Proving a robust approach to assess bio-physical interactions with floating tidal turbines

Blog on data collection in the Fall of Warness

Characterised by their ever-changing yet predictable nature, tidal currents provide a reliable renewable energy source and also present a great opportunity to observe patterns and processes in our most dynamic coastal seas. However, working in these harshest of environments, using an orchestra of ocean observing instruments, can be a real challenge. In this blog, I'll try to give you a flavour of what it is like to plan and implement the collection of real-world data that can help us to better understand the dynamic flows and marine fauna distributions in these energetic environments.

What did we try to do?

This study was based on some previous work where we noticed that wake signatures from both tidal energy structures and natural features (e.g. islands), may not only change the downstream flow, but can also generate predictable foraging opportunities for marine fauna (see articles in *the Conversation* here and here). Specifically, we used aerial drones to track seabirds and near-surface turbulence features in combination with *in situ* water column measurements to visualise wake features. **In this study, we put our methods to the test: around the world's most powerful tidal turbine, the O2 (Orbital Marine Power; 2MW), installed in the tidal stream of the Fall of Warness, Orkney, Scotland.** However, this time, and with the help of this Supergen ECR fund, I was able to gather a larger, multidisciplinary team to look at every aspect above and below the water surface - a fantastic team with expertise in fisheries science, ecology and physical oceanography. We set out to map the dynamic and powerful currents in the Fall of Warness using current profilers (ADCPs) and aerial drones. We also deployed a fisheries echosounder to quantify fish as well as turbulence features (e.g. upwelling boils or regions of bubble entrainment), such as the wake of the O2 tidal turbine. And last but not least, we collected sightings on marine fauna foraging distributions.

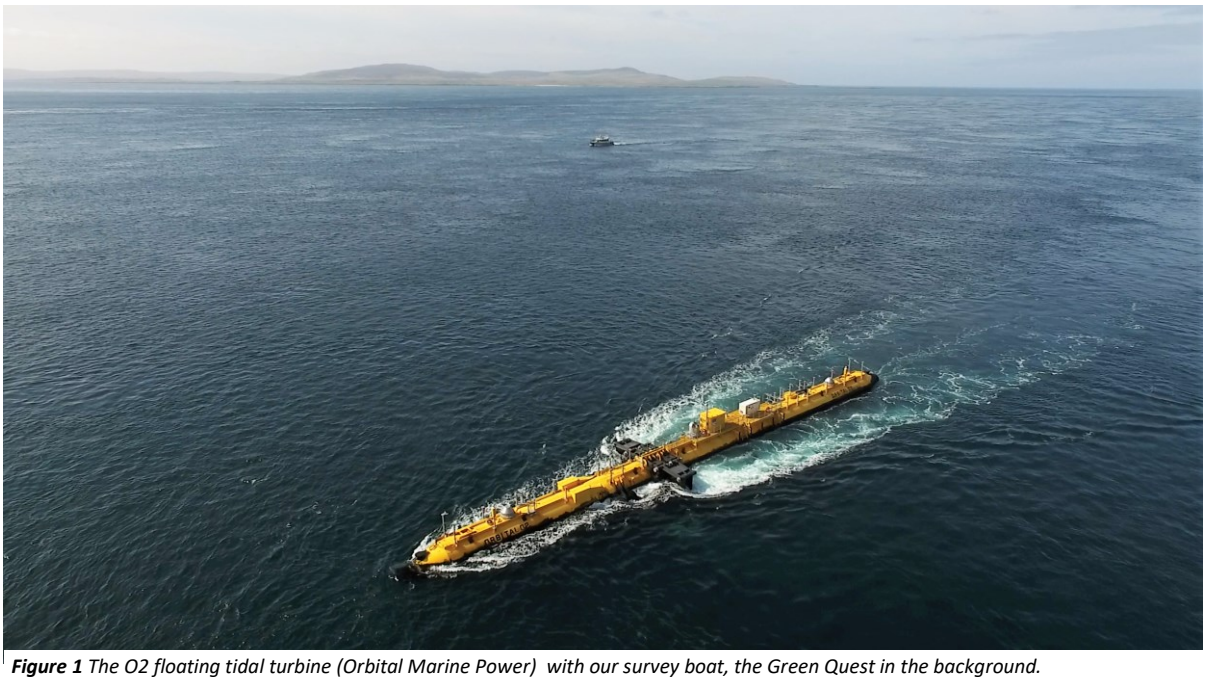

Figure 1 *The O2 floating tidal turbine (Orbital Marine Power) with our survey boat, the Green Quest in the background.*

Where did our data collection campaign take us?

The Fall of Warness tidal stream lies to the west of the island of Eday, approximately 20 Km north of Kirkwall, Orkney. The site experiences current speeds exceeding 4 meters per second during spring tides and here, EMEC's tidal test site provides eight grid-connected test berths for various tidal energy developers. This is where the O2 is installed, a floating tidal turbine that, unlike more conventional seabed-mounted turbines, generates power from the stronger currents close to the sea surface (away from the benthic boundary layer). However, ADCPs

mounted either on or near the O2 structure to measure current velocities cannot provide accurate measures of flow velocities and associated turbulence very close to the water surface and they can't give you a measure of the spatial variation in flows across the turbine. This is particularly important in the case of the O2: the 74 m-long steel hull body has turbine arms extending over 10 m to either side of the hull. Our proposed data collection, using a combination of aerial drones and ADCP transects was therefore aimed to address these knowledge gaps in realistic tidal flows, providing industry-relevant data to accelerate the optimisation of tidal energy generation.

Our characterisation of the flows was aimed to provide direct engineering insight for the assessment of device performance, array spacing as well as environmental assessments - a great example of an Industry-Academia collaboration.

Figure 2 (left to right): *Day of mobilisation and getting to the Green Quest anchored in Stromness; mounting the echosounder on the moonpool pole; mounting the ADCP on the side pole; deploying the side pole on-site.*

Survey planning: behind the scenes

The first step of the field work preparations was to find a suitable window for data collection to cover spring tides. Of course one thing you can not plan for weeks in advance is: the weather! This is why we wanted to plan in a 10-day window to collect the data, giving us flexibility on the days we go out as this was important for the drone surveys that rely on winds <20 knots. However, these plans were abandoned during the boat procurement. We now agreed to run the 5 survey days consecutively (fingers immensely crossed!). Weeks before the field work, we carefully filled in and signed all risk assessments, from the University, EMEC, the boat (The Green Quest, Green Marine UK) and of course the drone site surveys and risk assessments. All slightly different, but what they all had in common was to wear suitable protective clothing (PPE) and to not get in the way when poles were mounted into the water when at-site.

Having never worked in that site before, nor having seen the boat until a week before the surveys, we had to get our creative hats on and make sure that mounting brackets, cable lengths and everything else would be suitable on the day of mobilisation (time is money!). We also had to design our surveys and providing lat/long positions for the skipper along with a good briefing can save you a lot of headache. Designing the drone surveys beforehand using different alignments with the flows also proved worthwhile. We even created our own NOTAM – a notice to airmen as the airspace turned out to be trialled for drone deliveries (airmail) operated by Windracers Ltd. And last but not least, permits to survey the Fall of Warness were needed along with text messages of entering and leaving site on a daily basis, this was all facilitated by EMEC. Another key thing was to stay in good communications with Orbital who also advised us on minimal distances to the O2 when measuring the inflow and downstream wake. When mobilisation was complete, all was in place and we headed to the Fall of Warness on that first day, I couldn't help but feeling relieved and grateful for such a great team and crew. That moment when you start pinging your acoustic instruments (the ADCP and the echosounder) after frantically trying to get a GPS signal, is….priceless. And to top it all off, just when flying our very first drone survey, the team shouted: "ORCAS"! Seriously, these are the perks of field work! However, we kept our cool and resisted aborting the drone mission and later realised that we still caught a glimpse of them at the edge of our drone's field of view. Looking back this still makes me smile.

Figure 3 (left to right): *Glimpse of one of the orcas passing below our drone hover when mapping surface currents; Shaun Fraser operating the echosounder; James Waggitt ready for marine fauna visual surveys; Catherine Tait helping with visual surveys on the bad weather day.*

The next day, our first full survey day, everything went to plan and we ran our small-scale transects around the O2. Looking at the acoustic signatures of the wake, we started to notice the influence of the large-scale shear lines though and our oceanographic curiosity was piqued! On the third day, the weather changed and we knew we could not fly the drone. Therefore, sitting over that field work pint the night before in the skipper's bar in Kirkwall, we came up with an adapted methodology for the two bad-weather days we were expecting. Instead of continuing with the small-scale transects, we wanted to better understand the shear flows on the edges of the main channel and quickly started to design a new set of transect lines that would cross the most interesting hydrodynamics. The next two days we therefore crossed the entire width of the Fall of Warness, covering all tidal states, which provided us with that insight on the flow dynamics we needed to put the O2 into context. As if we got rewarded with bracing the rough seas for two days and sticking with it, the final day of data collection turned out to be ideal again for our small-scale transects and drone flying. That's a wrap.

Here, I'd like to thank my fantastic collaborators for being so switched on, enthusiastic and fun to work with, namely Alex Nimmo-Smith (Plymouth University), Shaun Fraser (UHI Shetland) and James Waggitt (Bangor University).

Figure 4 (left to right): *Demobilisation; gathering around the echosounder real-time display; myself (Lilian Lieber).*

I'd also like to highlight the invaluable support provided by EMEC for facilitating this field work and providing funding for the boat, as well as for Ana Couto and Catherine Tait (EMEC) for not only joining us on the boat, but also for offering their hands & eyes during the surveys. I believe our survey provided a great platform for knowledge exchange, information sharing and industry-academia collaboration. I'd also like to thank the great skipper(s) and crew onboard the Green Quest, their expertise of the site was much appreciated and the neatness of the transect lines across the strong tidal flows speaks for itself.

Lastly, I am grateful for the Supergen ORE Hub and the EPSRC for the award of this ECR grant and the opportunities it brought. From sketching out ideas to finding ways to implement a study such as this, I embraced the whole endeavour. I also hope that this encourages more women to work in STEM: Working in ocean energy can mean you may be the only woman on-board, but I hope that sharing my experiences here will encourage others to follow through with their career paths, too.