Programme Area: Marine

Project: ReDAPT

Title: Antifouling Systems for Tidal Energy Devices

Context:

One of the key developments of the marine energy industry in the UK is the demonstration of near commercial scale devices in real sea conditions and the collection of performance and environmental data to inform permitting and licensing processes. The ETI's ReDAPT (Reliable Data Acquisition Platform for Tidal) project saw an innovative 1MW buoyant tidal generator installed at the European Marine Energy Centre (EMEC) in Orkney in January 2013. With an ETI investment of £12.6m, the project involved Alstom, E.ON, EDF, DNV GL, Plymouth Marine Laboratory (PML), EMEC and the University of Edinburgh. The project demonstrated the performance of the tidal generator in different operational conditions, aiming to increase public and industry confidence in tidal turbine technologies by providing a wide range of environmental impact and performance information, as well as demonstrating a new, reliable turbine design.

Work Package ME8: Antifouling systems for tidal energy devices

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Work Package ME8: Anti fouling systems for tidal energy devices

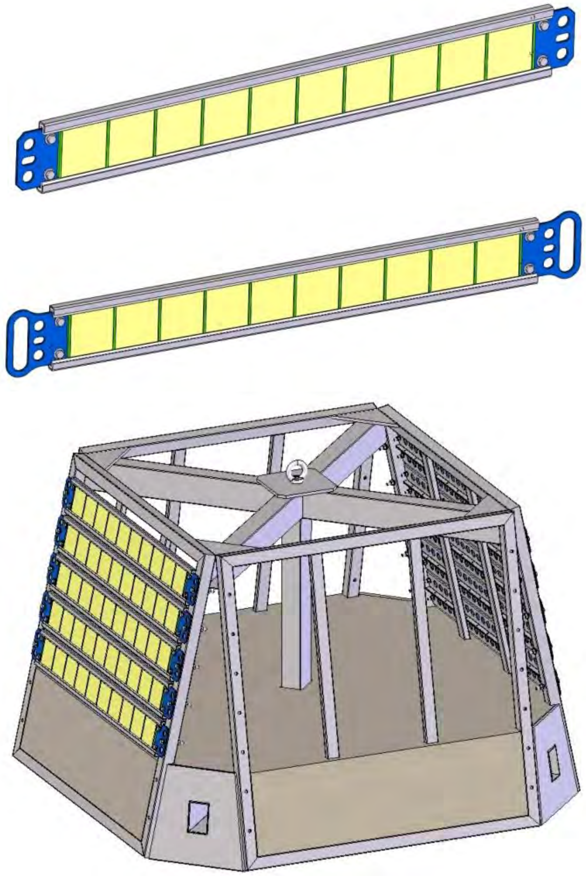
1. To develop a protocol for identifying optimum anti-fouling systems (biofouling management) for tidal and wave energy devices and critical associated infrastructure (ME8.1)
2. Technical literature review and consultation with device developers (ME8.2)
3. Development of experimental design, construction and deployment of test arrays (ME8.3)
4. Deploy arrays, monitor biofouling (ME8.4)
5. Synthesis of results & report (ME8.5)

Broad Aims

- Develop an experimental design and infrastructure to secure statistically robust outcome
- Characterised fouling potential at the site
- Identify leading coatings products and assess their performance and robustness
- Develop recommendations for optimum protocol for biofouling management and selecting antifouling coatings
- Ultimately to help to de-risk and improve reliability of renewable energy devices

Design Stage

- Design stage critical:
  - How to mount & demount panels on the turbine
  - Experimental design e.g. statistical replication, redundancy etc.
  - Minimising risk of lost experiments – losing panels, pods etc
  - Safety



Coating Test List

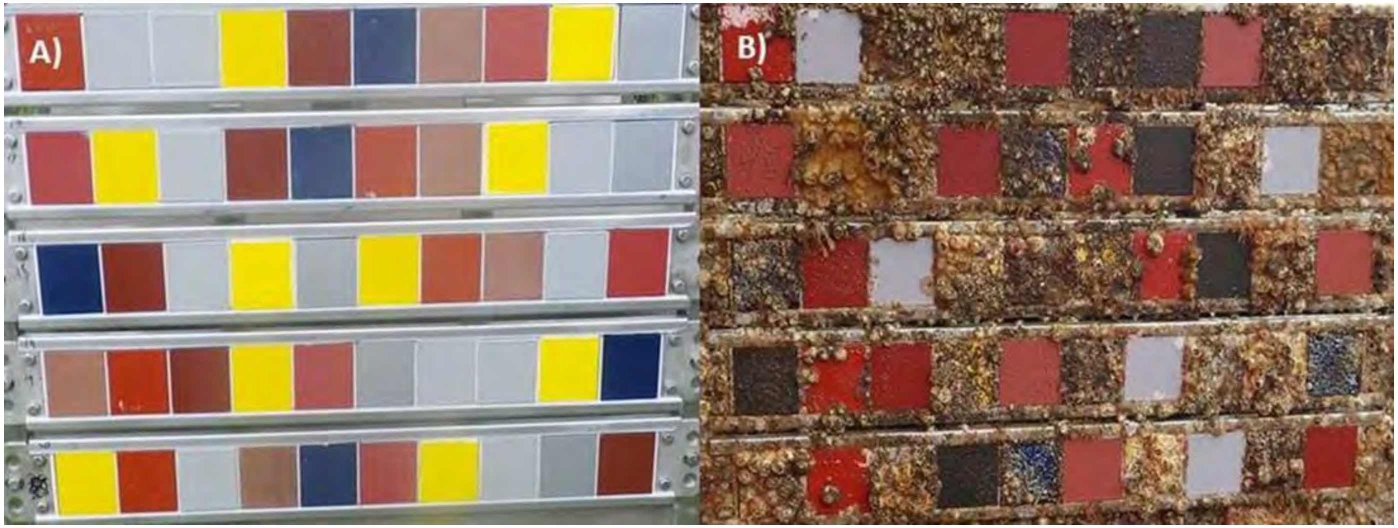
- Range of antifouling and protective coatings
- Includes biocidal, FRC and epoxy based technologies
- Applicable to different components, materials and budgets.

Manufacturer	Brand	Technology Type	Anticorrosive (DFT info supplied by manufacturer)	Tie Coat	Top Coat (DFT info supplied by manufacturer)	Pre-test Total Dry Film Thickness	Notes
Hempel	Hempasil	Fouling Release	Multi-strength 457751-12340 (DFT 250µm)	Nexus 27302-55001	Hempasil Topcoat	~1000µm	Manufacturer applied
International	Not supplied	Fouling Release	Aluminium pure epoxy (150µm x 2 coatings)	Silicone Tie coat 100µm	Flouropolymer Antifouling 150µm	~550 µm	Manufacturer applied
Coppercoat	Coppercoat	Biocidal copper filled epoxy resin	GP120 (DFT 250-300µm)	N/A	Coppercoat (DFT 250 – 300µm)	~350µm	Manufacturer applied
Jotun	Seaquantum Ultra	Self polishing biocidal	Jotamastic 87	Safeguard Universal AS	Seaquantum Ultra	~600µm	Manufacturer applied
International	Not supplied	Not supplied	Not supplied	Not supplied	Not supplied	~550 µm	Manufacturer applied
Plastimo	Plastimo Classic	Self polishing biocidal	Primocon (see below for details)	N/A	Plastimo Classic	~180µm	User Applied
International	Interzone 954	Epoxy	N/A	N/A	Interzone 954	N/A	User Applied
Jotun	Baltoflake Ecolife	styrene free, glass flake reinforced polyester	Jotamastic 87	Safeguard Universal AS	Baltoflake Ecolife	~1200µm	Manufacturer applied
Ecospeed	Ecospeed	Vinyl ester resin base, reinforced with glass platelets	N/A	N/A	Ecospeed (DFT 500µm x2 layers)	~1300µm	Manufacturer applied
International	Primocon	Tar free quick drying primer	This product is an anticorrosive primer and was used as a control coating.	N/A	Primocon	~150µm	User Applied

Approach 2012

- Two seabed pods deployed 200m from turbine test site – 28.05.12
  - Each pod roughly 1.3 metres cubed
  - 3.5 tonnes concrete in each pod
  - 2 panel arrays of 5 panel holders each with 10 panels
- Panels fitted to turbine - summer 2012
  - 6 panel arrays of 5 panel holders each with 10 panels

Results: Seabed pod panels May 2014 - 24 months



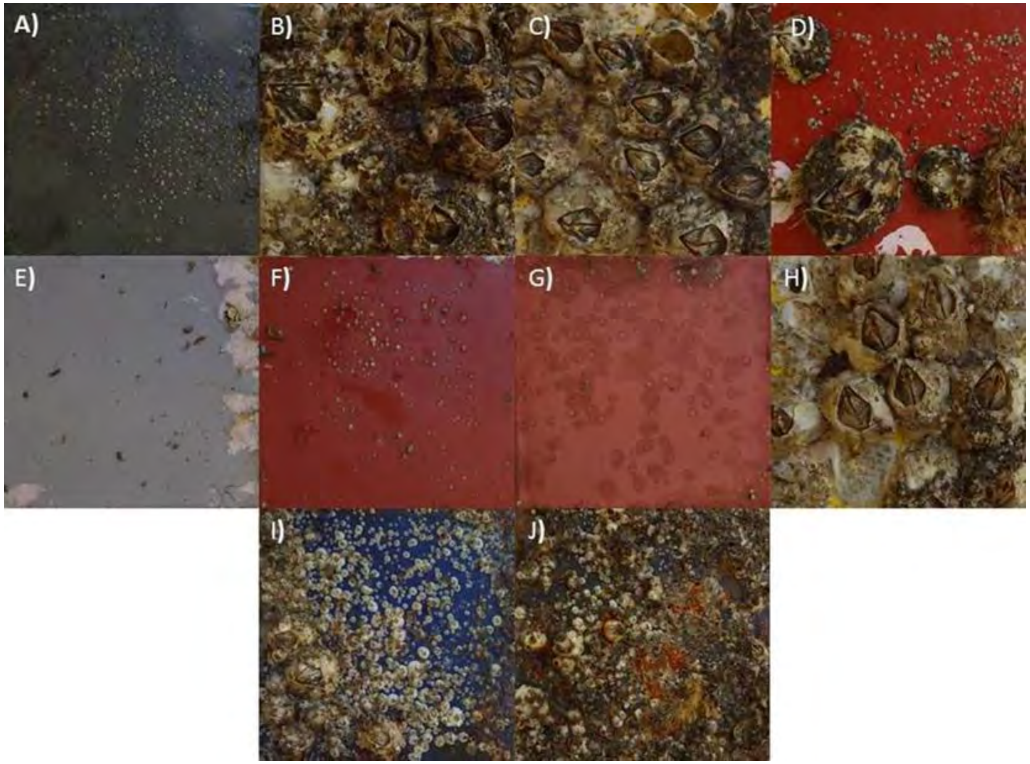
- Rig intact and all panels recovered
- Clear difference in performance
- Consistent pattern between replicates

Results: Seabed pod panels May 2014 - 24 months

- Fouling assemblage dominated by calcareous species, notably *Chirona hameri*
- Significant damage to coatings caused by growth of individuals

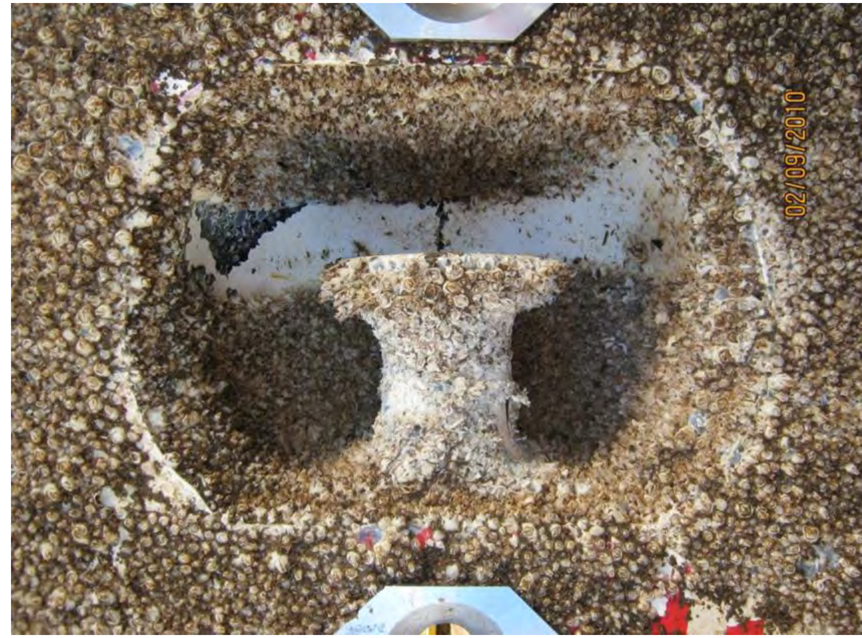
Chirona hameri on FRC coating after 24 months

Results: Seabed pod panels May 2014 - 24 months



Representative image of the extent of biofouling due to panel coating type. Panel material: A) Coppercoat, B) Ecospeed, C) GRP, D) Hempel Red, E) International Grey, F) International Red, G) Jotun Red, H) Jotun Yellow, I) Pastimo AF and J) Primacon.

Niche areas



Niche area biofouling

- After 8 weeks – camera lens covered in barnacles
- Critical retrieval point becoming blocked (non turbine)
- Sensor performance - ADCPs

Results: Seabed pod panels 24 months – Hydrodynamic Drag

- Considerable "roughness" or hydrodynamic drag penalty caused by hard fouling assemblage of this size and complexity

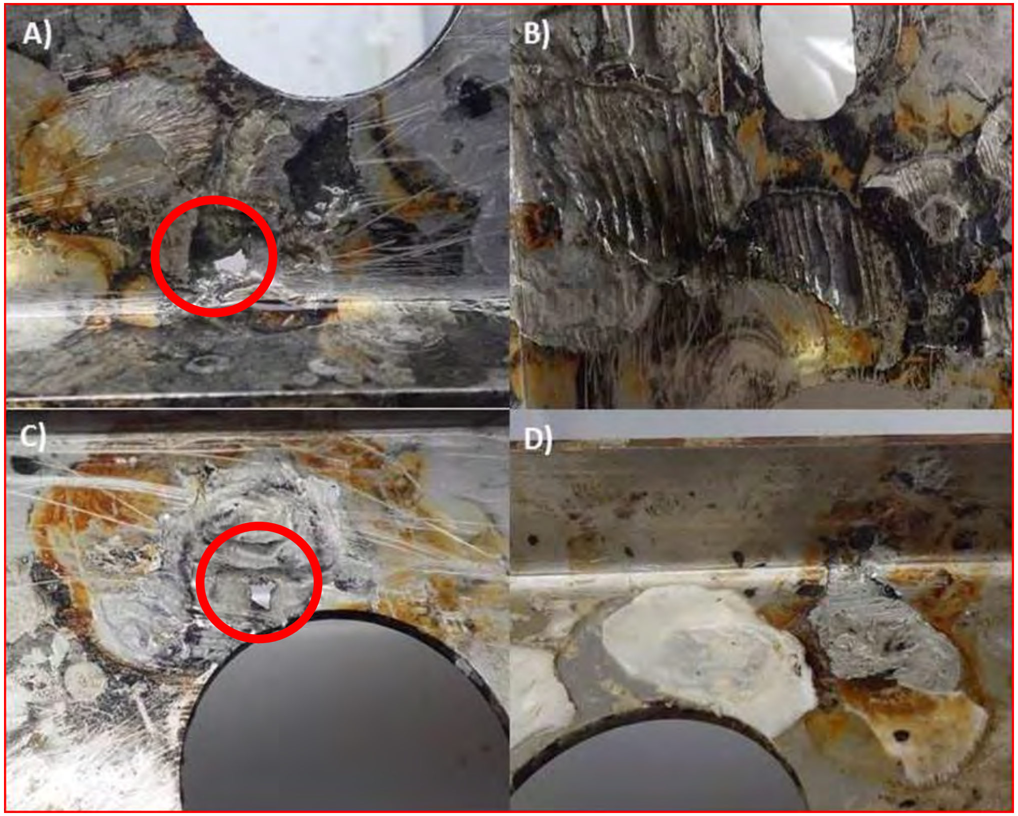
- Implications for energy conversion potential over time

- Investigating with PhD:

  - Combine with CFD models to scale effects
  - Predictive tool – differentiate between fouling penalty and other issues

Results: Seabed pod panels 24 months - Corrosion

Pit corrosion on 5mm thick 316 marine grade stainless steel after a 24 month exposure in the tidal stream.

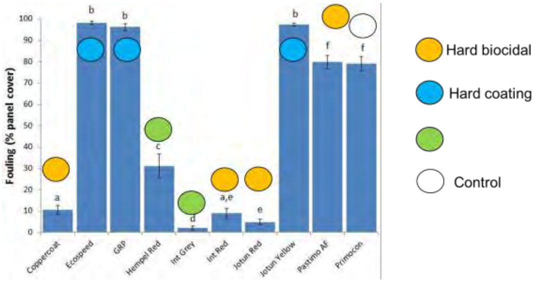


- Holes in 5mm & 6mm thick marine grade 316 SS after 2 years
- Approx 3mm loss per year – (Conservative estimate due to barnacle growth not being significant until second year)
- More likely to be …..4mm (or possibly even 5) per year?!
- Bio-corrosion requires more research

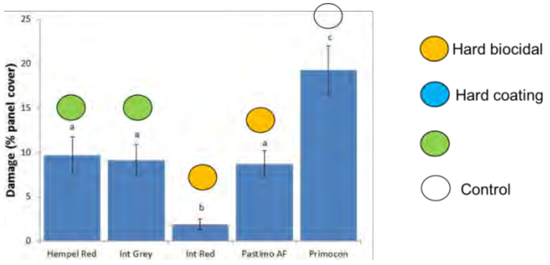
ReDAPT

Results: Which coating?

- FRCs very good until mechanical damage occurs - conflict with other reports of FRC performance
- FRCs for niche areas, new technologies.
- Hard epoxy coatings fouled readily, but can be cleaned and resist corrosion damage
- Hard biocidal (SPC) coatings appear best overall, but longevity is not clear – further testing underway
- Hard biocidal coatings designed for 5 year cycle on commercial vessels, not 7+ years in a tidal stream!
- No silver bullet. Match coating to application - selection guide in final ME8.5 report



Antifouling performance



Damage resistance

Achievements

- Characterised fouling potential at the site.
- Biofouling needs consideration from design stage
- Highlighted coating selection requirement
- Niche areas awareness - instrument susceptibility
- **Big step forward to de-risk and improve reliability of renewable energy devices.**

Take Home Messages & Lessons Learned

- Increasing scrutiny of biosecurity risks and hence infrastructure movements
- As industry moves from prototype to arrays, device reliability, asset maintenance and biofouling management will become critical.
- Consider biofouling from the design stage!
  - Conduct a desk based review to identify high risk areas or processes
  - Consider what each component requires for biofouling management
  - Are active antifouling methods suitable and compatible with coating systems?
  - Budget for biofouling management with coating compatible methods

Next Steps

- Reach a coating testing period that matches maintenance schedule aspirations for tidal turbines, 5 – 7 years (EDF funded 3 year extension to ReDAPT testing at EMEC)
- Investigate combinations of active and coating based antifouling for niche areas. Electro-chlorination, U.V., Ultrasonic etc.
- Research and characterise drag penalties from biofouling assemblages.
- Fully understand corrosion mechanisms – design specifications
- Work on optimum cleaning schedules and procedures to minimise drag without damaging coatings.

Further Information

- Please see ME8.5 Report (http://www.eti.co.uk/project/redapt/) or call us on 01752 633412 or e-mail Dr Tom Vance on thva@pml.ac.uk

Thank you for listening. Any questions?

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