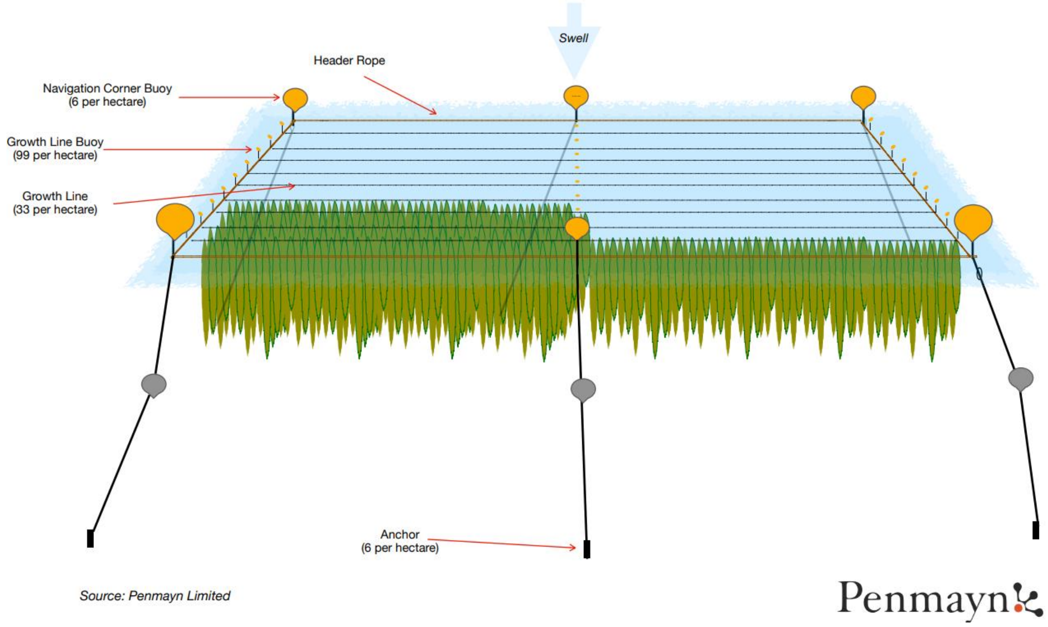
Third Party Verification
For
Save Port Isaac Bay Group

Penmayn Limited
Seaweed Farm Design



This is to certify that we the undersigned, for and on behalf of AquaMoor Limited, did at the request of Save Port Isaac Bay Group (SPIBG), complete a review of the farm structure and moorings design and associated documentation for Penmayn Seaweed Farm, North Cornwall and report as Third Party Verification on the fitness for purpose of Penmayn Seaweed Farm structure and moorings.

Date: 10th June 2024
Our Ref: 2024-10-SPIB
Issue: 1.0

Issue Control
1.0 First Issue

Contents

1 Introduction

Save Port Isaac Bay Group (SPIBG) is a community group established in 2024 to challenge the process followed in the determination of marine license application MLA_2022_00180.

Penmayn Limited is a company registered in England at 48 Arwenack Street, Falmouth, Cornwall, United Kingdom, TR11 3JH. The company has been awarded a marine license to install MLA_2022_00180

[figure]

The proposed development's deployment location and mooring configuration for a large scale farm to be installed in the Port Isaac Bay site at the north coast of Cornwall.

The device consists of a sub-surface, suspended rope structure with buoyant nodes which maintain the cultivation structure a small distance below the water surface. The whole assembly is moored to the seabed. As waves pass through the structure, the various members and nodes will move in the passing waves causing relative movement between the nodes.

The device is to be installed in the summer of 2024 [?]. It is the role of AquaMoor Limited to undertake this third party verification.

2 Verification Process

Ordinarily, the verification process we undertake comprises three stages of work - Assessing that the input values used in the modelling and that calculations are reasonable; Checking that the calculations follow a recognized, standard methodology; Review of the results to check fitness for purpose and compliance with rule requirements; and a review of the subsequent design that incorporates suitably specified and dimensioned components.

In this piece of work, where the input data, calculations, predictive modelling, specification and dimensions are absent, some commentary is provided on expected best practice drawn from experience and industry norms.

We have not conducted a physical survey of the mooring assembly and components to verify that they relate to the components in the design report. Insufficient information is available to do this.

We have not run any calculations, or undertaken our own independent design process, and Penmayn Limited remain entirely responsible for their design and the results of the design calculations they have made. Ordinarily, this report would review the estimated and predicted loads, and utilizing our experience would compare with similar designs, and loads of comparable mooring systems for structures in the aquaculture sector.

3 Scope of work.

The scope of work as agreed with SPIBG is as follows:

- Verification of hydrodynamic and environmental data inputs
- Verification of calculation methods for forces, loads & factors of safety
- Check calculation outputs
- Review mooring design for the Penmayn Farm
- Review mooring specification & dimensioning for the Penmayn Farm
- Review assembly & installation considerations
- Report on fitness for purpose of the Penmayn Farm structure and moorings and regulatory compliance

4 Reports & Documents

The verification process relies on a review of the design work undertaken by Penmayn and as appropriate, reference to documents from other sources. This is contained within a number of reports and documents supplied to, or sourced by AquaMoor as follows:

4.1 Penmayn Documents

Licence Schedule 2_ Penmayn Farm Structure for MMO

WaveReport2014_PtI

Penmayn Ltd - Navigational Risk Assessment and Emergency Response Plan

Penmayn Screw Brief

No documents have been identified as containing engineering analysis of the design.

4.2 Reference Documents

Farm Design for Coastal & Offshore seaweed cultivation in Europe, L. Stove, Seagriculture 2020

BS 6349-1-1:2013 General. Code of practice for planning and design for operations

Scottish Technical Standard for Fin-fish Aquaculture

ISO 16488:2015 Marine finfish farms. Open net cage. Design and operation.

NS 9415:2021 Floating aquaculture farms – Site survey, design, execution and use

DNVGL-OS-E301 Position mooring

DNVGL-RP-C205 Environmental conditions and environmental loads

TonyButt_Letter

Dr Hawcroft Wave Report

2017 Regulatory expectations on mooring devices from HSE and MCA

EN 1990 Eurocode: Basis of structural design

EN 1993 Eurocode 3: Design of steel structures

ISO 12944 Protective paint systems

ISO 12473 General principles of cathodic protection in seawater

EN 1999 Eurocode 9: Design of aluminium structures

EN 1992 Eurocode 2: Design of concrete structures

ISO 19903 Concrete offshore structures

EN 12201 PE Pipes

ISO 527 Plastics - Determination of tensile properties

EN 13121 Glass fibre reinforced plastic

EN 16245 Glass fibre reinforced plastic

ISO 15607 Welding metals

NS 416 Plastic welding

NS 470 Welded steel structures

EN 10204 Metallic products - Types of inspection documents

5 Verification of Penmayn hydrodynamic and environmental data

AquaMoor's Standard Operating Procedure is to employ DSProteus hydrodynamic software in order to simulate reasonable forces and loads acting on the mooring system. This is an industry standard software package with a track record of use to support offshore industry, in particular aquaculture, modelling interconnected floating and submersed bodies, and reporting on the forces and moments acting on and between the bodies resulting from wave and current forces and other applied loadings.

The environmental inputs for any hydrodynamic modeling of flexible aquaculture structures are below:

1. **Wave** data. Significant wave height, wave steepness, wave period and wave direction should all been input into the simulation. Only data from Port Isaac itself was provided in the application. This is not deemed to be suitable as it is from a very sheltered location in a port
2. **Wind** data should be utilised from historical records of the nearest available meterological station.
3. **Current** data should be input from surveyed measurements at the farm site. This should be collected using and ADCP (Acoustic Doppler Current Profiler) over a period of at least 60 days and incorporating one of the equinoxes.
4. **Bathymetric** inputs are normally sourced using Navionics Sonar Charting software, and are confirmed by an additional independent detailed site bathymetry survey.

There is no Hydrodynamic Modelling and Analysis in the application by Penmayn so it does not follow accepted industry practice. It cannot therefore be specifically reviewed.

From AquaMoor's knowledge and experience of marine environmental conditions in the region, the environmental inputs provided by Penmayn are not within expected parameters so should not be deemed to be reasonable.

6 Verification of criteria and calculation methods for forces, loads & factors of safety

Ordinarily it is not the scope of work to repeat the process of the modelling calculations but to review the methods and procedures chosen to evidence these have been followed and to check the accuracy of the calculations. In this case no modelling has been done nor any engineering calculations.

The following criteria should normally be applied to the design process.

General requirements for design:

6.1 Limit states definitions

The application contains none.

"Limit state" refers to a level of severity or a condition beyond which a structure or component is no longer designed to fulfill its intended function. Limit states are used to ensure that a structure or component is designed and built to be safe and fit for its intended purpose. Limit state design is used in the referenced codes.

Ultimate limit state (ULS):

The ultimate limit state is the maximum load or stress that the structure can withstand before it potentially fails. This limit state is also known as the "failure limit state." The most severe ULS cases are considered to be the most severe waves, current and wind in combination with tidal level, wear, corrosion and severe fouling.

Accidental limit state (ALS):

The accidental limit state is the maximum load or stress that a damaged structure can withstand. Damage may occur due to accidental or extraordinary loading, such as a rogue wave or a collision. The most severe ALS cases are considered to be severe waves, current and wind in combination with reduced buoyancy or broken (mooring) lines.

Serviceability limit state (SLS):

The serviceability limit state is the load or stress that the structure can withstand in case of service. Cases include the handling of the system during inspection, maintenance and repairs. Severe SLS cases include the loading of the system during seeding and harvesting of the seaweed. To some extend a vessel may transfer loads to the mooring construction.

Fatigue limit state (FLS):

The fatigue limit state is the maximum load or stress that a structure or component can withstand over a given a load spectrum (wind, current, wave) without failing due to fatigue. The FLS is expected to be continuous loading caused by wave motion during the life of the components.

6.2 Load combinations

The application contains none.

Various load combinations should be modelled incorporating peak wind, wave and current for various return periods, eg: 10, 25, 50, 100 years. Due to the random nature of marine energy, extreme events will occur when certain combinations align.

6.3 Load factors

The application contains none.

The following load factors should be considered in the design process:

Permanent loads (G)

Permanent loads are loads that will not vary in magnitude, position or direction during the period considered.

Variable loads (Q)

Variable functional loads are loads which may vary in magnitude, position and direction during the period under consideration, and which are related to operations and normal use of the installation.

Environmental loads (E)

Environmental loads are loads which may vary in magnitude, position and direction during the period under consideration, and which are related to operations and normal use of the installation.

Accidental loads (A)

Loads related to abnormal operations or technical failure.

Deformation loads (D)
Deformation loads are loads caused by inflicted deformations.

6.4 Design fatigue factors

The application contains none.

The fatigue life should be equal to or longer than the design working life specified in the product documentation.

6.5 Material factors

The application contains none.

Material factors are factors of safety that are applied to inherent material characteristics of structural components. For example, synthetic ropes should have a Material Factor of 5 applied if the ropes have been knotted. Knots will reduce the minimum breaking load (MBL) of a rope by around 50%.

6.6 Corrosion allowance

The application contains none.

Corrosion allowance according to DNV-OS-E301 is dependent on location and inspection scheme. Corrosion allowance should be evaluated according to the inspection scheme chosen and the conservatism of the chosen corrosion allowance.

6.7 Marine growth allowance

The application contains none.

Marine growth should be taken into account on the full system and should be estimated for each component based on the location. Marine growth properties will vary by latitude. Local data should be obtained taking into account cleaning intervals and depth within the water column.

The hydrodynamic analysis method calculates the capacity of the structure to withstand a particular load or moment, and compares this against the loads applied. If the load applied is less than the load resistance, the structure passes. Various factors are applied to take into account uncertainties ('Safety Factors') according to set rule requirements. It is noted that these safety factors are used in the oil and gas industry for Consequence Class 2 designs where failures can 'lead to loss of life, collision with an adjacent platform, uncontrolled outflow of oil or gas, capsize or sinking'. Clearly this Consequence Class is for risks far in excess of any associated with the seaweed aquaculture. In the lesser Consequence Class 1 applicable to aqauculture the equivalent safety factors are applied.

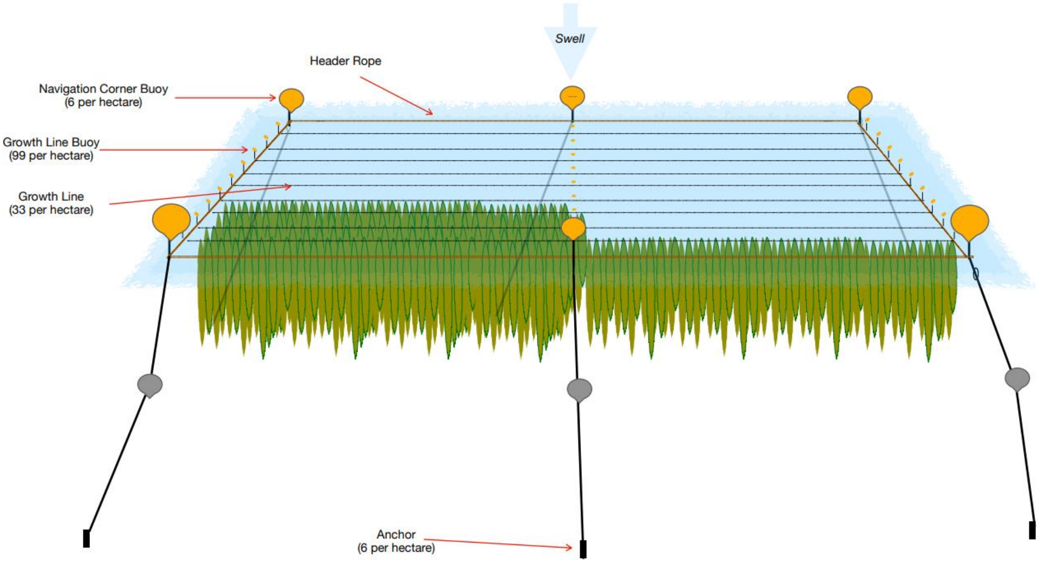
The output of the simulation process is a time domain response of the mooring loads and the motions and moments applying to the system being analysed. The simulation is run for a sufficiently long time to reasonably capture maximum peak loadings. The peak values for line loading are taken as the dynamic line load.

We find Penmayn have not undertaken best practice in following any recommendations to establish the ultimate limit state (ULS) and the accidental limit state (ALS) and incorporated this analysis into their design criteria.

It is noted that fatigue loadings have not been considered. As the deployment of the unit is planned for an extended period of time (greater than 24 months) this is an oversight that can reasonably be expected to have critical consequences.

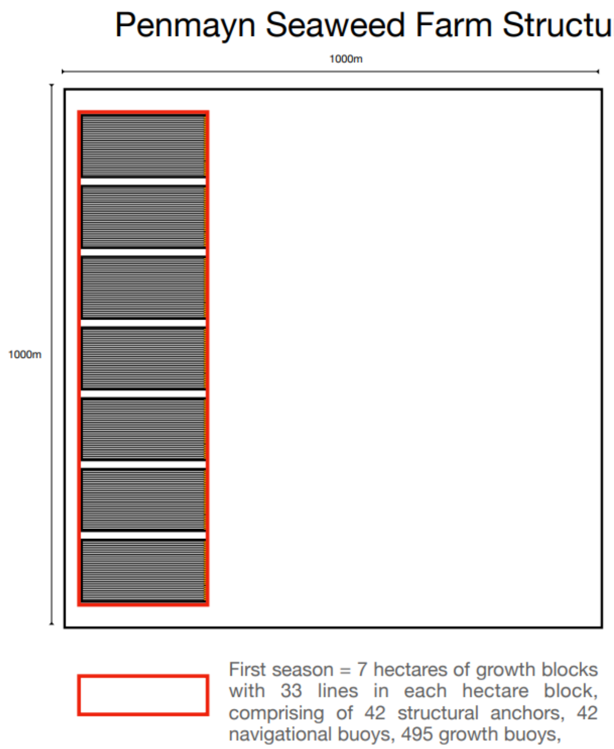
7 Review of Mooring Design for Penmayn

We undertook to review the mooring design as detailed in documents and drawings provided below.



Source: Penmayn Limited

Penmayn



Source: Penmayn Limited

Penmayn

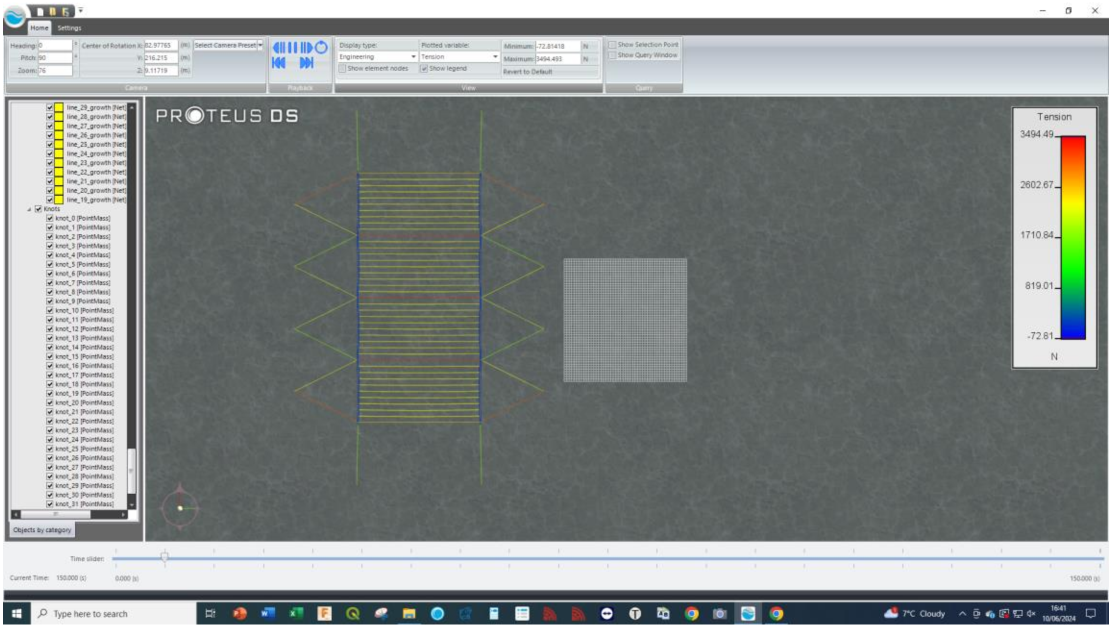
The square grid geometry of the frame and parallel growing line array lends itself well to a orthogonal mooring design. This is a simple, stable and strong geometry which uses the same principle as a single point mooring system. This is an industry standard approach when it is required to keep a marine asset moored on station and is a robust design solution in the right environment.

This application does not use this design but relies on multiple twin moorings opposing each other.

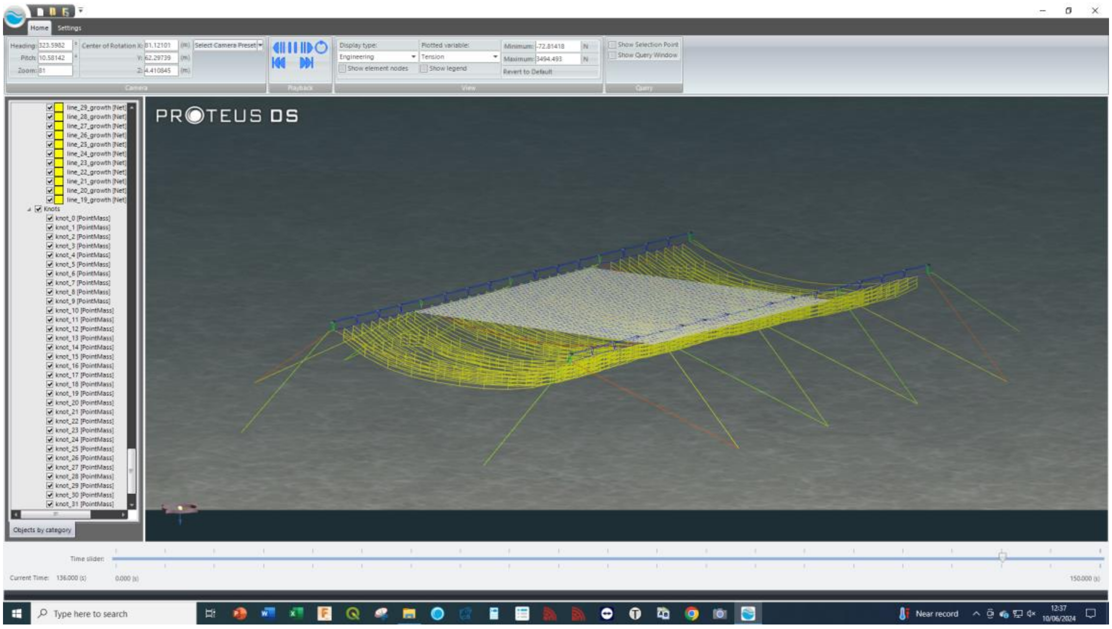
The mooring legs are not therefore operating as a holistic system but as numerous independent pairs. This is not a conventional approach and is likely to result in an under-tensioned system that will be subject to entanglement within itself and fatigue induced failure at some point in the future. This very issue has occurred on a similar seaweed farm structure on the West Coast of Scotland in 2022.

The selection of helical screw anchors is recognised as the best possible engineering solution for the anchoring of the farm and Fielder Marine Services are a reputable choice of supplier for this technology. We find this to be a robust and high performance anchor design solution.

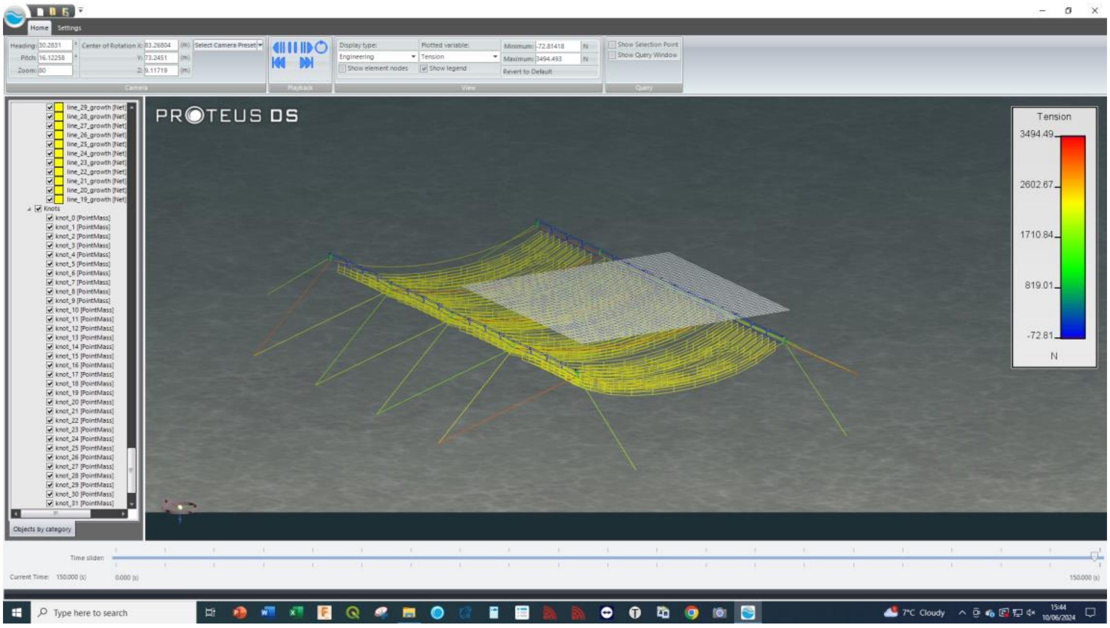
8 Review of Mooring specification and dimensioning for Penmayn



Plan view: Representation of Penmayn farm design produced as 3D CAD model for DSProteus analysis



Load simulation and tension calculation with static forces applied



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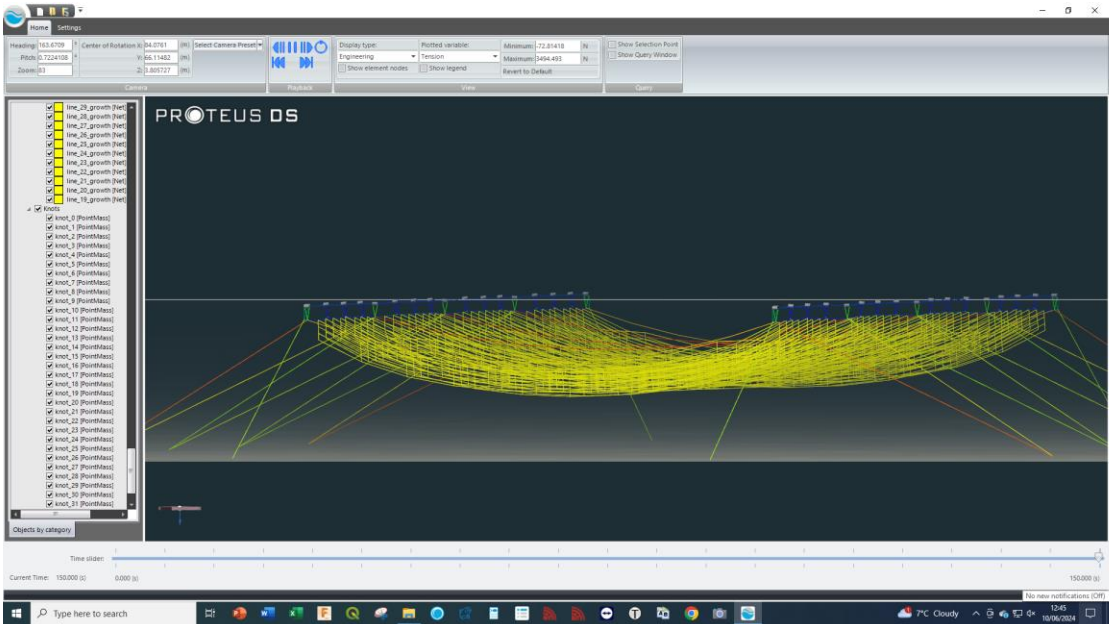
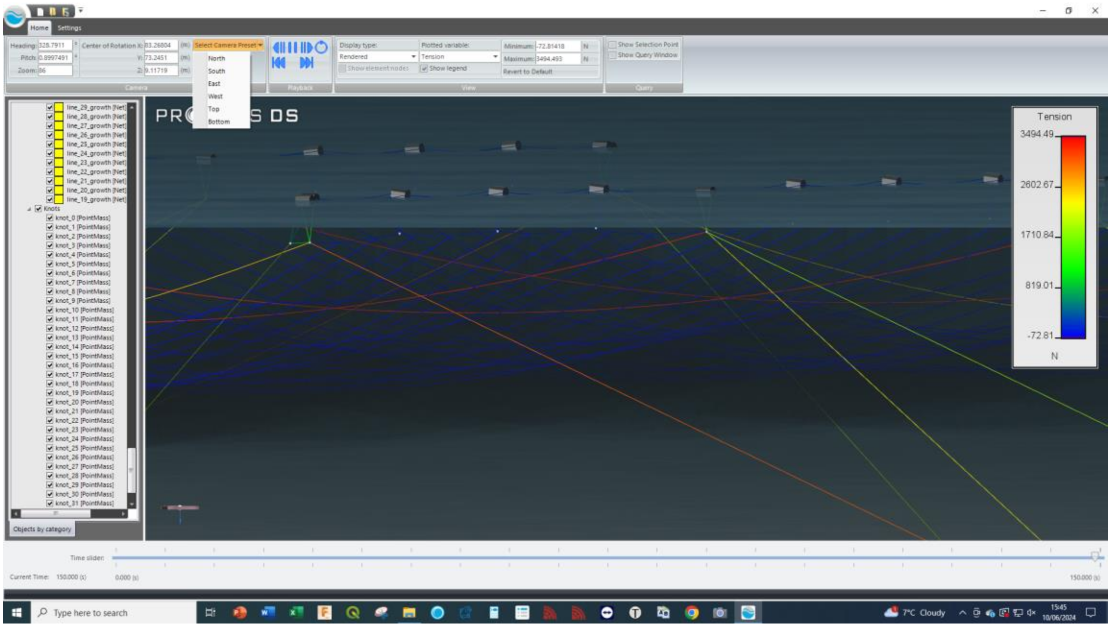


Load simulation and tension calculation with dynamic forces applied



Load simulation and tension calculation with static forces applied

The ULS figures for the mooring equipment components should be provided to a reputable preferably certified equipment supplier who is responsible for the performance claims of these materials. This is standard practice which we find to be a reasonable approach.

There is no tabulation of the mooring equipment in Penmayn's documentation. The Mooring Design investigation has been reviewed and we find that no method of specifying suitable mooring materials has been applied.

9 Review of assembly & installation considerations

[Commentary on FMS screw anchors to be added]

– reputable and reliable operator in this industry.
- High performance, environmentally sound anchoring solution
- no doubt anchors installed will remain in place …IF:

- has geotechnical investigation established there is sufficient depth of sediment to screw into?
-what depth is the overburden is above the rockhead?
-what composition is the substrate? Screw anchor holding power is a function of the seabed composition – cohesive/non-cohesive soil, particle size etc

- serious doubt the rest of the farm structure will survive
- DSProteus may give us an indication of likely first point of failure

10 Report on fitness for purpose of Penmayn moorings and regulatory compliance

The Penmayn design is by no means the first iteration of this type of design. Similar versions of this type of structure have been deployed elsewhere in the UK and Europe with mixed results.

An inherent problem with this type of design is the lack of sufficient tension on the system. The large number of multi axis articulated joints will be subject to great demands on the structure in a hostile environment.

From our examination of the work it is not clear what demonstrable experience the designers of the system are able to draw upon and standard engineering practice and codes applicable to similar offshore structures do not appear to have been utilised.

In order to ascertain the input loadings, a detailed 3 dimensional model of the system was created in the software tool DS Proteus. With the application of current and waves, the bodies move relative to each other in a time domain simulation. The loads from each connection and in each body are recorded, and the peak loadings determined. The software is well tried and tested and used extensively for offshore work.

In AquaMoor demonstration of Proteus modelling of this type of structure, the input hydrographic and environmental data were derived from standard industry techniques and we found that the results were in the expected order of magnitude.

In reviewing Penmayn's mooring design, AquaMoor has drawn on its experience of designing and specifying a range of mooring solutions for applications in floating cage aquaculture, single point moorings, aids to navigation, pontoons, docks and breakwaters. In conclusion, our review finds that Penmayn have not followed best practice in designing, specifying and dimensioning a mooring system for the seaweed farm. The approach is neither prudent nor conservative and does not rely on the appropriate design codes for this type of development. It is our opinion that notwithstanding unforeseen circumstances, the farm structure and moorings design is such that the survivability and integrity of the mooring system cannot be assured as can reasonably be predicted.

11 Conclusion

In conclusion, our review finds that the application for Penmayn does not followed best practice in designing, specifying and dimensioning a seaweed farm structure and mooring system.

The design approach adopted cannot be considered prudent or conservative for the chosen site.

Appropriate design codes and standards have not been utilised or even referenced.

Hydrodynamic analysis of the structural design has not been utilised or even referenced.

The design and engineering process is not sufficiently rigorous.

This site should not be deemed suitable for this kind of farming. The wave climate is far too energetic and will inevitably wreak destructive levels of wave energy onto the structure. The application was misleading as to the wave climate at the site. There is a good chance the crop will be stripped off the farm if the structure is suitable robust and doesn't yield at all. If the structure isn't suitably robust there is a good chance of a catastrophic failure of both structure and crop.

It cannot be considered to be a safe choice for locating a farm for the above reason.

The chance of failure of this farm structure at this site is undoubtedly high, if not inevitable. If it is not installed with sufficient tension it will suffer fatigue damage over time and highly like to suffer from entanglement in itself. If it is installed with too much tension it will suffer impact damage from shock loading during storm events.

It is our opinion that the structural and moorings design is such that the survivability and integrity of the Penmayn Seaweed Farm cannot be assured to a reasonable threshold.

The design is therefore not fit for purpose and if deployed may present a risk to Safety of Life at Sea (SOLAS).

Disclaimer.

It has not been our position to perform any design, specification or calculations for this review, nor inspect, test or independently verify any component. Our role is to check the validity of the input data, review adherence to methods, undertake checks to verify suitability of mooring material specification, form a view and report our findings. Penmayn remain entirely responsible for the design and performance of the mooring system.

Lawrie Stove, Director
For and on behalf of
AquaMoor Limited 10th June 2024