Private & Confidential

Project Information Summary

Loch Duart Wave Energy Converter Trials MK1.0

June 2024

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

Table of Contents

List of Figures & Tables

Document Summary

1.0 Version Control

V1.0 Initial release

1.1 Project Title

Loch Duart Wave Energy Converter Trials - Industry Led

1.2 Document Authors

Samuel Etherington: Aqua Power Technologies Limited

Executive Summary

Aqua Power Technologies is seeking to test its MANTA wave energy converter in a typical market sector, aquaculture. Specifically, Aqua Power Technologies is seeking to test a MANTA unit at Loch Duart's Uig Bay site for operational trials.

Aqua Power Technologies specifically designs wave energy converters and over the past 5 years has attained a good knowledge base of both the technical and commercial aspects required to bring a wave energy technology to market.

Aqua Power Technologies MANTA device is a point absorber technology with a direct drive power take off generator and load shedding capability built into the operating system. MANTA is a truly innovative converter design, which has been influenced by the development of previous technologies at Aqua Power Technologies, and the observation of ocean nature to spot biomimicry opportunities within the wave power industry, therefore fast tracking development timeframes.

As part of a feasibility study, Aqua Power Technologies contracted Aquatera (a specialist market research company based on the Orkney Isles) to review the current status of the wave industry and highlight any markets where wave power technologies may be applicable. The report work highlighted a number of potential market sectors including, but not limited to; eco tourism, data buoy power systems, unmanned autonomous vehicle charging, and aquaculture.

After reviewing the report work and then conducting internal research, Aqua Power Technologies set about designing MANTA, which is a system designed with the end markets specific requirements in mind. Initially Aqua Power Technologies is focusing on developing and ultimately selling MANTA units into the aquaculture market for the following key reasons:

- The anticipated growth of the aquaculture market teamed with the anticipated rise in fuel costs makes the aquaculture market attractive to invest development time and resources into.

- The potential to export units and continue to grow the company and the technology, due to the global nature of the aquaculture market.

- The suitability of MANTA to the typical conditions experienced at more exposed farm sites. Further investigation is being undertaken using wave data buoys, which will confirm the level of the wave resource available at farm sites, and indicate whether MANTA will be able to produce power viably.

- The industry's movement to develop offshore farms, which are in more exposed locations. MANTA requires wave amplitude to operate and developing farms further offshore will enable a higher renewable power production to be achieved.

- For the operators of fish farms, Aqua Power Technologies is offering a solution, MANTA, which has the potential to provide the following benefits (subject to pilot testing and power output analysis):

    1. A reduction in diesel consumed at the sites due to MANTA being capable of powering the lower power demanding appliances instead of using the diesel generator. Low power appliances may include the net lights, seal scare systems, and the computer systems.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

2. An operational cost saving thanks to MANTA displacing the diesel required for the low power systems. MANTA is designed with a 20 year life expectancy and Aqua Power Technologies anticipates MANTA to have paid itself off at least 3 times over in that period, pending a good wave resource.

3. The aquaculture market is coming under pressure to consider the emissions associated with farming fish. Deployment of renewable MANTA units may aid in farm operators winning contracts with supermarkets and distributors.

The project aims to run for at least a year from the date of deployment to gather sufficient data to understand the viability of the system in typical aquaculture environments. If the initial years trials are successful, the deployment period may be extended to observe other fundamental development data, such as wear rates.

After initial performance validation, MANTA will be connected to Aqua Power Technologies battery storage system, which will be installed on a Loch Duart barge. The battery storage system will then be integrated into the barge's power systems and pending an appropriate wave resource, start to reduce the farms consumption of diesel for powering the farms auxiliary systems. The full integration of the MANTA system into the barge will be monitored to assess the diesel consumption reduction and the associated cost saving to the farm, which underpins the economics of the product.

MANTA is a non invasive seabed system and does not require any subsea piling or ground works. Mooring systems akin to that of a fish farms will be used, which helps to reduce the number of unknown's about the deployment and testing of the MANTA system.

Given the small size and scale of the MANTA system, Loch Duart workboats will be used for all operational and maintenance procedures.

Due to the size and scale of the MANTA system, all the deployment operations can be conducted from either the shore base, or local ports (such as Uig). Access to the pier and the logistics (such as depth of water, tidal heights, access times) of deployment will be discussed with the local harbour master prior to any deployment work is conducted.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

Company Background

Aqua Power Technologies was founded in June 2014 as a spin out company from Sam Etherington's (company founder) final year thesis at Brunel University. The thesis focused on a novel wave energy converter design, which continued to win the James Dyson Award and Best Of British Engineering, beating both Sir James Dyson and Sir Jonathon Ive.

Aqua Power Technologies has received grant funding totaling £550,000 from Innovate UK, Innovus, and the Regional Growth Fund. In parallel, the company is sponsored by ANSYS, Siemens, and RevZone by way of free issue software and components.

The company has recently undergone a seed investment round of £300,000, which has been completed. All of the investor group are business orientated and have all taken products to market on multiple occasions.

Aqua Power Technologies has one technical advisor, Dr Joao Cruz. Joao co founded his own wave and tidal consultancy engineering company, Cruz Atcheson. Aqua Power Technologies have completed a number of projects with Cruz Atcheson. Joao and his team are now heavily involved in the numerical performance modelling of the MANTA system.

Aqua Power Technologies is a micro company with a pragmatic and commercial approach to the development of wave energy systems. As such, over 1080 different tests have been conducted on the MANTA system at Aqua Power Technologies custom tank facility. This 'dyson' approach to design helps to iteratively refine the MANTA system through extensive prototyping and testing.

Technology

4.0 Technology Background

MANTA is the result of an intensive 3 year design and industry feedback loop, which has helped to shape the design into a technically and economically viable wave energy converter.

Similarly to Pelamis Wave Power and Aquamarine, Aqua Power Technologies (APT) also started by designing grid scale machines, such as MultiWave (Figure1). However, through continued interaction with the end users, APT's wave energy converter moved away from grid scale devices and developed into a system which is in line with the markets demand - small scale and low cost wave energy converter solutions.

The series of renders below highlights the development journey APT has undergone to produce a simple, robust and market focused wave energy converter.

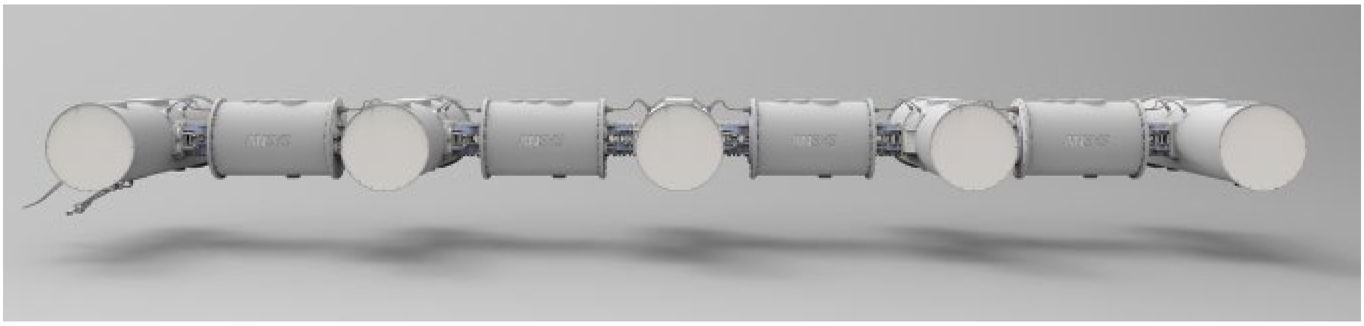

Figure 1 MultiWave, the predecessor to RWP001.

Figure 2 QuadWave - A smaller WEC design.

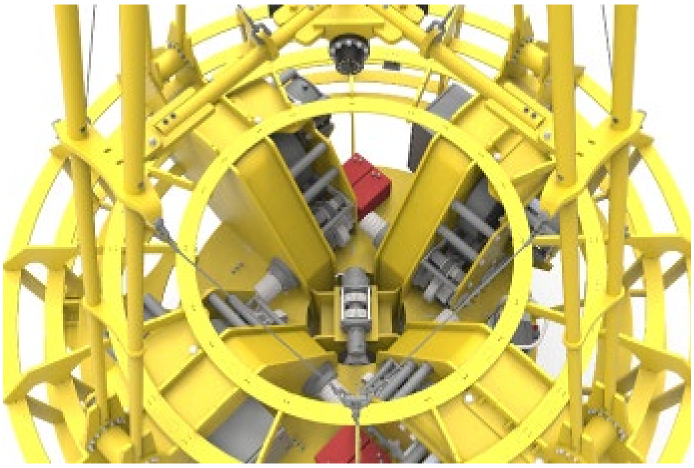

Figure 3 Inside QuadWave.

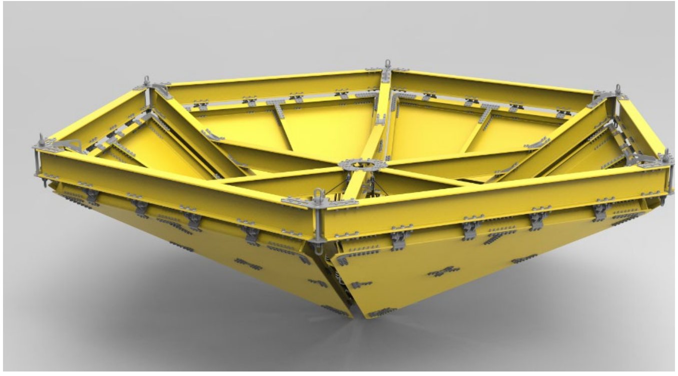

Figure 4 Load shedding heave plate MK1.

Figure 5 Load shedding heave plate with reference.

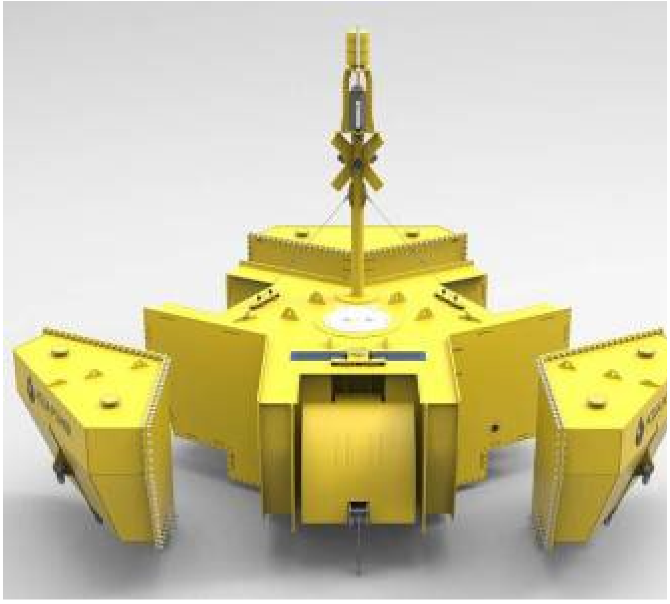

Figure 6 TriWave MK1 - a development of QuadWave.

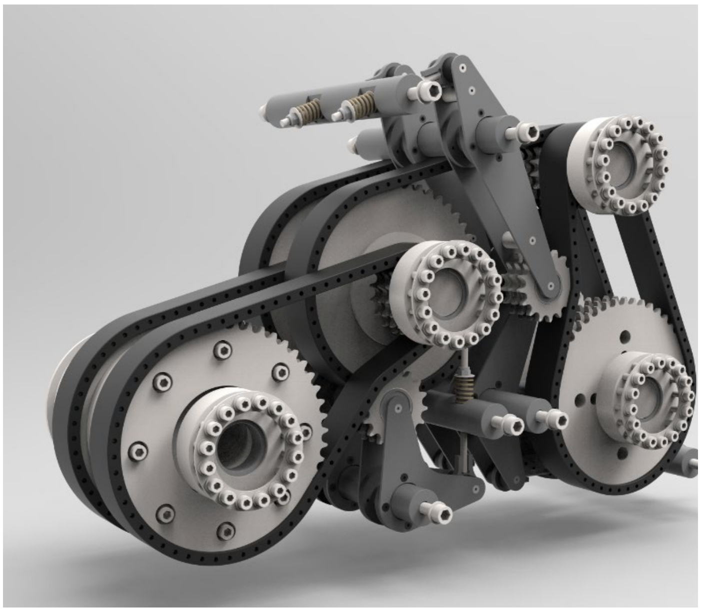

Figure 7 Clutch PTO drivetrain for TriWave.

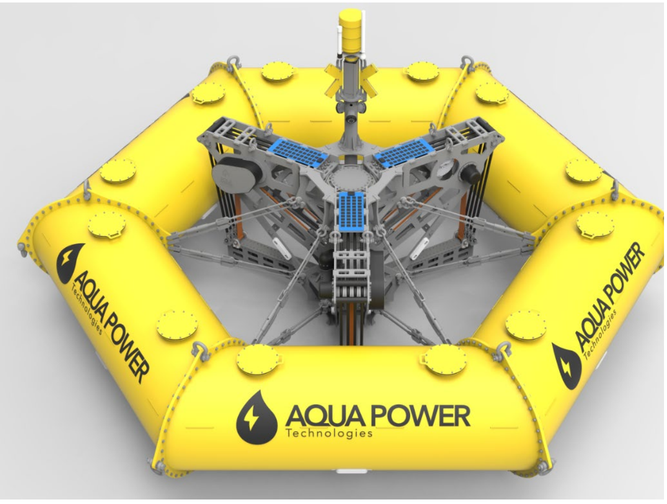

Figure 8 TriWave MK3. More power and lower cost.

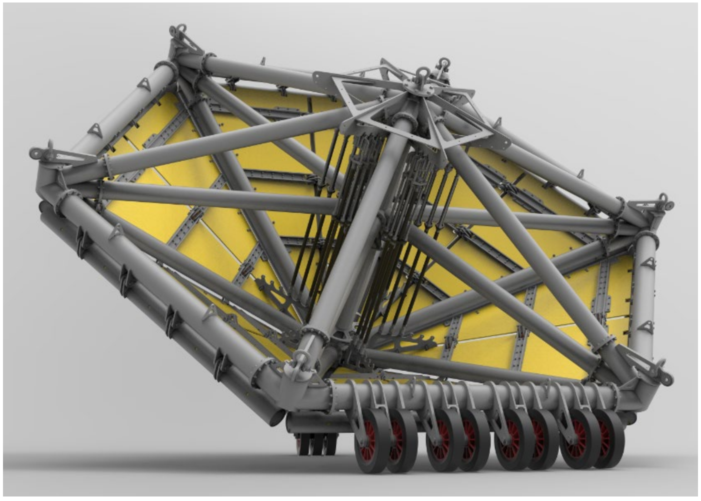

Figure 9 Developed prototype heave plate design MK3.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

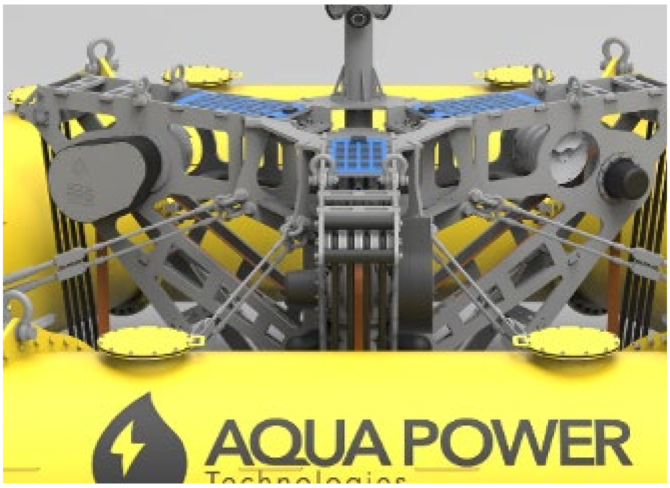

Figure 10 Introduction of belt driven PTO in TriWave.

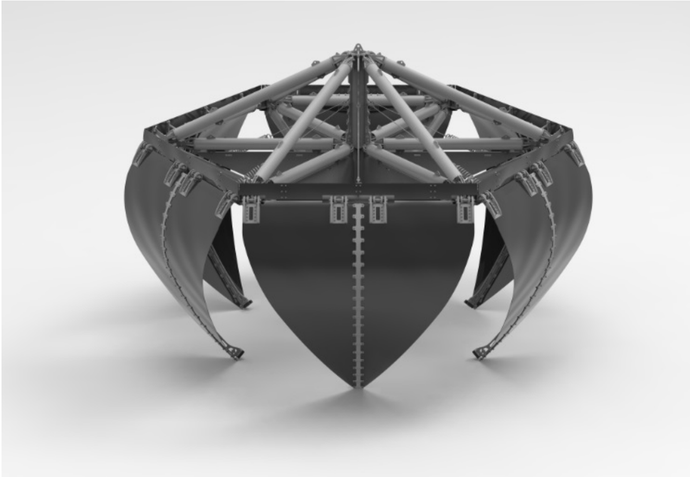

Figure 11 A development of the heave plate MK6.

Figure 12 Early concept of MANTA MK1.

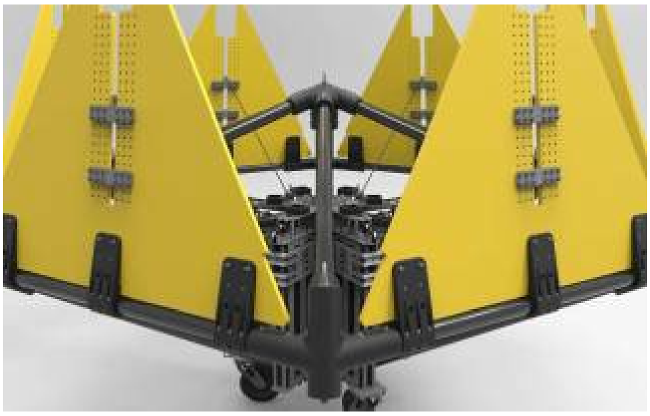

Figure 13 MANTA's linear PMG within MANTA MK1

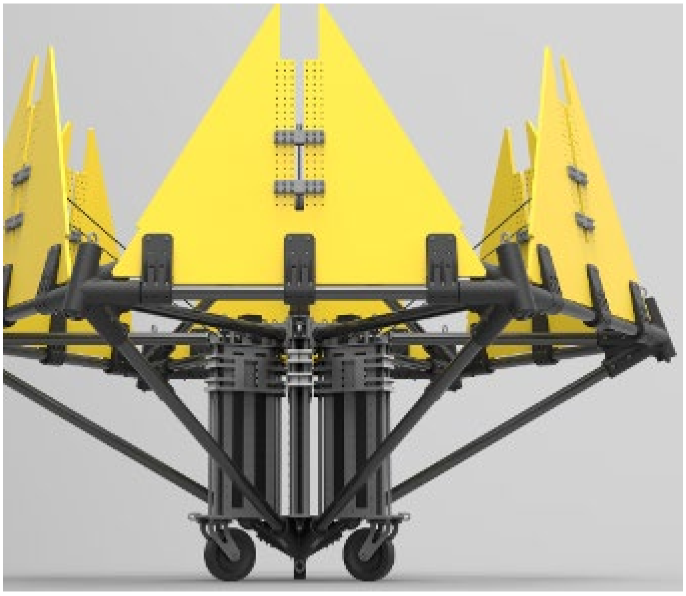

Figure 14 MANTA in descent mode.

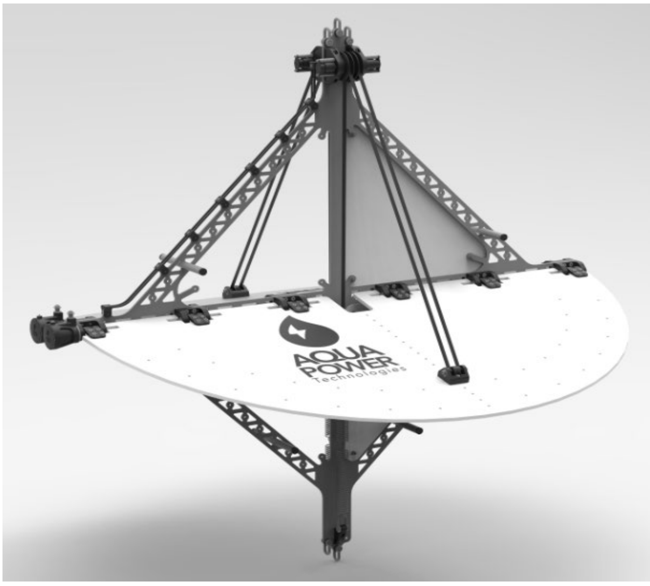

Figure 15 MANTA MK5.

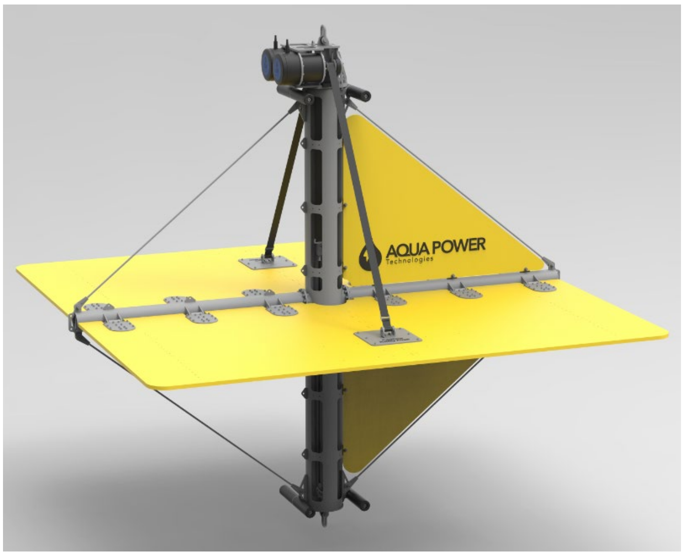

Figure 16 MANTA MK7.

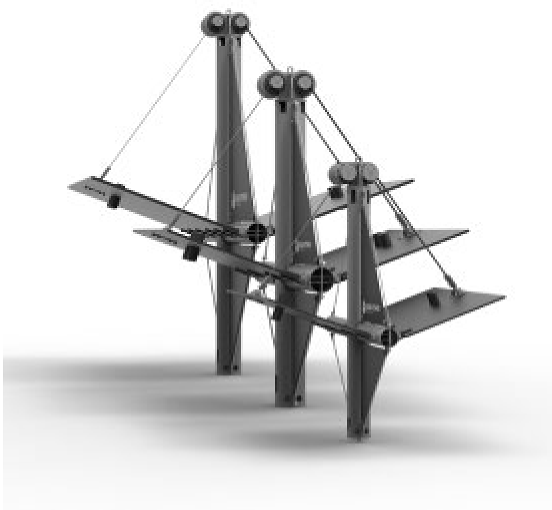

Figure 17 MANTA 4,9,and 16.

4.1 Project Background

Figure 18 MANTA – the latest iteration.

The current version of MANTA is the culmination of 5 years research and development into wave energy systems. MANTA overcomes a number of barriers that APT and the wave energy industry have found, such as:

- Slow speed and high torque prime shaft movements, which are difficult to efficiently extract power from. However, MANTA's wings provide large forces, due to surface area drag, and are coupled to the direct drive Power take off (PTO) Permanent Magnet Generator (PMG) via a heavy duty timing belt and pulley. Although a pulsing output, the shaft speed is much higher than traditional prime shaft speeds. This enables a number of off the shelf components to be used, which keeps the total system cost down.

- Scalability issues. Some wave energy designs prefer a certain wave spectrum for economic and power efficiencies. However, MANTA is very scalable due to the simple operating principle working over a broad wave spectrum, and the use of mainstream manufacturing processes, which keeps manufacturing costs down. This enables APT to develop and deploy MANTA units at a small scale into high energy cost markets, whilst continuing to work towards grid scale machine developments. This is a commercial approach to product development, which has often been overlooked by other wave developers primarily seeking to develop capital expensive grid connected machines.

- No hull. The whole device is free flooding, except for the floating object (rotationally molded polyethylene float), which actuates MANTA. Manufacturing a hull can become very expensive very quickly, which reduces the potential of the wave energy converter to produce low cost energy. In addition, the device is not self referenced, which helps to reduce material consumption, system mass, and cost of the device.

- Shedding excessive loads. MANTA automatically sheds load as the wings fold downwards, due to the total surface area and associated drag being reduced. This folding action absorbs the wave energy, but also reduces the systems drag and ultimately aids in the system surviving in extreme wave scenarios. This inbuilt load shedding technique is not an afterthought. APT's objective with wave power is for the device to survive, and secondly to produce low cost power.

- Tidal height reference changes. Tidal height doesn't affect MANTA's performance as the converter is suspended from a float. Therefore as the tidal height changes, the reference height between MANTA and its actuator, the float, is always the same distance.

- Environmental factors. Seabed mounted converters are subjected to seabed sediment movement and high installation costs. In addition, surface mounted converters are subjected to the slap zone, which can be a particularly destructive zone, especially when considering moving components. However, MANTA is submersed mid water, which is out of the slap zone, and above the changeable seabed landscape. MANTA's surface actuator is merely a float with no moving parts. It is purely a floating object, albeit with an optimized shape, but it can withstand the surface environment without any technical concerns.

This is not an exhaustive list of barriers, but these are some of the main problems APT and the industry have come across when designing wave energy devices. APT is excited about MANTA as the preliminary testing results have highlighted the effectiveness of the large surface area of MANTA's wings for absorbing large drag forces in relatively low wave environments, which is in line with the intended markets local wave environment.

For reference, MANTA 4 is approximately 2 meters tall. The numbers relate to the surface area of MANTA's wings.

- MANTA 4: 4.67kW name plate power capacity.
- MANTA 9: 13.7kW name plate power capacity.
- MANTA 16: 26.2kW name plate power capacity.

4.2 How MANTA Works

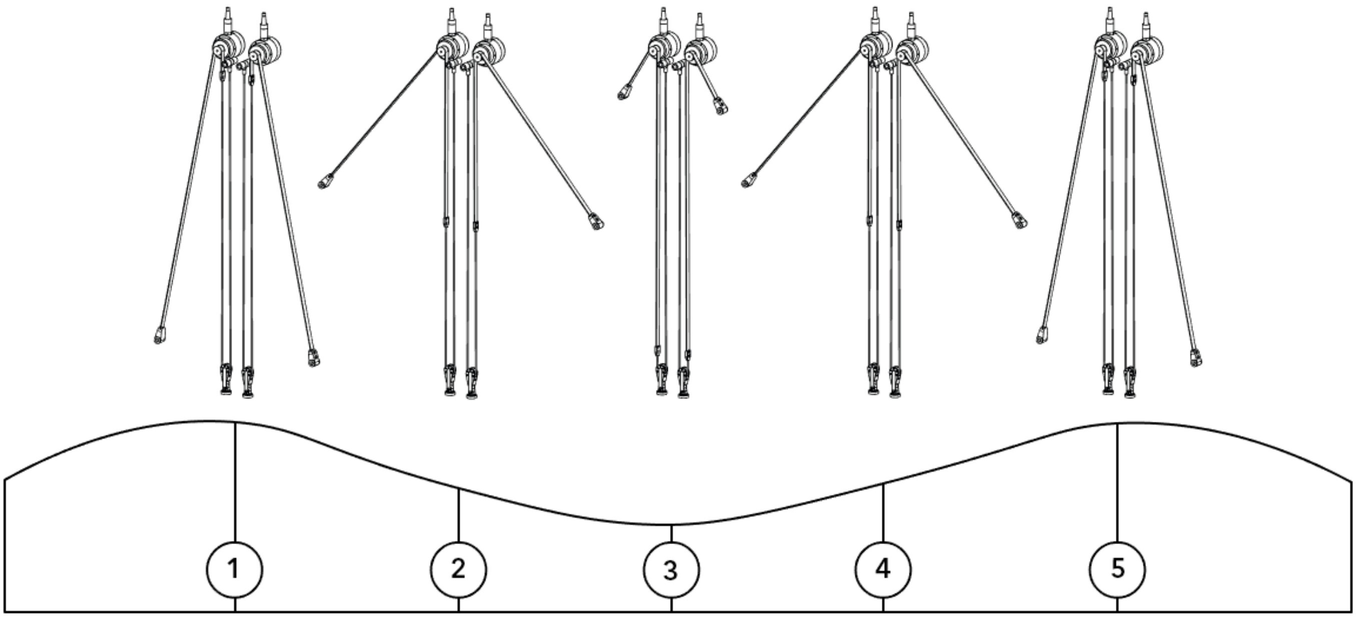

Figure 19 Operating principle over a wavelength.

Figure 19 shows the internal power generator components of MANTA and the difference in the belts length in a variety of different positions along a wavelength.

1. At point 1 the wings are in the down position, the belt is extended and the retraction spring is fully extended. This position occurs when the float on the sea surface has ascended up a wave crest. This is when the energy is absorbed and converted.

2. This is MANTA's at rest position, in the trough of a wave. It is important to note that when MANTA is in zero wave conditions that this is the wings default position. Compared to position ,1 it is clear to see that the belt has retracted and that the spring has also retracted.

3. Position 3 shows MANTA's inner workings when in the trough of a wave. This position would occur when MANTA has fully descended and when the float has fallen into the trough of a wave. In this position the flaps are in the upright position and primed for the next power generating sweep of the flaps.

4. Position 4 either occurs when MANTA is in calm waters, or when MANTA is ascending upwards from the trough of wave. Just as in position 3, the PMG is engaged and applying resistance relative to the current wave environment.

5. Position 5 is a return to position1, which denotes a complete cycle of the operating principle.

MANTA cycles through this operating principle with every wave. MANTA effectively pulses the power into a capacitor bank, which smoothes MANTA's erratic output. The power is then fed into a battery pod via a DC-DC converter. Power can then be fed through an inverter to the farms power demanding applications.

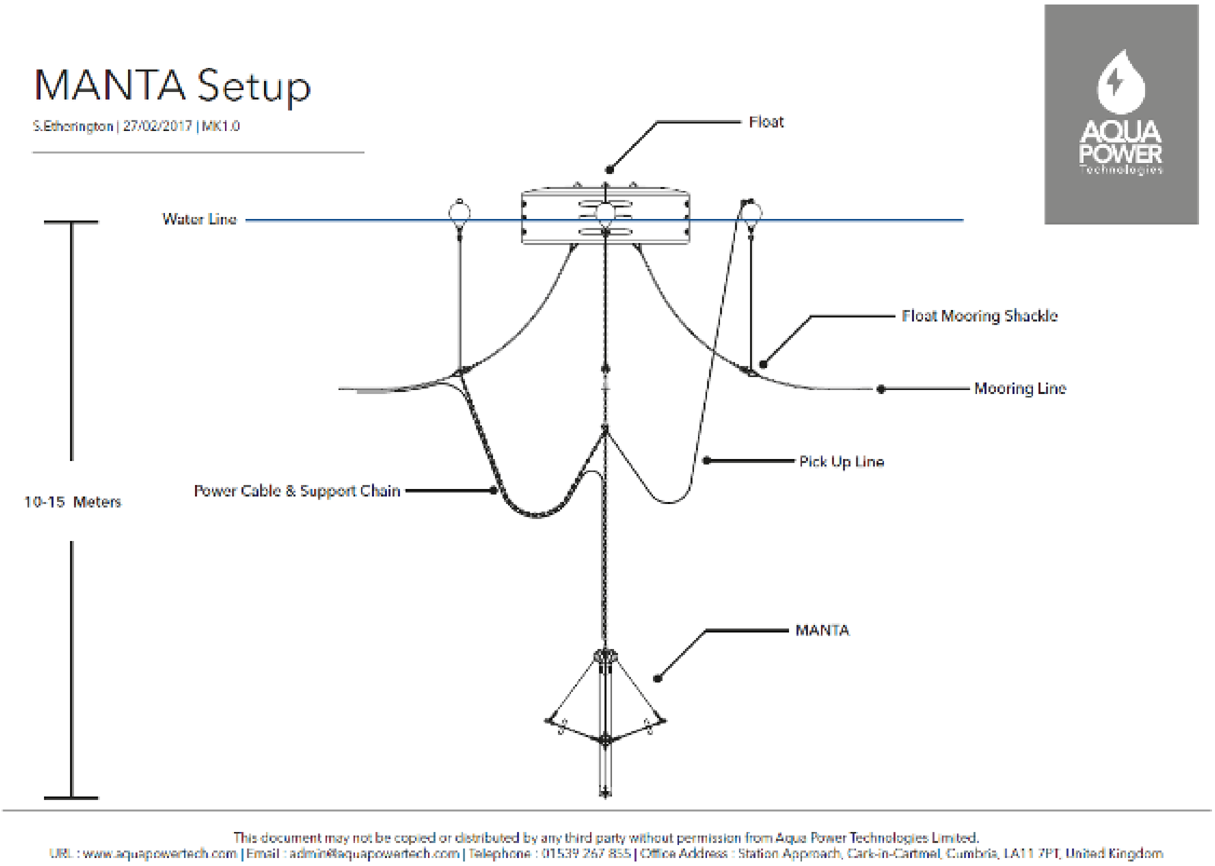

Figure 20 MANTA mooring setup.

As figure 20 depicts, MANTA hangs below any floating object, which has the capability to be heave upwards and downwards in the waves. The heaving excitation of the floating object is transferred to MANTA via the tether. As MANTA moves in phase with the float, the wings on MANTA articulate and try to remain stationary due to the drag forces acting on the flap surfaces. As MANTA rises upwards, the wings are absorbing the energy, and as MANTA descends, the wings are partially absorbing the energy.

The cyclic motion of MANTA ascending and descending causes the wings to articulate upwards and downwards, which provides a simple energy absorption technique with load shedding built in. As the wings are forced downwards, the wings quickly pull the timing belt over the PMG's pulley and cause the spring/bungee to extend in length. In this direction the PMG can set the resistance/load with reference to the current sea state, which helps to absorb and convert the maximum amount of power possible.

As the wings are forced upwards when the float descends off a wave, the PMG's resistance is lowered significantly, and the spring retracts the belt in an orderly manner. The spring is not designed to retract the flap, it is merely included to retract the belt so that it is ready for the next power sweep.

4.3 Materials Used

MANTA is constructed using only the following materials:

- Stainless steel 316L (non corrosive) 750kg
- Acetal (non corrosive) 50kg
- High Density Polyethylene (non corrosive / recycled material) 600kg
- Rigid Polyurethane (non corrosive) 300kg

MANTA is a direct drive permanent magnet machine and as such there is no oil, no grease, and no hydraulic fluid. In addition, bearing surfaces on the hinge of MANTA's wings are polymer bearings, which are commonly used as bearings for ships propeller shafts. Importantly, at no point on MANTA are there materials where galvanic corrosion could occur, which should ultimately enable a long-lasting operational life.

4.4 Monitoring Systems

MANTA uses an in house designed monitoring system which can achieve the following functions:

- GPS position.
- Geo-fence warning - warns if the mooring has dragged or MANTA has floated off.
- Wave height and wave period monitoring.
- Temperature.
- Power output.
- MANTA's wing position.
- Can communicate via all or any of these; Wifi, Bluetooth, RF, GSM, Iridium.
- External battery life can be monitored and is anticipated to be 180 days.
- All data displayed on a live web platform.

This remote monitoring system enables APT the opportunity to check the status of the MANTA wave energy converter. However, more importantly, it has several methods of communicating to any number of assigned 'in case of emergency' (ICE) contacts in the event of system failure of mooring breakage. The selected ICE contacts can then quickly respond to the emergency.

Deployment

5.0 Locations

Based on the information of exposed sites provided by Loch Duart, APT proposes that the prototype MANTA unit be deployed at the Uig Bay site, Skye.

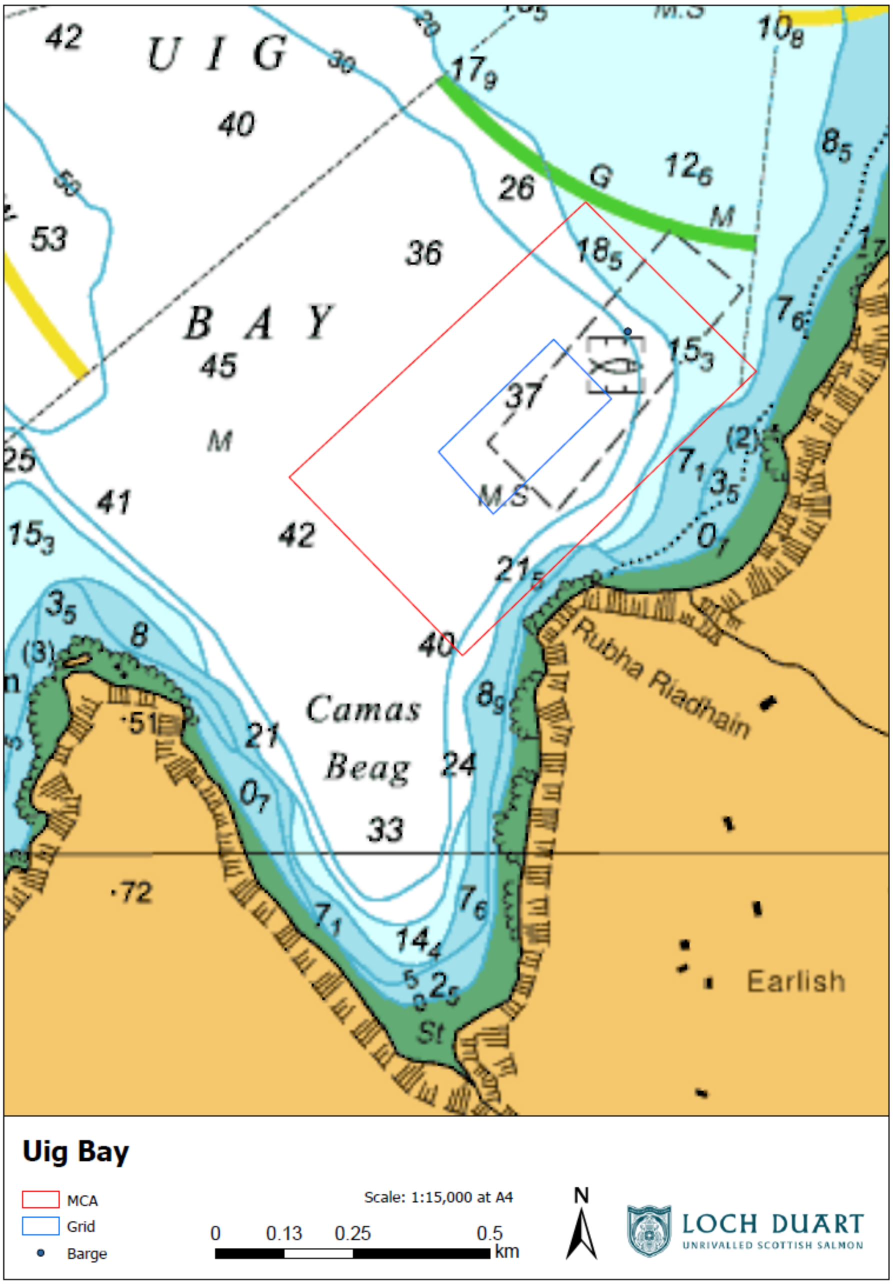

Figure 21 Uig Bay, Skye

Uig Bay Location

Site Operator: Loch Duart

Loch Duart Site: Uig Bay

5.1 Uig Bay Deployment

The MANTA deployment will be at Loch Duart Uig Bay site (WGS 84). Specifically, the deployment will occur in the South West corner of the site, which is typically in 37 meters of water. The MANTA deployment will sit within the following boundary coordinates, which are within Loch Duart's consented site:

Table 1 Manta's Site Boundary Coordinates.

Latitude	Longitude
57°34.640'N	006°22.711'W
57°34.474'N	006°22.399'W
57°34.195'N	006°22.936'W
57°34.370'N	006°23.253'W

5.2 MANTA's Position At Uig Bay

Below is the layout for Loch Duart's Uig Bay site, which is a typical layout of a fish farm. Figure 22 shows the position of the farm in relation to the site boundary, and the MANTA deployment site (red box). APT designed MANTA to be a small-scale wave converter which could retro fit to existing infrastructure. In the case of this deployment, MANTA will be deployed in a spare grid space.

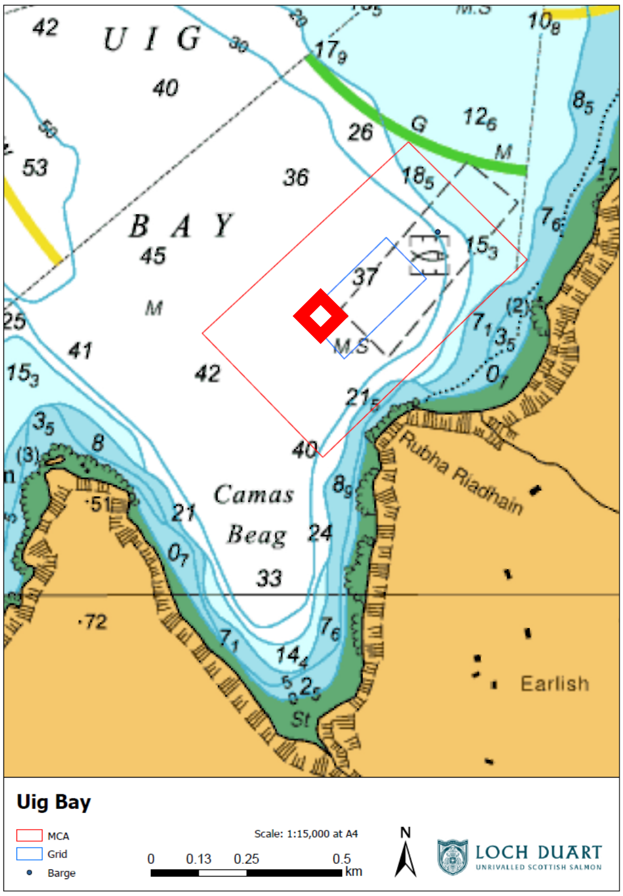

Figure 22 Example Farm Mooring Setup

The red box indicates the position of the spare grid space where MANTA will be deployed. Compared to the other potential MANTA locations on the farm, the grid cell chosen posses the most active wave conditions, which MANTA requires for operation.

5.3 Mooring System

Due to the MANTA system sitting within a spare grid cell, the mooring system is simplified significantly. The MANTA system will tether directly to the grid, as opposed to laying separate mooring blocks. As a result, 4 radially equispaced bridle lines will secure the MANTA system to the grid at the farms common corner shackle plates.

This mooring approach means that specialist workboats (as depicted in figure 24) are not required to lay mooring blocks. Instead, standard issue workboats (depicted in figure 23) can be used for all of MANTA's operations.

Figure 23 Farm Workboat

Figure 24 Specialist Workboat

5.4 Installation Procedure

The installation procedure consists of the following activities in the correct chronological order:

1. MANTA's high density polyethylene float will be moored in place and coupled to the farms grid using bridle lines. The coupling of the float to the grid will involve locating the visible shackle plate marker buoys, lifting the plates clear of the water, coupling the float to the mooring shackle plate, and lowering the shackle plate back into position.

2. Once the float has been installed on site, the MANTA system can be installed. MANTA hangs directly below the float, so a mooring pickup line is preinstalled on the float to ease the coupling of the float to MANTA. Once the float and MANTA's mooring line are shackled together, MANTA can be lowered into position using either a capstan winch, or the onboard palfinger crane.

5.5 Decommissioning Procedure

After testing the MANTA machine, all deployed equipment and materials will be removed. The decommissioning procedure loosely follows the reverse of the installation procedure. To clarify, the decommissioning procedure is as follows:

1. Remove the MANTA converter using the method described in figure 25 - MANTA Installation and Retrieval Method. Once removed, the MANTA converter will be transported back to shore and loaded onto its road transport.

2. Remove the float by unshackling the multi point bridle lines from the grid. After decoupling the float from the grid, the float is towed back to shore base, where it is lifted out of the water and onto road transport.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

5.6 Installation & Retrieval Method Of MANTA

The installation and retrieval of the MANTA device has been discussed and reviewed with Loch Duart technical staff to ensure the device is within the workboats capability for future deployments. The preferred method of retrieval is to lift and lock, in as many cycles as required, to bring the MANTA system completely clear of the waterline and onto the workboat deck

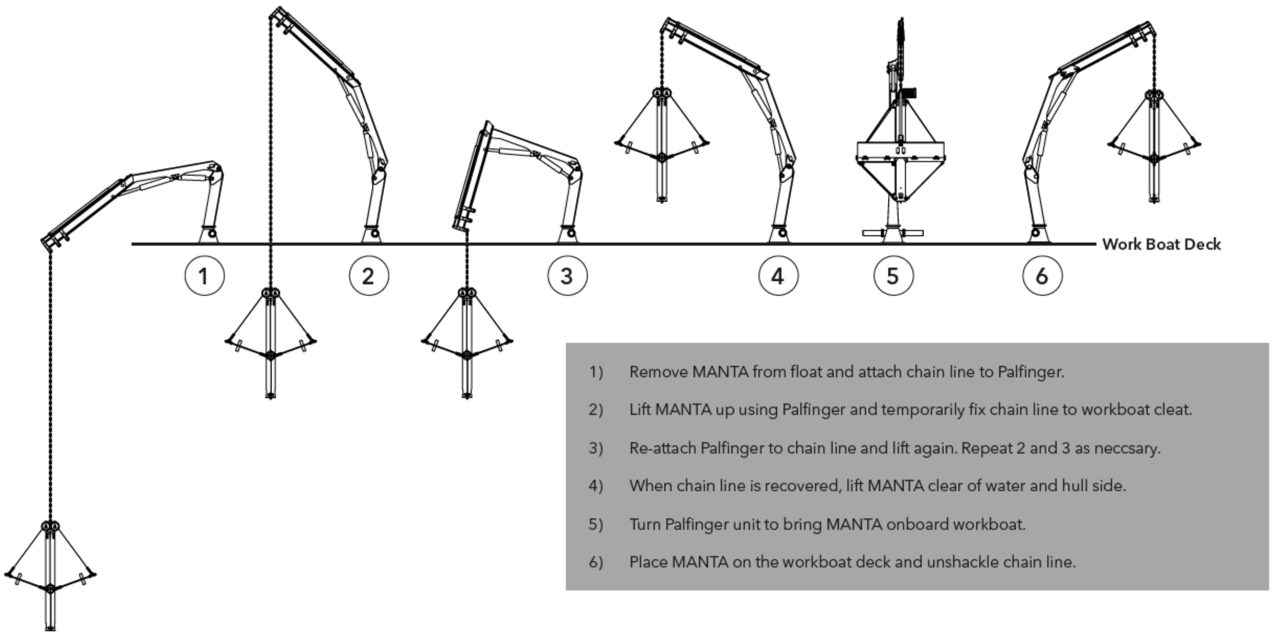

Figure 25 MANTA Installation and Retrieval Method.

To access the pickup point for the palfinger to shackle onto, there is a pickup line on the mooring, which is connected to the main tether shackle point. This setup enables the whole operation to be undertaken on the surface using the workboats already on Loch Duart sites.

The other component of the setup, the float, can be towed to its deployment location. The float also has intermediary shackle points which are marked by surface buoys. Pulling up the line below the surface buoy reveals the shackle for mooring the float tether to the farms grid shackle plates. This is repeatable for all four of the floats mooring lines.

Over the testing period, several inspections will be made on the system. Inspections will consist of subsea checks, and surface inspections. Subsea inspections will be undertaken using an ROV, and surface inspections will be undertaken by lifting the MANTA machine onto the workboat deck for a more detailed and controlled inspection. The device is designed to be easily maintained using three common components. Any maintenance will be undertaken on the workboat deck using standard tools.

5.7 Monitoring Systems

The MANTA system will be monitored onsite and remotely via site operators, and APT's internally developed telemetry systems. The monitoring systems will provide real-time feedback of the system, but crucially enable rapid intervention by site operators, via warning alerts, if any aspect of the system is failing.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

6.0 Environmental Monitoring

MANTA has no mechanical transmission, due to its direct drive setup. This, in theory, should make MANTA a particularly quiet converter, which is important when in such close proximity to fish farms. To verify the theory, hydrophone samples will be taken for set periods before and during MANTA's installation to understand the noise pollution, if any.

Due to the MANTA system using the existing mooring system of the farm, no mooring blocks will be required. Therefore, the installation of the MANTA system should not cause any seabed disturbance. However, prior to the deployment, an ROV will video the seabed directly underneath the deployment site. In addition, at the end of the testing period, the seabed will be surveyed to ensure no debris is left on site, and that the seabed has not suffered any damage.

6.1 Local Biological Conditions & Associated Environmental Risks

An Atlantic salmon aquaculture site, owned by Loch Duart, has been operating in the area of the proposed MANTA wave converter with previous site owners, Grieg. The seabed surrounding the site is monitored periodically as part of compliance with the site's CAR (Controlled Activities Regulations) license, regulated by SEPA.

FEAST (Feature Activity Sensitivity Tool), developed by Marine Scotland, can be used to assess the potential impact of wave energy[1] on sensitive local features. However, it is important to note the wave energy activity was specified as "wave turbine energy production" and implies a larger scale device as well as the requirement for some form of dredging operations (i.e. the assessed risk of sub-surface abrasion). The tool is therefore used here as a guide to assess some of the potential risks deemed most relevant to the operation of the MANTA device in the context of both its scale and proposed deployment at an existing aquaculture site. FEAST highlighted habitat and species sensitivity to the following potential impacts, which are assessed in terms of likelihood and scale of risk:

Possible impact	Likelihood of impact	Scale of environmental risk
1.barrier to mobile species movement	Low, due to scale of device and in the context of proximity to fish farm	Low
2. death or injury to mobile species by collision	Low, due to scale of device and in the context of proximity to fish farm. MANTA's two wings are the only moving parts on the converter, but they are 15 meters below the water surface and out of the way of surface operations.	Low
3. introduction or spread of non-indigenous species (INNS) & translocations (competition)	Nil. The MANTA will be undergoing its first trial at Uig Bay and therefore will not have been in the sea prior to deployment at Uig	Nil

[1] An activity report was generated for wave energy production from this site, keep in mind the limitations of this report as discussed in the paragraph http://www.marine.scotland.gov.uk/FEAST/Index.aspx

	Bay. Local contractors will be carrying out deployment and their boats are unlikely to be vectors of INNS.	
4. Synthetic compound contamination	Nil. MANTA has no oils or liquids that can leak into the local area, so there is no risk of contaminating the fish pens with oils or liquids. The patent pending system avoids the use of any shafts seals and thus voids the potential for water ingress, which would lead to failure.	Nil
5. underwater noise	Thought to be low, but unknown. See section 6.0	Unknown, but thought to be low
6. localised water flow (tidal current) changes	Low, due to scale of device	Low
7. localised wave exposure changes	Low, due to scale of device	Low
8. visual disturbance (species behaviour)	Low, due to proximity to operating fish farm. All that will be seen on the surface is the yellow float, which is 3 meters diameter and 1.5m above sea level.	Low
9. physical sediment changes	FEAST suggested ocean quahog sensitivity to physical sediment changes and sub surface abrasion. The Aqua Power MANTA device is small scale and is moored by blocks sitting on the seabed floor, with no dredging, piling operations or burial requirements for either installation or decommissioning.	Low. Any effects to ocean quahog populations will be highly localised and highly unlikely to result in significant harm to local populations of the species.
10. sub surface abrasion (caused by dredging operations).		

Other possible risks not accounted for the FEAST relate to proximity to an operating fish farm. MANTA has been assessed for risk of damage to fish farm components such as nets and cages and therefore risks to fish containment.

The float is filled with high density foam, which means even if the skin of the float is pierced, it still will not sink. MANTA is designed to automatically dissipate drag and reduce loading in extreme conditions. As MANTA's wings fold downwards, the drag and loading on the system is automatically reduced. This load shedding principle is built directly into the operating principle, and as such is not an auxiliary load monitoring system which has to be activated. MANTA is inherently heavy as it has to hang below the float and operates in sync with the floats' tracking of the waves. If MANTA were disconnected from mooring or float system during an extreme storm event it would sink on a directly downward trajectory due to its considerable weight (750KG) and even in a worst case scenario- the downward trajectory would unlikely be angled enough to come into contact with cages or nets or be at enough force to adversely affect farm containment. The risk of MANTA causing damage to fish farm components has therefore been assessed as low.

MANTA's float is a high density polyethylene rotationally molded float, similar to navigation buoys. In a worst case scenario where the float broke free from its mooring it would likely drift into the nets. However, the float will be GPS geo-fence tracked and can create custom distress calls to specific people at the site. Failing the GPS distress calls the float has a very low draft (less than 0.5 meters), and is made from HDPE. Therefore the risk of damage to the nets is significantly reduced due to the lack of polar opposite materials wearing against each other, and the lack of draft being able to wear against the nets.

6.2 Navigational Risk Assessment

Navigation requirements dictated by the Northern Lighthouse Board, and the Maritime and Coastguard Agency will be adhered to. In addition a notice to mariners will be issued in advance of any deployment proceedings.

Although anticipated traffic is low, the MANTA float will be colored bright yellow, have a 2NM light flashing at an appropriate frequency, and have a yellow X mark. A passive radar reflector may also be installed on the float to avoid collision with any other craft.

6.3 Anticipated Vessel Traffic To Site

In addition to the normal baseline value of vessel traffic, APT anticipates that a site visit will be conducted at least once every month to inspect the mooring system, MANTA, and potentially the power storage system. Inspections may include diving to observe the wear rates and identify any issues with the submerged MANTA unit, and surface observations when lifting the MANTA onto the workboat deck.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

Other

7.0 Proposed Timescales

For data collection purposes, it would be beneficial to have the MANTA system deployed for at least a year to expose the technology to year round conditions at the site, and identify whether, on a yearlong basis, the converter can displace enough diesel to create an economic case.

As the technology proves itself at the site, it may be advantageous to incrementally add subsystems and development cost to test a complete developed system. For example, in the first instance, it may be easier for MANTA to dump the power immediately, as this reduces the requirement for a power cable. However, if the power output from MANTA is as expected, it may be beneficial to install the battery bank, the power cable, and feed the power into the barges system to provide a fully operational setup.

In terms of time until deployment, APT would estimate that a deployment date of September 2024 is realistic.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

Additional Information

8.0 Battery Storage System

It is important to note that in the first instance, the project will not include a power cable back to the barge. Initially, the power will be dumped into a load resistor inside the float, which will be monitored to calculate the power created. This setup is a self-contained solution and does not involve any power cables or battery systems.

If the trials go well, the inclusion of a battery bank and power cable system will be revisited.

However, to clarify, if the battery storage system were to be installed, it would be on the fish farm barge. This is due to the availability of space, and to ensure that the technology within the MANTA system is as simple as possible. All the MANTA system ever does is supply power, not store it.

It is not uncommon for a fish farm barge to have a backup battery system for power storage, and also to prevent power outage in diesel generator failure circumstances. Therefore, MANTA could make use of existing infrastructure (batteries) to enable the easiest possible integration into the farm.

With regards to the cable routing from the MANTA system to the battery storage system, the cable could potential use the farms central mooring line as its support. The routing of power cable follows a tried and tested routing setup used by the feed systems, and the cage lights. If and when power cables may be installed, the cables will not be in contact with the seabed, due to the central grid line support.

URL : www.aquapowertech.com | Email : s.etherington@aquapowertech.com | Telephone : 01539 267 855
Office Address : Station Approach, Cark-in-Cartmel, Cumbria, LA11 7PT, United Kingdom

8.1 Float Detachment

If MANTA's float were to become detached from the Uig Bay grid mooring there are a two potential scenarios:

1. If the MANTA float becomes detached from the mooring grid with the MANTA converter still attached, the system would drift into the submerged mooring grid lines that surround the converters position (yellow circle). The tether that couples the MANTA converter to the float would then restrict the systems movements due to the submerged mooring grid line.

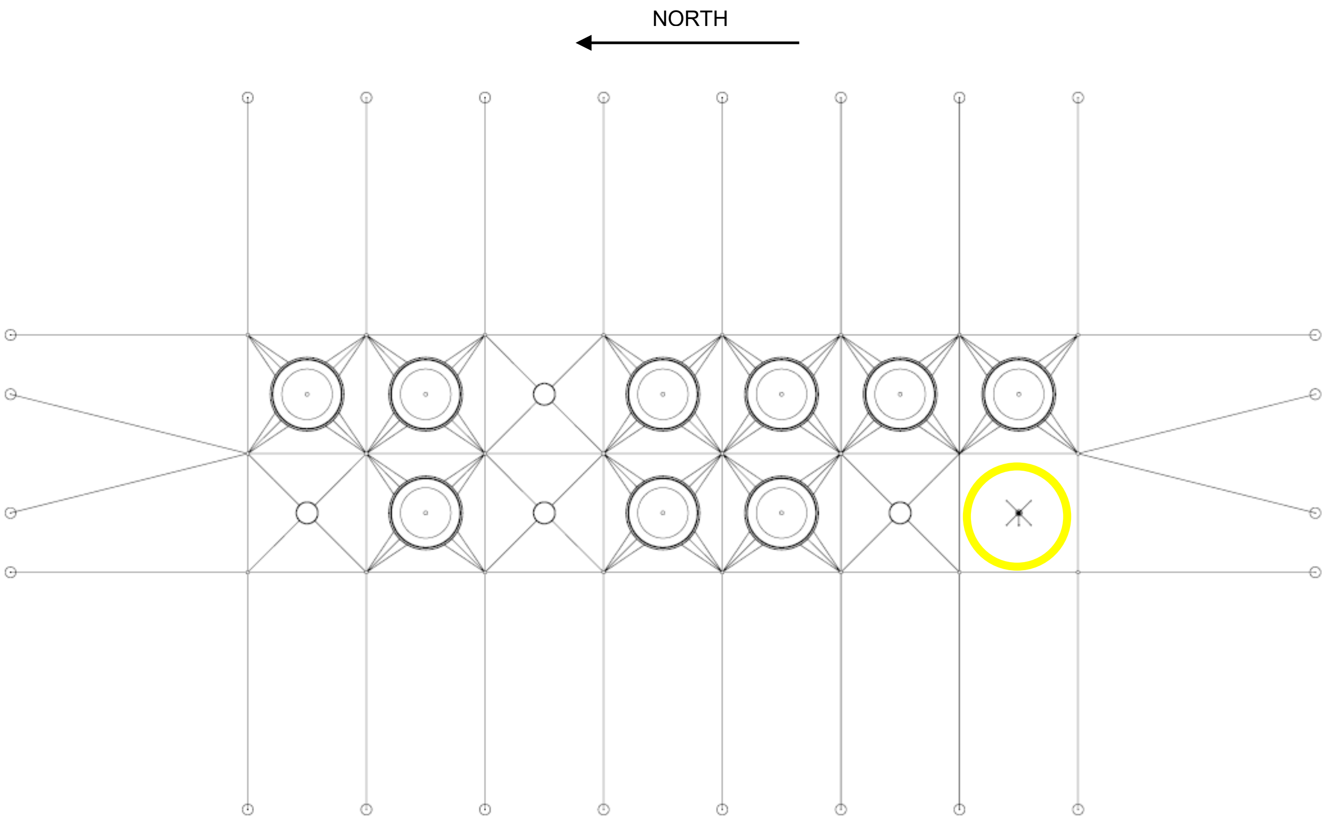

Figure 26 Representative Aerial View Of Uig Bay

2. In the unlikely event that the MANTA converters tether to the buoy breaks and the converter falls to the seabed, and the MANTA float breaks free from all four of its mooring grid bridles, the float would in essence be free to drift wherever.

   The predominant wave direction at the Uig Bay site is from the NNW to the SSW. If the buoy is free to drift, it is likely that the buoy would drift towards the shoreline on the North East.

   With regards to tidal current and float movements, it is likely that the buoy would remain in the Uig Bay area if the tide is flowing in. The float would likely drift with the current up towards the head of the Bay. If the tidal current is flowing out, it is likely the buoy would drift out into open water.

However, in the above scenarios, the monitoring systems would have raised alerts as the buoy would have travelled outside of its GPS fence. Since the monitoring system is updated every 0.1 seconds, an alert can be raised very quickly. Alerts can be sent as emails or texts to any number of recipients.

8.2 Required Vessels

MANTA is designed to be deployed using the standard issue catamaran workboats that are found at fish farms.

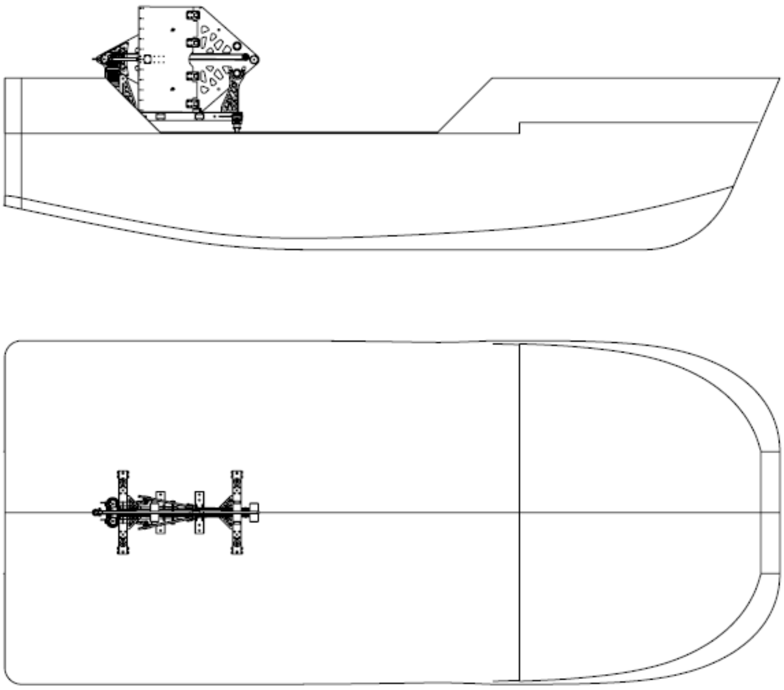

Figure 27 Scale Of MANTA On MacDuff Workboat

8.3 Monitoring System

The monitoring system is a system of nodes that provide the systems telemetry. The MANTA converter has two nodes, the MANTA float also has two nodes. If an issue were to occur with the converter (such as a leak/breakage from tether), the monitoring system would flag the fault. Likewise, if an issue occurred with the float, the monitoring system would log and flag the error.

For reference, the monitoring systems antenna are attached to the float