were reported by Natural England, Scottish Natural Heritage, Department of Agriculture, Environment and Rural Affairs Northern Ireland or the National Trust (for areas other than Porthdinllaen). The reasons given for this were that the majority of locations with intertidal seagrass were within designated sites and management of those sites required action to prevent damage to the designated features. This action can take a variety of forms such as:

- **Pre-activity assessment and licensing/consenting processes for development control.** Potential impact of vehicles on intertidal seagrass arising from proposed activities and developments is formally assessed and conditions set to prevent damage occurring. This is generally achieved by prohibiting access across the area where the seagrass is present and determining alternative access routes for the proposed work. For example, Natural England use Marine Protected Area conservation advice that is

[14] http://gov.wales/topics/environmentcountryside/consmanagement/natural-resources-management/environment-act/?lang=en

[15] http://www.biodiversitywales.org.uk/Environment-Wales-Bill
Section 7 of the Wales Environment Act 2015 replaces the duty in Section 42 of the Natural Environment and Rural Communities (NERC) Act 2006 which required preparation of a list of species and habitats of principal importance for the purposes of conserving biodiversity. The precursor to the NERC Act 2006 was the UK Biodiversity Action Plan (UK BAP). Between 1995 and 1999 a list of UK BAP priority species and habitats was prepared to identify those species and habitats that were most threatened and requiring conservation action under the UK BAP. Seagrass beds (intertidal and subtidal) were identified as a UK BAP priority habitat. Since 2010 much of the work under UK BAP has been re-focused at a country level within the UK, within country-level biodiversity strategies. The UK BAP priority species and habitats lists have been used to help draw up statutory lists of priority species and habitats as now required under Section 7 of the Wales Environment Act 2015.

[16] Different acts enabling designation of conservation areas and marine protected areas apply in different parts of the UK. Further information for the environmental legislative framework for the UK is available from the website of the Joint Nature Conservation Committee (JNCC) (http://jncc.defra.gov.uk/)

based on the MarESA sensitivity assessments (see section 3.5) in relation to the two main pressures likely to arise from vehicle use on intertidal seagrass.

- **Subsequent assessment of activities post designation as part of marine protected area management.** For example, assessment of fishing activities in SACs and SPAs in England identified whether measures were required on a site-by-site basis to minimise and prevent future impacts from fishing access. For example, in Morcambe Bay the seagrass beds are now closed to fishing access under a fisheries byelaw implemented due to the revised approach to fisheries in England under Article 6 of Habitats Directive.
- **Reacting to incidences of impact and damage to seagrass beds**. Comments were made that incidences that were readily seen would be reported to relevant local authorities and appropriate measures taken to address the problem and prevent further damage. Any subsequent measures would be dependent on relevant legislation that could be enacted by the authorities involved, which could include introduction of new measures such as a byelaw, application of existing legislation such as the Road Traffic Act, and prosecution and fining the perpetrators. This option relies on incidences of damage being reported and action being taken by the appropriate authorities.

Measures put in place under legislative requirements are not, on their own, a guarantee of protection and may require monitoring and, if necessary, enforcement. The example of ATV use over the intertidal seagrass at Traeth Melynog is an example of this (section 3.4). In this case, a prompt on-the-ground response by site managers to meet and talk to the people involved prevented further breaches of the agreed access arrangements (R. Sharp, pers. comm., 2017).

There seem to be few examples of vehicle impacts on intertidal seagrass. Where this has occurred it has either been where measures have not been adhered to, or where no management is in place, but these situations do not seem to be very common in the UK.

4.2.2 Collaborative co-management approaches

Less prescriptive approaches to the management of human activities are more prevalent where there is no legal framework for protection. They are also used in situations where there may be a legal requirement to provide protection to a natural habitat, but where a degree of human use is an integral part of the management approach for an area and therefore requires a more creative, dynamic or integrated approach to address a particular issue.

In these situations, approaches are often used that foster dialogue and cooperation with local users, and develop a collaborative agreement for appropriate management measures. Such an approach may be driven purely by voluntary initiatives to address an issue, or may be the approach taken in response to a legislative requirement to take action. In this way users, working together with site managers, have an integral role in helping address the issue that has been identified. Commonly used mechanisms in these situations are codes of practice, local agreements such a voluntary restrictions, zoning or seasonal limits, awareness raising and education programmes. Liley *et al.* (2012) considered a

number of examples of measures to address impacts due to disturbance and damage from recreational activities.

In relation to vehicle use, Buckley (2004) summarises a number of management approaches that have commonly been used to reduce or prevent impacts from vehicles on natural habitats, these include:

- restricting vehicles to a small number of well-maintained tracks
- clearly marking and signposted areas that are closed to vehicle use
- restricting the location or time when vehicles can be used
- education campaigns to make vehicle drivers aware of issues and improve driving skills.

Other measures may be applied to simply prevent further vehicular access; at Angle Bay in Pembrokeshire, South Wales, large blocks of stone (>1m^3) were placed at the top of the shore to prevent further un-regulated vehicle access along the shore (A. Bunker pers. comm. 2017).

In relation to seagrass, documented examples of non-prescriptive measures tend to focus on agreements with local boat owners to reduce or prevent impact from boats including from anchoring and mooring (e.g. examples in Jackson *et al.,* 2013). There are also country-wide programmes that aim to promote good practice and sustainable use of natural areas, for example The Green Blue[17], an environmental awareness programme set up by the British Marine Federation and the Royal Yachting Association with an aim to promote the sustainable use of coastal and inland waters by boating and watersports participants and the sustainable operation and development of the recreational boating industry.

Voluntary codes can be effective if all participants stick to the agreement. Where there is a legislative framework that could be used to provide more strict protection, adherence to a voluntary arrangements can be encourage by potential recourse to a more punitive statutory mechanism if the voluntary mechanism fails. Jackson *et al.,* (2013) cite an example relating to reports of dredging for shellfish in seagrass beds; the Southern Inshore Fisheries and Conservation Authority (IFCA) announced a voluntary code of conduct identifying areas where towed fishing gear should be avoided. The Southern IFCA agreed that evidence of breaches of the code of conduct (i.e. new scars in the seagrass) would lead initially to a warning being issued, and any further breaches would lead to the adoption of a regulatory approach with a district-wide byelaw and penalties up to £50,000 (Jackson *et al.,* 2013).

Working effectively with local communities and stakeholders is an essential component of non-prescriptive measures. This is particularly true if the measures are to be primarily self-regulating. Community participation is now a much more common aspect in the co-management of protected areas (terrestrial and marine) but the approach and its success depends on the local situation and individuals involved as presented by case studies Salm *et al.,* 2000.

The examples discussed by Liley *et al.* (2012) and Salm *et* al. (2000) demonstrate that appropriate and positive messaging at a local, regional and national scale can play a key role in supporting non-prescriptive management approaches as well as those driven by legislative requirements. Provision of information about the marine and coastal

[17] thegreenblue.org.uk

environment in a way that is relevant to a specific audience and which creates a positive connection is a fundamental aspect of on-the-ground conservation management.

Many non-prescriptive management approaches are being, or have already been applied, to aspects of the management of the Pen Llŷn a'r Sarnau SAC, including the Porthdinllaen Seagrass Project. These include dialogue with users, collaborative working, creation of codes of conduct, education programmes and citizen science initiatives.

5. Vehicle use in the intertidal area at Porthdinllaen: impact and potential management measures / approaches to address any impact

5.1 Intertidal seagrass at Porthdinllaen

The intertidal seagrass bed at Porthdinllaen comprises two distinct areas of *Zostera marina*: a more continuous and denser northerly area, and a less-dense southerly area, both of which are shown in Figure 5.1. The seagrass bed continues into the subtidal area of the bay forming an extensive seagrass meadow**.**

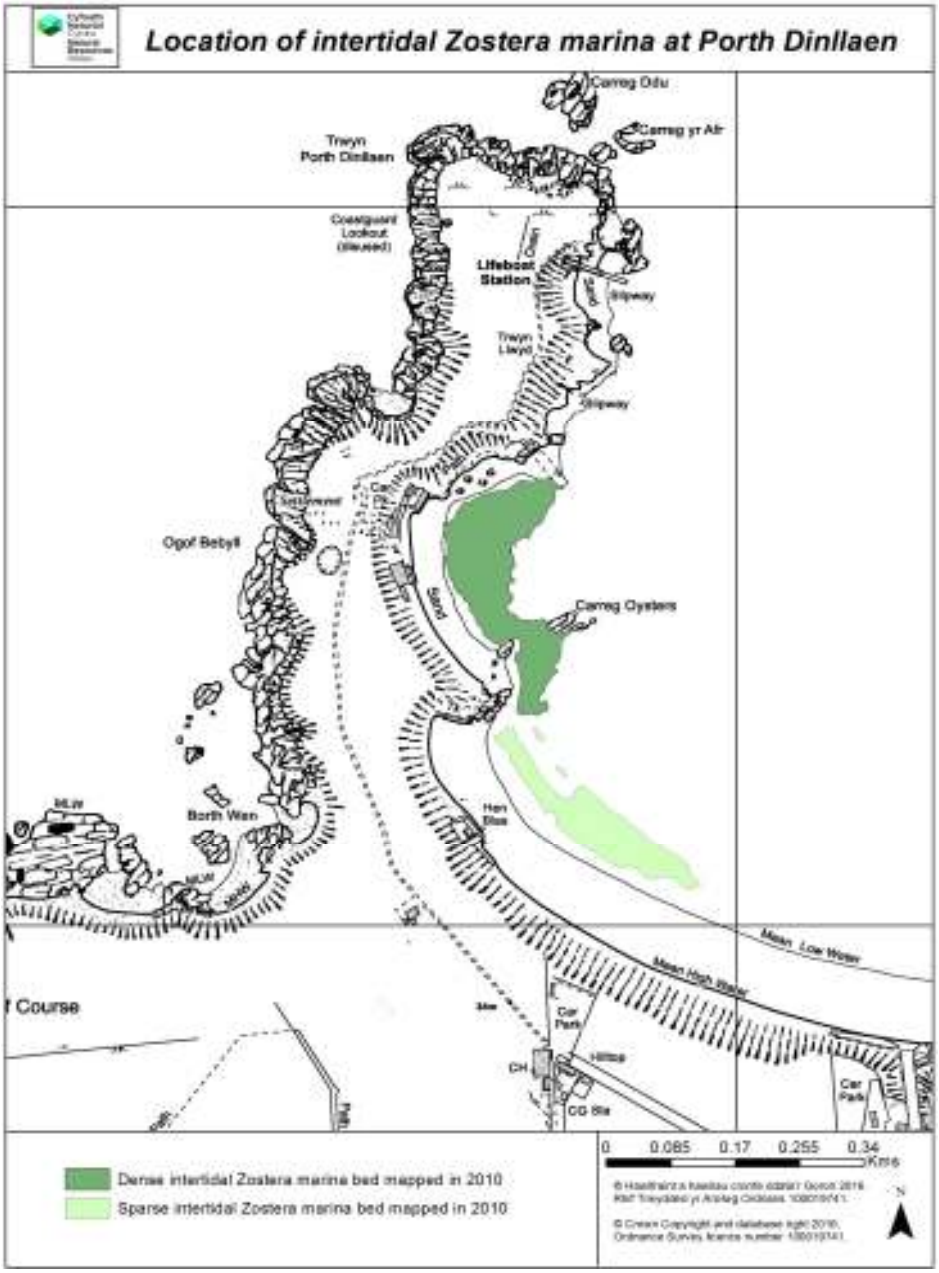

Figure 5.1 Map of Porthdinllaen bay showing the location of the two distinct areas of intertidal seagrass bed (from Davies et al., 2017). Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 1000019741. Crown Copyright and Database Right.

5.1.1 Monitoring of the intertidal seagrass bed at Porthdinllaen

The intertidal seagrass at Porthdinllaen was initially mapped in 1997 as part of the Wales-wide intertidal Phase 1 mapping programme undertaken by the Countryside Council for Wales (Brazier *et al.,* 2007). Since this initial survey further mapping of the intertidal seagrass has been undertaken in 2004, 2010 and 2016 as part of the SAC monitoring programme for the Pen Llŷn a'r Sarnau SAC (Boyes *et al.,* 2008; Mercer, 2011; Davies *et al.,* 2017). The intertidal monitoring records the extent of the seagrass bed, certain measures of density and quality of the seagrass bed (such as % cover of seagrass, associated fauna/flora, % cover of algae), and includes a damage assessment that records observed impacts.

Since 2013 additional intertidal monitoring has been undertaken by Project Seagrass[18], a charity established within the Sustainable Places Research institute, Swansea University. Project Seagrass records density (percent cover), blade length, epiphyte cover and presence/absence of seagrass seeds on seasonal surveys during the year. Further information has been collected as part of research work undertaken by Swansea University to improve understanding of the health of seagrass meadows across the UK.

The Welsh SAC monitoring programme implemented by Natural Resources Wales (NRW) recorded the lowest total area of *Zostera marina* at Porthdinllaen in the 2016 survey (2.95ha) compared with surveys in 2004 (2.96ha) and 2010 (3.79ha) (Davies *et al.,* 2017).

The less dense southerly area of seagrass, however, has shown more variability in its extent and density with more discrete patches of seagrass. The area of the southern bed has varied between 1.37ha measured in 2010 to 0.06ha in 2016. This variability may, in part, be due to the fact that that seagrass in this area is patchier which may lead to differences in how the mapping protocol is implemented on separate field surveys. It is also more exposed to wave action than the more northerly area which makes it more susceptible to uprooting by storm events (Davies *et al.,* 2017).

If the more continuous northerly area of seagrass is considered on its own, the field survey data alone shows an increase in extent of the bed of just over 0.5ha between 2004 and 2016. Davies *et al.* (2017), examined the SAC monitoring field data together with extent of the intertidal seagrass in the northerly area at Porthdinllaen measured from aerial photographs (with measures standardised to take account of variability due to differences in tide height and weather conditions). This work showed an overall increase in the extent of the northerly bed of just over 0.89ha between 2000 and 2016 with the greatest extent recorded in 2010.

Intertidal seagrass provides a habitat for a number of other species that can live on the seagrass, amongst the seagrass plants or in the associated sediments. The NRW SAC monitoring of the intertidal seagrass at Porthdinllaen has recorded a number of different species associated with the above-sediment component of the intertidal seagrass bed including, anemones (e.g. *Cereus pedunculatus*, *Anemonia viridis)*, hydroids, worms in the sediment and tube worms (e.g. *Lanice conchilega*, *Sabella pavonina*), crustaceans (*Macropodia* sp.), molluscs and seaweeds. Studies undertaken at Porthdinllaen provide strong evidence of the value of the seagrass (intertidal and subtidal) for supporting

[18] http://www.projectseagrass.org

biodiversity and providing an important habitat for juvenile fish of commercial importance (Unsworth & Cullen-Unsworth, 2015).

Further information about the seagrass at Porthdinllaen (intertidal and subtidal) is provided in a number of reports (Boyes *et al.*, 2008); Egerton, 2011; Mercer, 2011; Stamp, 2012; Stamp & Morris, 2012, Unsworth & Cullen-Unsworth (2015) and Davies *et al.,* (2017).

5.1.2 Protection of the intertidal seagrass bed at Porthdinllaen

The seagrass bed at Porthdinllaen is afforded protection under a number of legislative measures that place requirements on Welsh Government, statutory and public bodies and land owners to work to protect the seagrass (section 4.2.1). These include:

- EU Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora[19]). Protection of the seagrass bed as a component of the intertidal mudflat and sandflat feature of the Pen Llŷn a'r Sarnau Special Area of Conservation.
- Wildlife and Countryside Act 1981 (as amended)[20]: protection of the seagrass bed as a notified feature of the Porthdinllaen i Borth Pistyll Site of Special Scientific Interest.
- Environment (Wales) Act 2016[21]: (a) an enhanced duty on all public authorities to maintain and enhance biodiversity in carrying out their functions; (b) protection of priority habitats, which includes seagrass beds.

5.2 Use and management of vehicles in the intertidal area at Porthdinllaen

There is very little documented information available about the use and management of vehicles at Porthdinllaen. Information gaps were scoped during an initial meeting with the National Trust Ranger and Pen Llŷn a'r Sarnau SAC Officer. The details provided below are derived from information subsequently provided by the National Trust Ranger and Pen Llŷn a'r Sarnau SAC Project Officer following discussions with colleagues, local residents and fishermen and their personal knowledge of the locality.

5.2.1 Ownership of the foreshore at Porthdinllaen

The National Trust owns a stretch of coast at Porthdinllaen which extends seaward to Mean High Water (MHW). The ownership is more or less a continuous block except for a couple of privately owned houses and their surrounds. The boundary of National Trust ownership can be seen in Figure 5.2.

The land between MHW and Mean Low Water (MLW) is owned by the Crown Estate and is leased to the National Trust through a foreshore lease (a Crown Estate Master Regulating Lease). The National Trust's foreshore lease extends from the RNLI headland to Lon Bridin (the access point on to the beach at Morfa Nefyn), where it adjoins with Nefyn Town Council's foreshore lease. Lon Bridin is a public highway and a launch point at which vehicles access the beach to launch their watercraft. All the foreshore shown in Figure 1.1 is covered by the lease.

From the information provided, the National Trust as a landowner and foreshore lease holder has the role of landowner when it comes to management of vehicles on to and across the foreshore. In this context, the National Trust also has responsibilities in relation

[19] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
[20] https://www.legislation.gov.uk/ukpga/1981/69
[21] http://gov.wales/topics/environmentcountryside/consmanagement/natural-resources-management/environment-act/?lang=en

to the requirements on landowners under provisions of the Wildlife and Countryside Act 1981 (as amended) in relation to protection of SSSI features.

The Crown Estate lease includes provisions relating to the use of vehicles that mechanically-propelled vehicle are not to be driven on the property except (i) the tenants own vehicles for management purpose, and (ii) other vehicles where the landlord's consent has first been obtained.

Figure 5.2 Map showing the National Trust land ownership boundaries at Porthdinllaen.

5.2.2 Vehicular access to and across the beach by local residents

Some private owners and tenants of National Trust properties at Porthdinllaen access their properties via vehicle which, depending on the location of the property, involves crossing the beach.

Owners and tenants are not in the habit of driving their vehicles over the lower parts of the shore when gaining access to their properties as this provides no advantage and could result in their vehicles getting stuck in softer sediment.

It is not clear if local residents use vehicles over the intertidal seagrass to launch, retrieve or reach their boats. Those who lease the intertidal moorings are specifically told that lease of mooring does not permit vehicle access to the shore at Porthdinllaen and they are not supplied with a fob to open the gate at the top of the private access road.

5.2.3 Vehicular access across the beach for mooring maintenance and replacement

The National Trust lays and maintains moorings within the intertidal area at Porthdinllaen by virtue of the Porthdinllaen Harbour Company Act. Bean & Appleby (2014) note that with regard to all port authorities, section 48A of the Harbours Act 1964 imposes a duty on them, in formulating or considering any proposals relating to their functions under any enactment, to have regard to *[inter alia*] the conservation of the natural beauty of the countryside and of flora, fauna and geological or physiographical features of special interest.

The intertidal moorings are inspected at least annually. Access for these inspections and the resulting maintenance has in the past been via vehicle to make the process quicker and carry equipment. Periodically the moorings have to be replaced which requires the use of heavier plant – specifically mini digger and tractor and trailer – in order to extract the old block moorings and replace them with new blocks.

Plate 5.1 Mini digger being used to excavate old intertidal mooring block at Porthdinllaen (© National Trust/Laura Hughes)

Recently efforts have been made to reduce the use and impact of vehicles for mooring maintenance and replacement. Inspections and maintenance are carried out on foot with equipment carried in a wheelbarrow. Where vehicle use is unavoidable i.e. for mooring

replacement a route is pre-planned to minimise the number of vehicle passes that need to be made. Replacement of the moorings together with associated operational methods are consented by NRW under the requirements of the Porthdinllaen i Borth Pistyll SSSI.

5.2.4 Vehicular access to and across the beach by local fishermen

At Porthdinllaen there are currently five local fishermen who lease inner harbour moorings from the National Trust to moor tenders for their fishing vessels which are moored in the deeper outer harbour. Access to the fishing vessels is usually by launching a smaller tender from the shore, rowing to retrieve their moored tender, loading the dinghy with bait, equipment and crew and then accessing the fishing vessel moored in deeper water. This process is then reversed at the end of the day when they land their catch.

Fishermen mainly use tractors and trailers but sometimes 4WD vehicles or vans are used. The preferred access point is the private road through the golf course and the vehicles are parked either in the small parking area in the village or on the top of the beach to the south of Whitehall in the case of tractors.

Plate 5.2 (a) & (b) Use of tractors by local fishermen to launch and retrieve tenders and, (c) storage of tractors at the top of the beach at Porthdinllaen (© Gwynedd Council/Catrin Glyn)

(a) ***(b)*** ***(c)***

The requirement to drive over the seagrass is determined by the tide height when fishermen need access to and from their vessels. At low water fishermen drive around the breakwater wall, and sometimes across the seagrass to access their moored tenders. Driving over the seagrass is seen as an occasional activity, occurring approximately three times a month for each fishing vessel (local fishing vessel owner pers. comm.). This is likely to be more frequent in peak summer fishing season than in winter months. The level of use of vehicles by fishermen at Porthdinllaen is not considered to have changed significantly over recent years.

The fishermen regularly change moorings depending on the tide height, allowing them to use a preferred tender launch and retrieval option without having to drive over the seagrass and/or drag a tender over the seagrass to land. An issue has been raised about the number of moorings that are accessible to them as this affects how flexible they can be as to where they moor their tender, and may increase the amount they have to use their vehicles over the seagrass to access their vessels.

5.3 Impact of vehicles on the intertidal seagrass at Porthdinllaen

5.3.1 Evidence of vehicle impacts on the intertidal seagrass at Porthdinllaen

Vehicle tracks on the Porthdinllaen intertidal seagrass were recorded during the initial SAC monitoring in 2004 (Boyes *et al*., 2008), although vehicular access across the seagrass has probably occurred for some time prior to the first monitoring events. Tracks have been documented in the subsequent SAC monitoring events up to and including 2016. These are only periodic sampling events and vehicles are known to be used on a more regular basis when required. The impact of vehicles is visible as tracks and ruts in the seagrass bed. Scour from mooring chains and boat keels have also been recorded as physical impacts on the bed.

Plate 5.3 Examples of (a) vehicle tracks over the seagrass and, (b) damage caused by mooring chain, recorded during the SAC monitoring in 2004 (Boyes et al., 2008; Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved)

(a)

(b)

Plate 5.4 Examples of (a) vehicle tracks over the seagrass and, (b) damage caused by mooring chain, recorded during the SAC monitoring in 2016 (Davies et al., 2017; Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved)

(a)

(b)

Despite a small overall increase in the extent of the intertidal seagrass bed (Davies *et* al., 2017, discussed in section 5.1), the SAC condition monitoring of the intertidal seagrass in 2010 and 2016 recorded a lower percent cover of seagrass in the northern area of the northerly bed. This coincides with where there is a greater degree of human activity within the bay at Porthdinllaen; surveys in 2004, 2010 and 2016 have all recorded a greater concentration of impact and damage primarily from moorings and vehicles in this northern region of the seagrass bed (Boyes *et al.,* 2008; Mercer, 2011; Davies *et al.,* 2017); see Figure 5.3.

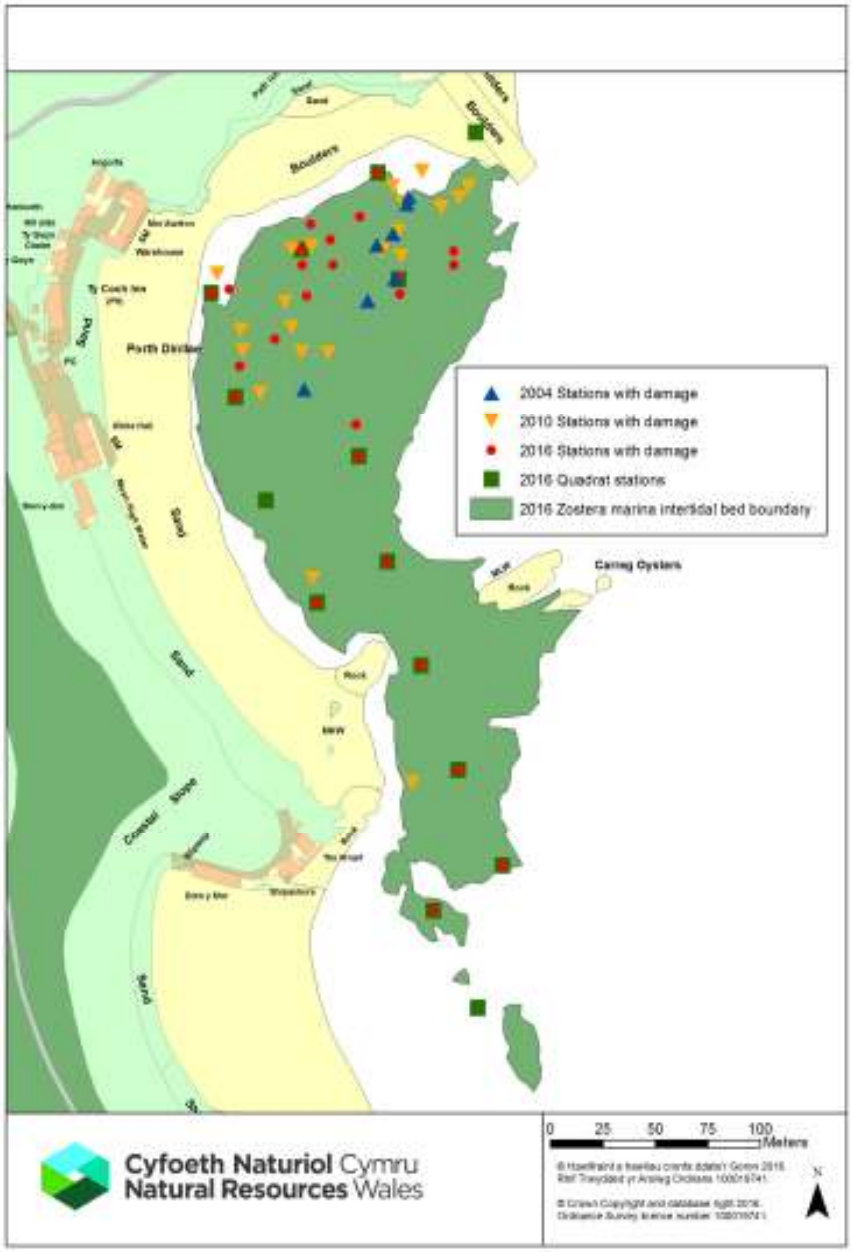

Figure 5.3 Map of Porthdinllaen bay showing the location of incidences of impact to the seagrass bed recorded during the 2004, 2010 and 2016 SAC monitoring (from Davies et al., 2017). Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 1000019741. Crown Copyright and Database Right.

Whilst there have been a number of studies of the seagrass undertaken at Porthdinllaen in recent years, there has not been any investigation specifically into the effects of vehicle use on the seagrass bed. The monitoring of impacts and damage assessment undertaken as part of the SAC monitoring have not been carried out sufficiently long to provide a time-series of data other than a general picture of impacts as shown in Fig 5.3. The observed impacts of vehicles in the seagrass are in keeping with those from other areas (as discussed in section 3), with the presence of tracks and ruts persisting for some time and localised impact on the density of seagrass observed in the tracks.

The longevity of the vehicle tracks on the seagrass at Porthdinllaen has not been monitored. At any one time, tracks and ruts from vehicles can be a mixture of what look like fresher tracks and those that are older and starting to infill (author observations and photographs from survey events). Based on documented information and case studies discussed in section 3, it is reasonable to consider that the tracks and ruts will remain visible for at least 2 years even from a single pass event, and may persist longer if heavier vehicles are used and there are multiple passes along the same track. Persistent and multiple-pass events will, inevitably, have a greater effect and can lead to permanent loss of seagrass from the impacted area.

5.3.2 Is vehicle use affecting the condition of the intertidal seagrass bed?

The increase in extent of the more continuous northerly area of seagrass at Porthdinllaen (Davies *et* al., 2017, discussed in section 5.1.1), if taken on its own, may be seen as sufficient evidence that the intertidal seagrass bed at Porthdinllaen is healthy.

However, the same studies found a decrease in seagrass density (percent cover) in areas of highest use of the northern part of the bed (Davies *et* al., 2017, discussed in section 5.3.1). The quality of the seagrass bed is determined by more than just its extent; parameters such as density of seagrass, associated species, areas of erosion and scale of observed impacts are also extremely important measures of its health. The available data on these at Porthdinllaen gives some cause for concern, or potential 'early warning signs'. In addition, it is not known whether the recorded increase in the extent of the seagrass bed is actually a recovery of the bed to a previous state that existed prior to either the first surveys (1997) or the known mass mortality of seagrass in the UK wasting disease (1930), which seagrass beds around the country are still recovering from.

The 2016 SAC monitoring also recorded areas of erosion in the northerly bed where the underlying sediment of the seagrass bed had been eroded leaving a soft clay sediment and very little seagrass (Davies *et al.,* 2017). The reduction in the density of seagrass cover recorded in the northern part of the northerly bed cannot be directly linked specifically to vehicle use as there are other activities and impacts, in particular associated with the moorings which are known to scour softer surface sediments (Stamp, 2012). However, it is reasonable to consider that vehicle use has, in part, contributed to the reduced seagrass density that has been recorded. The exact reasons for substrate change in the northern bed are not known, but complete loss of the substrate as well as seagrass plants is of concern as it works against recovery of the seagrass as discussed in section 3.5. Areas of sediment loss leave the remaining seagrass plants vulnerable to uprooting, particularly those on the edge of where the erosion has occurred, meaning that additional vehicular damage may increase recovery time, or even reduce the likelihood of recovery.

Deterioration of a seagrass bed can present itself in a number of ways. The extent of a bed can change (either the overall size or loss parts of a seagrass bed), creating a fragmented bed comprising patchy areas of seagrass. Alternatively, there may be gradual decline in the density of seagrass on part or all of a bed (e.g. reduction in biomass, percentage cover or shoot density) (Unsworth & Cullen-Unsworth, 2014). Fragmented beds are more

vulnerable to the effects of erosion as the surrounding sand is not held in place by the seagrass root network. Fragmentation of seagrass beds can result in a reduction of the structural complexity of the seagrass habitat and impaired structure and function of the bed overall. It alters the amount, type and quality of habitat available for other species associated with the seagrass and undermines the resilience of the bed to other stressors (human-induced and natural). As a result, the Porthdinllaen intertidal seagrass beds may be showing signs of degradation on several levels, and therefore may be more sensitive to cumulative pressures, particularly anthropogenic stressors such as physical damage (through vehicular access) or even from increased eutrophication and chemical loading from increased storm drainage in the face of climate change (Unsworth & Cullen-Unsworth, 2015).

The invasive non-native seaweed *Sargassum muticum* (wire weed) has been recorded as present in the intertidal seagrass bed at Porthdinllaen, but no quantitative data have been collected on its abundance in the intertidal area (Davies *et al*., 2017). Where impacts to the intertidal bed cause compaction and/or scour of the softer sediment, these may provide an opportunity for *Sargassum* to become established. *Sargassum* is noted to be able to anchor itself within the rhizomes of seagrass beds (Tweedley *et al.,* 2008). The significance of *Sargassum muticum* is that once it is established within a habitat, it can suddenly and rapidly spread to become a dominant component of a habitat, often outcompeting native species. As anthropogenic pressures upon *Zostera marina* increase, *Sargassum muticum* represents a significant threat to the health of *Zostera marina* beds (Unsworth & Cullen-Unsworth, 2015).

The level of vehicle use at Porthdinllaen equates best to a range between light and moderate level of use as defined by Tyler-Wales and Arnold (2008) (section 3.3 and Table 1). Impact from vehicle use at Porthdinllaen is not a daily occurrence and levels of activity are higher in the summer than winter. The greater level of activity coincides with the main period of active growth of seagrass plants which can leave them vulnerable to damage. Seagrass beds have been assessed by a number of researchers as highly sensitive to physical impacts (discussed in section 3.5). Tyler-Walters & Arnold (2008) ranked seagrass a beds as highly sensitive to high, medium and low intensity vehicle use and of medium sensitivity to a single pass event.

The specific impacts of vehicle use on the flora and fauna associated with intertidal seagrass and the physical and chemical condition of the seagrass sediment habitat have not been addressed in any of the literature sourced for this report. It is, therefore, not possible to quantify the specific nature and scale of any such impacts at Porthdinllaen. However, based on the considerable body of documented information about the effect of vehicle use and other physical impacts on sediment habitats and seagrass, it is reasonable to consider that impacts on these aspects of the seagrass habitat are likely to be occurring to some degree as a result of the use of vehicles over the intertidal seagrass at Porthdinllaen.

There is a clear cause and effect link that can be attributed to use of vehicles and impact on the condition of seagrass beds generally. Given the specific and general evidence that is available, it is reasonable to conclude that vehicle use is contributing to the reduced condition of the Porthdinllaen seagrass bed. However, based on the available data it is not possible to quantify the specific contribution that vehicle use is making to the overall observed impacts and reduced seagrass density in the most impacted part of the bed.

Vehicles are one part of the picture when looking at the overall management of the intertidal seagrass area at Porthdinllaen. There are a variety of activities taking place here and a number of these will, in some way, be contributing to physical impacts on the bed (see

Unsworth & Cullen-Unsworth 2015 for a list of physical stressors and causal activity observed on seagrass at Porthdinllaen). In addressing specific issues, consideration needs to be given to the effect of cumulative impacts and how these can collectively be best addressed within the management of the area. This raises issues that are outside the scope of this report, but the literature reviewed as part of this report provides an information base that may be helpful when considering the overall picture of human use and activities at Porthdinllaen.

5.4 Possible measures for management of vehicle use at Porthdinllaen

The management approaches considered in section 4 can be divided into a limited number of options:

1. Stop/prevent the activity
2. Limit the activity (i.e. reduce overall land impact by limiting the type of vehicle, number of passes, area that can be driven over etc).
3. Divert the activity to another area
4. Do nothing

There are a variety of management mechanisms or approaches that can be used to take any/each of these options forward, some of which are already being applied to other aspects of the Porthdinllaen Seagrass Project (e.g. education and awareness raising and focused discussions with particular user groups to determine an agreed way forward).

The aspiration for the management of seagrass as part of the Porthdinllaen Seagrass Project is clear: to support continued use of the area whilst meeting obligations to protect the seagrass and to ensure the future health of the seagrass bed (Hargrave, 2017).

There are also clear requirements under a range of legislative drivers to protect the seagrass bed (discussed in section 5.1.3). In addition to these legal drivers, there are good reasons for society to take action to protect the seagrass as it provides many benefits for everyone.

Given the above, options 1 and 4, to stop the activity or do nothing, are unlikely to achieve both meeting the legal requirements to protect the seagrass, as well as the intention to support continued use of the Porthdinllaen area.

This leaves the options of limiting the activity in some way (option 2) or diverting the activity to another area in order to remove or reduce the impact on the seagrass (option 3) and meet the legal obligations for protection of this habitat. Possible measures to achieve these, together with associated issues to consider, are suggested below. These need to be seen within the context of other activities that are also occurring on the site and which also contribute to the physical impact on the intertidal seagrass.

Based on the information provided, vehicle use by tenants, private owners and recreational users of Porthdinllaen is not having a regular impact on the bed, and is therefore not considered further.

5.4.1 Possible measures to reduce/avoid vehicle impact on the intertidal seagrass bed

a) Mooring maintenance (intertidal moorings)

There is scope to limit vehicle use for work associated with checking and basic maintenance of the intertidal moorings. For example, establish a clear protocol for access to, and maintenance of the moorings. Vehicles have been used in the past for these operations but are not necessarily essential. The protocol should clearly specify how access is to be achieved to cause least impact and ensure that this is adhered to. The

intention should be to avoid use of vehicles where possible but also to be mindful of, and minimise, impacts of foot traffic on the seagrass.

b) Replacement of intertidal moorings
Establish a protocol for and access and mooring replacement methodology to cause least physical impact to the seagrass, e.g. establish a method that requires the least vehicle movements to achieve the task and thereby achieve the least impact footprint for the works. Consider further development of the intertidal moorings systems to reduce the frequency of replacement and/or reduce the requirement of vehicles for mooring replacement.

c) Best practice for vehicle use
Studies on the impact of vehicles on natural habitat have shown that multiple passes and how vehicles are driven can increase the severity of impact. Movements such as turning or sharp breaking and rapid acceleration can increase the amount of physical impact on the ground. Agreeing and adopting best practice for any vehicle use to avoid unnecessary movement and rapid acceleration/braking and turning would be beneficial.

d) Vehicle use by fishermen
The majority of vehicle use at Porthdinllaen is by local fishermen who have vessels moored in the bay. Vehicle use is an integral part of how fishermen access their fishing vessels at Porthdinllaen and retrieve their catch and fishing gear. As described in section 5.2.4, the pattern of vehicle use by fishermen is linked to the tide height and availability of mooring options when they go to, and return from sea.

At high tide, the boat tenders can be launched and retrieved without impact on the seagrass, and so solutions need to focus on access at lower tide levels. Possible solutions need to take account of how the intertidal area dries as the tide drops and which areas become exposed more quickly and might therefore support or hinder potential solutions.

There may be an option to concentrate vehicle movements in one specific location, such as at the very northern edge of the bay and around to the breakwater. This area, immediately in front of the boulders here, has a number of moorings and is already an area where some vehicle movement occurs. Diverting vehicle use to a specific area of the bed may be a more straightforward option than trying to secure just a general reduction in use of vehicles, but this needs to be discussed in relation to the operational requirements of the local fishermen.

Fishermen have commented that recent reductions in the number of intertidal moorings and specific allocation of moorings restricts options available to them when going to and returning from their fishing vessels. This may lead to more use of vehicles on the seagrass and dragging of dinghies to load and unload. It would be worth exploring whether there are different options for mooring allocation that would support fishermen to make less extensive use of vehicles.

There needs to be discussion with local fishermen at Porthdinllaen to discuss the issue of vehicle use and impacts, explore potential solutions and agree a way forward.

5.4.2 Wider considerations
There are some over-arching issues in relation to the question of vehicle use and impacts on the intertidal seagrass at Porthdinllaen that it would be helpful to address to inform future action by the Porthdinllaen Seagrass Project. These are wider than the scope of this report

but are mentioned here as they should be considered in conjunction with any specific measures to reduce vehicle impact.

i) Communication and provision of information

Given the existing framework and operation of the Porthdinllaen Seagrass Project, possible management options need be discussed with all relevant users and stakeholders. Collaborative discussion is required to ensure understanding of why the issue needs to be addressed and how this could be achieved, to provide up to date information about the condition of the seagrass bed and the benefits that could be realised from a healthy and resilient seagrass bed.

ii) Monitoring

Monitoring the condition of the seagrass needs to continue (for example as discussed in Davies *et al.,* 2017 and Unsworth and Cullen-Unsworth, 2015) in order to better understand changes to the seagrass bed, the ongoing situation regarding its condition and the recoverability of the bed to impact. Specifically in relation to use of vehicles, monitoring of the recovery of vehicle tracks and vehicle impact during replacement of the moorings would be helpful to better inform understanding of the severity and persistency of impact. If new management measures are implemented to reduce vehicle use it is important that ongoing monitoring is sufficient to record the effectiveness of this. The impact and damage monitoring undertaken as part of the SAC monitoring (Davies *et al.,* 2017) provides a basis for this.

Research and monitoring being undertaken by different organisations needs to be more effectively combined to ensure that all relevant information is available and considered. This could be supported by ensuring that all information generated by research, monitoring and scientific studies at Porthdinllaen is provided to a central database. This would necessitate an appropriate organisation to create and take ownership of such a database, or for all those undertaking work at Porthdinllaen to submit their data to an existing facility such as Marine Recorder (the data entered into Marine Recorder can take many forms, from minimal to complex). A formal requirement to submit and share data could be part of condition of any permission given by the National Trust (as landowner and foreshore lease holder), NRW Marine Licenses, and/or Crown Estate Seabed Survey Licenses for surveys under their jurisdiction.

It would be helpful for the Porthdinllaen Seagrass Project to produce an annual or bi-annual update on the results of the surveys and monitoring. There may be scope for this to be provided as part of site condition monitoring undertaken by Natural Resources Wales.

It would also be useful to keep a formal log of the surveys and fieldwork being undertaken at Porthdinllaen to help foster collaboration, understand how current studies contribute to addressing information gaps and identify opportunities for further work.

iii) Condition of the seagrass bed

The SAC monitoring identifies reduced seagrass density as well as incidents of impact occurring on the intertidal seagrass. Both of these measures indicate an impaired condition in parts of the intertidal seagrass bed (section 5).

There are statutory requirements to protect the seagrass bed and management action under the Porthdinllaen Seagrass Project is aiming to reduce the scale and severity of impacts on the seagrass. At the moment there are no clearly defined targets for the condition of the seagrass bed. If management options are not able to entirely remove potential impact, there needs to be an agreed view on what the condition of the intertidal seagrass should be and what level of impact is considered acceptable. Given the limited amount of time-series data currently available from the SAC monitoring, this may need to

be an interim decision based on current best available information with an intention to review this as more data becomes available and informs an understanding of acceptable condition. It is suggested that target levels for conditions could include measures such as:

- extent, patchiness, and density of seagrass,
- presence and abundance of associated species,
- abundance of *Sargassum*, and
- upper limits for damage from various activities.

As part of this, advice should be sought from NRW as to whether multiple single passes is better for the bed in the long term as opposed to creating a preferred 'sacrificial route' . A ‘sacrificial route’ may encourage multiple passes, therefore increasing potential for fragmentation of the seagrass bed at this point.

iv) Legal responsibilities

From the information provided (section 5.2.1) the National Trust has responsibilities as lease holder for the foreshore at Porthdinllaen. There are, however, still questions regarding the powers and duties of the National Trust under the foreshore lease and also under the Porthdinllaen Harbour Company Act and how these relate to the responsibilities of the Crown Estate over the seabed below mean low water into the subtidal. It would be useful to clarify where responsibility lies for management of vehicle use below mean low water, as well as other activities that impact the seagrass. This may be needed in the future in relation to determining responsibilities for other measures and to ascertain which organisations need to play a lead role. It would be helpful to clarify the spatial areas to which the powers and duties of the relevant organisations apply.

v) Other activities, cumulative impacts and zoning

Vehicle use is just one of the physical impacts on the intertidal seagrass bed at Porthdinllaen. Overall management of the area needs to consider the other activities that also have high potential to impact the seagrass and contribute to reduced health of the bed. It may be worth considering, through working with stakeholders, some degree of zoning of the intertidal area; this could help to reduce physical impacts from activities as much as possible as well as help address some of the concerns raised about conflict between different users of the area (e.g. power boats and swimmers). Possible considerations could include:

- An area of seagrass that is left alone as much as possible - i.e. as a wildlife area. This might link with initiatives such as a swimming area or snorkelling trips.
- Rationalise the distribution and number of intertidal moorings to reduce their impact footprint.
- A preferred area for vehicle use to limit the area of impact and reduce potential conflict between vehicle and other users of the beach.

Concerns have been raised by the local fishermen in discussion with the Pen Llŷn a’r Sarnau SAC Project Officer about use of the beach and safety on the beach and around the buoys offshore. Some of these issues might also be addressed through zoning in

conjunction with raising awareness and appropriate signage and provision of information. Issues raised included:

- Recreational boats and personal water craft travelling at high speed around the buoys, putting swimmers at risk and the fishermen themselves when they are traveling in their dinghy, to and from the fishing vessels.
- People swimming behind the trailer as the fishermen are loading.
- People walking behind the trailer whilst loading.
- People sitting/sunbathing in the path of vehicles.
- Dogs off the lead running around the moving vehicles.

Suggested possible measures to address these were notices boards or signs, telling people about the vehicles on the beach, and to have a restricted speed zone around the buoys.

6. Conclusions

Vehicles are one source of physical impact that can cause damage to natural habitats. The nature and scale of the impact is dependent on a range of different factors to do with the type of vehicle, how it is driven and the sensitivity of the habitat and associated community where the activity occurs.

The effect of vehicles on seagrass beds is readily seen as tracks and ruts which can persist for a number of years even following single pass events. Seagrass can recover from the impact of vehicle use, but persistent use in the same area can cause complete loss of seagrass cover. Whilst there are very few studies specifically looking at the impact of vehicles on seagrass beds, information from work on the effects of trampling on seagrass and use of vehicles on coastal sediment habitats shows that these activities cause compaction of the sediment habitat, reductions in seagrass cover and associated infauna and damage to the underlying root system of the seagrass, and can contribute to patchiness and fragmentation of seagrass habitat.

Sensitivity assessments consider seagrass habitats to be highly sensitive to activities that lead to penetration or disturbance of the substratum below the surface and those that cause mechanical modification of the sediment (and hence damage to roots and leaves).

There is evidence of impacts on the intertidal seagrass at Porthdinllaen particularly from moorings and vehicle use. Whilst it is not possible to quantify the specific contribution of vehicle use to these impacts it is reasonable to consider that vehicle use is, in part, contributing to the damage.

Vehicle use at Porthdinllaen is primarily by fishermen using tractors to gain access to and from their fishing vessels and transport equipment and catch, although there is also some use of four wheel drive vehicles and pick-ups associated with maintenance and replacement of moorings.

Most measures in place in the UK to prevent damage to seagrass are implemented in accordance with the legislative framework that requires protection of seagrass habitat. Examples of vehicle impact on seagrass have occurred either where measures have not been adhered to, or no active management is in place, but these situations are not common. There are legal requirements under European and UK legislation to protect seagrass beds. A 'do nothing' approach to ongoing damage by vehicular access across the intertidal Porthdinllaen seagrass is not a viable option as it fails to meet the legal requirements to protect the seagrass bed.

The aspiration of the Porthdinllaen Seagrass Project is to take a softer approach of co-management to enable and support continued use of the bay whilst still meeting obligations to protect the seagrass habitat and ensure its future health. This supports a collaborative approach to identify and agree options to address the issue of vehicle impact.

There are a number of options that could be considered to reduce the impact of vehicles on the seagrass. The most important of these is to initiate a discussion with local fishermen at Porthdinllaen to discuss the issue, explore potential solutions and agree a way forward. Preferably, vehicle use and solutions to reduce its impact need to be seen in the context of other direct physical impacts and other pressures on the seagrass bed and how these could best be dealt with.

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