Advanced Mooring Systems (AMS)

LIFE Recreation ReMEDIES: Lessons learned and good practice

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Working in Partnership with:

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1 Introduction

The LIFE Recreation ReMEDIES: 'Reducing and Mitigating Erosion and Disturbance Impacts affecting the Seabed' project (LIFE 18 NAT/UK/000039) ran from July 2019 - October 2024 with aims to improve the condition of seagrass beds and maerl in five Special Areas of Conservation (SACs) between Essex and Isles of Scilly. This was achieved by restoration, demonstrating suitable management options and reducing recreational pressures. Promoting awareness, communicating, and inspiring better care of sensitive seabed habitats was key. Natural England (lead partner) worked with the Marine Conservation Society, the Ocean Conservation Trust, Plymouth City Council/TECF and the Royal Yachting Association. The project is financially supported by LIFE, a financial instrument of the European Commission.

As part of the ReMEDIES project, trials of Advanced Mooring Systems (AMS) were installed as both boat moorings and as markers to reduce impacts to the seabed. This information note aims to summarise the lessons we have learned through ReMEDIES, as well as knowledge gathered from other organisations involved in similar trials and projects during this time. This note aims to be of use to anyone looking to install AMS or involved in future trials.

1.1 Traditional moorings

Traditional swing moorings are most commonly used in UK waters. The boat is secured to a single buoy and therefore swings in the wind or current. A mooring generally consists of an anchor (or sinker), chain (rode or riser) and float (mooring buoy). A mooring strop is a rope which attaches a boat to the mooring buoy. However, these types of mooring can result in abrasion to sensitive habitats such as seagrass beds. As the tide rises and falls, differing amounts of chain will lie across the seabed, and will be pulled around in a circle as the tide and wind direction changes. Abrasion from the chain causes damage to the surrounding habitat (Griffiths and others, 2017; Unsworth and others, 2017).

Photo: Damage to seagrass bed from swing mooring in Salcombe Harbour (Keith Hiscock)

As well as swing moorings, other mooring types include trot moorings where the boat is secured by two buoys at the stern and bow (chain risers can be attached to ground chains running along the seafloor), pile moorings where a post in the seabed is raised above the water so a boat can tie on or running moorings where boats are attached to fixed points on pulleys that are used to bring the boat closer to shore. Generally, these types of mooring cause less damage to the seabed as there is limited movement of the various components below the water.

1.2 Advanced Mooring Systems

Advanced Mooring Systems (AMS) are designed to reduce the interaction between the mooring and sensitive seabed habitats. There is growing evidence globally as well as in the UK of the reduction in impacts to seagrass habitat from switching to AMS (Solandt and Parry, 2023; Luff and others, 2019). This mainly involves keeping the riser off the sea floor, for example through using a stretchy or elastic riser or attaching floats to the existing chain. The use of a helical screw as an alternative to a traditional block means a smaller surface area of seabed habitat is damaged by the mooring system. Figure 1 shows two common options for AMS that are in use in the UK alongside the setup of a traditional mooring.

The term AMS has been developed to convey that they are not just better for the environment but can also be better for boaters and owners. Manufacturers of AMS with elastic risers report reduced loads on boat connections in harsh weather, reduced motion during normal conditions, less maintenance and greater longevity than traditional chain moorings, which typically need replacing every few years.

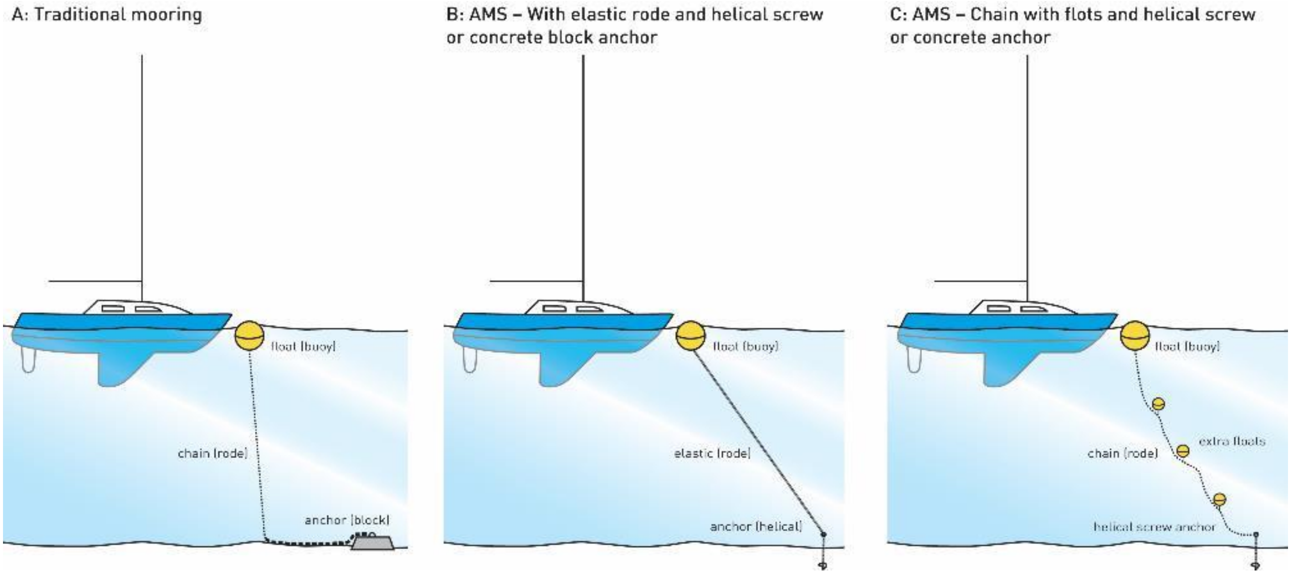

Figure 1: Traditional mooring and AMS (The Green Blue)

AMS are in use across the world but primarily in large numbers in America and Australia. In 2023 the ReMEDIES project commissioned a review of AMS technology and developed a global database of installations (Stainthorpe, 2023). The adoption of AMS in the UK has been slower largely due to historical concerns from stakeholders on their suitability for UK tidal environments as well as limited legislative options to drive forward market development and adaption (in comparison to requirements in the US and Australia for example). The Tevi (Cornish for 'grow') project carried out a very useful review of current experience of AMS in the UK to inform development of options and future AMS trials in Cornwall (Didcock and Goodwin, 2020). The ReMEDIES project aimed to address some of these evidence gaps and provide more information on use in UK environments through installations of AMS trials in Cawsand (Plymouth) and the Isle of Wight (see case studies).

The use of AMS designs to install markers (for example as navigation markers or to mark out Voluntary No Anchor Zones) can also reduce the impact of these types of installations on the seabed.

1.2.1 Designs and manufacturers

The below list is not exhaustive and comprises examples of designs currently in use in the UK. Natural England does not provide endorsement of these manufacturers but chose to work with certain suppliers as part of the ReMEDIES project based on previous UK experience, support and engagement for the project, and availability of staff to help with installation advice.

Further detailed information about the wide range of different designs available around the world and in the UK can be found here:

- LIFE Recreation ReMEDIES: Advanced Mooring Systems Information Pack for Harbour Authorities
- LIFE Recreation ReMEDIES Advanced Mooring Systems worldwide (NECR508)
- The decline of UK seagrass habitats and the importance of advanced mooring systems

Stretchy risers

Seaflex

Seaflex Moorings

Seaflex is an elastic mooring system that can be used with either mooring buoys or pontoons and is anchored using either deadweight or embedment anchors. The Seaflex mooring system consists of a reinforced homogenous rubber hawser (cable), built around a homogenous rubber core. A specially braided cord is wrapped around the core, and the outer layer consists of a durable rubber cover which forms the outer shell of the hawser.

Current installations: Cawsand (Plymouth), Strangford Lough, Porthdinllaen, Lundy

Photo: Seaflex mooring being demonstrated at the Green Tech Boat show by staff from The Green Blue, Natural England and Hampshire and Isle of Wight Wildlife Trust (RYA)

Blue Parameters based in the UK have worked with Seaflex and English Braids to develop a system called the Mermaid-K and are also developing a multiple point system for recreational vessels, which will allow increased mooring capacity in a reduced area. *Current examples of installations include the Channel Islands and the Solent.*

Hazelett

Hazelett Moorings

The system consists of galvanised hardware for attaching to a Helix anchor (recommended) or block anchor, hard trawl floats to keep the components afloat, one or more elastic rodes (the line between anchor and boat), a spar buoy, and a stainless steel swivel. The rodes are manufactured from an advanced polyurethane elastomer blend, with polyethylene thimbles (loop of reinforcement) pressed into the ends.

Photo: Hazelett mooring in Studland bay (Left image: Sara Parker (Dorset Council)/middle image: Studland Bay Marine Partnership/right image: Boatfolk)

Current installations: Studland Bay, Dorset.

Safemoor

[Safemoor Systems]

Mooring tether comprised of stretch controlling nylon and vulcanized rubber with aramid (aromatic polyamide - a class of synthetic, high-performance fiber) strengthening the centre core.

Current installations: Porthdinllaen

Photo: Safemoor system on the intertidal – as a demonstration, due to be moved to a subtidal location. A section of 'isolating rope' between shackle connections was used as an option to prevent any issues with dissimilar metals causing corrosion (Alison Hargrave, Pen Llŷn a'r Sarnau SAC).

Adding floats

'Stirling' type design

The Stirling design is an adaptation to traditional mooring configurations. It has been developed by the Ocean Conservation Trust in conjunction with Harbour Authorities on the South Coast of England and mooring service providers. The aim has been to create a cost-effective flexible mooring solution by suspending the lower portion of the riser using mid-water floats. Similar designs have been based on this system in other locations.

Current installations: Cawsand (Plymouth), Salcombe, Torbay, Strangford Lough, Falmouth, Yarmouth Harbour, Portland. Adaptation as markers for Cowes Harbour (Isle of Wight) and for Voluntary No Anchor Zones (with rope risers) in Falmouth, Durgan (Helford), Portland, Jennycliff bay, Osborne Bay (Isle of Wight) and Studland Bay.

Photo: Stirling AMS in Cawsand (Plymouth) showing the mid-water floats attached to the riser (Mark Parry, Ocean Conservation Trust).

Elastic risers

Adding mid-water floats to elastic risers may also be required to prevent mooring gear fouling the seabed, potentially an issue in areas with high tidal variation (see case study). The greatest challenge is where tidal range is greater than minimum water depth which can be common in UK coastal environments.

Seto and others (2024) following AMS installation monitoring in Massachusetts, found that AMS installed without subsurface buoys resulted in mooring gear dragging around the helical anchor and recommend the addition of mid-water floats in future installations to mitigate this.

Anchor blocks

Helical screw

During the ReMEDIES project, Natural England's preferred option was to use a helical anchor screw when replacing existing moorings as it offers the greatest reduction in impact on sensitive habitat due to the smallest surface area compared to a traditional concrete block. Helical anchors are screwed into the seabed using divers and specialist installation equipment.

Helical screws provide additional benefits in terms of being a fully engineered solution with known maximum load profiles compared to gravity base systems that are reliant on friction with the seabed to remain in place.

There are a number of helical screw providers in the UK. For the ReMEDIES project we sourced from ABC anchors. In Porthdinllaen, North Wales these have been sourced from a local manufacturer. Rowhedge Mooring Association in Essex have also reported using helical anchors made locally.

Always seek advice from professional mooring installers and the AMS manufacturer on the most suitable anchor type.

Where the use of helical screws was not feasible or appropriate (e.g. due to substrate depth), optimal size concrete or granite blocks were used as alternatives in the ReMEDIES project to keep the footprint to a minimum. Blocks of higher density (and therefore smaller size) have a lower footprint.

Photo: Screw anchors ready to install with Hazelett moorings in Studland bay (Studland Bay Marine Partnership)

Other anchor designs

There are examples globally of mooring blocks designed with eco-enhancements such as crevices and rough surfaces to aid colonisation and habitat creation. We are not aware of any trials of these in relation to AMS projects in the UK.

1.2.2 Intertidal/drying options

In intertidal habitats, there are fewer examples in the UK where traditional mooring systems have been replaced by AMS. This is due to the current lack of suitable designs available on the market for intertidal conditions. Deployment of a Safemoor system in Porthdinllaen in North Wales is one example of use in intertidal seagrass.

Simple replacement of mooring chains with rope can significantly reduce damage to sensitive benthic habitats such as seagrass (Unsworth and others, 2022). The suggestion being that due to the lighter weight and more buoyant nature of the rope relative to the chain, even if the rope does pull close to the seabed, it does not scour in the way that a chain does. The absence of links within the rope also minimises tearing as the mooring moves. This approach has been used in Porthdinllaen where rope moorings were already in frequent use with positive results. It is worth considering that rope is likely the most feasible option for smaller vessels during summer months in sheltered conditions (e.g. where moorings are removed for winter).

Photo: Rope mooring in North Wales at low tide (Gwenan Griffith)

Impacts from the boat itself interacting with the surface of the seabed may be another issue to consider on intertidal moorings as well as the potential damage from traditional chain moorings. However, anecdotal evidence from Porthdinllaen in North Wales suggests that this depends on the type of keel - with flat bottomed boats having minimal impact on the seagrass.

1.2.3 Mooring contractors

Professional mooring contractors are best placed to advise on the appropriate mooring and anchor block for the environmental conditions as well as maintenance requirements. The following contractors worked on installations for the ReMEDIES project and are examples that have experience of both supply and installation of Advanced Mooring Systems:

- Commercial Diving and Maritime Ltd – Cornwall -*installation and supply of Stirling moorings, installation of Seaflex and helical screw anchors.*
- Mylor Mooring Services - *installation of Stirling type AMS markers and moorings*
- BW Moorings - Isle of Wight – *installation of Stirling moorings*
- ABC Subsea - *installation of VNAZ and helical screws in the Isle of Wight*

2. How to choose the best design?

2.1 Environmental conditions

The following information is usually required by manufacturers to provide the correct system (for example, depth and tidal range will influence optimal riser length) and to confirm that their system will work in these conditions (and the warranty will be valid):

- Depth (including highest tidal range)
- Predominant wind direction
- Maximum wave heights
- Maximum wind speeds
- Current speeds
- Substrate type and depth (relevant to helical screws)

The above information can be sought from local harbour authorities or mooring contractors with knowledge of the area.

2.2 Helical screw vs block

Considerations for using helical screws:

- These are easy to install manually intertidally as demonstrated in Porthdinllaen by the National Trust where a strong pole that fits through the eye of the anchor was used to screw it into the seabed (Palmer Hargrave and Cullen-Unsworth, 2022). However for subtidal installations commercial divers and specialised installation equipment are usually required which can add to costs and safety requirements. See 'Helical Screw Pile Installation' video. Operating in poor visibility and stronger tides can also make installations more difficult and time consuming as experienced during installation of AMS markers in Cowes Harbour for the ReMEDIES project.
- Alternative options to the use of divers to install helical screws subtidally have been developed. The installation of helical screws for the Osborne Bay VNAZ in Spring 2024 was carried out using a portable subsea remotely operated rig, controlled and monitored from the surface (see case study).
- Annual inspection on subtidal moorings attached to helical screws requires divers (or cameras depending on visibility) as they cannot be hauled up.
- Helical screws are reported to have longer life spans (dependent on galvanisation and environmental conditions) and stronger holding power than traditional blocks.
- The seabed might not be suitable for using a helical screw (e.g., sufficient depth before bedrock) and in such situations the only alternative is a traditional block.
- In some instances, the existing mooring block will be embedded in the seabed, therefore removing it to replace with a helical screw may actually cause more of an impact than it is worth (e.g., creating a crater). Use of the existing mooring block with an AMS riser is then more appropriate.
- There is evidence that the retrieval and replacement of traditional type blocks for maintenance of the moorings can be an issue as this can cause damage as well as the actual block smothering the seagrass. So, depending on current practice with maintenance, replacing with helical screws would reduce the need to do this (as they do not need to be retrieved). Alternatively, accurate use of GPS points for replacement of retrieved block moorings can mitigate the impact on seagrass.

Photo: Helical screw anchor in place on boat mooring in Cawsand bay (Mark Parry, Ocean Conservation Trust (left image) and Natural England dive unit (right image))

If mooring blocks are required, these should be the optimum size to reduce the surface area on the seabed as much as possible. Concrete or granite blocks were used as alternatives in the ReMEDIES project as blocks of higher density have a lower footprint. Installing an AMS riser on an existing or new block, is still beneficial as it represents a reduction in impact to the seabed.

Environmental conditions and boat size will also be relevant to choosing the correct anchor. Advice should always be sought from a trusted mooring contractor.

2.3 Boat type

The length and weight of boat is required information by AMS manufacturers to ensure that the design is supplied to the correct and optimal specifications. **Note that the manufacturer warranty may become invalid if a boat is used that is above the maximum length and tonnage that the AMS was designed for.**

3. Consents and permissions

3.1 Marine licences (England)

For installation outside a harbour authority, the onus is on the applicant to satisfy themselves whether or not a marine licence is required using Do I need a marine licence? though general considerations include:

- any new mooring installation (which requires a deposit on or in the seabed) a marine licence is required from the Marine Management Organisation see Deposits
- replacement of an existing mooring rode system (mooring riser) with an Advanced Mooring rode system (mooring riser) to an existing anchor block or existing helical screw anchor can be applied for under self-service marine licence which may require a method statement and consultation with Natural England to ensure that the method used is considerate to any sensitive habitats or species in that area

The Marine Management Organisation has confirmed that marking out an area where seagrass restoration is taking place or a voluntary no-anchor zone can be classed as a 'point of interest'. Therefore, this is covered by the activities for which a self-service licence can be applied.

Statutory Harbour Authorities that install moorings and aids to navigation are exempt from marine licensing. The Statutory Harbour Authority is therefore the competent authority and is responsible for all environmental assessments required as set out by the relevant legislation, e.g., Habitats Regulations (2017), Marine and Coastal Access Act (2009) and Wildlife and Countryside Act (1981). Therefore, harbour authorities have a duty to ensure that there is no detrimental effect on a protected species or habitat.

3.2 Other consents (England)

Harbour authority approval is required for anyone not installing on their behalf. This includes agreement of any navigational or safety requirements such as lights. The Harbour authority will also need the necessary information to post a Local Notice to Mariners (LNTM).

See Other Consents for guidance on other potential consents. For example, all intrusive works on the seabed within 12 nautical miles of the coast are likely to require consent from the Crown Estate.

4. Installation

Considerations for installation based on experiences through the ReMEDIES project and others.

4.1 Assembly instructions

Seek advice from the manufacturer directly to ensure AMS are assembled correctly (they may be delivered in component parts) and ensure mooring contractors also have that direct support from manufacturers. From a Natural England perspective, it was found to be easier to request mooring contractors – as they have the knowledge of what is required - to purchase all components directly from manufacturers rather than try to purchase separately.

4.2 Top buoys

Consider use of pick-up lines for visitor moorings for ease of use. These are in place for the AMS visitor moorings following user feedback in Studland Bay. More information can is available from the Studland Bay Marine Partnership. Through chain top marks have been used on individual moorings in Cawsand as part of the ReMEDIES project to minimise the need for mooring users to add any additional lines which could cause instability.

Photo: Using a pickup line on a Hazelett mooring in Studland bay (Sara Parker- Dorset Council)

4.3 Shackles

Ensure correct shackles (e.g., between helical anchor connection and riser) are used to avoid issues with dissimilar metals causing corrosion. A section of ‘isolating rope’ between shackle connections could be used as an option if this is an issue (Palmer Hargrave and Cullen-Unsworth, 2022).

4.4 Helical screws

If installing sub-tidally, professional mooring contractors with HSE qualified divers and specialist installation equipment are usually required. The availability of mooring contractors with experience of installing subtidal helical screws is currently limited. However, as noted above, the installation of helical screws for the Osborne Bay VNAZ in Spring 2024 was carried out using a portable subsea remotely operated rig, controlled and monitored from the surface (see case study).

5. Maintenance

Considerations for installation based on experiences through the ReMEDIES project and others.

5.1 Inspections

Annual maintenance checks by a qualified mooring contractor are recommended as standard practice. Where moorings are installed on helical screws maintenance inspections will require divers (as they cannot be readily hauled and replaced by barge) if they are not removed for the season and inspected on land. An alternative is the use of a drop-down camera or similar if visibility allows.

5.2 Removal and replacement

Where whole moorings are removed and replaced at the end and start of the season, accurate GPS points can be used to ensure they are replaced in the exact same footprint therefore reducing any additional impact to the seabed. This is the approach that is in place in a number of locations including Studland Bay where the helical screws remain in place but the risers are removed during the winter for maintenance and to reduce visual impact out of season.

5.3 Longevity of components

As with traditional moorings, steel chain components usually have a longevity of around 3 years and then require replacement. Warranty and lifespan of other types of AMS e.g. with elasticated risers, will vary depending on manufacturer and will depend also on the environmental conditions in which it is being used. For example, Hazelett recommend yearly inspections and replacement at 10 years under normal working conditions.

5.4 Modifications

A lesson we learnt from the ReMEDIES project is to engage with the manufacturer as early as possible if there are any issues found with the mooring so that adjustments can be made). There is often a simple solution that can be easily rectified and provides valuable experience and learning for other trials. One example is the installation of Stirling type markers in Cawsand which were installed as swim markers in the bay. These are rope risers with mid-water floats on mainly helical screws. Initially the top float markers were too buoyant, this is due to the mid-water floats taking some of the weight off the riser which would otherwise act to pull down the buoy. A simple solution was to add some chain underneath to weigh down the buoys and ensure they stood upright above the water at low tide.

Another example of lessons learned during early installation is from a project in Strangford Lough, Northern Ireland where during the first year of Stirling AMS boat mooring trials, 5 of the float attachments failed leading to the chain dragging along the seabed. Failure was due to the deterioration of the rope ties attaching the net float buoys to both ground and rising chain. These ties were then replaced with 8mm galvanised wire attached to the chains with shackles.

Photo: Rope ties, and then replacement galvanise wire on Stirling type moorings in Strangford Lough (Dr Rachel Millar & Dr David Smyth (on behalf of Cuan Marine Services))

Similar experience has been highlighted from the US and Australia (Seto and others, 2024) who found that adjustments may be required for local environmental conditions following installation. This highlights the importance of monitoring the mooring and the value of contractors with local knowledge who can advise on potential modifications to account for site specific environmental conditions.

5.5 Biofouling

Anecdotal evidence from the ReMEDIES project team as well as those involved in trials in the Fal and Helford has highlighted the additional level of biofouling apparent on both Seaflex and Stirling type mooring systems. It is suggested that the extra equipment within the water column compared to a traditional chain mooring provides a greater surface area for fouling. One AMS owner in Cawsand reported that the midwater buoys attract significant weed – expressing concerns that this will add to the current drag and that maintenance costs may be higher to remove. There is also the potential risk of colonisation by marine invasive non-native species. Natural England divers surveying Seaflex moorings in Cawsand in 2022 noted species such as Wakame (*Undaria pinnatifida),* a type of invasive seaweed which often rapidly colonises new artificial structures.

Photo: Fouling on Seaflex mooring in Cawsand, Plymouth (NE dive unit, 2021)

6. Insurance

Generally accepted best practice for boat owners is to ensure they have appropriate insurance for their vessel (appropriate insurance is a common requirement by harbour authorities for the use vessels within the limits of their jurisdiction).

The focus from an insurance perspective is the potential liability should a mooring fail and the moored boat suffers damage or damages other craft.

Policies usually carry a standard condition requiring the policyholder to carry out inspections annually – insurers have more confidence in the systems if they are being effectively maintained.

Enquiries by the RYA, a project partner on ReMEDIES, confirmed that as long as moorings are inspected annually, insurance would be the same for an AMS as a traditional mooring.

This is supported by the experience of participants in the ReMEDIES project. For example, Yarmouth Harbour Authority informed the insurance company of the trials of AMS moorings and the company confirmed that the moorings are covered in the same way as any other mooring and at no extra cost.

The opinion of consultees to a study on the potential for eco-moorings as management options for Marine Protected Areas was that an AMS installed by a well-trusted harbour authority may continue to be covered under the existing insurance policy and at the same price though this would be a "material change" that would have to be agreed with the insurance company in each case.

Note: Any faults due to the actual mooring itself should be covered under manufacturer warranty and any fault due to installation covered by the relevant mooring contractor.

7. Monitoring effectiveness

7.1 Performance

7.1.1 Modelling performance

Numerical modelling can be undertaken with appropriate software used for the design and analysis of moorings. This allows hypothetical assessment of performance of different types of AMS relating to vessel response characteristics and behaviour of the AMS under different environmental conditions.

Morek Engineering Ltd has recently carried out desktop studies to model the performance of different Advanced Mooring Systems:

- Seagrass Protection and Advanced Moorings: Modelling of Advanced Mooring Systems in Cornish Harbours (2021)
- LIFE Recreation ReMEDIES Advanced Mooring Systems Modelling: Project Summary Report (2022)

The outputs of these desk-based studies help to provide evidence on the hypothetical performance of AMS under different conditions and can support design choices prior to field trials.

Morek Engineering Ltd also used software designed to model the mooring design prior to installation of the Falmouth Harbour AMS trial in 2022. The aim was to optimise the AMS to perform as well as, or better than the existing traditional block and chain moorings currently in use: Falmouth Harbour Advanced Mooring Systems

7.1.2 Field testing

Factors that may be useful to consider in monitoring performance of an AMS during trials in the field include:

- Stability and swing mooring radius
- Dynamics and flexibility to water level variation
- Ability to withstand exposure to site-specific environmental conditions
- Damping effect to mitigate peak loads at attachment points
- Corrosion resistance
- Anchor design with enough holding power to withstand site-specific load (i.e. vessel size, frequency of use etc).

As part of the ReMEDIES project we didn't have the opportunity to carry out any practical in field performance tests on the AMS installations. However, as an example, Falmouth Harbour conducted an AMS trial in 2022 which included some in field performance tests using pull tests and load cells to monitor cleat tension and excursion (distance from anchor block to vessel): Falmouth Harbour Advanced Mooring Systems

Another example is a pull test demonstration that was undertaken in New South Wales, Australia to compare the performance of block and chain moorings with two types of AMS. Each mooring was pulled on by a tug with a load cell inserted in line to measure and compare the forces experienced by each mooring. A video is available of this pull test.

7.1.3 Feedback from mooring users

For the ReMEDIES project, a series of questions were developed in order to seek information from both individuals and harbour authorities on how they were finding the use of their AMS in comparison to experience of traditional mooring systems. Feedback that is useful to gather includes:

- Installation challenges
- Frequency of mooring use/weather conditions
- Does the boat act differently on the AMS compared to traditional mooring?
- Does the boat swing more on the AMS?

- Is there any difference in the snatch load[1] on the AMS compared to traditional mooring?
- Has there been any difference or challenges with maintenance requirements and costs?
- Have any modifications been required?
- Overall satisfaction with the performance of the mooring and recommendations to others

More widely, there have been a number of studies investigating the perceptions and attitudes towards the use of AMS including interviews held by the Marine Conservation Society on the use of AMS in Cawsand (Marine Conservation Society, 2024) and a study by Parry-Wilson and others (2019) in Torbay which involved providing questionnaires to boaters to explore social perceptions on the trial of an AMS.

Monitoring in the field and getting feedback from users, especially during the early stages of installation, can be invaluable in ensuring any immediate issues can be resolved and modifications carried out if required (see case studies). Evidence on performance and potential issues can also be helpful to inform future alternative design options. For example, following AMS trials in Falmouth, an issue was identified by the harbour authority that in this location, due to the high levels of boating activity and density of moorings, there may be potential navigational hazards at different tidal states when mid-water floats are just below the surface. Optimising the design of the 'Stirling type' mooring to ensure that this doesn't happen is a priority for future trials. Falmouth Harbour Advanced Mooring Systems provides more information.

7.2 Ecological success

In order to demonstrate the benefits and justify the replacement of traditional moorings with AMS, it is important to build our evidence base that this is a management option that does result in seagrass recovery and improved condition of the habitat.

Evidence from previous studies in Cawsand (Solandt and Parry, 2023) and further afield in Massachusetts (Seto and others 2024) highlight the need for long term surveys (~5years) as seagrass regrowth around mooring scars can take a while to show signs of significant recovery. This can be due to a number of reasons including the damage to the root and rhizome systems inhibiting recovery, natural variability in growing seasons and other limiting factors such as issues with water quality or ongoing anchoring impacts.

Ideally, surveys should be carried out at the same time of year so that datasets over the years are comparable and seasonality doesn't impact on the results. In addition,

[1] When the mooring spring is extended to its maximum extension.

monitoring a traditional mooring at the same location simultaneously could provide a useful comparison to the results from the AMS surveys.

7.2.1 Methodology

During the ReMEDIES project the University of Plymouth and Natural England dive teams monitored the growth of seagrass around the AMS in Cawsand and the Solent. The methodology replicated previous studies in the area (Solandt and Parry, 2023 & Bunker and Green, 2019) in order to have a consistent approach and comparable data sets.

Divers enter the water in pairs, using the fixed mooring line and reel off the base of the mooring using a tape measure to 9m. Quadrat sampling at set distance intervals (9m, 5m, 0.5m) is carried out along each of four bearings (north, south, east and west) (see figure 2). A 0.25m2 quadrat is placed on the righ (or in some surveys on both sides) of the tape measure looking back towards the mooring line and the following measurements are taken:

1. Photograph of the quadrat
2. Number of individual plants counted within the quadrat
3. Percentage cover of seagrass
4. Percentage cover of algae
5. Canopy height (greatest length)
6. Estimate of sediment classification.

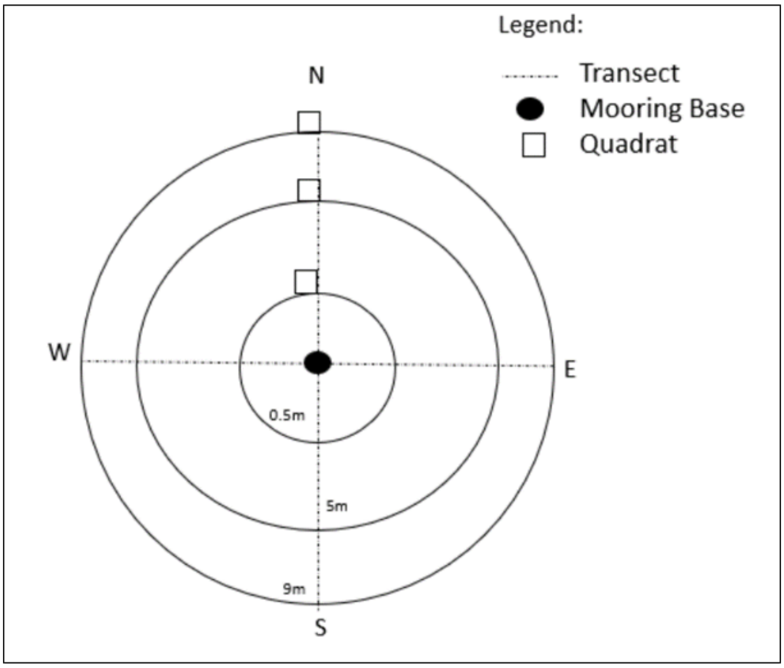

Figure 2: Diagram illustrating dive survey methodology around the central mooring point (Natural England)

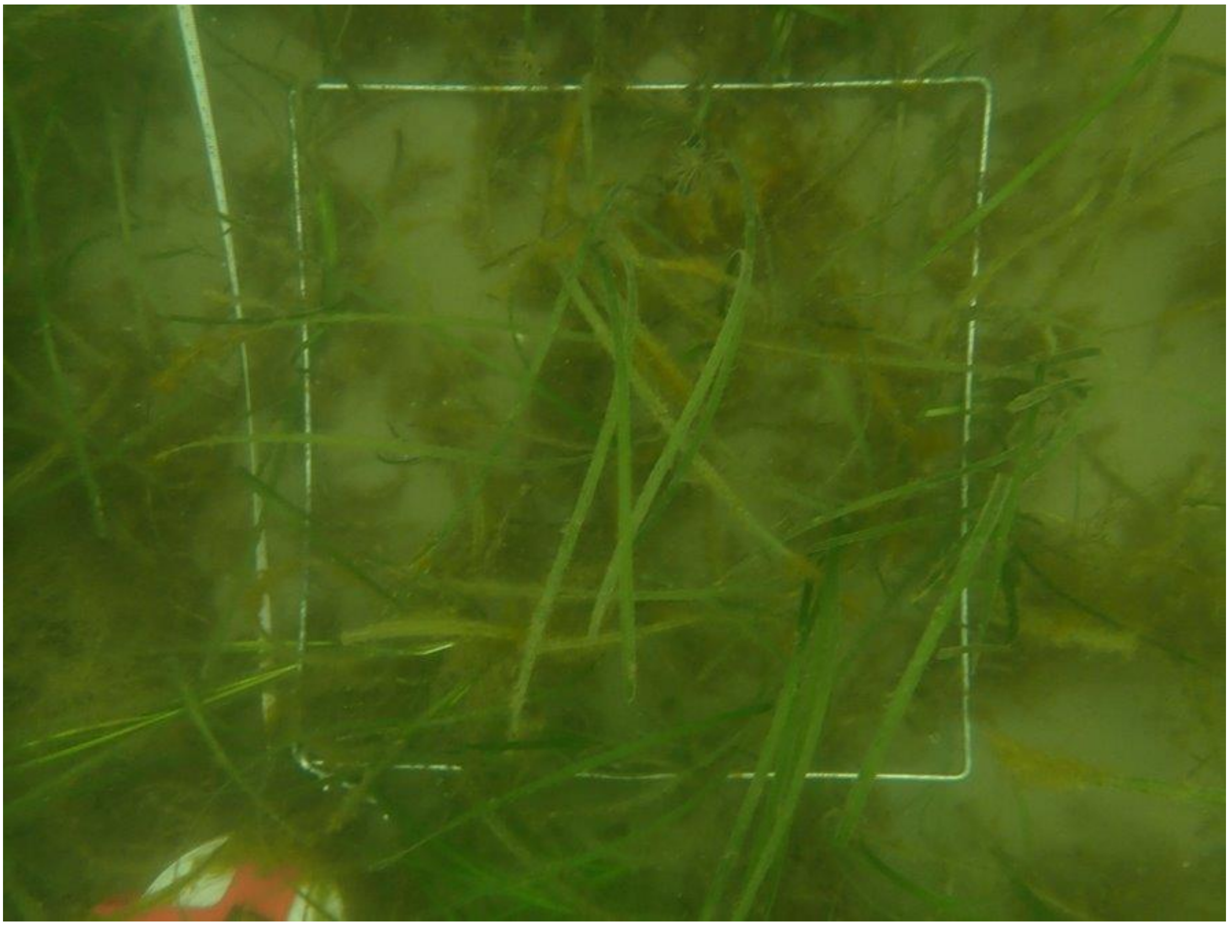

Photo: Recording seagrass measurements in 0.25m2 quadrat (Natural England dive team)

Mooring scar area was not a measurement recorded during the ReMEDIES surveys for a number of reasons including the natural patchiness of seagrass beds in the survey sites making it tricky to determine where the scour area begins and ends. However, these measurements have been taken in other studies successfully as a way in which to monitor scar recovery and therefore reduction in impact and recovery of habitat (Seto and others, 2024).

Alternative options

Dive surveys can be expensive and time consuming – other options could be use of drop-down video cameras or Remotely Operated Vehicles which can provide a snapshot of the seabed around the mooring in good visibility. For example, Unsworth and others (2017) used a camera frame containing a GoPro Hero 4 mounted above a 0.25m2 quadrat which was lowered by hand into the seagrass (at low tide) every 2 m along 20 m transects rotated around a central point (mooring). Again, the transect was measured away from each mooring four times, in the N, S, E, and W directions. Snorkel surveys could also be a more efficient and cost-effective option depending on visibility and depth of moorings.

8. Recommendations

General recommendations for authorities to consider in order to further progress the use of AMS in the future as a management option for mitigating impacts to sensitive seabed habitats:

1. Prioritise installation of AMS to replace existing traditional moorings in sensitive seabed habitats to mitigate anchoring and mooring impacts.
2. Continued monitoring of the performance, maintenance and effectiveness of AMS systems in the UK over longer time scales, both for the installations funded by the ReMEDIES project and from wider trials and projects, in order to build the evidence base and help future mooring owners and managers make informed decisions about mooring options.
3. Development of future technical guidance on the different mooring designs suitable for different conditions and use scenarios based on the collective experience of UK trials.
4. Ensure in-water monitoring, post-installation adjustments and capturing knowledge of installers to account for site specific environmental conditions is forefront in the development of future trials to ensure success.

Recommendations for individuals or local organisations looking to install AMS:

- Speak to manufacturers and mooring contractors directly for advice and suitability of systems currently available on the market.
- Monitor your mooring post installation – minor adjustments may have to be made to account for local conditions, seek advice from manufacturer and mooring contractors as early as possible to rectify.
- Use experienced installers
- Inform insurers about any changes to mooring types so coverage is confirmed.
- Speak to other people who own or use AMS to get top tips and advice.
- Seek support from a local university or similar to help monitor seagrass beds around installations – building evidence of effectiveness at reducing impacts of traditional moorings.
- If you have installed a visitor AMS please contact the RYA so that this information can be provided on their environmental facilities map.
- Consider the information provided on an AMS – QR codes are useful to provide more information on the benefits of protecting sensitive habitats or to direct for further information. Seto and others (2024) suggest that increasing the visibility of the mooring as an environmentally friendly option could increase take up and use through promoting peer influence.

Photo: QR code use and payment information on Studland Bay AMS (Studland Bay Marine Partnership)

- Some top buoys can have logos or information embedded as part of the design and manufacturing process. However, others may be more difficult to attach information to. Consider the quality, long term effectiveness and maintenance of stickers on either buoys or top plates in terms of reducing risk of degradation into the environment.

Sharing best practice – organisations currently involved in trialling and installing AMS in the UK:

- Falmouth Harbour Commissioners
- Studland Bay Marine Partnership
- Cowes Harbour Commission
- Ocean Conservation Trust
- Project Seagrass
- Porthdinllaen Seagrass Project
- Strangford Lough and Lecale AONB

9. Case studies

9.1 Cawsand, Plymouth

Photo: AMS in Cawsand Bay, Plymouth (Muriel Plaster, Natural England)

Background

In 2017, the Ocean Conservation Trust worked with the local Rame Head boat club to identify volunteers to take part in a trial of AMS on their private moorings. Successful engagement with relevant stakeholders led to the installation of 5 Stirling moorings on helical screws in 2019 (Solandt and Parry, 2023). The success of this trial and feedback from mooring owners provided a valuable starting point for the support of further AMS installations in the bay.

Moorings are usually used in the summer months (April to October) as boats are usually taken out of the water during the winter.

This case study highlights: a) the importance of continual checking in with mooring users, b) the importance of working closely with mooring contractors and manufacturers to find quick solutions and c) carrying out modifications in order to maintain user confidence.

ReMEDIES installations

Building on the success of previous work, the approach taken by the ReMEDIES project was to provide information to volunteers (boat owners and harbour authorities) about AMS and the different systems available to make the decision on which they would like to use, therefore hopefully instilling greater confidence and buy in to being part of the trials. In total, 14 AMS as private boat moorings were installed in Cawsand during the ReMEDIES project (11 Stirling and 3 Seaflex).

Seaflex

Installation process

2 Seaflex moorings were installed on helical screws in 2021. Unsuccessful piling attempts (due to seabed depth limitations) for the other 2 moorings meant that a concrete block anchor was required as an alternative and a further Seaflex mooring was installed in 2022. Due to delays in commissioning the moorings the 4th volunteer withdrew from the project. Feedback from the installer to the ReMEDIES project manager at time of installation highlighted the need for clear manufacturer instructions and engagement as assembly was more complex than expected.

Modifications

During a Natural England dive survey in 2022, it was noted that the top buoy of one of the Seaflex moorings was submerged due to rope entanglement at the bottom of the mooring. The rope length between the anchor point and the bottom of the Seaflex riser is particularly long in the Cawsand installations, designed as such in order to cope with the high tidal variation found in the bay. It is assumed that this entanglement may have occurred at a particularly low tide when the rope in the water would have been unusually slack. The rope was untangled during the dive to resolve the immediate issue of the submerged top buoy. We then worked closely with Seaflex engineers to determine the best course of action, and it was recommended to add additional mid-water floats to avoid entanglement issues on any future installations. The 3rd Seaflex installed in Cawsand, has an additional 4 mid-water floats and the other 2 Seaflex have been monitored to determine whether this issue occurs again.

Similar recommendations were made by Seto and others (2024) following AMS installation monitoring in Massachusetts, where evidence showed that AMS installed without subsurface buoys resulted in mooring gear dragging around the helical anchor.

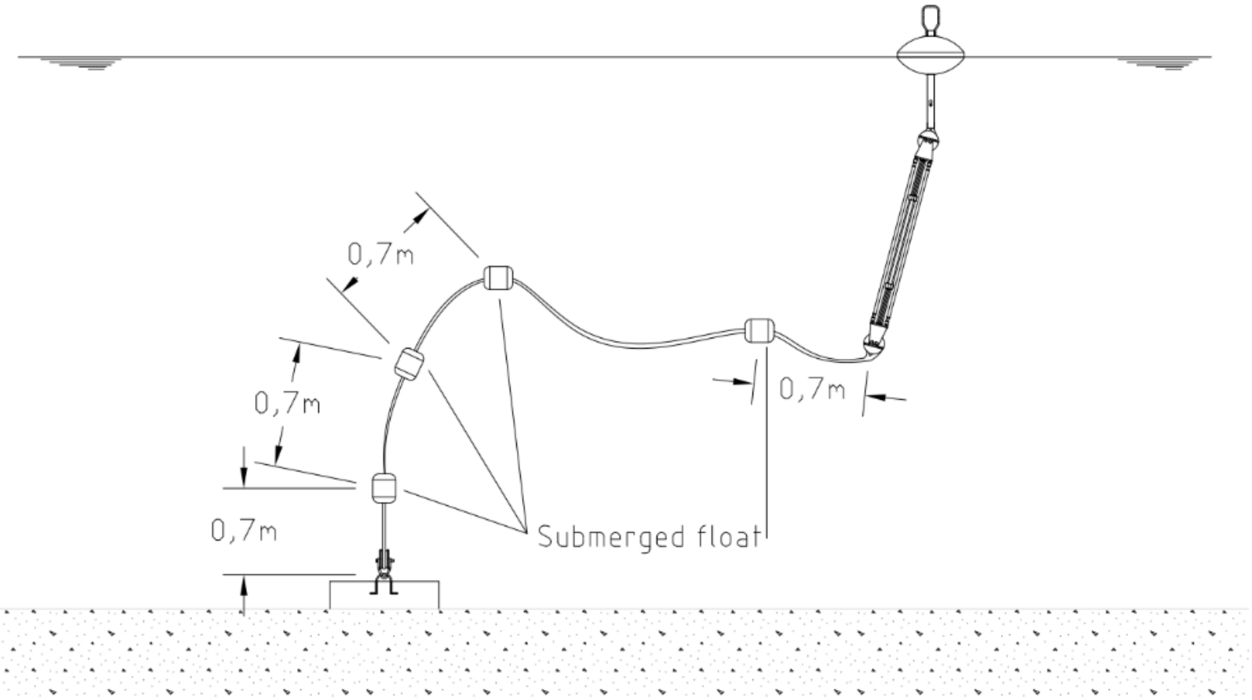

Figure 3: Example of potential configuration of additional mid water floats as an adaptation for locations with particularly high tidal variations (Seaflex)

Furthermore, in 2023 a new owner took on the use of one of the Seaflex moorings and reported that the top buoy was causing issues scratching the boat hull. The Seaflex top buoy that was originally purchased is designed with a spar attached for ease of pick up. In discussion with Seaflex and the mooring contractor for advice, an alternative option will be provided. However, another Seaflex user has fed back that this type of top buoy with the spar actually works very well for their boat, so it really does depend on user preference and the type of boat.

Photo: A Seaflex mooring in Cawsand Bay, Plymouth (NE dive team)

Feedback

Users of the 2 Seaflex without the additional mid-water floats have either reported that they have had no entanglement issues or where it has entangled this has just been a couple of times and they have been able to pull it free. A potential issue flagged is the appearance of the first mid-water float, particularly at low water and needing to avoid this for navigation. In addition, the level of biofouling was highlighted but the user did express this as a benefit for marine life rather than being an issue. Generally users are happy with the mooring performance but gathering longer term feedback on use over time would be really beneficial.

Stirling

Modifications

Some mooring users experienced entanglement or snagging issues with the painter (rope attached to the bow and used for tying up to the mooring) and the mid-water floats on the mooring riser. This has been resolved in most cases by users just using a shorter length of rope. However, one user did request to withdraw from the trial due to this issue and the mid-water floats were removed effectively converting the AMS back to a traditional mooring.

A further potential risk was identified from mooring users adding additional lines to the top buoys (originally net buoys) of the AMS which could hinder the performance of the mooring. This has been resolved by converting all the top buoys into through chain buoys with the fixing point for the vessels boat rope above the water which eases pick up.

Feedback

Detailed feedback from interviews and workshops on the AMS installations in Cawsand was carried out by the Marine Conservation Society in 2023:

- Social Science Report
- Workshop Report

Key feedback included:

- Overall AMS are perceived positively by participants in Cawsand - AMS had proven successful overall in terms of community acceptance and user experience.
- Potential risks with the different way in which the boat behaves on the mooring due to the mid-water floats taking the weight off the chain. There is less damping action than that provided by a mooring which has one long catenary chain to keep the boat steady.
- Potential hazard of the floating buoys and chain at the surface at low tide and potential ongoing risk of entanglement with pick up lines etc.
- Greater infrastructure under the water compared to traditional moorings, causing issues with significant biofouling which could result in increased drag and higher maintenance costs.
- Concerns about the use and potential risk of loss of more plastic floats into the environment when we are trying to reduce plastic waste.

9.2 Yarmouth Harbour, Isle of Wight

Photo: Stirling AMS on a trot mooring at Yarmouth Harbour (Caitlin Napleton, Natural England)

The below case study highlights the need and value for hands on installation support, especially with unfamiliar designs and technology as well as ongoing engagement and flagging any issues early with the manufacturer.

Seaflex

A Seaflex mooring was installed as a trial in 2020 on a trot mooring in Yarmouth Harbour. However, in 2021 this was removed by the harbour authority. There were no specific incidents and it was in use with a boat attached during challenging winter conditions with no issues on performance or safety. However, there were a number of issues both with installation and ongoing maintenance which reduced confidence in the AMS by the harbour authority staff.

Key lessons learned:

- During installation there was no in person support available on site – although discussions were had with manufacturer support remotely and installation guides provided, a more hands on approach would have improved confidence in the installation process.

- There were potentially issues with installation and ongoing maintenance that reduced the confidence of the harbour authority in the mooring – the lack of the ability to check for chafing of the rope was reported.
- Lack of communication as a result of remote working (and later covid) prevented any issues being resolved at installation stage and later before the decision was made to remove the mooring from the water.
- Installing Seaflex on a trot mooring with the chain as the anchor is not a standard solution for Seaflex mooring which are designed as swing moorings.
- Due to unfamiliarity with the system, the harbour authority had concerns about ability to withhold in large tidal height and strength in the area compared to use in more sheltered bays.

Photo: Seaflex destined for use in Essex instead (Jules Agate, Natural England)

Stirling

Following positive experience of using a Stirling mooring installed in 2020, a further 3 Stirling moorings were installed on the trot mooring in 2021. One issue that was reported was the shackles originally used deteriorated much quicker than expected, particularly the smaller shackles that attached the floats along the chain riser. An alternative high carbon material for the shackle was recommended and some chain/shackles were replaced as part of the maintenance of the moorings in 2024. In addition, in some very specific conditions at slack tide and certain winds, the boats on this line of AMS on the trot mooring have been bumping together. This has been an infrequent occurrence, but the recommended solution has been to provide further space between the moorings.

Generally, the confidence in this type of mooring was greater due to the familiarity of materials and design to a traditional type mooring. Installation was simple and in addition, support from the manufacturer was provided in person at time of installation.

9.3 AMS as markers, Osborne Bay (Isle of Wight)

Following ReMEDIES recreational activity surveys, Osborne Bay was identified as an area of above average boating pressure in comparison with other areas causing potential damage to the seagrass bed. A Voluntary No Anchor Zone (VNAZ) was determined as the best management intervention to propose and in consultation with the local community and sailing clubs, it was decided that 8 VNAZ markers would be used to mark out the area of the seagrass bed.

There were four existing moorings installed in Osborne Bay used to mark a ‘Swimming area’. The moorings comprised a steel clump weight and a standard chain catenary and therefore did not protect the seagrass beds. The ReMEDIES project therefore needed to retrieve and remove these and replace them with 8 AMS which comprised a 2m long helical screw pile with integrated swivel attachment and a chain riser which uses floats to give it neutral buoyancy. The top buoys from the original four moorings were re-used as part of this installation.

In order to install these markers, a Mooring Installation Tool that could be deployed from a barge without the need for divers was developed by specialist contractors, ABC Subsea consortium. A key advantage of not using divers is the ability to install in strong currents, improved efficiency and safer operations. Each installation is under an hour (including time to move the pontoon to each location) – once the installation tool is on the seabed it takes about 2 minutes to install.

Overall, the installation went smoothly and the effectiveness of the VNAZ markings will continue to be monitored. This was the first trial of the Mooring Installation Tool by ABC Subsea Consortium, hopefully it will lead to further installation and mooring innovation.

Photo: Mooring installation tool (ABC Subsea consortium)

Photo: VNAZ marker in the water (ABC Subsea consortium)

Lessons learned

The markers for Osborne Bay were not installed on behalf of a harbour authority within their jurisdiction (unlike other moorings in the area) and as a result the consenting process was a bit longer. Requirements involved harbour authority approval, Natural England method approval, an MMO self-service licence and a legal agreement with The Crown Estate.

The main lesson learned from this process was that it took more time to secure all the consents than expected. So, understanding exactly what consents and licences are required at the beginning of a project and ensuring adequate time before the installation is planned is a key recommendation. A lot of the same information is required for different approvals so consolidating this will save time and allow a smoother consenting process.

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