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Bio-optimisation of a tidal channel

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Scotland has ambitious decarbonisation and climate change objectives, such as generating 100% of gross annual electricity consumption from renewable sources by 2020. Tidal stream energy is a renewable and predictable source of energy that converts the kinetic energy within tidal currents, into electricity, using a hydrokinetic device such as a horizontal axis turbine. However, economically viable tidal stream development is currently confined to areas of exceptionally high current speeds, and this can severely limit the choice of area. If the speed threshold required for an economically viable tidal site can be lowered then the number of potential sites could increase dramatically.

It is well known that macro-algae (e.g. kelp) grow in perspective tidal energy sites, as they requiring similar water depths and current speeds. Furthermore, kelp is known to grow in dense patches, reaching from the sea-floor to the ocean surface, and can modify tidal current speeds. Indeed, observations have shown that “kelp forests” can locally reduce current speeds by a third (Jackson and Winant, 1983). This local reduction in current speed will cause an increase in speed elsewhere, in order to conserve mass. Therefore, we hypothesise that by adding a kelp forest in the vicinity of a tidal channel, the current speed and tidal stream resource could be increased sufficiently for the site to become economical.

A three dimensional finite volume hydrodynamic model has been used to model an idealised tidal channel. The drag imposed by kelp was theoretically calculated and represented in the model as a sub grid scale momentum sink. The changes to the current speed resulting from this bio-optimisation of the tidal channel were investigated and show that the current speed in the centre of the channel can be increased. Kelp were then added to a previously developed hydrodynamic model of the Pentland Firth and Orkney Waters to investigate how such bio-optimisation could influence an area currently being considered for substantial tidal stream development. The changes on both the areas of suitable tidal stream development and the power yield are investigated.

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References

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