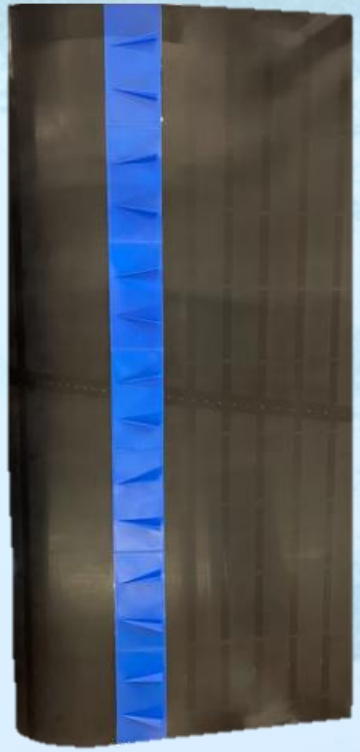
Project: From the Wind to the Tide

Modelling tidal turbine biofouling effects in a Wind Tunnel



Funded by Research Wales Innovation through Swansea University

Partnering with Sustainable Marine Energy Ltd and Plymouth Marine Laboratory

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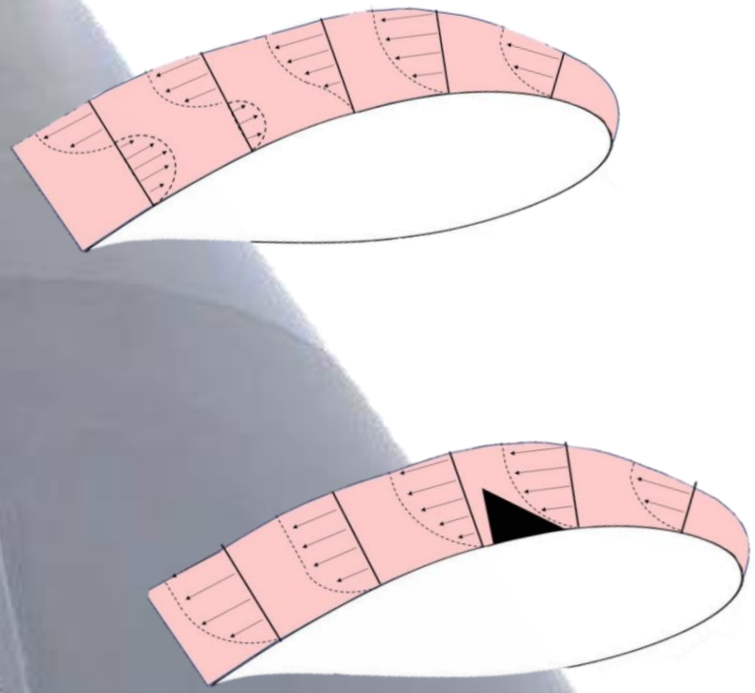
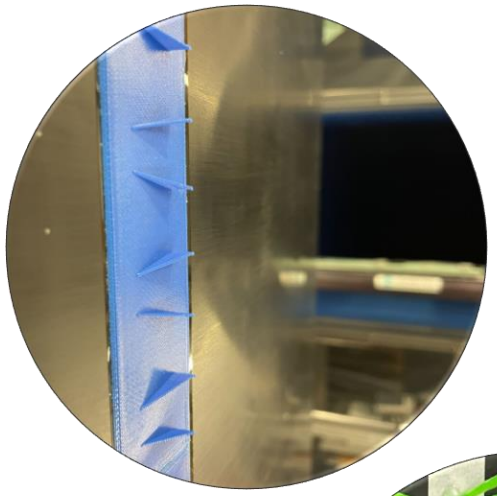
Biofouling

- Accumulation of organisms on submerged surfaces
- Disturbs flow around surface
- Detrimental to hydrodynamic performance
- Shown to degrade performance up to 43% [1]

Vortex Generators



- Well known for flow separation control by generation of vortices
- Common retrofit for large wind turbine blades
- Counteracts negative effects on performance from surface roughness
- Recent tests on tidal turbines profiles



Scope

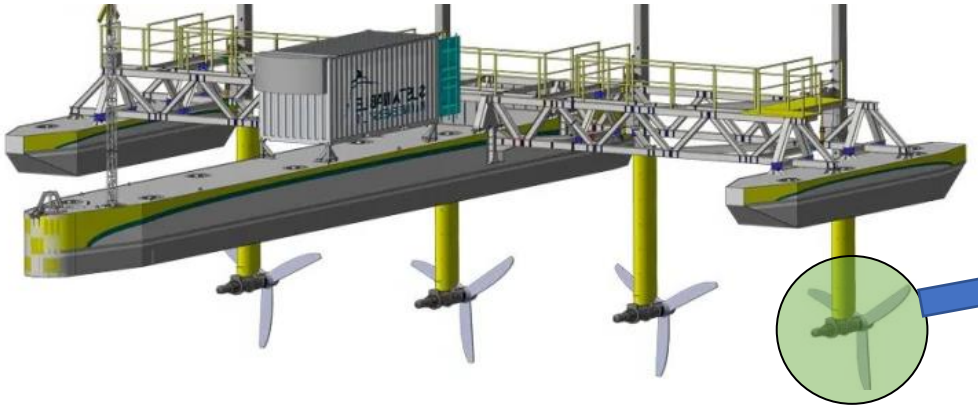
- Modelling of biofouling in a wind tunnel
- Design and 3D print Vortex Generators (VGs)
- Wind tunnel testing with force balance measurements

Objective: Model the effect of biofouling and examine the possibility of flow control with VGs

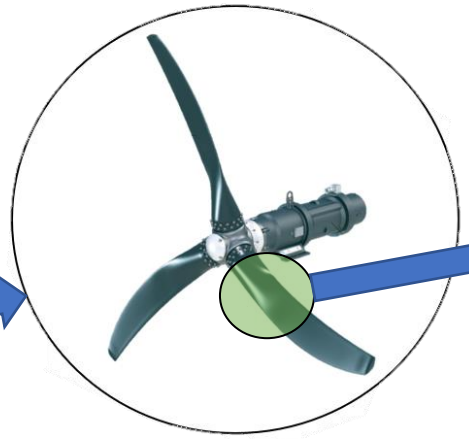
The Case

Sustainable Marine Energy

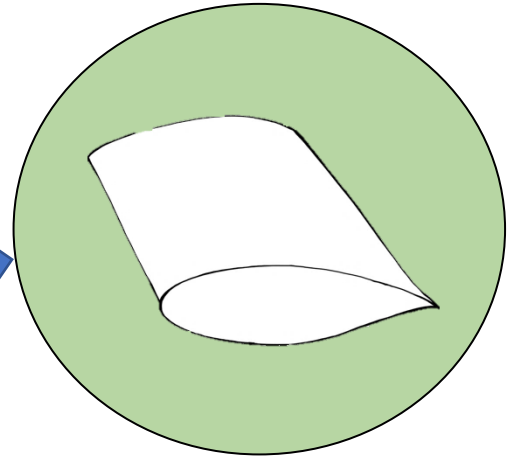
SME PLAT-I Platform



SIT250 – Schottel Instream Turbine



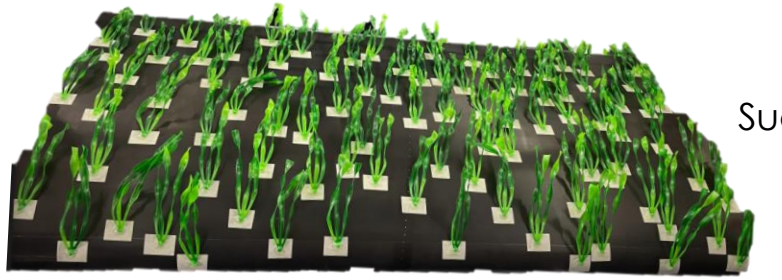
*20% hydrofoil located near the root**



* 20% hydrofoil profile not shown due to confidentiality reasons

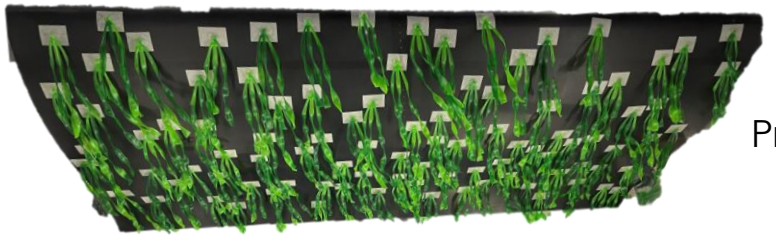
Biofouling Modelling

Trailing Edge



Suction Side

Leading Edge



Pressure Side

Trailing Edge

Sample provided by Plymouth Marine Laboratory

Filamentous green algae

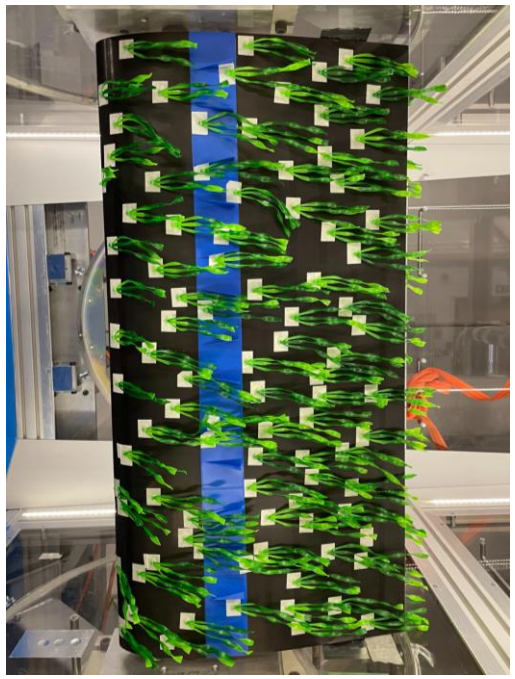
Artificial specimen tested

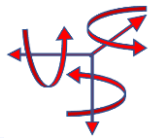
Experimental Method

- Cases tested:
  - Baseline
  - Bio-fouled profile
  - Bio-fouled profile with VGs
  - VGs
- Optimum VG in terms of L/D improvement chosen: Scaled up to h = 4%c

Wind Tunnel Measurements

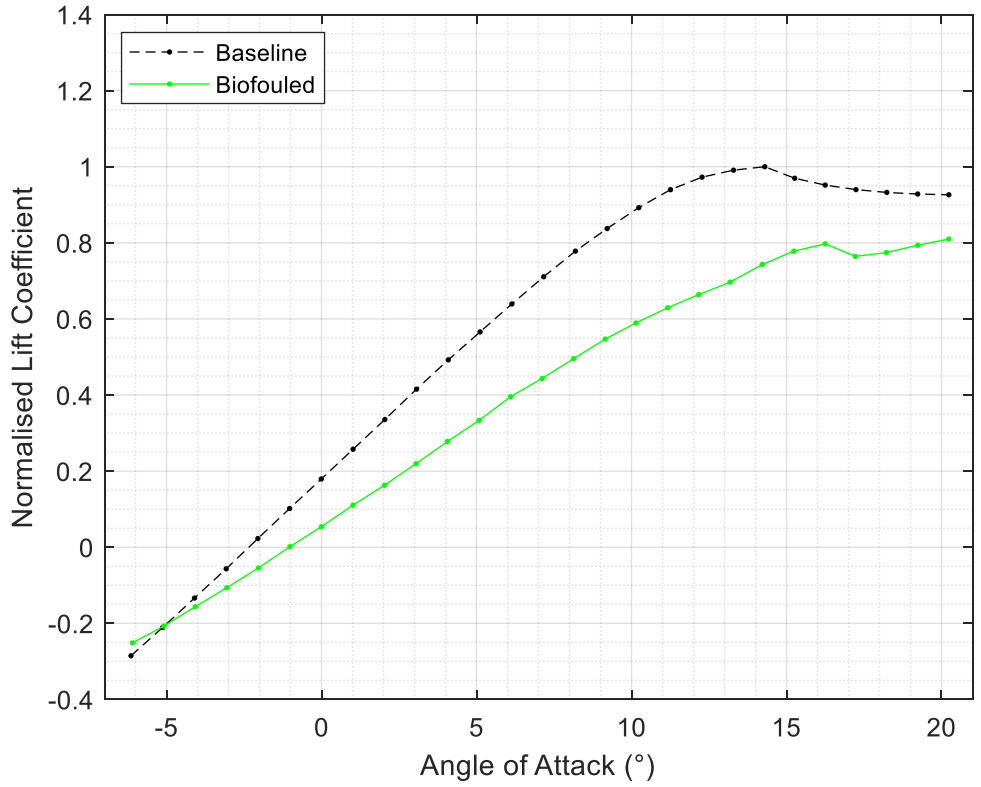
V∞





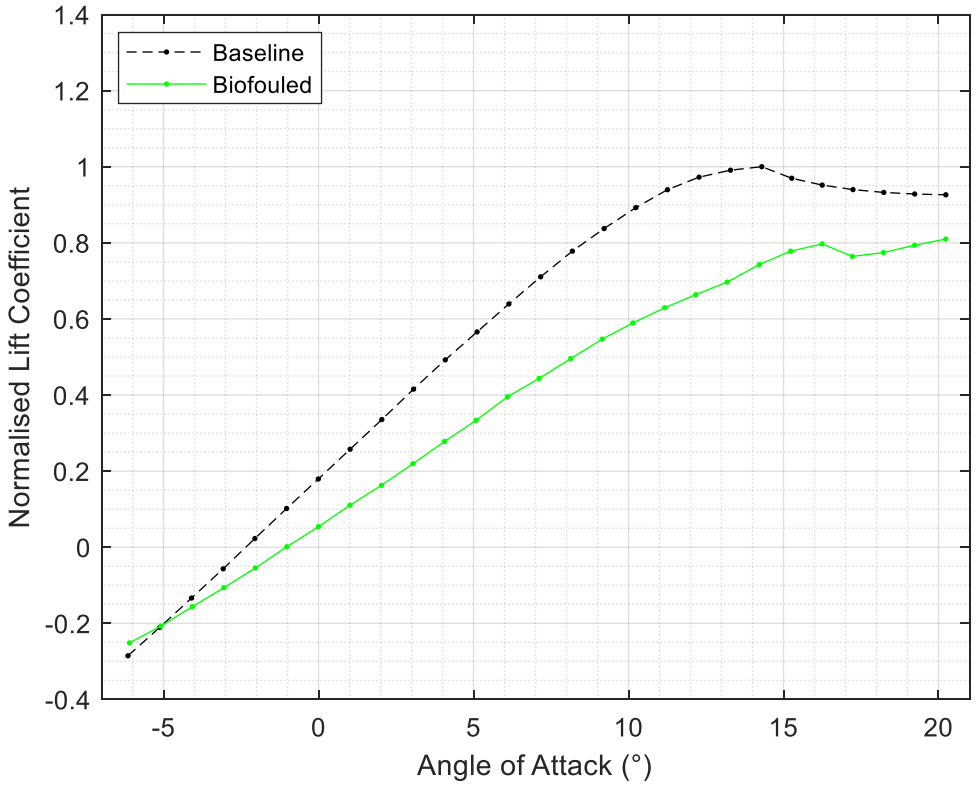
- Forces and moments measured with balance scales either side of the wind tunnel
- Forces resolved to calculate lift and drag
- Test conducted at a Reynolds number of 1 Million

Results – Biofouling

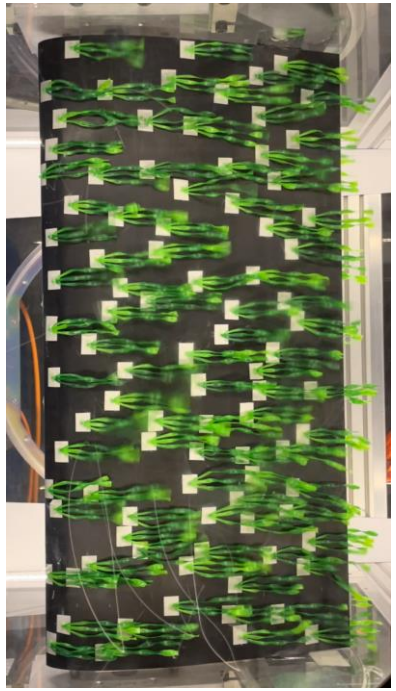


- Lift reduction with lower gradient in linear region
- Maximum lift reduced by 20%
- Stall delayed by 2°

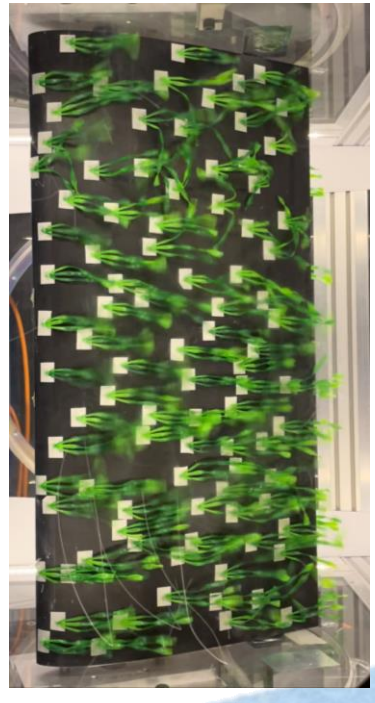
Results – Biofouling



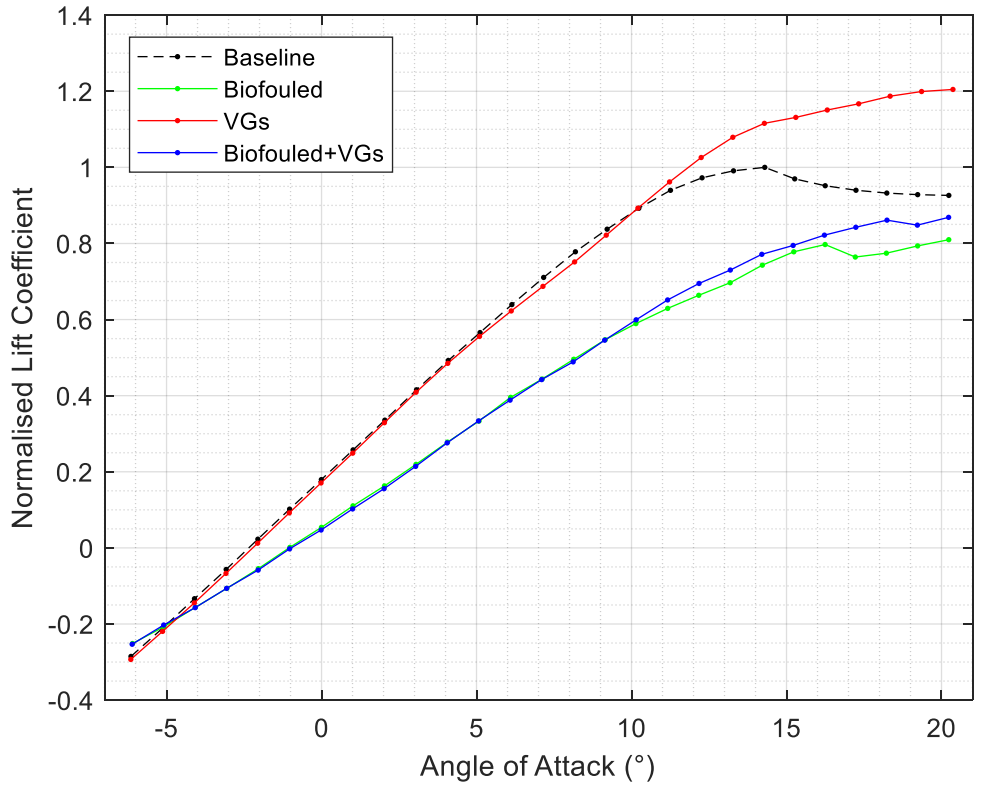
Attached



Separated

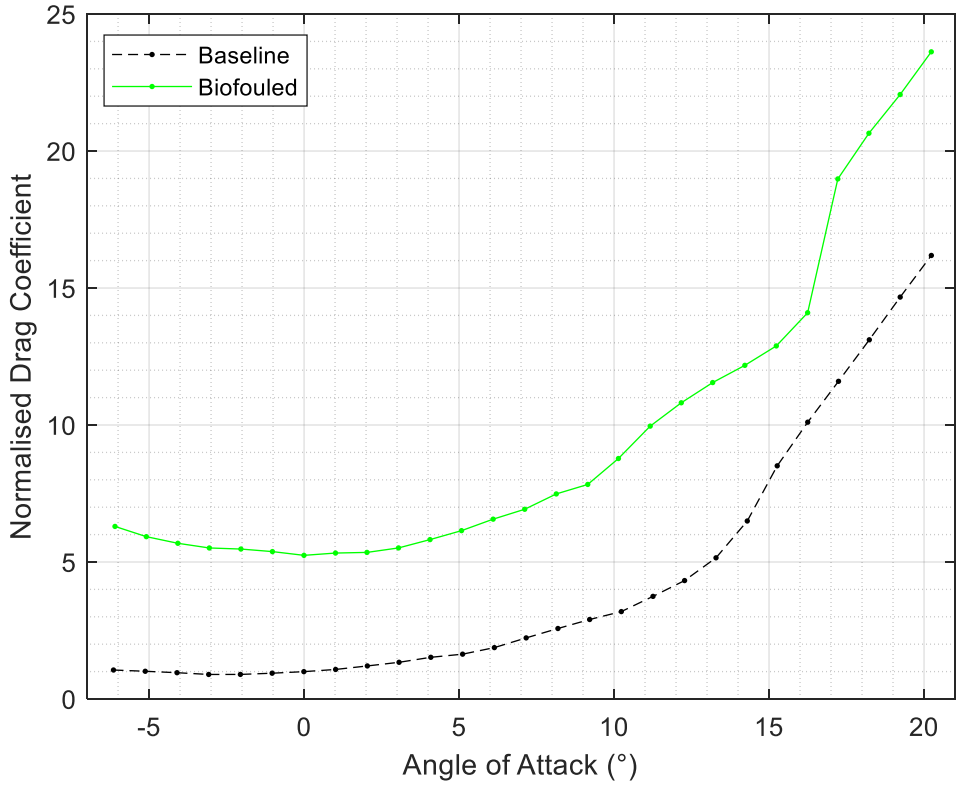


Results – Biofouling + VGs



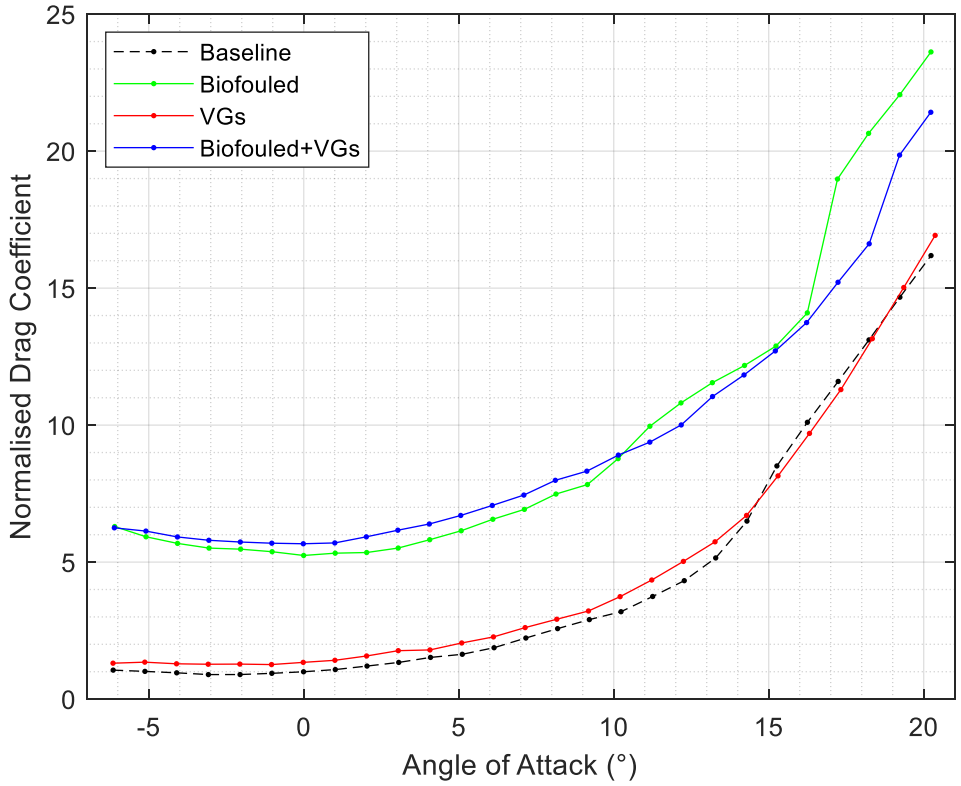
- VGs show no improvement in linear region for biofouled profile
- But show improvements at high angles:
  - Delay stall by 2°
  - Increase maximum lift by 8% compared to biofouled case

Results – Biofouling



- Biofouled profile increases drag significantly for all angles of attack tested
- Increase of over 5 times observed at 0°

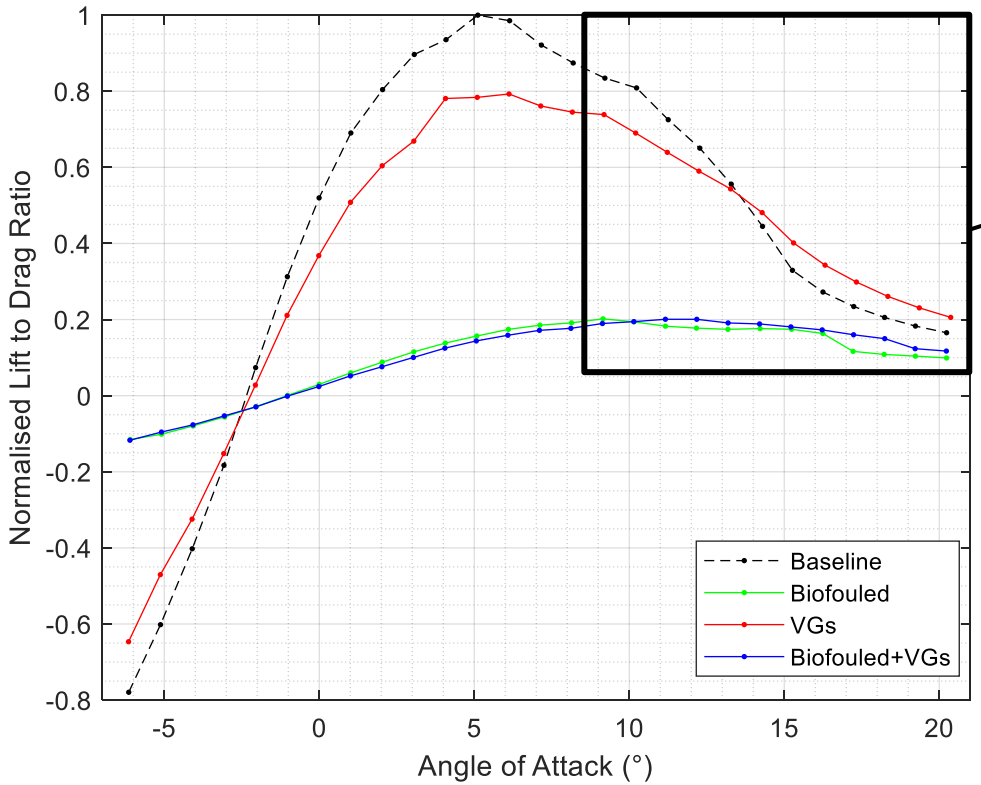
Results – Biofouling + VGs

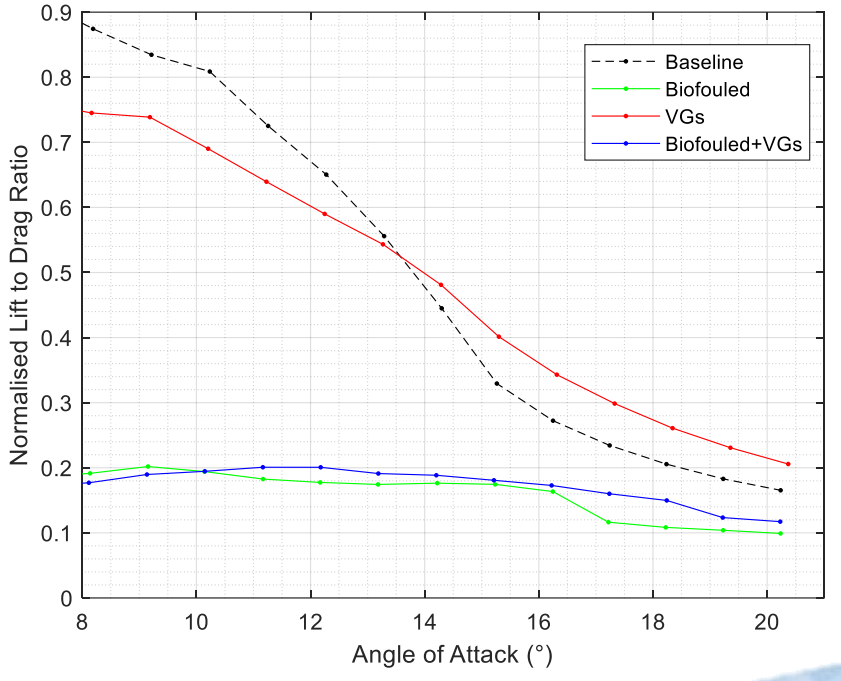


- Addition of VGs to biofouled case increase drag. At 0° an increase of:
  - + 0.43
- While VGs compared to the baseline:
  - +0.34

- VGs reduce drag at higher angles of attack

Lift to Drag Ratios





Conclusion

- Biofouled profile reduces lift to drag ratio
  - Reduces lift gradient in linear region
  - Delays stall by 2° - Generation of vortices?

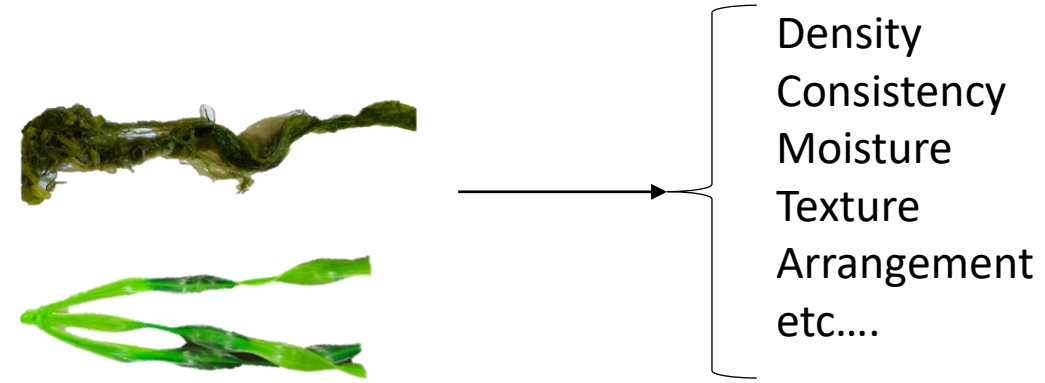
- Addition of VGs for biofouled case show small improvements in performance
  - Delays stall by 2°
  - Improves lift to drag ratio at high angles of attack
  - BUT reduces lift to drag in the linear region

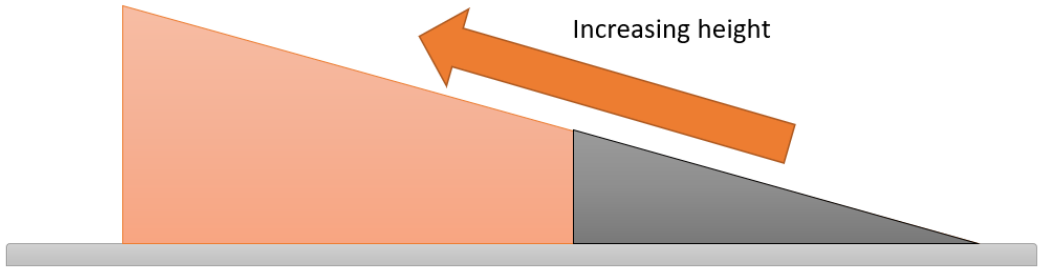
Future Work

- Improve biofouling model
  - Bespoke biofouling models
  - Characterise arrangement
  - Consistent and repeatable biofouled models

- Effect in of testing within water or wind tunnel

- Increase vane height of VGs





References

[1] Starzmann, R., Kaufmann, N., Jeffcoate, P., Guerra, M., Hay, A., and Pieroway, R. (2021) Effect of Fouling on the Performance. Proceeding of the 14th European Wave and Tidal Energy Conference. 5-9th September. Plymouth.