EVOPOD 1:10TH SCALE MOORING INSTALLATION AT RIA FORMOSA

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1 Introduction

The University of the Algarve (UAlg) wish to deploy Evopod 1kW Unit (E1) at the tidal site of Ria Formosa, a coastal lagoon protected by a multi-inlet barrier system located in southern Portugal (Algarve Region). The device will be used to assess energy extraction efficiency and eventual impacts that extracting energy from the flowing currents will have on the ecological communities and physical settings.

This document describes the mooring installation and the launch, tow-out and hook-up procedure.

2 General Characteristics

Evopod is a floating tethered tidal stream turbine. The device consists of a semi-submerged floating body supporting a single horizontal axis turbine. The diameter of the turbine on the 1/10th scale trial unit is 1.5 metres. The turbine is coupled to a 1kW generator.

Figure 1: Evopod ready for slip launching

The E1 unit is moored off to a midwater buoy by a yoke structure. The midwater buoy is spread moored in location by a four point catenary mooring system. Power is exported from the E1 unit into the midwater buoy and via an umbilical cable to the seabed. For the deployment in Ria Formosa the power export cable is deleted and instead the generated power is dumped into resistors inside E1's nacelle and the heat is dissipated into the sea. Figure 2 illustrates the main components.

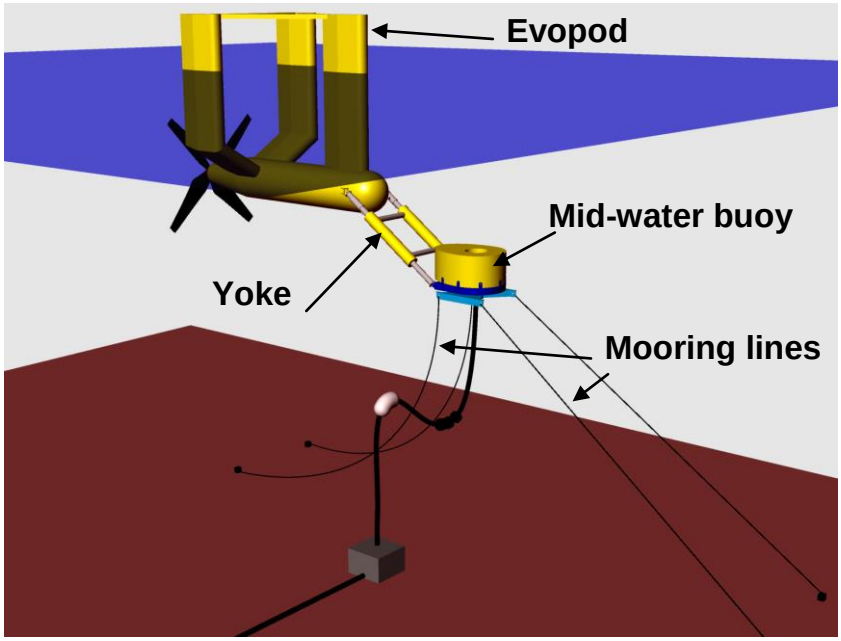

Figure 2: Evopod System

3 Mooring Location

The proposed location of the mooring at Ria Formosa is indicated by the red cross in Figure 3. The water depth reference level in Figures 3 and 4 is the hydrographic zero which is 2m less than the mean sea level.

Figure 3: Ria Formosa Sea Inlet

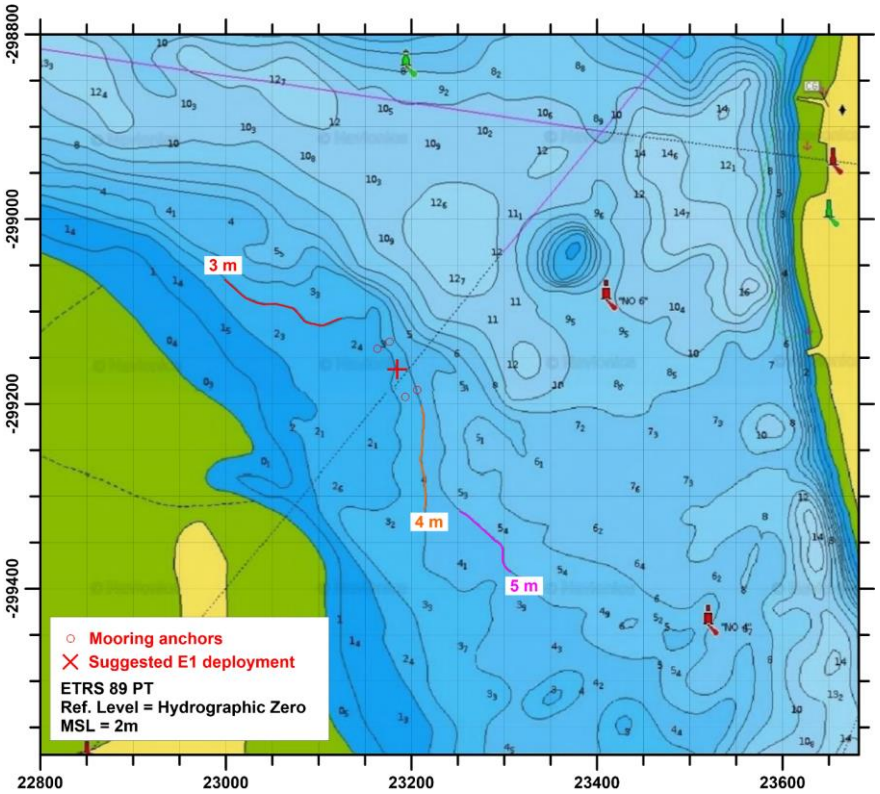

Figure 4: Ria Formosa channel showing E1 mooring location

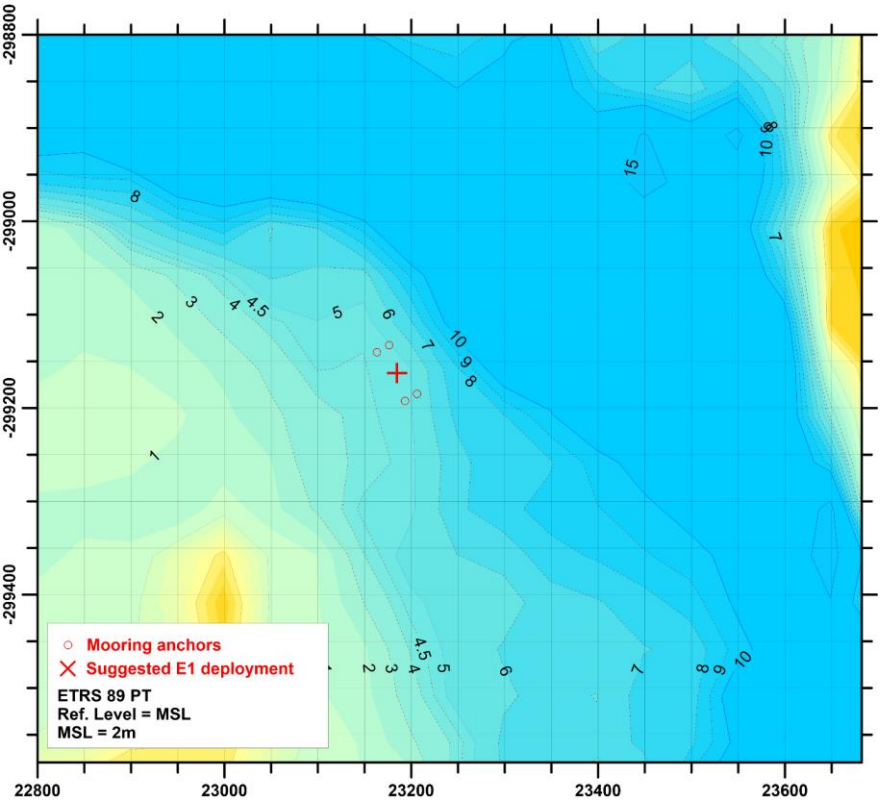

Figure 5: Bathymetric contours - reference level is Mean Sea Level

4 Water Depths

The mooring consists of a four point spread mooring with anchor locations roughly as shown by the red circles on Figure 4. The seabed over the mooring spread is not flat but is contoured as indicated by the MSL contour lines in Figure 4. The mean water depth at mid tide at the E1 moored location is approximately 5m MSL (3m Hydrographic Zero – Chart Datum)

The tidal range at Ria Formosa is as indicated in Table 1 below.

Table 1: Ria Formosa Tidal Range data

Maximum tidal range – Spring tides	3.5m
Minimum tidal range – Neap tides	1.1m

5 Tidal Flow Speeds

The anticipated flow speeds at the deployment site used for the design of the mooring system are:

Table 2: Tidal stream characteristics used in mooring design

Predicted spring tide peak flow	1.5m/s
Percentage time flow exceeds 0.7m/s	20%
Percentage time flow exceeds 1.75m/s	0%
Estimated wind induced surface current	0.2m/s
Extreme current speed for mooring design	1.7m/s

5 Wave Conditions

The Ria Formosa channel is sheltered from ocean wave systems. In addition the deployment is over the summer months only. Nevertheless the mooring location could experience fetch dependant waves generated by wind blowing over the inland water from the NW or NE directions (see Figure 3). Therefore in designing the mooring system the following wave conditions have been assessed.

Table 3: Wave characteristics used in mooring design

Wind direction	NE or NW
Wind speed	35km/hr (9.7m/s or 18.8knots)
Fetch	4km (2.2 nautical miles)
Hs	0.45m (1.5ft)
T1/3	2.6 sec
Tz	2.4 sec

6 Mooring System

The mooring system is to consist of chain and galvanised wire mooring lines attached to clump weight anchors.

The layout of the mooring spread is illustrated in Figure 6.

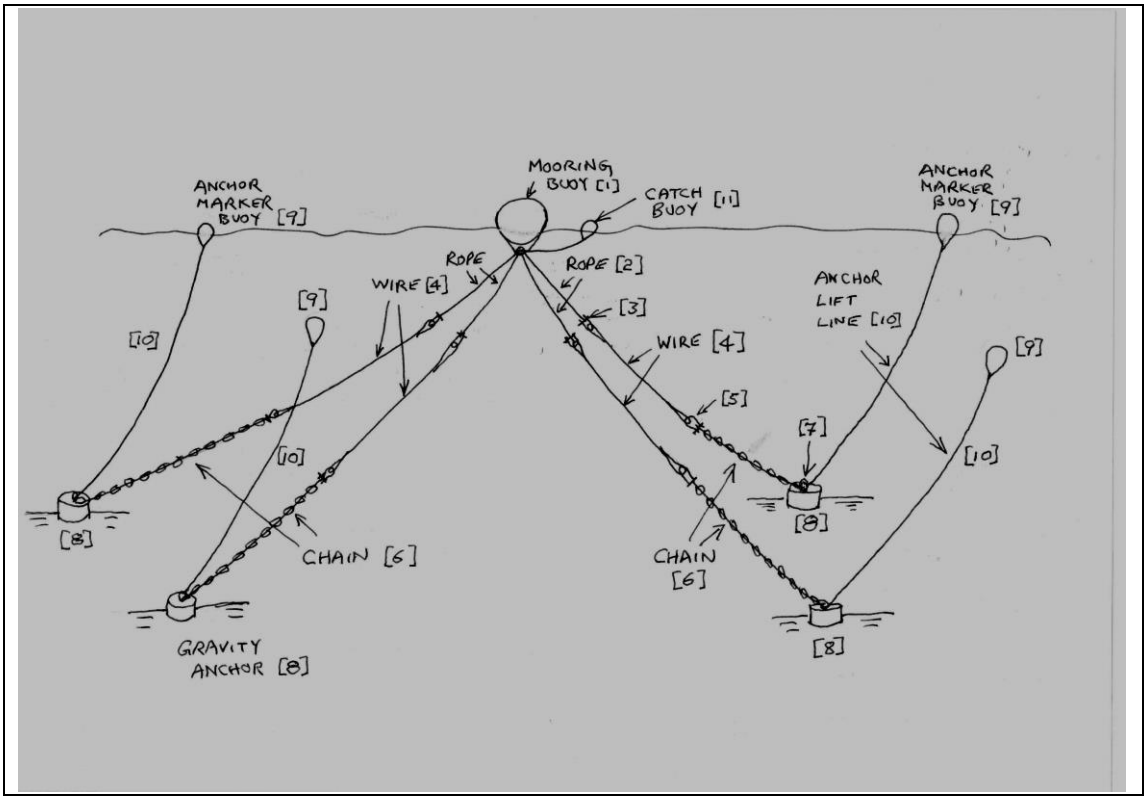

Figure 6: Mooring spread

Each leg of the 4 leg spread mooring is to consist of the items listed in Table 4.

Table 4: Mooring Components

Item No.	Description	Purpose	Specification
1	Mooring Buoy (1 only)	To support all four mooring lines where they come together for when E1 is not on its mooring	Circa 300 litre mooring buoy.
2	Tie-off line	For tying off the mooring lines to the Mooring Buoy	5m x 10mm nylon or polyester rope
3	D-shackle	Connecting E1 chain tails to wire rope [4]	11mm drop forged galvanised (SWL 1.5 tonnes).
4	Wire rope	Mid section of mooring	15m x 10mm 7-19 IWRC (independent wire rope strands and core) galvanised wire rope with hand spliced eyes fitted with galvanised thimbles at either end.
5	D-shackle	Connecting mooring line components [4] and [6]	11mm drop forged galvanised (SWL 1.5 tonnes).
6	Chain	Lower section of mooring	20m x 10mm short link galvanised MBL 4tonne
7	Bow-shackle	Connecting mooring chain to anchor	11mm drop forged galvanised (SWL 1.5 tonnes).
8	Gravity anchor	To anchor device	Clump weight having a weight in water of not less than 450kg.
9	Anchor Marker Buoy	To mark position of anchor lift line	20 litre pick-up buoy
10	Anchor lift line	To attach marker buoy to anchor and facilitate repositioning of the anchor	14mm nylon or polyester rope with a short length (1m) of 10mm chain connecting the line to the anchor and the other end tied off to the Anchor Marker Buoy. The Anchor Lift Line should be long enough to engage with a capstan or winch to lower and lift the anchor, but no longer than necessary otherwise it could foul boat propellers.
11	Catch Buoy	To facilitate pick-up of Mooring buoy	Small catch buoy (circa 10 litre) connected by a rope to the eye of the Mooring Buoy to facilitate picking up the Mooring Buoy when attached to E1's moorings
12	Chain	E1 chain tails for connecting E1 to the mooring lines	2m x 10mm short link galvanised MBL 4 tonnes

All items specified in Table 2 are to be procured, assembled and deployed by UAlg. Four (4) off of each item is required in order to make up the four line spread mooring with the exception of Item 1 – Mooring Buoy and Item 11 – Catch Buoy of which only one is required.

All shackles are to be protected from coming undone by plastic cable ties or monel seizing wire.

The galvanised wire used in the mooring lines is to have an eye splice made up at either end with a galvanised thimble fitted into the eye. The wire is to be hand spliced and not crimped as soft metal crimp fittings can suffer galvanic corrosion in sea water. If hand splicing is not available then multiple “bulldog” clips can be used.

Tags are to be attached to the eyes at the Mooring Buoy end of the wires to help identify the mooring line. A simple system is to use different numbers of tags to distinguish the mooring lines, e.g. SW - 1 tag / SE – 2 tags / NW – 3 tags / NE – 4 tags.

Clump weight anchors should be made of heavy material such as steel or concrete with steel punchings added to the mix to give a greater density. Suitable anchor can be made up of scrap railway wagon wheels which are circa 650mm to 750mm in diameter and 230kg to 300kg weight. Two such wheels tied together with chain will form a clump weight which is in excess of the minimum anchor weight requirement.

Item [12] – chain tails (4-off) are for connecting to E1’s midwater buoy to the mooring wires and are not part of the initial mooring installation. They are to be held in storage until required for E1 installation.

The anchor marker buoys and mooring buoy should be no smaller than the size specified to avoid being dragged under by the flow.

7 Navigation Aids

When deployed the device exhibits a yellow occult light flashing once every 5 seconds and visible to 2 nautical miles. The light operates off an internal battery which is charged by solar panels and by DC power from the tidal generator when the tide is flowing.

8 Installation of Moorings

The four point spread mooring is to be installed at the Ria Formosa test site prior to the deployment of E1 on its moorings.

The location of the four clump weight anchors is as given in Table 5. The labelling of the anchor positions is shown in Figure 7.

Table 5: Anchor Coordinates

Anchor	Eastings	Northings
South West - SW	23213.9	-299233.0
South East - SE	23226.2	-299224.4
North West - NW	23173.8	-299175.6
North East - NE	23186.1	-299167.0

The Anchor Marker Buoys are to be marked with the lettering SW, SE, NW and NE for identification once in the water.

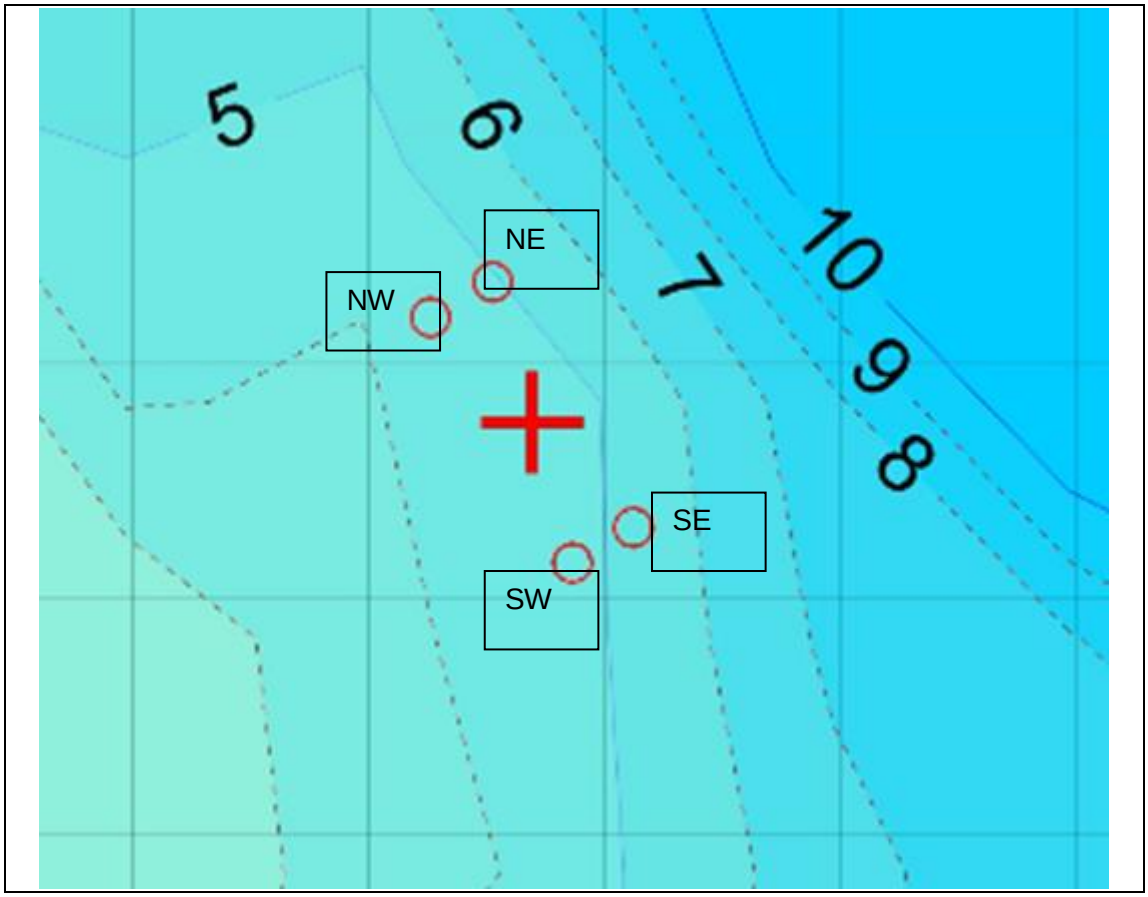

Figure 7: Anchor point labelling

The proposed mooring installation methodology is detailed below. The mooring installation is to be carried out by an Anchor Deployment Workboat (ADW) with a Rigid Inflatable Boat (RIB) in support.

i. The mooring lines are to be made up and attached to the clump weight anchors. Only the lower chain and wire is to be attached to the anchor. A further 5m of 10mm nylon or polyester rope (Tie-off Line) is to be tied to the upper end of the wire rope. This 5m of rope is for tying off the mooring line to the Mooring Buoy. [When E1 is deployed on its moorings it will be connected directly to the wire mooring lines and the tie-off lines will be removed.]

ii. The ADW is to arrive at site during a period of neap tides before low water slack and, using the Anchor Lift Line, is to lower the SE clump weight anchor with mooring chain and wire attached at the required coordinates. The Anchor Lift Line is buoyed off with the Anchor Marker Buoy and released. The free end of the mooring line is passed to the RIB which holds station.

iii. The ADW next lowers the SW clump weight anchor with mooring chain and wire attached at the required coordinates. The Anchor Lift Line is buoyed off with the Anchor Marker Buoy and released.

iv. The RIB passes the free end of the SE mooring line back to the ADW. The 5m rope Tie-off Lines that are attached to the free end of the SE and SW

mooring lines are tied off to a shackle in the base of the large Mooring Buoy. The Mooring Buoy can now be released.

v. The ADW next lowers the NE clump weight anchor with mooring chain and wire attached at the required coordinates. The Anchor Lift Line is buoyed off with the Anchor Marker Buoy and released. The free end of the mooring line is passed to the RIB which holds station.

vi. The ADW next lowers the NW clump weight anchor with mooring chain and wire attached at the required coordinates. The Anchor Lift Line is buoyed off with the Anchor Marker Buoy and released.

vii. The RIB passes the free end of the NE mooring line back to the ADW.

viii. The ADW motors against the incoming tide towards the Mooring Buoy, picks up the Mooring Buoy and attaches the NE and NW mooring lines to the buoy using the Tie-off lines.

ix. The Mooring Buoy, now has all four mooring lines attached, is released.