Historic Assets Management Plan

Stijn den Haan & Dr. Richard Unsworth

Accompanying Marine License application DEML2248 to restore 10 hectares of seagrass in North Wales

20 October 2022

PROJECT SEAGRASS

Table of Contents

Figures and tables

Preface

Project Seagrass aims to establish 10 hectares of seagrass in North Wales by planting seagrass seeds in the marine sediment. Currently, seven potential locations ("seagrass search areas") are considered for seagrass restoration across North Wales. However, the exact locations of seagrass restoration activities will be determined together with local stakeholders and will depend on sites' ecological suitability for seagrass to grow. Our main proposed method to restore seagrass meadows is to fill biodegradable hessian bags with seagrass seeds and sand, which will be laid down on top of the marine sediment at suitable locations.

In line with the Welsh National Marine Plan's SOC_05 policy on historic assets, this document outlines how Project Seagrass will avoid, minimise, or mitigate any negative impacts on known and unknown marine historic assets whilst restoring seagrass meadows in North Wales.

After an initial introduction to seagrass ecology, restoration, and the known impacts of seagrass meadows on historic assets, we list all historic assets found at the *seagrass search areas* as per Marine License application DEML2248. Subsequently, we discuss a management plan to avoid, minimise, or mitigate negative impacts on marine historic assets. The final sections outline a monitoring protocol for historic assets, a Protocol for Archaeological Discoveries, and a note on the Welsh 2016 Environment Act, relating to the duties of Welsh public bodies to protect and enhance biodiversity.

1. A brief introduction to seagrass ecology, restoration, and the impacts on historic assets

In contrast to algae and seaweeds, the seagrass *Zostera marina* is a flowering plant that has adapted to life in the sea through millions of years of evolution[1]. They cannot grow on hard substrate such as rocks or wood; their roots require soft sediments to grow and form dense meadows. *Inter alia*, seagrass meadows reduce coastal erosion through stabilising the seabed and attenuating waves, they capture carbon at high rates, and they support a diverse assemblage of commercially important fish species[2]. These and other ecosystem services they provide, make seagrass meadows one of the most valuable ecosystems on the planet[3], yet up to 92% of UK seagrass meadows have been lost in the past century[4], along with the ecological services they provide to society. To reverse this trend, our main method to restore seagrass will be to place hessian bags filled with seagrass seeds and sand onto soft sediments only, as explained in further detail in Marine License application DEML2248.

With regards to the potential impacts of our seagrass restoration activities and the protection of historic assets, our restoration methods involve neither any deep digging into the sediment, nor do they involve the removal of objects from the sea. In section 2, we systematically assess the potential impacts of restoring seagrass meadows on historic assets.

Based on a literature review, we note that academic studies show how the restoration of seagrass meadows may positively contribute twofold to the preservation of historic assets. First, via their leaves, roots, and rhizomes, seagrass meadows alter their environment by slowing down the movement of water, stabilising the seabed and trap and accumulate sediment. In effect, this sediment build-up is recognised as a means of enhancing the preservation of maritime archaeological objects and features[5]. Second, further research has documented how seagrass meadows across the world have protected archaeological objects throughout time as the meadows form thick sedimentary deposits, and thereby bury and seal archaeological objects in anoxic sediments that prevent decay[6]. The same researchers additionally note that as seagrass meadows accrue sediment and stabilize the seafloor, they reduce soil erosion and protect archaeological objects from erosion and exposure.

Moreover, threats to maritime archaeology are expected to increase as climate change heightens the frequency and intensity of storms, leading to increased erosion of maritime archaeology[7]. Similarly, an increase in storm frequency may destabilise marine sediments, resulting in the loss of soil carbon[7], e.g. submerged peat layers. Hence, due to the abovementioned positive impacts of seagrass meadows to reduce erosion and stabilise the seafloor, seagrass could increase the protection of historic assets in the face of climate change. Overall, the presence of seagrass can indeed help preserve the historic assets of North Wales.

In the next section, we address each historic asset that was identified to be inside or in the vicinity of the *seagrass search areas* specified in Marine License application DEML2248.

2. Desk-based assessment of the potential impacts of seagrass restoration on historic assets

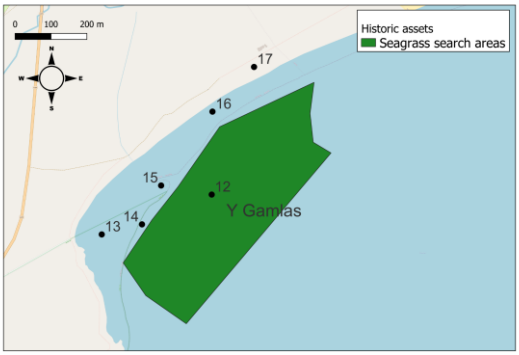
Table 1 lists all historic assets found inside or nearby the seagrass search areas of DEML2248, as well as the potential positive and negative impacts. Note that this list was compiled using data from the Gwynedd Archaeological Trust Regional Historic Environment Record (https://archwilio.org.uk), and Coflein, the online database for the National Monuments Record of Wales (https://coflein.gov.uk). Furthermore, Figure 1 shows the location of historic assets in relation to where *seagrass search areas* are proposed – note that the coordinates of the historic assets do not fully represent the shape and size of the historic assets, e.g. in the case of the large fish traps or submerged walls.

Figure 1 Locations of the seagrass search areas and known historic assets. Note that map scales vary between the maps.

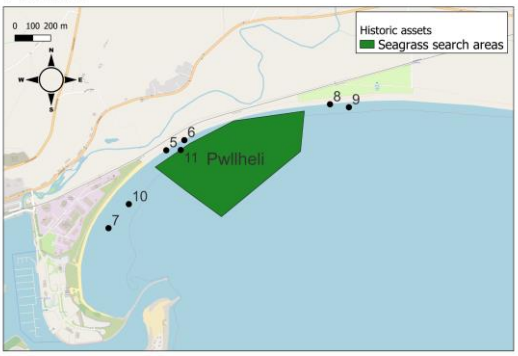
Abersoch

Warren

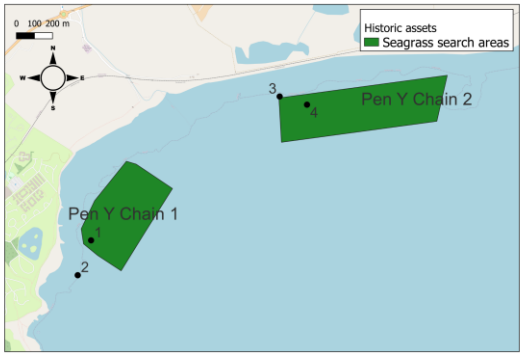
Y Gamlas



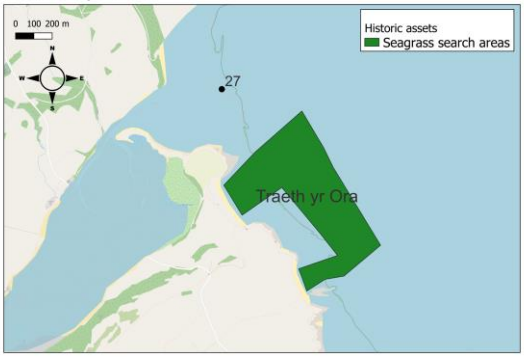
Pwllheli



Pen Y Chain 1 & 2



Traeth yr Ora



Based on the *locations* of the historic assets, the majority of known historic assets are located outside the seagrass search areas, as shown in Table 1. This reduces their risk of being impacted (negatively or positively) by seagrass restoration.

Based on the *material type* of the historic assets, 20 out of 27 historic assets are physical structures. As the seagrass *Zostera marina* can only grow on soft sediments, there is no risk of seagrass growing on top of or inside these 20 historic assets, including shipwrecks, fish traps, stone walls, and WWII airplane remains. For the seven historic assets that are not physical structures (e.g. prehistoric submerged forest, intertidal peat deposits, and mobile finds), the existence of five historic assets has been confirmed, according to data of both Coflein and the Gwynedd Archaeological Trust Regional Historic Environment Record. All of these five assets' recorded locations are outside the seagrass search areas. Whilst acknowledging that these locations do not represent the size, shape, and extent of the assets and that seagrass may positively contribute to the assets' protection, this shows a relatively low risk of negative impacts of seagrass restoration on the listed historic assets.

3. Avoiding, minimising, or mitigating identifiable negative impacts on historic assets

As per the SOC_05 policy of the Welsh National Marine Plan, below we outline a management plan to avoid, minimise, or mitigate identifiable negative impacts on historic assets; this management plan is summarised in Figure 2 and outlined in the following steps:

1) First, the seagrass search areas will be narrowed down to *seagrass restoration areas* that are identified to be ecologically suitable for seagrass to grow, and where we have support of local stakeholders to plant seagrass in these specified locations.

2) Second, if historic assets are present inside the seagrass restoration areas, we will locate the historic assets through systematic non-intrusive surveys via wading and/or SCUBA diving in the full extent of the seagrass restoration areas. If historic assets are found, we will mark these with GPS devices, and install an Archaeological Exclusion Zone (AEZ) which include a 2-meter buffer zone around the asset's outline, in which no seagrass planting will take place. The edges of the AEZs will be marked with temporary buoys or similarly visible markers during the seagrass restoration activities, to ensure that no restoration activities take place in the AEZs, and these markers will be removed after the completion of the restoration activities. To increase chances of finding the historic assets at Warren and Abersoch, we will consult Jake Davies, a Project Seagrass trustee who is a local resident at these sites and a highly experienced marine biologist who works in these areas.

3) Third, the state of the historic assets will be documented, and the assets will be included in a monitoring scheme outlined in the next section. This information will subsequently be communicated to RCAHMW and Gwynedd Archaeological Planning Service (GAPS).

4) Fourth, during and after the restoration of seagrass, the state of the historic assets will be monitored to ensure that any negative impacts are documented, which will be communicated to RCAHMW and GAPS.

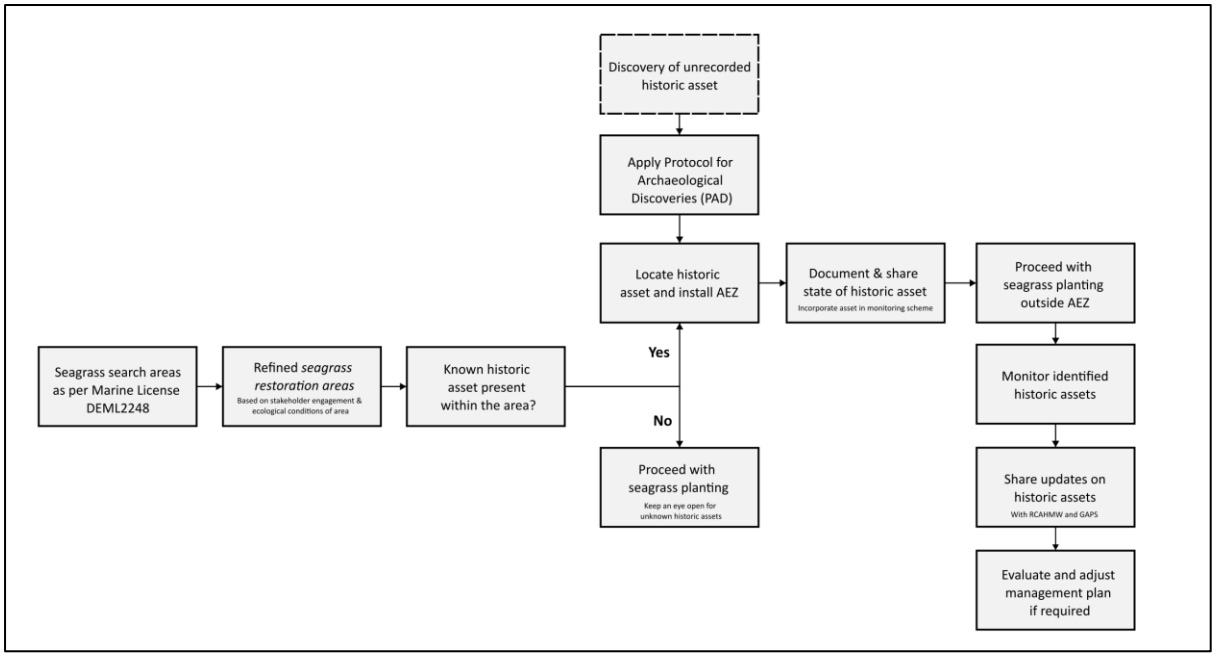
5) Fifth, if any negative impacts on the monitored historic assets are found and these impacts are caused by the seagrass restoration activities, the management plan will be evaluated and adjusted to avoid, minimise, or mitigate negative impacts.

If unrecorded historic assets are identified inside the seagrass restoration areas during above-mentioned wading and/or SCUBA surveys or during the restoration activities, the Protocol for Archaeological Discoveries (PAD) will be followed. The asset will be recorded, and its status will be communicated to RCAHMW and GAPS. Subsequently, the asset will be included in the monitoring scheme.

If no known historic assets are present inside the seagrass restoration area, we will remain vigilant and keep and eye open for any historic assets identified. If historic assets are found, the PAD will be followed.

During the length of the restoration project, the historic assets located within the seagrass restoration areas and the AEZs will be monitored to ensure no negative impacts take place. If seagrass does spread into the buffer zones of the AEZs, and the positions of RCAHMW and GAPS remain that seagrass should not be present near historic assets, seagrass found to be present inside AEZs will be removed by hand.

Figure 2 Management plan for historic assets encountered as part of Marine License DEML2248.



In contrast, if a natural perturbation (e.g. a storm) or human error (e.g. accidental dislodging) by a third party moves a historic asset from outside to inside an existing seagrass meadow, no seagrass will be removed around the historic asset. Instead, in this situation,

Project Seagrass, RCAHMW, and GAPS will discuss on a case-by-case basis whether the historic asset is to be moved to a new location or whether it is to remain in place.

Lastly, whether the existence of a historic asset is “possible” or “definite”, we will survey the seagrass restoration area and attempt to locate the historic asset. If, however, the existence is “possible” as per the archaeological record and we are unable to locate it, we will communicate this to RCAHMW and GAPS and install a Temporary Exclusion Zone (TEZ) at the location associated with the asset’s record. If we receive verifiable evidence from RCAHMW or GAPS on the existence of the historic asset that allows us to locate it, the TEZ will be turned into an AEZ. However, if no such evidence can be provided, the TEZ will be lifted and we will proceed with seagrass restoration activities, whilst remaining mindful that the asset could be present at a nearby location.

4. Monitoring of historic assets to prevent negative impacts

To ensure historic assets are not negatively impacted by restoration activities, we will monitor all previously recorded and newly recorded historic assets present within the finalised restoration areas. Monitoring of the seabed shall take place via SCUBA and/or wading surveys, using non-intrusive observational methods. These include size measurements of any historic assets, detailed photographic documentation, and written visual observations using quadrat surveys. Monitoring data will be shared with RCAHMW and GAPS. Monitoring will follow guidelines produced by the Crown Estate.

Monitoring of historic assets will take place throughout the lifecycle of the restoration project, i.e. before, during, and after the restoration activities. The initial monitoring of historic assets will create a baseline of the state of historic assets, while the monitoring during restoration activities will help to rapidly identify negative impacts on historic assets – if any. As described in section 3, if negative impacts are identified and caused by seagrass restoration, the management plan will be evaluated and adjusted to avoid, minimise, or mitigate further negative impacts. Monitoring will continue after the restoration activities have been completed to ensure no encroachment of seagrass into the AEZs takes place.

Moreover, if a historic asset is found after the start of restoration activities, restoration activities will be paused until the historic asset is located, documented, and an AEZ is installed; this asset will then be included in subsequent monitoring surveys.

If required, additional monitoring training will be provided by Dr. Julien Whitewright of RCAHMW, as offered via communications with Dr. Richard Unsworth on 30 September 2022.

5. Protocol for Archaeological Discoveries

In the event of discovering unrecorded historic assets, we will mark their location using a GPS device, the assets will be photographically documented, their measurements will be recorded, and any additional observations will be written down. If present within the

seagrass restoration areas, we will install an AEZ – which includes a 2-meter buffer zone around the asset's outline – around the historic asset. This discovery and information on the historic asset will be communicated to RCAHMW and GAPS, the relevant landowner, the Receiver of Wreck, and the local Finds Liaison Officer for the Portable Antiquities Scheme, so that this historic asset can be included in *inter alia* the Coflein online database. Furthermore, in line with Policy SOC_05 of the Welsh National Marine Plan to promote opportunities to better understand the significance of historic assets, we will communicate any discoveries through the Project Seagrass communication channels, to help spread awareness on the rich maritime history of North Wales. Prior to the start of restoration activities, we will brief our staff members and volunteers on this Protocol for Archaeological Discoveries.

6. Environment (Wales) Act 2016

Where the Welsh Marine National Plan provides Project Seagrass with an opportunity to protect – and raise awareness on – historic assets in North Wales, the Environment (Wales) Act 2016 provides an opportunity for the RCAHMW to protect and enhance marine biodiversity through this seagrass restoration project. As per the Environment (Wales) Act 2016, section 6, "A public authority must seek to maintain and enhance biodiversity in the exercise of functions in relation to Wales, and in so doing promote the resilience of ecosystems, so far as consistent with the proper exercise of those functions". As per section 7 of this same legislation, seagrass beds are one of the ecosystems referred to in section 6. Hence, the seagrass restoration project of Project Seagrass is an opportunity for the RCAHMW, as a Welsh public authority, to fulfil its duty under the Environment (Wales) Act 2016.

Table 1 Overview of the historic assets present nearby and inside the seagrass search areas of Marine License application DEML2248.

Item number	Location	Object type	Object number	Most recent source date	Description	Possible / definite presence at site	Location (lat/long)	Location (BNR)	Location inside / outside seagrass search area?	Potential positive impacts of seagrass restoration	Potential negative impacts of seagrass restoration
1	Pen Y Chain 1	Fish trap	NPRN408622	2020	82 m x 72 m fish trap.	Definite	52.901310, -4.3225773	SH4388036290	Inside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the fish trap.	Dependent on the height of the fish trap, it may become more difficult to locate without a GPS device if seagrass is growing close-by.
2	Pen Y Chain 1	Fish trap	PRN6788	2000	Unknown fish trap.	Possible	52.899581, -4.3236743	SH4380036100	Outside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the fish trap.	Dependent on the height of the fish trap, it may become more difficult to locate without a GPS device if seagrass is growing close-by.
3	Pen Y Chain 2	Intertidal peat deposit	NPRN524728	2007	Peat exposures reported at this location.	Definite	52.908447, -4.3070459	SH4495037050	Outside	Seagrasses accumulate sediment and stabilise the seabed[8–11]. This can protect peat layers against erosion.	The peat layer may become buried deeper, making it more challenging to excavate for research purposes.
4	Pen Y Chain 2	Intertidal peat deposit	PRN16588	2013	The feature could be a jetty or breakwater. "Known only from a single brief reference".	Possible	52.908041, -4.3047935	SH451370	Inside	Seagrasses accumulate sediment and stabilise the seabed[8–11]. This can protect peat layers against erosion.	The peat layer may become buried deeper, making it more challenging to excavate for research purposes.
5	Pwllheli	Shipwrecks	NPRN271622	2002	Scotia vessel was lost in the vicinity. Exact location unknown.	Possible	52.893896, -4.3957000	SH3893535627	Outside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwreck, reducing its visibility.
6	Pwllheli	Shipwrecks	NPRN271279	2002	Fanny vessel was lost in the vicinity. Exact location unknown.	Possible	52.894403, -4.3941966	SH3903835680	Outside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwreck, reducing its visibility.
7	Pwllheli	Shipwrecks	NPRN271281	2002	Indefatigable vessel was lost in the vicinity. Exact location unknown.	Possible	52.889996, -4.4004947	SH3859835204	Outside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwreck, reducing its visibility.
8	Pwllheli	Shipwrecks	NPRN271623	2002	John and Ann vessel was lost in the vicinity. Exact location unknown.	Possible	52.896202, -4.3821038	SH3985835853	Outside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwreck, reducing its visibility.
9	Pwllheli	Shipwrecks	NPRN524910	1851	Olivia vessel was lost in the vicinity. Exact location unknown.	Possible	52.896053, -4.3805345	SH3996335833	Outside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwreck, reducing its visibility.
10	Pwllheli	Aircraft crash site	NPRN515886	1984	Aircraft crashed into the western end of Pwllheli beach – remains could be present.	Possible	52.891199, -4.3988070	SH3871635334	Outside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion – which makes it plausible that aircraft remains will similarly be protected by seagrass meadows[6].	The sediment accumulating traits of a nearby seagrass meadows may increase sedimentation rates near the shipwrecks, reducing the visibility of the wreck.

11	Pwllheli	Timber object	PRN 34202	2006	3-meter-long timber shaft; could be part of shipwreck	Definite	52.893911, -4.3944966	SH3901635626	Inside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks and related objects from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the timber object, reducing its visibility.
12	Y Gamlas	Submerged structural remains	NPRN408997	2006	Possible area of artificial submerged walls and stone structures	Possible	52.867785, -4.4603071	SH3449032870	Inside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the submerged structural remains.	Dependent on the height of the structure, it may become more difficult to locate without a GPS device if seagrass is growing close-by.
13	Y Gamlas	Submerged structural remains	PRN16609	2002	Curving arc, about 150 m across, high up on the beach.	Definite	52.866791, -4.4648570	SH3418032770	Outside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the submerged structural remains.	Dependent on the height of the structure, it may become more difficult to locate without a GPS device if seagrass is growing close-by.
14	Y Gamlas	Prehistoric Submerged Forest	NPRN524724	2007	A peat deposit, behind a sandy offshore bar.	Definite	52.867042, -4.4631921	SH3429332794	Outside	Seagrasses accumulate sediment and stabilise the seabed[8–11], and can reduce oxidation of historic assets through the accumulation of sediment[6]. Hence, they may protect the prehistoric submerged forest against erosion.	The peat layer may become buried deeper, making it more challenging to excavate for research purposes.
15	Y Gamlas	Prehistoric Submerged Forest	PRN16599	2002	No peat or timbers visible during survey in 2001-2002. Identified in 1981 by Margaret Griffith.	Possible	52.868011, -4.4624001	SH34353290	Outside	Seagrasses accumulate sediment and stabilise the seabed[8–11], and can reduce oxidation of historic assets through the accumulation of sediment[6]. Hence, they may protect the prehistoric submerged forest against erosion.	The prehistoric submerged forest may become buried deeper, making it more challenging to excavate for research purposes.
16	Y Gamlas	Mobile Archaeological Finds	NPRN516069	2011	Roman brooch, bronze casting, silver coins, copper allow buckles	Definite	52.869854, -4.4602756	SH3450033100	Outside	Through accumulating sediment, seagrasses can reduce both erosion and oxidation of historic assets, acting as time vaults for the preservation of historic assets[6].	The mobile archaeological finds may become buried deeper, making it more challenging to excavate for research purposes.
17	Y Gamlas	Field system	PRN7304	1996	Field wall on sandy foreshore, 0.5 m high, 1 m wide	Definite	52.870968, -4.4585556	SH34623322	Outside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the submerged structural remains.	Given the height of the structure, it may become more difficult to locate without a GPS device if seagrass is growing close-by.
18	Warren	Prehistoric Submerged Forest	NPRN421684	2018	160 m peat on the beach	Definite	52.837580, -4.4944280	SH3207729590	Outside	Seagrasses accumulate sediment and stabilise the seabed[8–11], and can reduce oxidation of historic assets through the accumulation of sediment[6]. Hence, they may protect the prehistoric submerged forest against erosion.	The prehistoric submerged forest may become buried deeper, making it more challenging to excavate for research purposes.
19	Warren	Shipwrecks	NPRN423310	2018	Unnamed wreck on the beach	Definite	52.841177, -4.4858284	SH3267029970	Inside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwrecks, reducing their visibility.
20	Warren	Shipwrecks	NPRN418877	2013	Unnamed wreck on the beach	Definite	52.840384, -4.4893469	SH3243029890	Inside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwrecks, reducing their visibility.

21	Warren	Aerial ropeway	PRN58438	1995	Aerial ropeway, with cable ropes present	Definite	52.844134, -4.4820174	SH3293830290	Outside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the submerged structural remains.	Dependent on the height of the structure, it may become more difficult to locate without a GPS device if seagrass is growing close-by.
22	Abersoch	Various finds	PRN32912	2022	A bronze age axe, a Roman brooch, and post medieval coin	Definite	52.805314, -4.4937223	SH3226	Outside	No impact: BNG reference refers to a terrestrial site.	No impact: BNG reference refers to a terrestrial site.
23	Abersoch	Slipway and boathouse	PRN59610	1996	A life-boat house and slipway	Definite	52.811267, -4.4885725	SH32372665	Outside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the slipway. No impact expected on the life-boat house as it is on land.	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the slipway.
24	Abersoch	Anchorage / drying berth	NPRN 525606	1748	Anchorage	Possible	52.810688, -4.4904537	SH3224126590	Inside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the submerged structural remains.	Dependent on the height of the structure, it may become more difficult to locate without a GPS device if seagrass is growing close-by.
25	Abersoch	Fish trap	NPRN411062	2010	Submerged wall, possible fish trap	Definite	52.812279, -4.4909009	SH3221726768	Outside	Seagrasses can reduce wave energy[9]. This can reduce erosion of the fish trap.	The fish trap may become more difficult to locate without GPS device if seagrass is growing close-by.
26	Abersoch	Shipwreck	NPRN525277	1825	Remains of wooden ship. Exact location unknown.	Possible	52.811016, -4.4902351	SH3225726626	Inside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwrecks, reducing their visibility.
27	Traeth yr Ora	Shipwreck	NPRN240054	2001	Remains of ship. Exact location unknown.	Possible	53.377899, -4.2729954	SH4889889191	Outside	Seagrasses can reduce wave energy and stabilise the seafloor[8–11], and seagrass has previously been shown to protect shipwrecks from erosion[6].	As seagrass traps and accumulates sediment, this may increase sedimentation rates near the shipwrecks, reducing their visibility.

7. Bibliography

1. Orth, R. J. *et al.* A Global Crisis for Seagrass Ecosystems. *BioScience* **56**, 987 (2006).
2. Barbier, E. B. *et al.* The value of estuarine and coastal ecosystem services. *Ecological Monographs* **81**, 169–193 (2011).
3. Costanza, R. *et al.* Changes in the global value of ecosystem services. *Global Environmental Change* **26**, 152–158 (2014).
4. Green, A. E., Unsworth, R. K. F., Chadwick, M. A. & Jones, P. J. S. Historical Analysis Exposes Catastrophic Seagrass Loss for the United Kingdom. *Front. Plant Sci.* **12**, 629962 (2021).
5. Pournou, A. Assessing the Long-Term Efficacy of Geotextiles in Preserving Archaeological Wooden Shipwrecks in the Marine Environment. *J Mari Arch* **13**, 1–14 (2018).
6. Krause-Jensen, D., Serrano, O., Apostolaki, E. T., Gregory, D. J. & Duarte, C. M. Seagrass sedimentary deposits as security vaults and time capsules of the human past. *Ambio* **48**, 325–335 (2019).
7. Wright, J. Maritime Archaeology and Climate Change: An Invitation. *J Mari Arch* **11**, 255–270 (2016).
8. Fonseca, M. & Fisher, J. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. *Mar. Ecol. Prog. Ser.* **29**, 15–22 (1986).
9. Fonseca, M. S. & Cahalan, J. A. A preliminary evaluation of wave attenuation by four species of seagrass. *Estuarine, Coastal and Shelf Science* **35**, 565–576 (1992).
10. Christianen, M. J. A. *et al.* Low-Canopy Seagrass Beds Still Provide Important Coastal Protection Services. *PLoS ONE* **8**, e62413 (2013).
11. Duarte, C. M., Losada, I. J., Hendriks, I. E., Mazarrasa, I. & Marbà, N. The role of coastal plant communities for climate change mitigation and adaptation. *Nature Clim Change* **3**, 961–968 (2013).