AWAA Aquaculture Activity Assessment:

Intertidal Planted Seaweed Aquaculture

Report No: 722

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Mae'r asesiad hwn yn berthnasol i'r rhai sy'n asesu effeithiau posibl dyframaethu gwymon planedig rhynglanwol. Mae'r asesiad yn arwain defnyddwyr trwy broses sy'n disgrifio'r gweithgaredd dyframaethu a'r pwysau a allai godi o ganlyniad i'r gweithgaredd. Yna defnyddir astudiaeth achos i ddangos sut y gall defnyddwyr nodi sensitifrwydd y biotopau (sy'n ffurfio cydrannau o gynefinoedd) a rhywogaethau mewn lleoliad gweithgaredd dyframaeth enghreifftiol gan ddefnyddio Offeryn Mapio AGDC a Dangosfwrdd / Taenlenni Rhyngweithiadau AGDC. Yn olaf, crynhoir effeithiau posibl pob pwysau ar yr amgylchedd morol ar sail tystiolaeth a gasglwyd fel rhan o adolygiad systematig o lenyddiaeth, ac fe’i cyflwynir yng Nghronfa Ddata Tystiolaeth AGDC.

Mae'r asesiad, ynghyd ag adnoddau’r Prosiect AGDC a ddisgrifir yn yr asesiad, yn fan cychwyn defnyddiol i gasglu a datblygu gwybodaeth a thystiolaeth y gellir eu defnyddio yn ystod proses arfarnu amgylcheddol. Dylid darllen pob Asesiad Gweithgaredd Dyframaethu ar y cyd ag Adroddiad Terfynol AGDC er mwyn deall y dulliau, y tybiaethau a'r penderfyniadau sydd wedi llywio'r asesiadau a'r adnoddau a ddatblygwyd fel rhan o'r Prosiect.

Executive Summary

This document is one of a series of Aquaculture Activity Assessments developed as part of Natural Resources Wales' (NRW) Assessing Welsh Aquaculture Activities (AWAA) Project. Each assessment presents a step-by-step guide on how to use the various resources produced by the AWAA Project to provide information on the types of impacts an aquaculture activity could have on the Welsh marine environment.

This assessment is relevant to those assessing the potential impacts of undertaking intertidal planted seaweed aquaculture. The assessment guides users through a process describing the aquaculture activity and the pressures with the potential to occur as a result of the activity. A case study is then used to demonstrate how users can identify the sensitivity of the biotopes (which form components of habitats) and species at an example aquaculture activity location using the AWAA Mapping Tool and AWAA Dashboard / Interactions Spreadsheets. Lastly, the potential impacts of each pressure on the marine environment are summarised based on evidence collated as part of a systematic literature review, which is presented in the AWAA Evidence Database.

The assessment, together with the AWAA Project resources described in the assessment, provide a useful starting point to gather and develop information and evidence which can be used during an environmental appraisal process. Each Aquaculture Activity Assessment should be read in conjunction with the AWAA Final Report to understand the methods, assumptions and decisions that have informed the assessments and resources developed as part of the Project.

Intertidal Planted Seaweed Aquaculture

Introduction

This document is one of a series of Aquaculture Activity Assessments developed as part of Natural Resources Wales' (NRW) Assessing Welsh Aquaculture Activities (AWAA) Project (the Project). Each assessment provides information and guidance on the types of impacts a proposed aquaculture activity could have on the marine environment.

The Project has developed a series of resources to support the assessment of the potential impacts of different aquaculture activities. The resources are:

- The Dashboard/Interactions Spreadsheets;
- The Mapping Tool; and
- The Evidence Database.

The assessments follow a step-by-step process that guides users on how to use these resources. They demonstrate how the resources can be used as a starting point to gather information and evidence on the potential impacts occurring from an aquaculture activity.

The step-by-step process is shown in Figure 1.

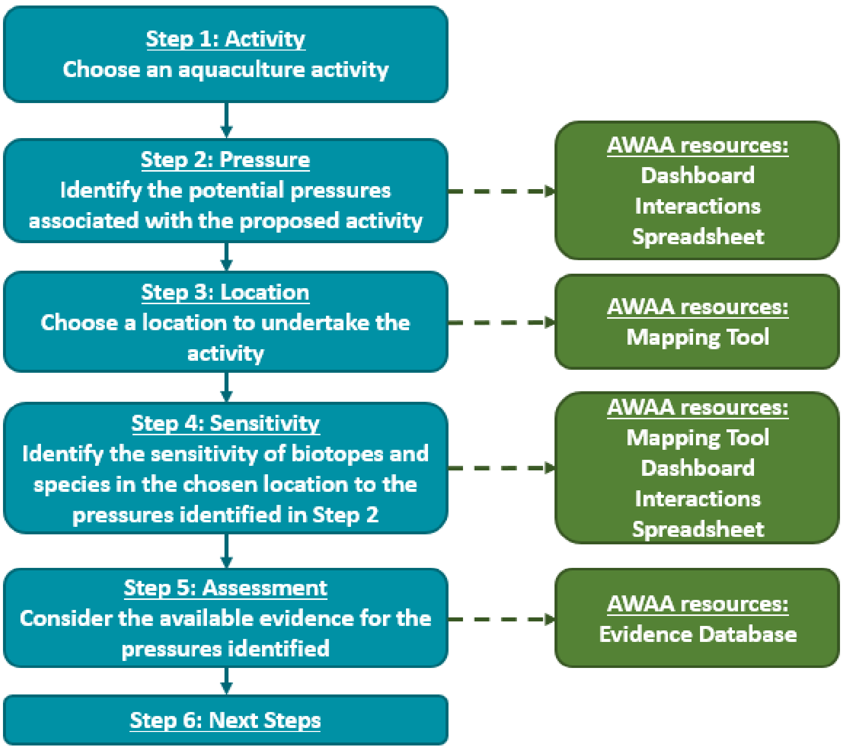

Figure 1. Flow diagram to show the step-by-step process of using the Project resources.

Aquaculture Activity Assessment General Rules

Users must remember:

- The results generated by all the AWAA resources are indicative. They are designed to provide guidance, information and evidence relating to the types of impacts that would be considered during an environmental appraisal process.
- The generic sensitivity scores, evidence summaries and mapping resources can be used as a starting point to develop a more detailed appraisal of the potential impacts the chosen aquaculture activity may have on specific marine habitats and species in an area of interest.
- The Project resources do not replace the requirement to understand the extent of the impacts a specific aquaculture activity may have on an area through, for example, consultation or by undertaking further detailed surveys to characterise an area of interest.
- Users should add specifics about the type of activity being considered within the environmental appraisal, such as its location, infrastructure, operation, species, footprint or duration etc. These factors have the potential to change the degree of exposure natural habitats and species may have to the pressures associated with the chosen aquaculture activity. This detail may require the user to consider the applicability of the indicative sensitivity values generated by the AWAA resources in terms of whether it would increase or decrease the significance of the effect of the pressures associated with the activity.
- The Project uses the sensitivity scores for biotopes (habitat communities) and species to OSPAR pressures from The Marine Evidence-based Sensitivity Assessment (MarESA) (Tyler-Walters et al., 2022) and the Natural England Mobile Species Sensitivity Assessment (2022). The sensitivity scores are indicative across a range of marine activities that could generate the pressure, including aquaculture. The pressure descriptions and benchmarks have been checked by the Project for their appropriateness to the various aquaculture activities, and comments and confidence levels are captured in the AWAA Dashboard and the Interactions Spreadsheet.

Each Aquaculture Activity Assessment should be read in conjunction with the AWAA Final Report to understand the methods, assumptions and decisions that have informed the assessments and resources developed as part of the Project, such as the AWAA Evidence Database, Dashboard, the Interactions Spreadsheets and the Mapping Tool.

Intertidal Planted Seaweed Aquaculture

Step 1: Activity

Choose an aquaculture activity

When planning to develop an aquaculture activity, one of the first steps is to consider the techniques to be used to grow and harvest the chosen species. The type and scale of the activity along with the methods used during collection, construction, operation and harvesting are important factors for determining the potential impacts the activity may have on the marine environment.

This assessment concerns intertidal aquaculture activity of cultivating planted seaweed.

Species cultivated

The culturing of intertidal planted seaweed is not currently undertaken in the United Kingdom (UK). However, bottom culture of seaweed is popular in warm temperate climates (Redmond et al., 2014) such as Asia, Africa and South America.

Smaller seaweed species, particularly native red algae, such as the red seaweed *Porphyra* spp. (‘Laverbread’ or ‘nori’) or the red seaweed *Gracilaria/Gracilariopsis* spp. could be suitable species to be farmed in the UK using bottom culture.

Infrastructure and equipment

Intertidal planted seaweed aquaculture can take a variety of forms. Some species can simply be planted directly into the seabed by inserting a cutting of the seaweed or propagule. Other techniques require some infrastructure, such as seeding seaweed fronds onto a hard substrate, including rocks, weights, containers, tiles or mats which are inserted just under the surface of the seabed. Sometimes nets are placed on the seabed with the seaweed frond attached to mesh, allowing the seaweed to grow up into the water column. The nets are secured to the intertidal seabed using poles or stakes. In some circumstances, floats can be used to suspend the net above the seabed when the tide is in and seaweed submerged to allow better light conditions for growth (Hossain et al., 2020).

Another intertidal method of growing seaweed includes attaching fronds to individual lines which are strung on stakes and suspended just above the bottom of the seabed. The stakes can be around 5–10m apart and the lines 20–30cm above the seabed (depending on harvesting length of the species). This can be undertaken in the intertidal or very shallow subtidal zone (Msuya, 2011) (Figure 2). Lines are often made of plastic and can vary in width depending on the size of the seaweed species being grown.

Equipment for collecting, laying and harvesting the seaweed also can include the use of vessels and potentially trawls or dredges at high tide, or vehicles to access the foreshore at low tide.

Figure 2. Intertidal seaweed farm in Zanzibar (Photo: Moongateclimber - Wikimedia Commons)

General methods for growing and harvesting

Seaweed can either be bought from a seaweed hatchery, seeded from natural settlement or directly removed from the seabed using trawls or rakes. Generally, seed can be re-laid or attached to line/nets after a month of growth and will be around 50–200g in weight depending on the species. Local seed is believed to provide the most resilient stock for an area.

Cultivation can take place in a variety of different ways. For example, cultivating *Gracilaria* species in Chile is undertaken via 'bottom stocking' where it is grown on rocks which are then inserted into a soft-substrate seabed. Or the *Gracilaria* species can be planted in holes in long plastic tubes laid horizontally along the seabed and filled with sediment (Pereira and Yarish, 2008).

The husbandry of the seaweed can vary depending on the location and species being cultivated. For some species and locations, once the seaweed is fixed in place, it can be left until it reaches marketable size. On the other hand, some species require regular husbandry to ensure the seaweed remains tied to lines or substrates, particularly after storm events, or to remove epiphytes which can reduce the productivity and growth of the seaweed being cultivated.

The time it takes to reach marketable size will vary depending on the species, with cultivation times ranging from one month to one to two years. Harvesting can take place by hand at low tide or by vessels when the seaweed is submerged. Rakes or knives are typically used to cut the seaweed when hand gathering at low tide but vessels with trawls or dredges can be used to mechanically harvest the seaweed when the seaweed is submerged (Flora, 2019). The seaweed is cut above the thalli to allow the same plants to produce more fronds, with several harvests made from the same plants in one growing season (Pereira and Yarish, 2008).

After harvesting, seaweed can be placed on racks to dry out. Further onshore facilities may be required for cleaning, processing and packing.

Intertidal Planted Seaweed Aquaculture

Step 2: Pressures

Identify the potential pressures associated with the proposed activity

Pressures are the mechanism through which an activity can have an effect on an ecosystem (Tyler-Walters et al., 2018). Aquaculture activities have the potential to impact the marine environment through physical, chemical and biological pressures and it is important to identify which pressures could occur from the proposed activity.

The potential pressures from growing intertidal planted seaweed are presented in Table 1. The Table includes a description of the pressure and how the potential pathways might occur. In line with the general rules of this assessment it is important to remember that, depending on the operation and scale of the activity, the pressure pathways or significance of the pressure's effect could change.

Table 1. List of pressures, their descriptions and how they occur from the aquaculture activity. The pressures are a relevant subset of those used in MarESA (Tyler-Walters et al., 2022), unless otherwise specified.

Pressure name	Description	Pathway from aquaculture activity
Above water noise (Pressure from Natural England, 2022)	Any loud noise made onshore or offshore by construction, vehicles, vessels, tourism, mining, blasting etc.	Above water noise generated by machinery, vessels or vehicles could disturb birds and marine mammals
Abrasion/disturbance of the substrate on the surface of the seabed	Physical disturbance or abrasion at the surface of the substratum in sedimentary or rocky habitats	Scouring caused by mechanical harvesting operations could cause abrasion
Barrier to species movement	The physical obstruction of species movements and including local movements	Intertidal cultivation plots may present a barrier to species movement or feeding birds

Pressure name	Description	Pathway from aquaculture activity
Changes in suspended solids (water clarity)	Changes in sediment, organic particulate matter and chemical concentrations can change water clarity (or turbidity)	Construction, operation and harvesting may stir up sediment and increase turbidity. Seaweed suspended in the water column may slow currents and lead to increased accretion
Collision ABOVE water with static or moving objects not naturally found in the marine environment (Pressure from Natural England, 2022)	The injury or mortality of biota from both static and/or moving structures	Vessels and machinery used for construction and harvesting may present a collision hazard above water
Collision BELOW water with static or moving objects not naturally found in the marine environment	Injury or mortality from collisions of biota with both static and/or moving structures	Vessels or infrastructure such as nets and lines may present a collision hazard below water
Genetic modification & translocation of indigenous species	Genetic modification can be either deliberate (e.g. introductions) or a by-product of other activities (e.g.. mutations)	Transplanting of indigenous species from one location to another could lead to interbreeding and alter the gene pool
Hydrocarbon and polycyclic aromatic hydrocarbon (PAH) contamination	Increases in the levels of these compounds compared with background concentrations	Introduced to the environment via vessels or vehicles oil or fuel leaks and spills
Introduction of light or shading	Direct inputs of light from anthropogenic activities. Also shading from structures etc.	Infrastructure and seaweed in the water column may cause shading of the seabed

Pressure name	Description	Pathway from aquaculture activity
Introduction of microbial pathogens (including metazoan parasites)	Untreated or insufficiently treated effluent discharges and run-off from terrestrial sources and vessels. Also, where seaweed is imported, 'infected' seed could be introduced	Diseases or parasites from imported aquaculture stocks could spread quickly amongst high densities of stock and could spread to wild populations
Introduction or spread of invasive non-indigenous species (INIS)	The direct or indirect introduction of INIS	Introduction of INIS for aquaculture purposes or the introduction of INIS on farmed seaweed. Spawning from farmed INIS stock could spread to surrounding areas
Litter	Any manufactured or processed solid material from anthropogenic activities discarded, disposed or abandoned	Lines, nets, planting material or other infrastructure may be lost to the marine environment
Nutrient enrichment	Increased levels of the elements nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations	Seaweed detritus (e.g. broken fronds) may introduce nutrients to the surrounding area, however, reductions in nutrient enrichment have been recorded as seaweeds uptake nutrients
Organic enrichment	The degraded remains of dead biota and microbiota; faecal matter from marine animals; or flocculated colloidal organic matter	Introduction of organic matter from seaweed detritus (e.g. broken fronds) may be introduced to the surrounding area
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Physical disturbance of sediments where there is limited or no loss of substratum from the system	Penetration or sub-surface disturbance of the seabed from insertion of stakes or planting materials

Pressure name	Description	Pathway from aquaculture activity
Physical change (to another seabed type)	The permanent change of one marine seabed type to another marine seabed type	Introduction of aquaculture infrastructure offers an artificial substrate for colonisation
Removal of non-target species	Removal of non-farmed species associated with management and harvesting activities	Wild species, particularly invertebrates which live around or on the farmed seaweed may be removed during harvesting
Smothering and siltation rate changes ('Light' deposition)	When the natural rates of siltation are altered (increased or decreased)	The effects of dredging causing the resuspension of sediments. Growing seaweed on the seabed and/or accumulation of broken fronds, particularly after storm events
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	Increases in the levels of these compounds compared with background concentrations	The use of pesticides
Underwater Noise Changes	Increases over and above background noise levels at a particular location	Noise generated by vessels and/or machinery during harvesting
Vibration (Pressure from Natural England, 2022)	Vibration from direct sources (e.g. drilling, trawling, dredging etc.)	Vibration generated by vessels and/or machinery during harvesting
Visual disturbance	The disturbance of biota by anthropogenic activities (e.g. increased vessel movements)	Visual disturbance to seabirds and marine mammals as a result of vessel, vehicle use, or personnel movement
Water flow (tidal current) changes, including sediment transport considerations	Changes in water movement associated with tidal streams, prevailing winds and ocean currents	Infrastructure and suspended seaweed could reduce flow speeds, increase turbulence or alter water flow direction

Pressure name	Description	Pathway from aquaculture activity
Wave exposure changes	Local changes in wavelength, height and frequency	Infrastructure and seaweed in the water column could reduce wave action and impact local coastal processes

Intertidal Planted Seaweed Aquaculture

Step 3: Location

Choose a location to undertake the activity

Choosing a location to undertake the aquaculture activity will depend on a range of factors, including but not limited to:

- Size of the aquaculture development;
- Accessibility of the location;
- Suitability of the environmental conditions (e.g. level of exposure to weather, tide and current);
- Suitability of the substrate;
- Land ownership;
- Location of supporting land-based infrastructure;
- Environmental considerations such as protected habitats and species in the vicinity;
- Rights of way, and
- Other users of the area.

The locations generally used for intertidal seaweed aquaculture will depend on the environmental tolerance of the seaweed. Seaweed can be grown in the intertidal or in shallow locations which remain submerged the majority of the time, with depths of water no lower than 0.5–1m at low tide (Waters et al., 2019). Seaweeds can also be grown in the intertidal area where they are uncovered by the tide for periods of the day, however, the location on the shore will depend on the species' tolerance to desiccation. In general, flat bottom substrates in very sheltered bays, estuaries and inlets can be used for cultivation to minimise fronds breaking with wave action.

Once a general location has been decided upon, the AWAA Mapping Tool and Dashboard, developed as part of the Project, allows the user to investigate the biotopes (which form components of habitats or protected features) and species in the surrounding area and their sensitivities to the potential pressures arising from the aquaculture activity.

An example case study in the Mawddach Estuary is provided in Step 4 that demonstrates how the AWAA Mapping Tool and Dashboard can be used if you are considering growing intertidal planted seaweed.

Intertidal Planted Seaweed Aquaculture

Step 4: Sensitivity

Identify the sensitivity of biotopes and species in the chosen location to the pressures identified in Step 2

Once you have chosen the aquaculture activity and possible location, the AWAA Mapping Tool and Dashboard can be used to investigate how sensitive biotopes and species in Welsh waters are to the pressures associated with the activity. This information can be used if undertaking an environmental appraisal.

The AWAA Mapping Tool allows the user to identify the biotopes overlapping or nearby a proposed location and therefore have the potential to be exposed to the pressures occurring from the activity. Before investigating the sensitivity of biotopes using the AWAA Mapping Tool, it is important to consider that:

- The operation and scale of the aquaculture activity might change the level of exposure of the biotopes to the pressure and hence the significance of the effect of the pressure.
- Micro-siting of the aquaculture activity can sometimes be used to reduce or avoid the pressures from impacting sensitive biotopes. However, it is also important to note that areas with no biotope records or blank areas on maps do not mean there is no exposure of biotopes to the pressure being assessed. Rather, blank areas, particularly in the subtidal, indicate there is no available survey data describing the biotopes for that location and as such further surveys may be required to characterise the area. Additionally, depending on the pressure and its zone of influence, the pressure may have the ability to affect biotopes and species at a distance from the origin of the activity, such as pressures related to pollution or sedimentation.
- The biotope data used in the AWAA Mapping Tool are a collation of surveys which have been undertaken over the last 50 years, with the majority of data collected since 1996. It is therefore important to consider whether further surveys are needed to update and/or confirm the presence of some biotopes.

Species including birds, fish, mammals and invertebrates have not been mapped by the Project as they can be exposed to the pressures being considered potentially anywhere. This reduces the value of species maps as vast areas of the sea would be highlighted as being potentially sensitive. Instead, users producing an environmental appraisal should concentrate on the other Project resources, such as the Dashboard, to understand species sensitivity to pressures, along with information such as the scale or operation of the activity and any information available on the use of the chosen area by the species of concern. It is important to acknowledge that mobile species, that form part of a site designation, should be considered wherever they occur if the proposed aquaculture location is potentially within their range.

The Dashboard provides a complete list of the biotopes currently recorded in Welsh waters. The sensitivity of both biotopes or protected species which could be exposed to the pressures at a proposed location of an aquaculture activity can be identified using the AWAA Dashboard (or Interactions Spreadsheet). In addition, the Dashboard shows the user which biotopes or species are protected within the Marine Protected Area (MPA) network or protected under Section 7 of the Environment (Wales) Act 2016.

MPA designations and protected features can be turned on or off in the AWAA Mapping Tool to allow the user to see if the biotopes or proposed location of the activity overlap with any of these areas. However, it is important to note that not all biotopes found within a proposed location will necessarily form part of an MPA or be protected under Section 7 of the Environment (Wales) Act 2016. The user should therefore use the AWAA Dashboard (or Interactions Spreadsheet) to identify which biotopes are protected in the area of interest.

A fictional example case study focussing on the Mawddach Estuary is presented to demonstrate how the AWAA Mapping Tool and Dashboard can be used to identify the potential sensitivity of biotopes and species in a particular area. It is important that the user considers the potential sensitivity of the biotopes and species for all of the pressures identified in Step 2 (**Table 1**), in their area of interest by repeating the exercise below for each pressure.

Case study

In this example, the potential sensitivity of biotopes and species are presented for two of the pressures associated with intertidal planted seaweed aquaculture identified in Step 2, Table 1:

1. Abrasion/disturbance of the substrate on the surface of the seabed; and

2. Visual disturbance.

The first pressure is used to demonstrate how to find out the sensitivity of biotopes in the proposed activity area. The second pressure is used to demonstrate how to find out the sensitivity of protected species in the same area.

1. Abrasion/disturbance of the substrate on the surface of the seabed

To examine the sensitivity of biotopes in the vicinity of the proposed activity, use the Mapping Tool to:

- Zoom in on the Mawddach Estuary;
- Select the aquaculture activity ‘Intertidal Planted Seaweed’; and
- Select the pressure ‘abrasion/disturbance of the substrate on the surface of the seabed’.

The user will then be able to see the individual biotopes displayed in different colours based on their sensitivity to the pressure selected.

For example, **Figure 3** shows the sensitivity of biotopes in the Mawddach Estuary to the pressure 'abrasion/disturbance of the substrate on the surface of the seabed'. When the AWAA Mapping Tool is open the biotope codes, names, and other relevant survey information can be found by clicking on each individual biotope.

The AWAA Dashboard provides a complete list of the biotopes currently recorded in Welsh waters. To check the whether the biotopes identified from the AWAA Mapping Tool are part of an MPA or listed under Section 7 Environment (Wales) Act 2016 search the AWAA Dashboard using the following filter options:

- Select the dashboard biotope screen;
- Select the aquaculture activity 'Intertidal Planted Seaweed';
- Select the pressure 'abrasion/disturbance of the substrate on the surface of the seabed'; and
- Select the Welsh MPAs which overlap the proposed location.

The AWAA Dashboard will display a list of the biotopes and the designated features which the biotopes form a component. It will also indicate whether the biotopes are listed under Section 7 habitats under the Environment (Wales) Act 2016.

For the purposes of the Mawddach Estuary example, the biotopes considered most sensitive to abrasion/disturbance of the substrate on the surface of the seabed from intertidal planting of seaweed aquaculture are shown in **Figure 3**. The biotope *Macoma balthica* and *Arenicola marina* in littoral muddy sand (LS.LSa.MuSa.MacAre) has been assessed as having a medium level of sensitivity to abrasion/disturbance of the seabed in MarESA (Tyler-Walters et al., 2022). The majority of the remaining biotopes have been assessed as having a low level of sensitivity to abrasion and disturbance, for example, *Cerastoderma edule* and polychaetes in littoral muddy sand (LS.LSa.MuSa.CerPo) and *Hediste diversicolor*, *Macoma balthica* and *Eteone longa* in littoral muddy sand (LS.Lsa.MuSa.HedMacEte). Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa) are assessed as not being sensitive to the pressure. Please see the AWAA Final Report to understand the process of how confidence was assigned by MarESA to the sensitivity scores. The AWAA Final Report provides further information on assessment conclusions such as any biotope sensitivity scores considered 'not relevant', 'not assessed' and having 'insufficient evidence'.

The majority of biotopes form a component of a number of MPA features such as estuaries, large shallow inlets and bays, and/or mudflats and sandflats not covered by seawater at low tide within the Lleyn Peninsula and the Sarnau Special Area of Conservation (SAC) and Mawddach Estuary Site of Special Scientific Interest (SSSI) with some of the biotopes also listed as Section 7 habitats.

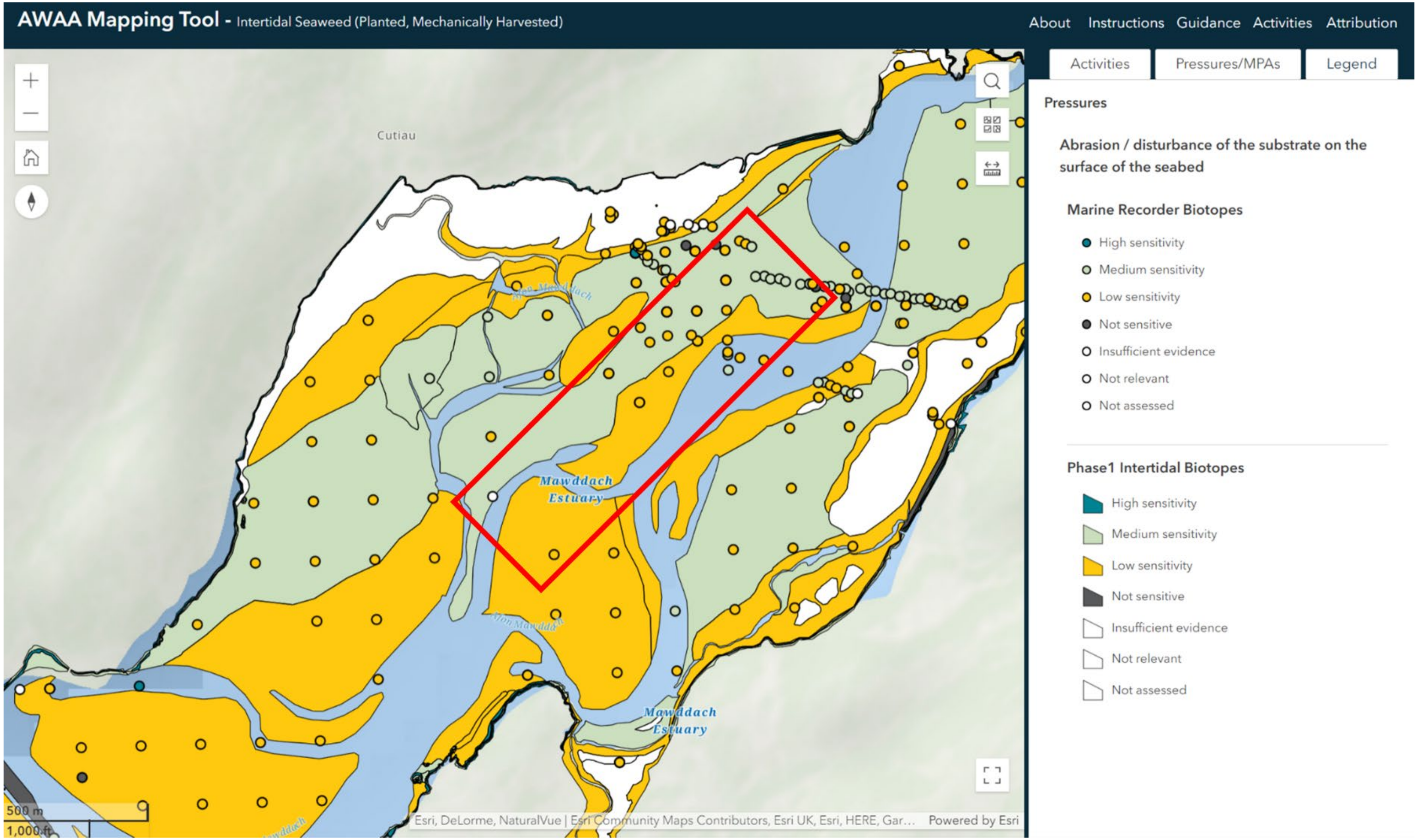

Figure 3. Use of the AWAA Mapping Tool to identify the proposed aquaculture activity location in the Mawddach Estuary and the biotopes overlapping with the proposed area (red box).

Table 2. The sensitivity of biotopes to the pressure ‘abrasion/disturbance of the substrate on the surface of the seabed’ using the example location of Mawddach Estuary, and the aquaculture activity of growing intertidal planted seaweed. Ordered from High to Low sensitivity. The Table also indicates if a biotope forms part of a Section 7 Environment (Wales) Act 2016 habitat and/or which MPAs and features the biotopes are part of.

Biotope name	Biotope code	Sensitivity [confidence]	Section 7 habitats which include the biotope	MPAs where the biotope is protected	MPA features which include the biotope
Macoma balthica and *Arenicola marina* in littoral muddy sand	LS.LSa.MuSa. MacAre	Medium [High conf.]	Not Section 7	Lleyn Peninsula and the Sarnau SAC	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide
Cerastoderma edule and polychaetes in littoral muddy sand	LS.LSa.MuSa. CerPo	Low [Medium conf.]	Not Section 7	Lleyn Peninsula and the Sarnau SAC	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide
Eurydice pulchra in littoral mobile sand	LS.LSa.MoSa. AmSco.Eur	Low [Medium conf.]	Not Section 7	Lleyn Peninsula and the Sarnau SAC	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide
Hediste diversicolor and *Macoma balthica* in littoral sandy mud	LS.LMu.MEst. HedMac	Low [Medium conf.]	Intertidal mudflats	Lleyn Peninsula and the Sarnau SAC; Mawddach Estuary SSSI	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide; Sheltered mud
Hediste diversicolor, *Macoma balthica* and *Eteone longa* in littoral muddy sand	LS.LSa.MuSa. HedMacEte	Low [Medium conf.]	Intertidal mudflats	Lleyn Peninsula and the Sarnau SAC	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide
Polychaetes in littoral fine sand	LS.LSa.FiSa.P o	Low [Medium conf.]	Not Section 7	Lleyn Peninsula and the Sarnau SAC	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide

Biotope name	Biotope code	Sensitivity [confidence]	Section 7 habitats which include the biotope	MPAs where the biotope is protected	MPA features which include the biotope
Polychaetes and *Angulus tenuis* in littoral fine sand	LS.LSa.FiSa.Po.Aten	Low [Medium conf.]	Not Section 7	Lleyn Peninsula and the Sarnau SAC	Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide
Polychaetes in littoral fine sand	LS.LSa.FiSa.Po	Low [Medium conf.]	Not Section 7	Lleyn Peninsula and the Sarnau SAC	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide
Polychaete/bivalve-dominated muddy sand shores	LS.LSa.MuSa	Not assessed	Intertidal mudflats	Lleyn Peninsula and the Sarnau SAC	Estuaries; Large Shallow Inlets and Bays; Mudflats and sandflats not covered by seawater at low tide

2. Visual disturbance

The sensitivity of protected species which could overlap with the proposed location of an aquaculture activity can be identified using the species AWAA Dashboard using the following filter options:

- Select the dashboard species screen;
- Select the aquaculture activity ‘Intertidal Planted Seaweed’;
- Select the pressure ‘visual disturbance’; and
- Select the MPAs which overlap or are adjacent to the proposed location and/or Section 7 species.

The AWAA Mapping Tool can be used to identify the MPAs which overlap with or are close to the proposed aquaculture site in the Mawddach Estuary example case study. The AWAA Dashboard can then be used to ascertain the protected species within the MPA or the Section 7 list and their sensitivity to the pressure being considered. The MPAs are shown in Table 3 and include:

- Lleyn Peninsula and the Sarnau SAC
- Afon Eden – Cors Goch Trawsfynydd SAC; and
- Mawddach Estuary SSSI.

Redshank, a feature of the Mawddach Estuary SSSI, has been assessed as having a high sensitivity to visual disturbance. Grey Seal, Bottlenose Dolphin and Otter, are all features of the Lleyn Peninsula and the Sarnau SAC. Grey Seal has been assessed as having a low level of sensitivity to the pressure, while Bottlenose Dolphin and Otter are not considered to be sensitive to visual disturbance in the Natural England (2022) sensitivity assessment. Please see the AWAA Final Report to understand the process of how confidence was assigned by Natural England to the sensitivity scores. Insufficient evidence was available to assess the sensitivity of Salmon in the Natural England (2022) sensitivity assessment, a feature of the Afon Eden – Cors Goch Trawsfynydd SAC. More investigation may need to be undertaken to understand the potential interaction between Salmon and this pressure. The AWAA Final Report provides further information on assessment conclusions such as any species’ sensitivity scores considered ‘not relevant’, ‘not assessed’ and having ‘insufficient evidence’.

To understand the potential impact of the pressure in the example case study location in the Mawddach Estuary, it is important to understand the potential use of the area by the species concerned.

Table 3. The sensitivity of designated species features to the pressure 'visual disturbance' using the example location of Mawddach Estuary, and the aquaculture activity of growing intertidal planted seaweed. Ordered from High to Low sensitivity. The Table also indicates if a species is a Section 7 Environment (Wales) Act 2016 species and/or which MPAs the species is a designated feature of.

Common Name	Scientific Name	Sensitivity [confidence]	Section 7 species (Y/N)	MPAs where species are part of the site designation
Redshank (breeding)	*Tringa totanus*	High [High conf.]	No	Mawddach Estuary SSSI
Redshank (non-breeding)	*Tringa totanus*	High [High conf.]	No	Mawddach Estuary SSSI
Grey seal	*Halichoerus grypus*	Low [High conf.]	No	Lleyn Peninsula and the Sarnau SAC
Bottlenose dolphin	*Tursiops truncatus*	Not sensitive [High conf.]	Yes	Lleyn Peninsula and the Sarnau SAC
Otter	*Lutra lutra*	Not sensitive [High conf.]	Yes	Lleyn Peninsula and the Sarnau SAC; Mawddach Estuary SSSI
Atlantic salmon	*Salmo salar*	Insufficient Evidence	Yes	Afon Eden – Cors Goch Trawsfynydd SAC

Intertidal Planted Seaweed Aquaculture

Step 5: Assessment

Consider the available evidence for the pressures identified

Once the habitats and species in the vicinity of the proposed activity have been identified and their sensitivities determined, it may be necessary to consider the potential impacts the pressures may have alone and in combination in an environmental appraisal process.

As part of the Project, an extensive literature review was undertaken to compile an Evidence Database. The AWAA Evidence Database provides the user with the available evidence to inform an environmental appraisal by bringing together the current evidence on the pressures generated by different aquaculture activities and the impacts they could have on habitats and species.

The AWAA Evidence Database was compiled over the duration of the Project and captures the existing knowledge at the time of writing. There is the potential that new evidence becomes available following publication, therefore, the user is encouraged to conduct a search for any new evidence, particularly for those pressures for which there is little or no direct evidence identified within the AWAA Evidence Database.

Any interpretation of the evidence and the sensitivity of biotopes and species will be dependent on a number of factors including the operation and scale of the aquaculture activity. In an environmental assessment, the available evidence should therefore be considered in the context of the proposal and confidence in the evidence, particularly where contrasting information on the impacts is available. Where no evidence is available on the impacts of a pressure occurring from an aquaculture activity, the user may have to consider the applicability of evidence from other activities that could generate similar pressures and clearly state what assumptions have been made along with any associated limitations.

Summaries of the evidence sources identified in the AWAA Evidence Database for each of the pressures relating to intertidal planted seaweed aquaculture identified in Step 2 (Table 1) are provided below. The evidence summaries for the pressures used in the Mawddach Estuary case study example in Step 4 are provided below in sections 2 and 22.

1. Above water noise

Although no evidence was found in the scientific literature for this pressure with respect to intertidal planted seaweed aquaculture, above water noise is expected to occur during seeding, maintenance and harvesting of seaweed. Above water noise has the potential to disturb bird species, particularly wading birds in the intertidal zone, and seals which haul out on the shore in the vicinity of the activity.

2. Abrasion/disturbance of the substrate on the surface of the seabed

Abrasion or disturbance of the seabed from intertidal planted seaweed aquaculture could occur during the collection of seed stock from wild populations or from harvesting planted seaweed by mechanical dredging.

Abrasion or disturbance of the seabed from hand harvesting methods will likely cause less of an impact in comparison to mechanical operations, however, this will depend on the methods used to harvest the seaweed.

Abrasion from mechanical dredging could lead to damage of the sediment surface and subsequently increase sediment suspension into the water. Abrasion could also have a strong influence on benthic communities in seed collection sites by, for example, directly causing damage to species, changing turbidity or smothering (Forrest et al, 2009). A review by Campbell et al. (2019) mentioned that kelp cultivation may lead to abrasion and a subsequent loss of some macroinvertebrates. This could occur where fronds come into regular contact with the seabed with the incoming and outgoing tides.

Disturbance in the form of trampling has been shown to affect seagrass beds. It is important to note, however, that the impacts of trampling can vary depending on the type of substratum (Major et al., 2004).

Abrasion from intertidal aquaculture can also occur from vehicle movements. A study undertaken in Ireland by Forde et al (2015) showed that disturbance from shore access to cultivation areas by vehicles can lead to compaction of the sediments. Pauls *et al*. (2017) investigated the impact of vehicle access on seagrass at Angle Bay, Wales, and the timescale for recovery after one impact event. The immediate disturbance of one tyre track led to an 80–90% decrease in seagrass blade frequency localised to the track. The seagrass took two years to fully recover after the tyre tracks caused compression of the sediment and local changes in hydrology.

Other studies (Everett et al., 1995; Beninger and Shumway, 2018) corroborate these impacts and state that the movement of aquaculture farmers and their vehicles can negatively impact sediment dwelling organisms, such as mudflat infauna and native flora.

3. Barrier to species movement

The presence of intertidal planted seaweed aquaculture and associated husbandry practices have the potential to act as a barrier to feeding birds if seaweed is grown in dense aggregations and where infrastructure such as rocks, tiles or lines are used.

It is likely that other species utilising the intertidal zone may be impacted by the presence of intertidal aquaculture, for example, seals which haul out or otters foraging on the shore, however, no direct mention of this was found in the scientific literature. When considering a location for an aquaculture activity, it would be useful to identify any potential seal haul out sites in close proximity and assess whether the activity could disturb or displace seals.

4. Changes in suspended solids (water clarity)

Natural aggregations of macroalgae reduce water velocity and attenuate waves which can reduce the resuspension of sediment. Evidence suggests that seaweed farming will have the same effect with one paper finding resuspension of sediments reduced by 50% (Zhang et al., 2016) which has the potential to increase water transparency.

However, harvesting of bottom grown seaweed using dredges has the potential to disturb the seabed leading to resuspension of sediments and increased turbidity in the water column. Suspended sediments in the water column have the potential to reduce the visibility of marine predators such as marine mammals, fish and diving or surface feeding seabirds, reduce light penetration, clog filtration mechanisms of filter feeders or lead to behavioural alterations (Todd et al., 2015; Ortega et al., 2020). Increases in suspended solids can also occur from disturbing the seabed during construction, seeding and maintenance of the seaweed farm. However, increases in suspended solids would likely be short-term and relatively localised.

5. Collision ABOVE water with static or moving objects

There is the potential for bird species to collide with vessels above water when dredging for seaweed. However, no evidence was found in the scientific literature relating to the collision of species above water with intertidal planted seaweed aquaculture. It is likely that any such instances would be relatively rare unlikely to cause a significant impact.

6. Collision BELOW water with static or moving objects

There is the potential for species to collide with an operational vessel during harvesting activities where trawls or dredges are used, however, no evidence was found for this pressure in the scientific literature. It is likely that any such instances would be relatively rare and unlikely to cause a significant impact unlikely to cause a significant impact.

7. Genetic modification & translocation of indigenous species

There are few studies investigating the impact of genetic modification or translocation of seaweed aquaculture species on the genetic structure and evolution of wild seaweed populations. However, it is expected that propagation of seaweed species from a limited number of individuals can artificially increase specific traits favourable to aquaculture such as increased reproductive fitness. Using these individuals in aquaculture could lead to genetic modification of wild populations, known as crop-to-wild gene flow. This may reduce genetic diversity and/or the ability for local adaptation (Wilding et al., 2021). Decreases in genetic diversity have the potential to increase seaweed susceptibility to disease and overall decreased fitness (Charrier et al., 2017).

8. Hydrocarbon and PAH contamination

No evidence was found in the scientific literature relating to hydrocarbon or PAH contamination from intertidal planted seaweed aquaculture.

However, it is expected that this pressure in the form of fuel or oil leaks and spills could occur through the use of vessels, machinery or vehicles during seed collection, construction and harvesting processes.

9. Introduction of light or shading

There is limited evidence on whether the shading from intertidal planted seaweed could impact habitats or species. However, the introduction of seaweed aquaculture to the intertidal could lead to shading of the seabed, particularly if infrastructure or the seaweed species covers a large area, potentially shading seagrass beds, algae or other photosynthesising species. The shading of benthic invertebrates is unlikely to be relevant, except where it may interfere with spawning cues (Scottish Government, 2020).

10. Introduction of microbial pathogens (including metazoan parasites)

The movement of seaweed species for aquaculture purposes has the potential to spread diseases (Cottier-Cook et al., 2021). Pathogens and disease in seaweed aquaculture can also be caused or exacerbated by abiotic stress as a result of unfavourable environmental conditions (Ward et al., 2019). Cultivated seaweed species can be particularly vulnerable to pathogens where species are not genetically diverse, typically due to stocks that have been produced from a limited pool of parent plants via sexual or asexual propagation (Cottier-Cook et al., 2016). It is recognised that disease within aquaculture has the potential to spread to wild populations, however there is limited evidence of this occurring in seaweed cultivation (Wood et al., 2017).

The use of plastics within aquaculture has the potential to act as a vector for higher abundances of pathogens and bacteria than the surrounding water, such as genera *Vibrio* (Mohsen et al., 2022). However, there is less evidence on the ability of these pathogens to transfer across to and infect aquaculture species.

Parasites occur naturally in the marine environment and can infect species used in aquaculture or wild populations. Compared to the natural environment, aquaculture facilities have high densities of stock which can facilitate parasites to spread quickly and easily. There is also the potential for parasites to spread from aquaculture sites and infect nearby wild populations or increase the parasitic load within wild populations where the parasites may already exist (Beninger and Shumway, 2018). In addition, stock imported for cultivation could harbour new and potentially non-indigenous parasites.

Parasites have the potential to lead to disease outbreaks in algae and could have negative impacts on both wild and cultivated algae (Carney and Lane, 2014). There is little evidence regarding the impacts of parasites, such as fungi and amoeba, on cultivated algae and whether this could spread to wild populations. Further research is therefore needed to understand the impacts of parasites associated with seaweed aquaculture on habitats and species.

11. Introduction or spread of INIS

Aquaculture can lead to the spread of INIS through a variety of different pathways, including the intentional introduction of INIS as the target aquaculture species and the unintentional introduction of 'hitchhiking' INIS which could be living on the aquaculture species and equipment. Infrastructure associated with suspended seaweed aquaculture could provide additional habitat for a range of benthic organisms including seaweeds, tunicates, razor clams and crabs (Wood et al., 2017) and have the potential to attract non-native species which can thrive on artificial structures.

In a global review of invasive macroalgae introductions, 54% of introductions were derived from aquaculture either through macroalgae cultivation or indirectly through imports for shellfish farming (Williams and Smith, 2007). Fletcher and Farrell (1998) describe the spread of the non-native kelp species Wakame (*Undaria pinnatifida*) introduced to France in the 1980s for commercial cultivation. It has now spread to the south coast of the UK where it has the potential to outcompete native species.

The impacts of INIS will depend on the particular INIS, the habitat they have been introduced to, and their ability to become established (Herbert et al., 2016). INIS introduced via aquaculture could cause a range of impacts, including;

- Competition with native species for food and space;
- Predation on native species;
- Introduction of pathogens;
- Smothering;
- Modifying currents and changing sedimentation; and
- Change habitat type.

Aquaculture which adds infrastructure to the environment could enhance INIS establishment due to their typically opportunistic nature and ability to thrive on artificial substrates, such as anchors (McKindsey et al., 2011).

12. Litter

In general, aquaculture activities are recognised as a potential pathway for the introduction of marine litter. It is likely that the introduction of litter from intertidal planted seaweed such as rocks, tiles, lines and stakes can pose a significant entanglement threat, especially for seabirds (Massetti et al., 2021). Skirtun et al. (2022) highlighted the key risks posed to wildlife from marine plastic pollution includes entrapment and entanglement of marine organisms; ingestion of macro- and micro-plastic by animals; transfer of harmful chemicals to wildlife; transport of non-indigenous species; and smothering of marine fauna.

Macro-plastic pollution in the form of lost or abandoned gear from aquaculture can impact marine biodiversity by altering or modifying species assemblages (Werner et al., 2016). This is primarily through the introduction of foreign species transported via floating plastic debris, or sunken litter that forms new artificial habitats, both of which threaten native biodiversity.

13. Nutrient enrichment

Intertidal planted seaweed aquaculture has the potential to add nutrients to the environment through the break-off and decomposition of fronds, however, seaweed is recognised as providing a net uptake of nutrients such as nitrogen. There is a growing interest in co-cultivation, whereby seaweed is cultivated alongside bivalve shellfish or fish due to its ability to uptake nutrients. Seaweed aquaculture, therefore, has the potential to mitigate against the impacts of eutrophication. Models have shown that seaweed farming can have limited impacts with regards to nutrient uptake, but intensive seaweed cultivation over large areas could have a negative impact on phytoplankton or filter feeders such as mussels by competing for nutrients (Aldridge et al., 2021).

14. Organic enrichment

Studies have shown that seaweed can be a significant contributor of dissolved organic matter in coastal waters, with up to 20% of dissolved organic matter coming from kelp (Wada and Hama, 2013). Models have indicated that farming kelp has the potential to enhance benthic production and species abundance and richness (Hadley et al., 2018), however, in turn it could change local macrofaunal assemblages (Walls et al., 2017). In addition, storm events could lead to a large volume of frond break-off and subsequently increased organic enrichment if they settle in one area.

15. Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion

No studies were found that investigated the impacts of seabed penetration from stationary aquaculture infrastructure. However, penetration and/or disturbance of the substrate below the surface of the seabed could result from infrastructure such rocks, containers or stakes used to plant seaweed on the seabed. This disturbance has the potential to lead to direct mortality or localised displacement of infaunal species with the amount of impact, dependent on the scale of the activity.

16. Physical change (to another seabed type)

Intertidal planted seaweed aquaculture has the potential to create a new habitat by adding seaweed to the existing seabed which may attract a range of different species. A Swedish study showed that seaweed cultivation attracted mobile fauna and different algal species, thus increasing species abundance and richness compared to areas without cultivation (Visch et al., 2020). The attraction of mobile fauna such as fish and macroinvertebrates at seaweed aquaculture sites could provide a feeding ground for marine mammals and birds which predate upon these species. Unlike at fish and shellfish aquaculture sites, the presence of carnivorous predators are unlikely to have a negative impact on the yield of the seaweed farm (Wilding et al., 2021).

17. Removal of non-target species

Seaweeds provide food and shelter for a range of invertebrate species which can often be found attached to the fronds of the seaweed. An Irish study by Walls et al. (2016) showed that the holdfasts of cultivated algae hosted a wide range of taxa, with benthic cultured individuals predominately hosting nematodes, polychaetes and molluscs, and suspended culture hosting predominately amphipods, polychaetes and decapods. The harvesting of seaweed can lead to the incidental removal of these non-target species. In addition, dredging activities could lead to the incidental capture of species living in close proximity to the algae, such as species sheltering under the seaweed canopy.

Entanglement is not expected to be an issue for this particular activity unless where nets or lines are used to suspend algae above the seabed.

18. Smothering and siltation rate changes (‘Light’ deposition)

There is little evidence in the literature that seaweed aquaculture could smother habitats. Dredging during harvesting may redistribute and suspend sediment into the water column, leading to potential smothering of benthic habitats and species. The direct planting of seaweed on the seabed may lead to a highly localised smothering directly under its footprint. In addition, storm events, could lead to large scale frond break off, which could lead to localised smothering if they were to settle predominately in one location. Smothering could lead to permanent or temporary displacement of benthic species. However, more information is needed to understand the potential scale of the impact occurring from this pressure and activity.

19. Synthetic compound contamination

There is limited information regarding the use of chemicals such as pesticides and antifoulants in seaweed aquaculture (Philips et al., 1990). Wilding et al., (2021) stated that once deployed at sea, seaweed farming sea is unlikely to require the use of pesticides or fertilisers. However, there is the potential that chemicals could be used for seaweed aquaculture to reduce pests, control disease and remove fouling organisms.

20. Underwater noise changes

Underwater noise can occur from the use of vessels during seed collection or harvesting operations. The impacts of noise from vessels used for cultivation may be lower in magnitude than typical vessel traffic, but this will be area specific and could still potentially affect species sensitive to noise (Wilding et al., 2021).

21. Vibration

There is no evidence in the literature on the impacts of vibration occurring from the mechanical collection or harvesting of seaweed. Whilst some vibration will occur from the use of equipment such as dredges on the seabed, it is likely to be highly localised in scale and temporary in nature.

22. Visual disturbance

Visual disturbance can occur by vessel/vehicle or personnel movement directly related to the cultivation practices associated with intertidal planted seaweed aquaculture. The construction of aquaculture infrastructure is characterised by a short period of acute disturbance, followed by the operational phase where disturbances are caused sporadically during maintenance, harvesting and reseeding activities (Becker et al., 2011).

Of particular concern is disturbance at seal haul-out sites, with the rate of disturbance been shown to increase significantly with increased harvesting (Becker et al., 2009). There are also significant concerns in relation to feeding birds in the vicinity of the aquaculture site, however, there is little direct research on this impact. Maslo et al. (2020) found that tended intertidal aquaculture activities reduced the probability of shorebird presence by 1–7% in the United States (US) whereas untended aquaculture activities led to no detectable impacts. However, foraging rates were mostly influenced by environmental conditions as opposed to disturbance.

There are concerns that birds in the vicinity of aquaculture sites could be disturbed/displaced by the presence of personnel or vessels and artificial lights (International Council for the Exploration of the Sea (ICES), 2022).

23. Water flow changes

The presence of seaweed in the water column absorbs energy from waves and current and acts as an obstruction to water flow (Wilding et al. 2021). There is the potential for water flow changes to occur both within and outside of seaweed farms as flow is diverted around the farm. Zhang et al. (2016) showed the culture of suspended kelp (as opposed to bottom grown) led to a reduction in flow velocity by almost 50%, and bottom friction velocity by 25%. Such changes in water flow have the potential to change the hydrodynamics of the local system, affecting the erosion and deposition of sediments within the system (Cao et al., 2007; Zhang et al., 2016).

In addition, the cycles of regular growth and harvesting of seaweed has the potential to lead to variable changes in water flow during the lifetime of the activity.

24. Wave exposure changes

There is the potential that the presence of seaweed in the water column can change wave exposure of a site, for example by dampening surface waves by reducing wave energy and longshore currents (Mork et al., 1996; Morris et al., 2020). Changes in wave exposure could affect physical processes such as sediment transport and also lead to changes in habitats and species communities.

In addition, the regular growth and harvesting of seaweed has the potential to lead to variable changes in wave energy during the lifetime of the activity.

Intertidal Planted Seaweed Aquaculture

Step 6: Next Steps

This Aquaculture Activity Assessment, along with the AWAA Mapping Tool, Dashboard, and Evidence Database, provide a useful starting point for users to further investigate the potential impacts from growing intertidal planted seaweed on the marine environment. Steps 1 to 5 of this Assessment have been designed to provide guidance on how the Project resources can be used to inform an environmental appraisal process.

Steps 1 to 5 provide the user with an initial understanding of the potential pressures occurring from an aquaculture activity and the tools to identify the most sensitive biotopes and species in an area of interest to the potential impacts from the proposed activity. Step 4 of this assessment should be repeated for all pressures identified in Step 2 to gain a full understanding of the sensitivity of biotopes and species to the activity.

However, to fully understand the impact of a specific aquaculture activity, the user needs to consider the footprint, location, intensity of the activity and the methods behind construction, operation and harvesting. Specific details about a proposed activity have the potential to change which pressures may occur, along with the exposure and significance of the effect of that pressure on relevant biotopes and species.

Environmental appraisals should also consider indirect impacts on biotopes and species from the proposed activities for example the impact on a habitat that provides food for a protected species. Whilst indirect impacts have not been included in the AWAA resources, it is important to consider how they could potentially have an impact. The environmental appraisal process may also consider the potential interactions between pressures which could exacerbate any potential impacts from pressures on their own.

Finally, it may be necessary to consult locally and to undertake area-specific surveys to gain further insight into potentially sensitive biotopes and species in the vicinity of a proposed activity.

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Abbreviations

AWAA	Aquaculture Activity Assessment
ICES	International Council for the Exploration of the Sea
INIS	Invasive Non-Native Species
MarESA	Marine Evidence based Sensitivity Assessment
MPA	Marine Protected Area
NRW	Natural Resources Wales
OSPAR	Cooperative of 15 governments and the EU for the Protection of the Marine environment of the North East Atlantic
PAH	Polycyclic Aromatic Hydrocarbons
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
TBT	Tributyltin
UK	United Kingdom
US	United States

Data Archive Appendix

Data outputs associated with this project are archived in [NRW to enter relevant corporate store and / or reference numbers] on server–based storage at Natural Resources Wales.

Or

No data outputs were produced as part of this project.

The data archive contains: [Delete and / or add to A-E as appropriate. A full list of data layers can be documented if required]

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] A full set of maps produced in JPEG format.

[C] A series of GIS layers on which the maps in the report are based with a series of word documents detailing the data processing and structure of the GIS layers

[D] A set of raster files in ESRI and ASCII grid formats.

[E] A database named [name] in Microsoft Access 2000 format with metadata described in a Microsoft Word document [name.doc].

[F] A full set of images produced in [jpg/tiff] format.

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