National Science Challenges

Webinar starts: 11am, Tuesday 3 February

SUSTAINABLE SEAS

Ko ngā moana whakauka

A step closer to a future powered by tidal current energy

Ross Vennell
Cawthron

Acknowledgements

Sustainable Seas Innovation Fund project:

Energy from tidal currents - Kick-starting a new marine industry with huge potential

Project team: Ross Vennell, Robert Major, Heni Unwinand Max Scheel (Cawthron), Brett Beamsley and Remy Zyngfogel (MetOcean Solutions)

Learn more at:

https://www.sustainableseaschallenge.co.nz/our-research/energy-from-tidal-currents-kick-starting-a-new-marine-industry-with-huge-potential/

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Innovation Fund

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Where we need to go!

- NZ's demand for electricity will increase

- We need significant expansion of renewable energy generation

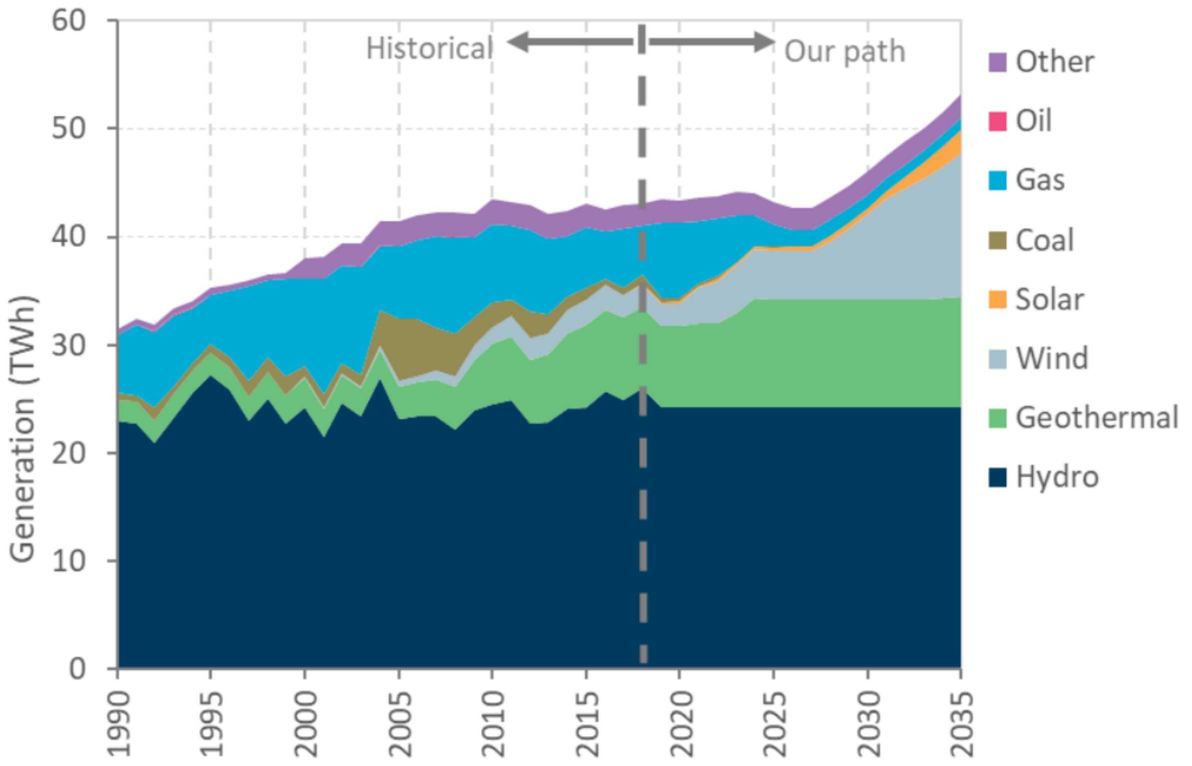


Figure 3.13: Electricity generation by fuel in our path.

Source: page 62, [2021 Draft Advice for Consultation](#)
He Pou a Rangi Climate Change Commission

Sources of ocean energy

1) Wave

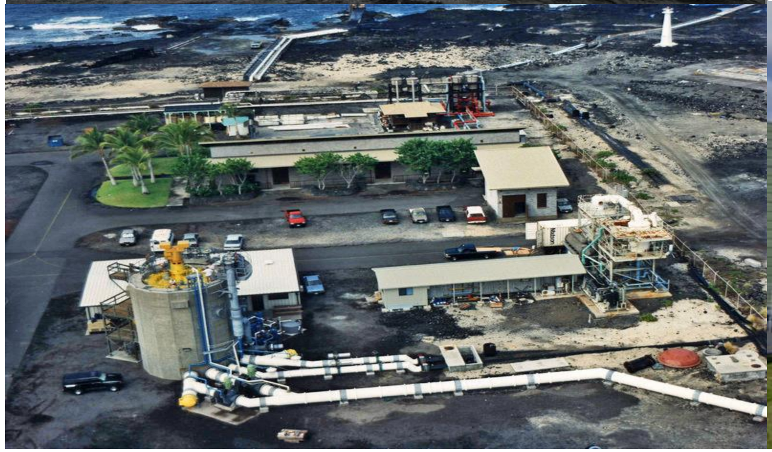
2) Tidal

3) Thermal (OTEC)

   – ocean heat pump

4) Osmotic power

   – fresh meets salt water



Tidal energy – predictable!

2a) Tidal "barrage" (dam)

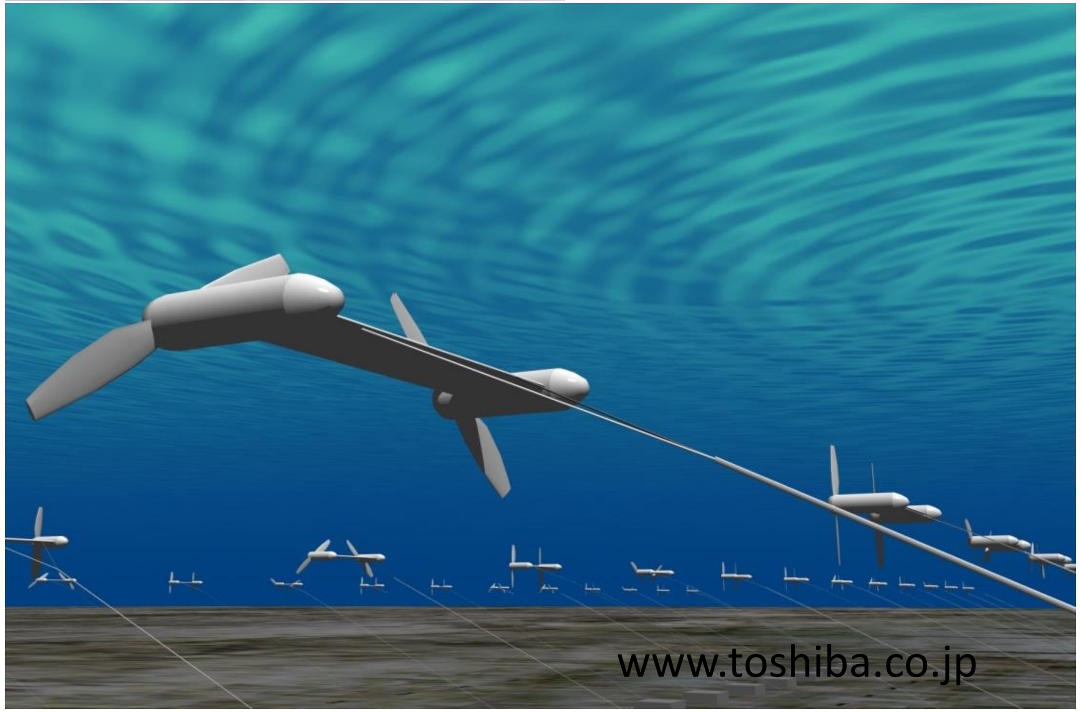
Requires large tidal range > 5m

World's largest 240 MW plant on the Rance River, France 1960s

2b) Tidal currents

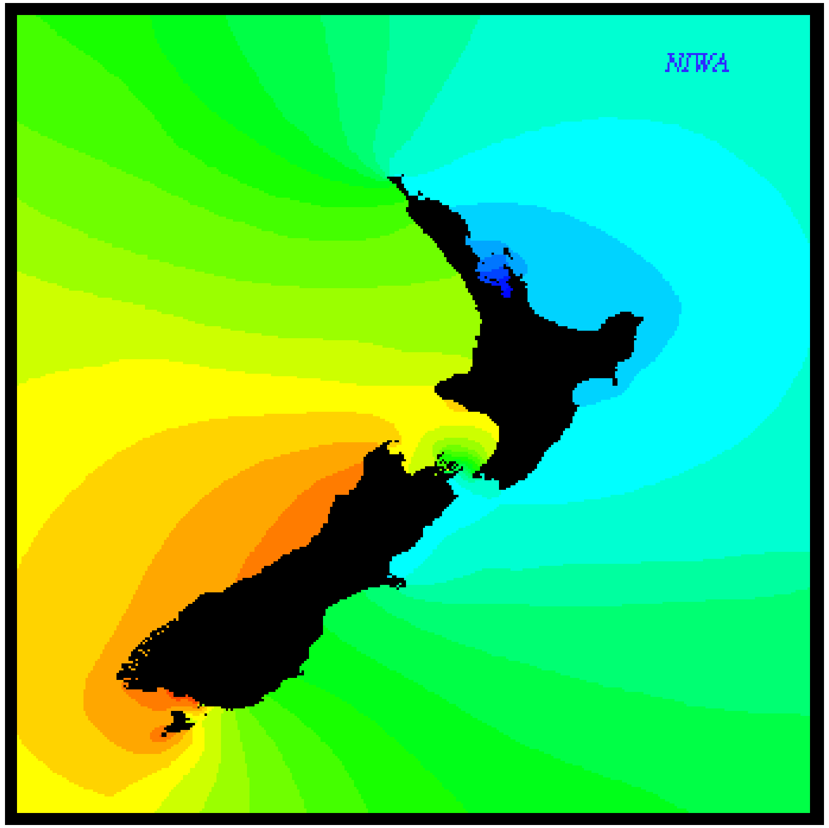
www.seageneration.co.uk
www.marineturbines.com

Tidal turbines – wet wind turbines?



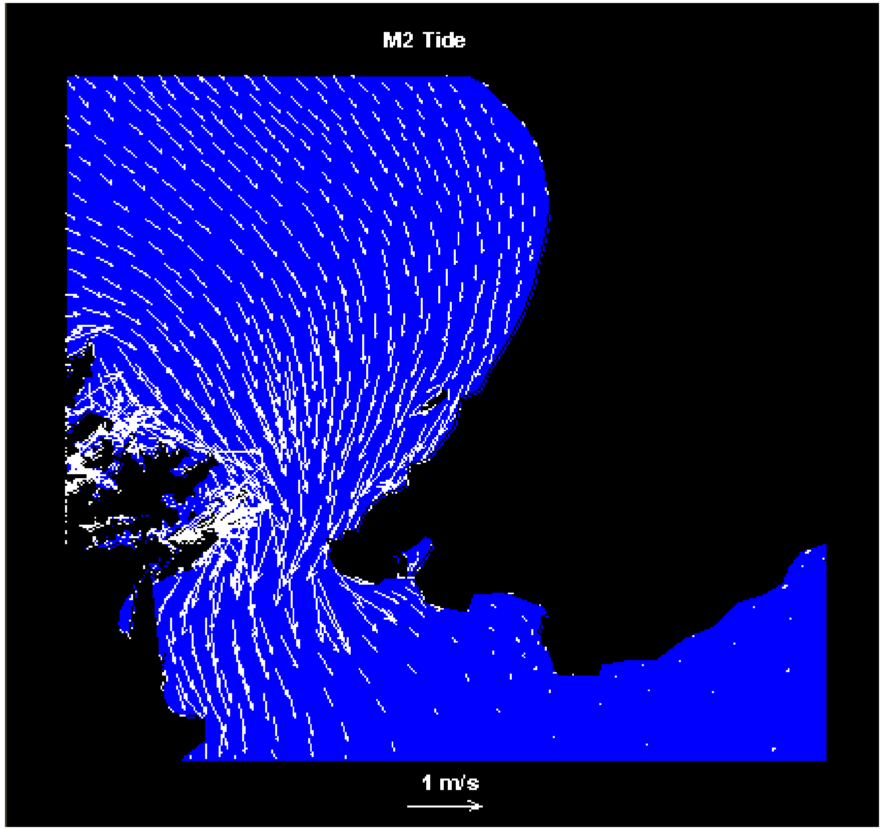
Why is NZ a great place to generate power from tidal currents?

1) Tidal Phase Distribution



NIWA tidal model

2) Cook Strait (maximum 15,000 MW averaged)



NIWA tidal model (Rickard)

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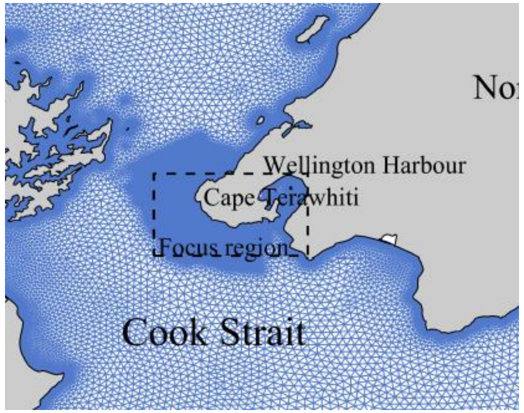
Tidal energy and Cook Strait

- Big waves!
- Best place in the world to generate energy from tidal currents
- Research focus region: Cape Terawhiti



Developing tidal turbine farms involves:

Engineering

Designing, manufacturing, installation, maintenance systems, cabling, grid connections, etc.

Assessing environmental impacts

Effects of flow reduction, underwater noise, changes in sedimentation, etc.

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But first, you need to know: Is it worth it?

How much power can we get from the turbines at a site?

One turbine = 1MW

or 100-200 homes

Need 100 - 1000's MW

eg, how much from 100's of turbines?

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To be really useful need 10s - 100s turbines in a farm

Do 100 x 1MW turbines give a 100MW output?

1MW

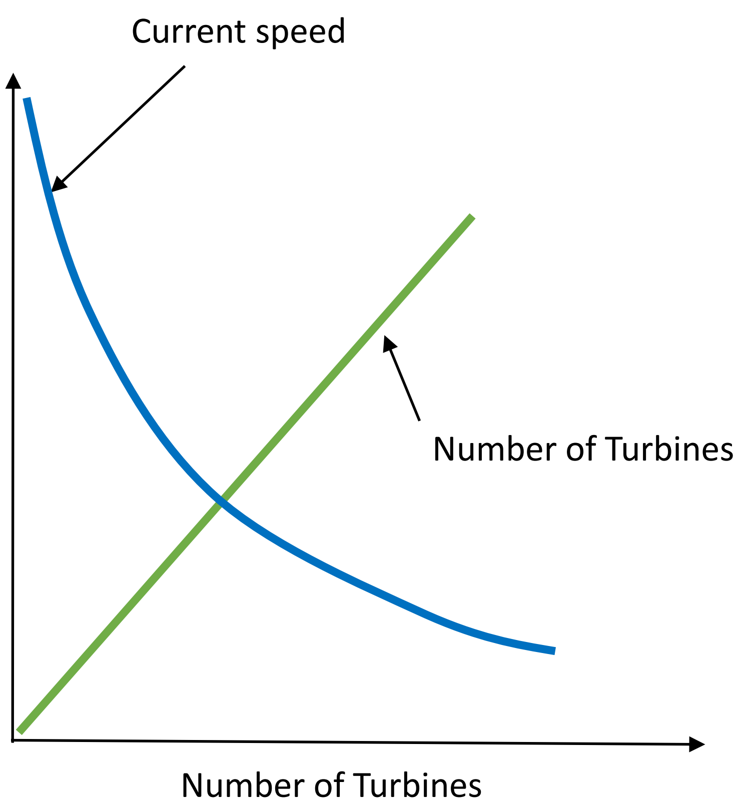
100 x 1 = ??

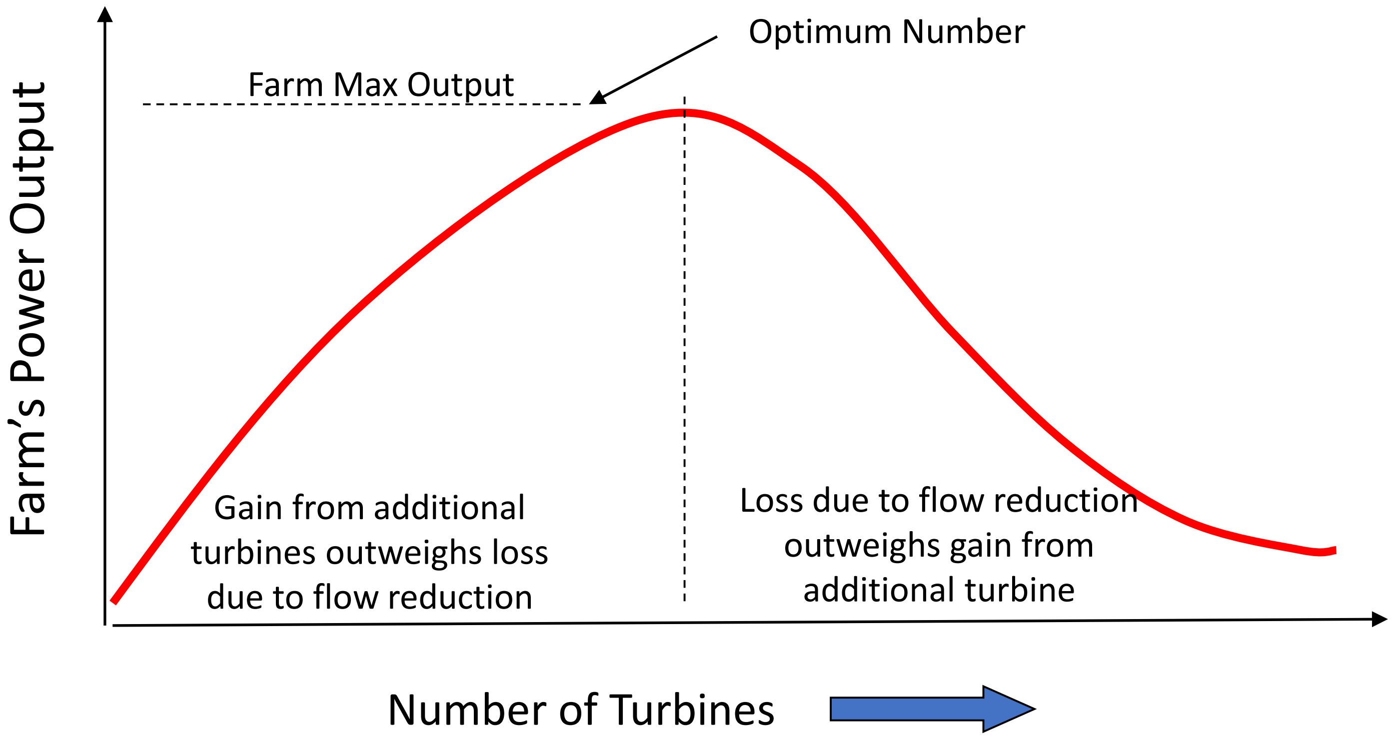
100MW

Depends!
100 turbines give:

- small channels < 100MW
- large channels > 100MW

Large turbine farms in channels

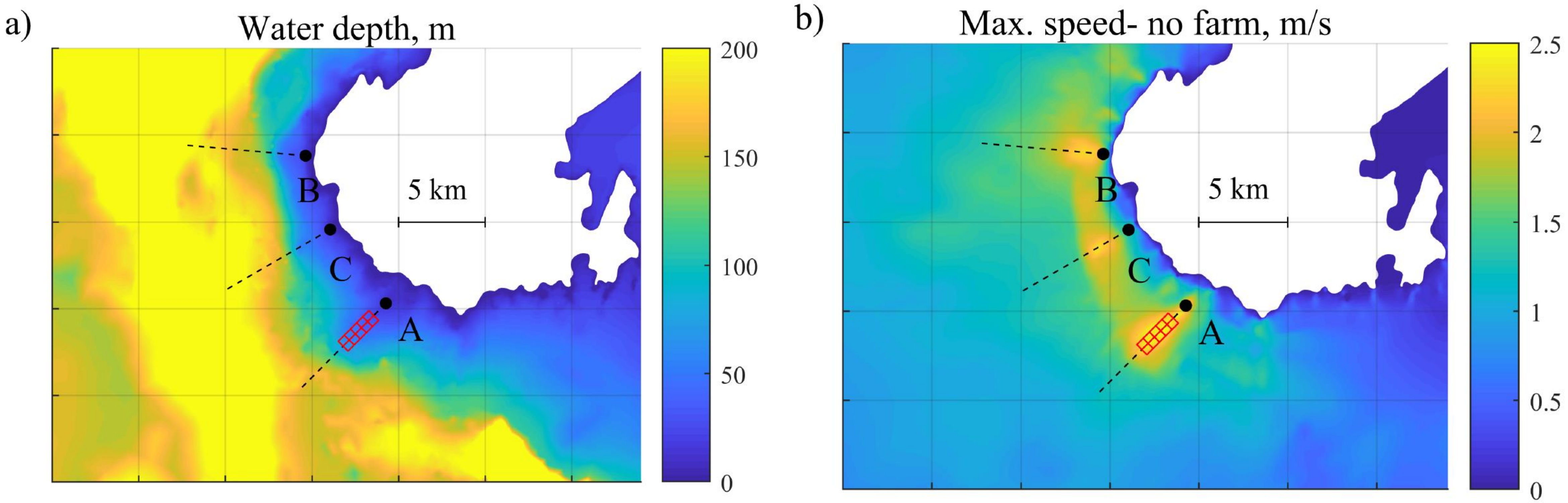




Farm Power output $\propto$ (number of turbines) (efficiency) (current speed)^3

We used a hydrodynamic model to quantify farm power output

Rapid initial assessment of 3 sites (A, B C) for many different farm sizes



2 m/s = 4 knots= 7 km/hr

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Need to tune turbines to maximise power

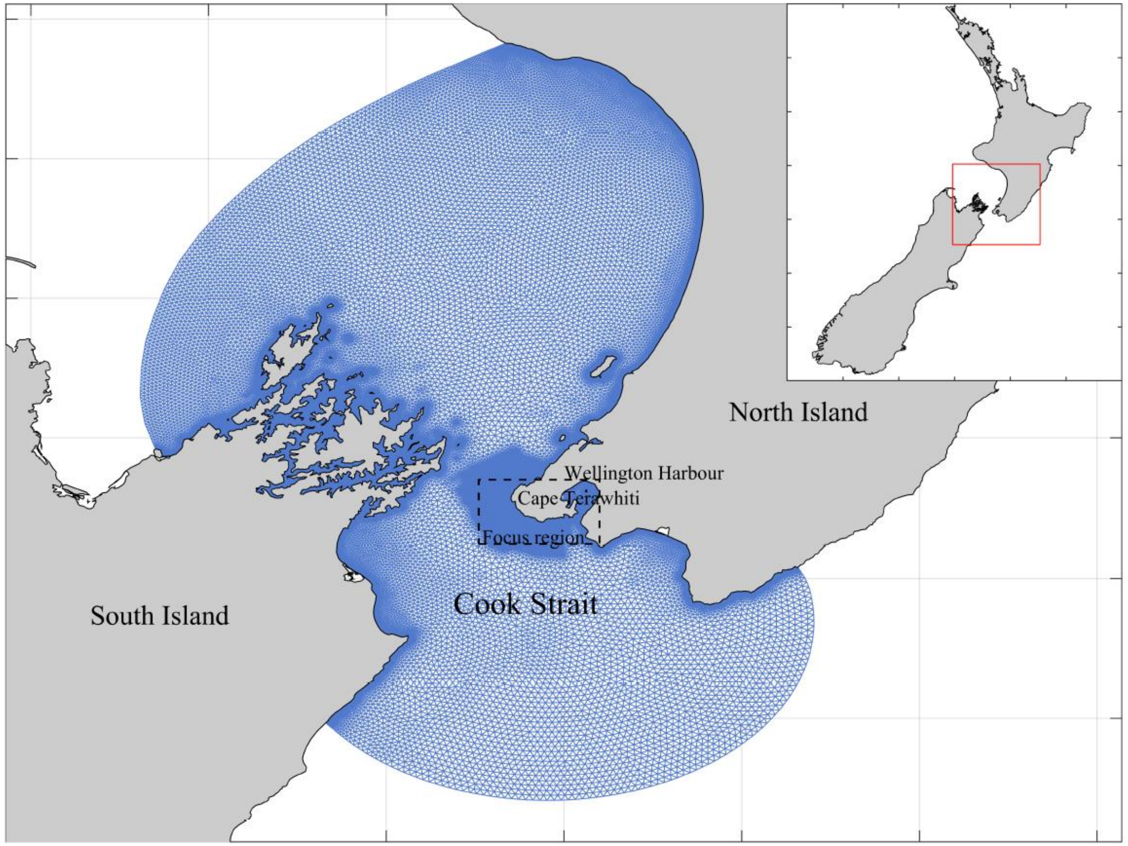
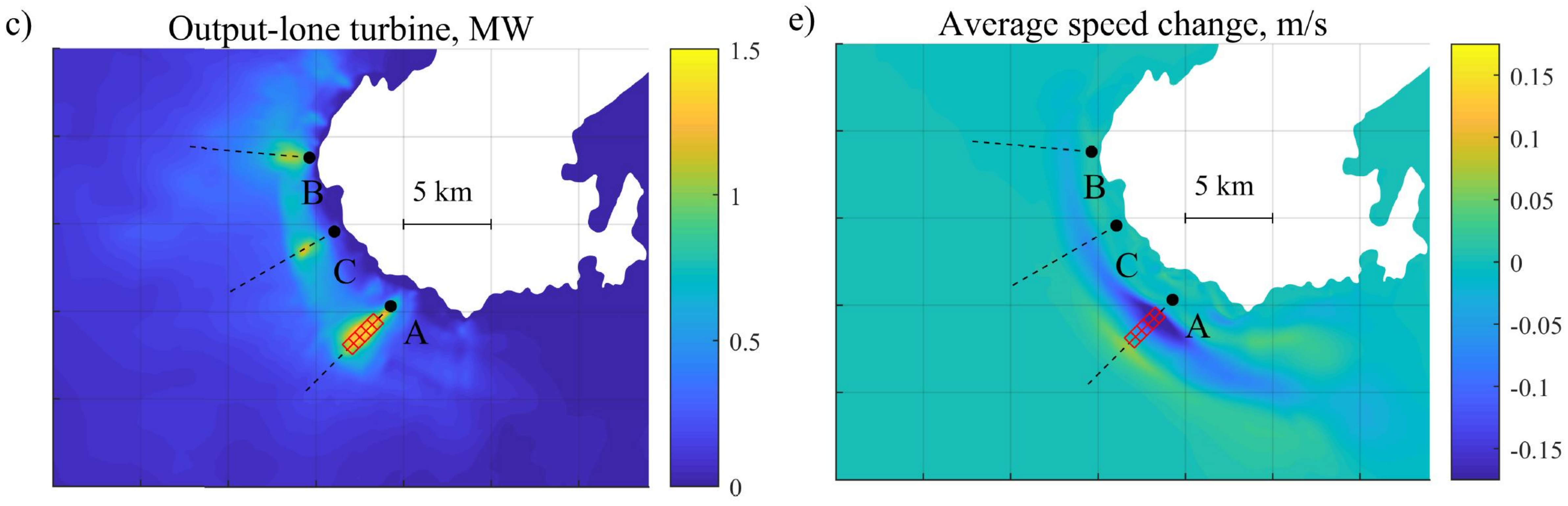


Figure 1: Cook Strait location map and model grid as blue triangles. The best high flows sites for tidal turbine farms are centered in the focus region, around Cape Terawhiti, where a 200 m grid refinement was used.

This is a technical challenge!

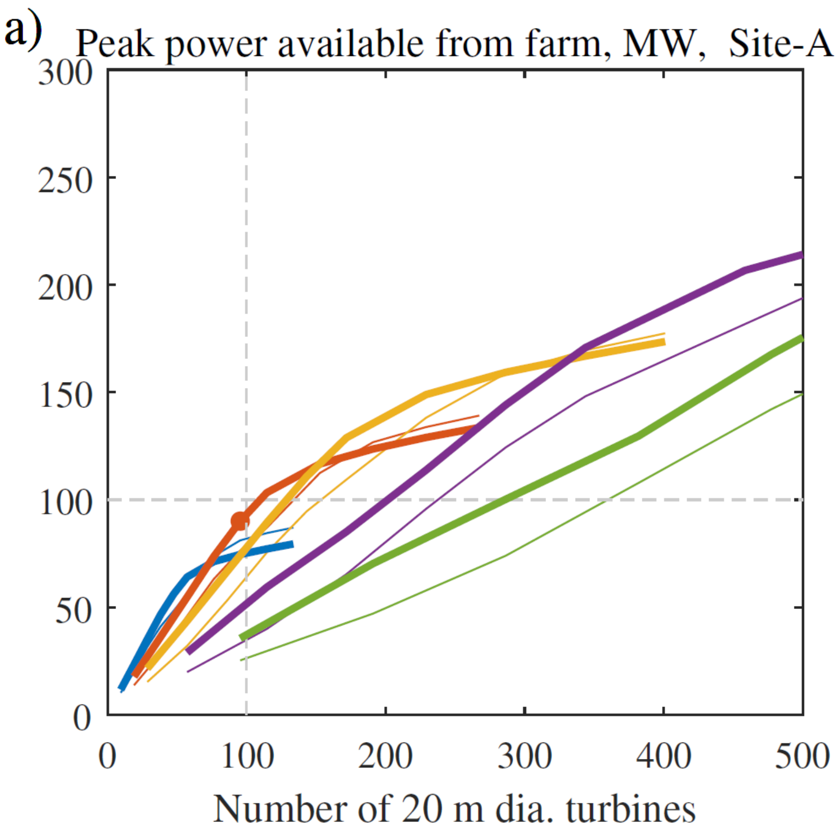
- Running model many times to maximize power output from 100's farm sizes and shapes
- Tuning balances flow going through the farm with flow diverted around the farm
- Rapid = days of computation, not months

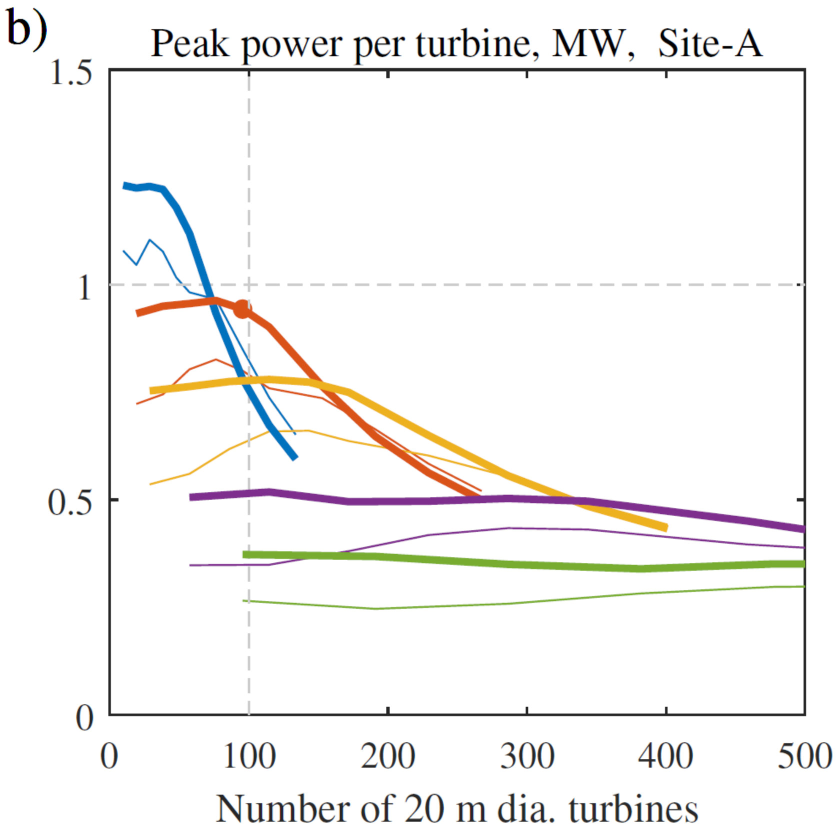
What are the best locations, sizes and shapes for farms?



Site-A: How much power/efficiency trade off

Power





Efficiency

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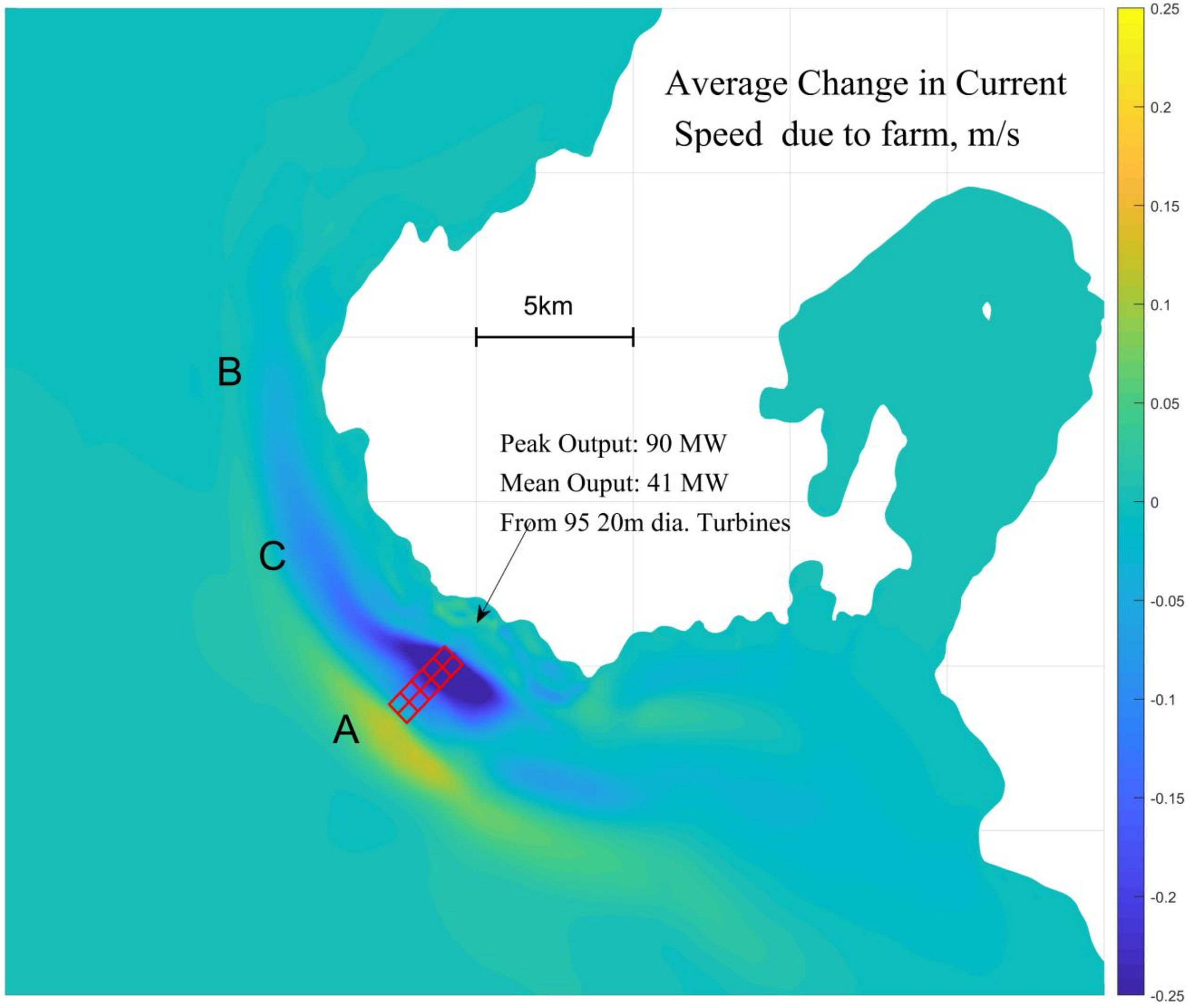
Results: Site A



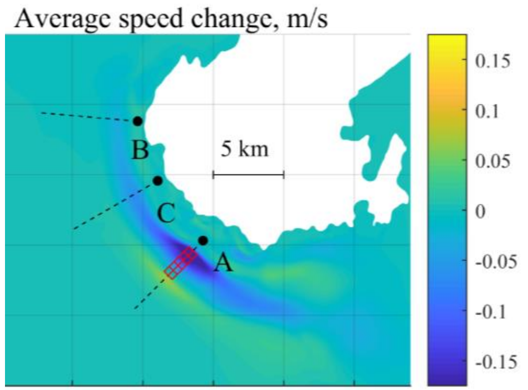
95 turbines spaced **100m** apart in **2** rows

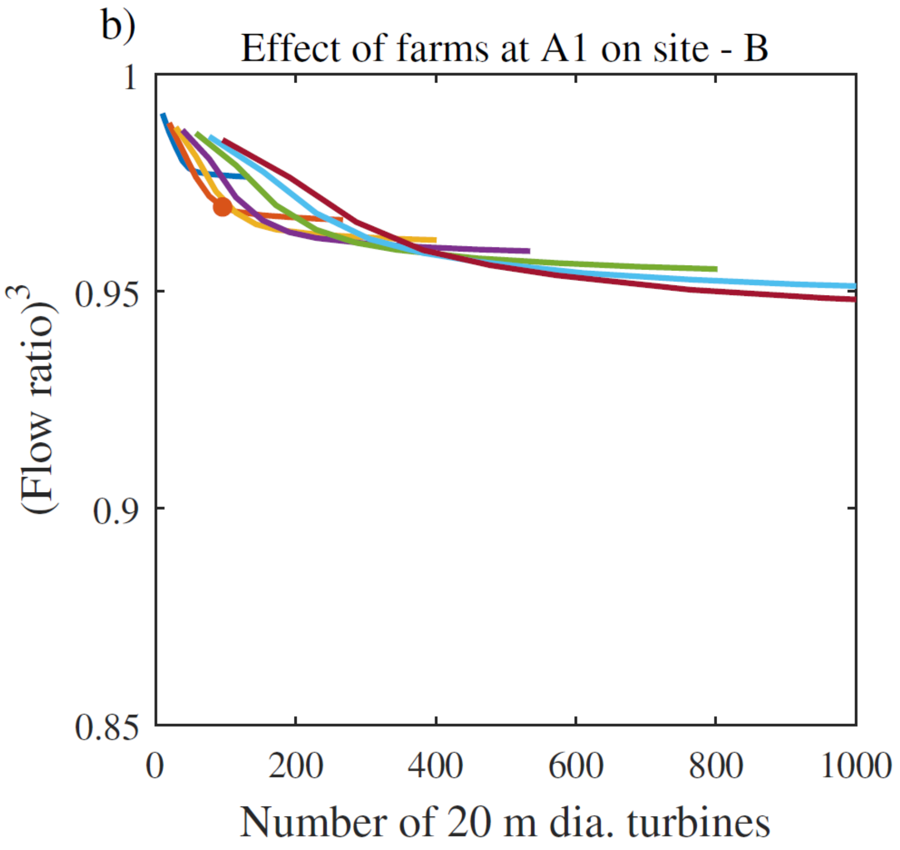
= **90 MW** (peak)

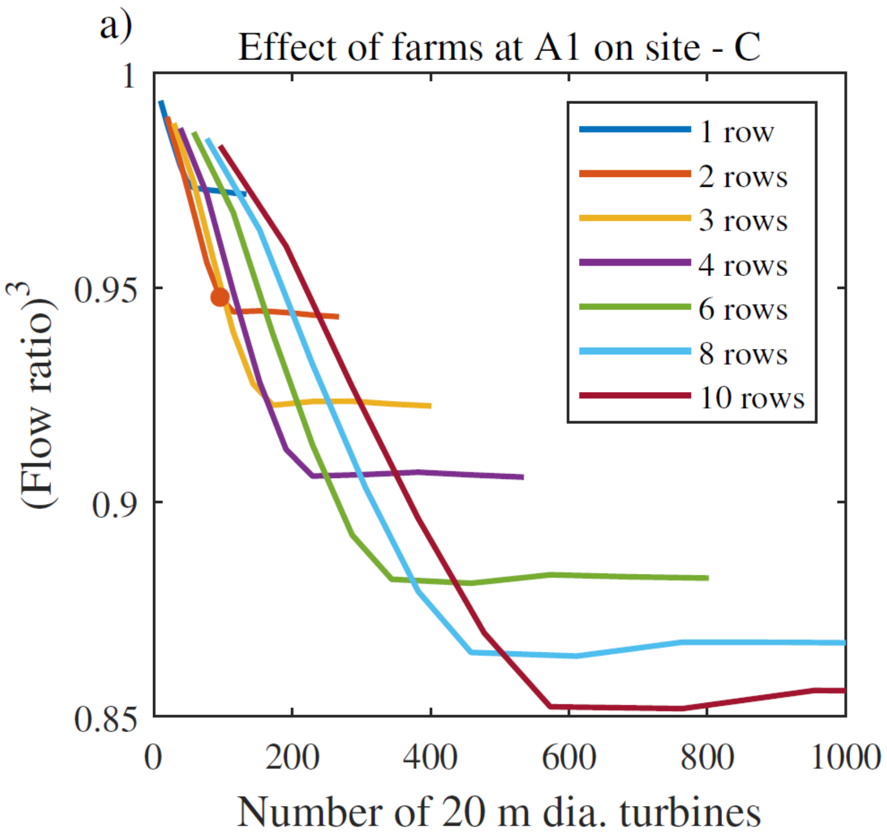
West Wind, Makara, Wellington

140 MW =
70,000 homes

Developing site A will affect sites B and C

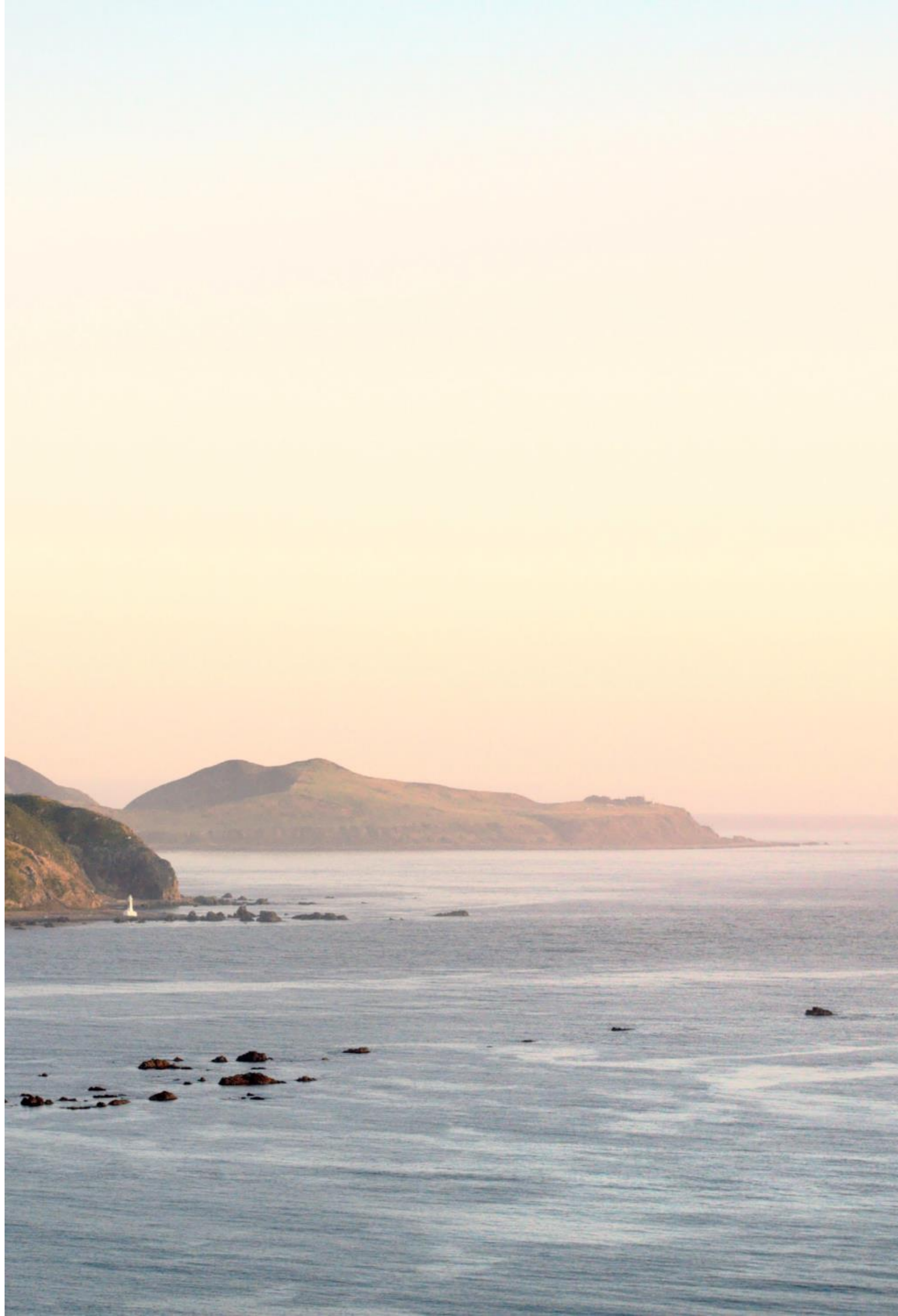






Key takeaways

- Model can rapidly assess a potential site
- Site **A** with **95** x 20m diameter turbines, spaced **100m** apart in **2** rows
- May be close to being economic now with existing turbine technology
- Larger farms need larger turbines to efficiently extract energy from weaker flows offshore of site A



Where to find the model:

ELSEVIER

Renewable Energy

Volume 162, December 2020, Pages 1890-1905

Rapid initial assessment of the number of turbines required for large-scale power generation by tidal currents

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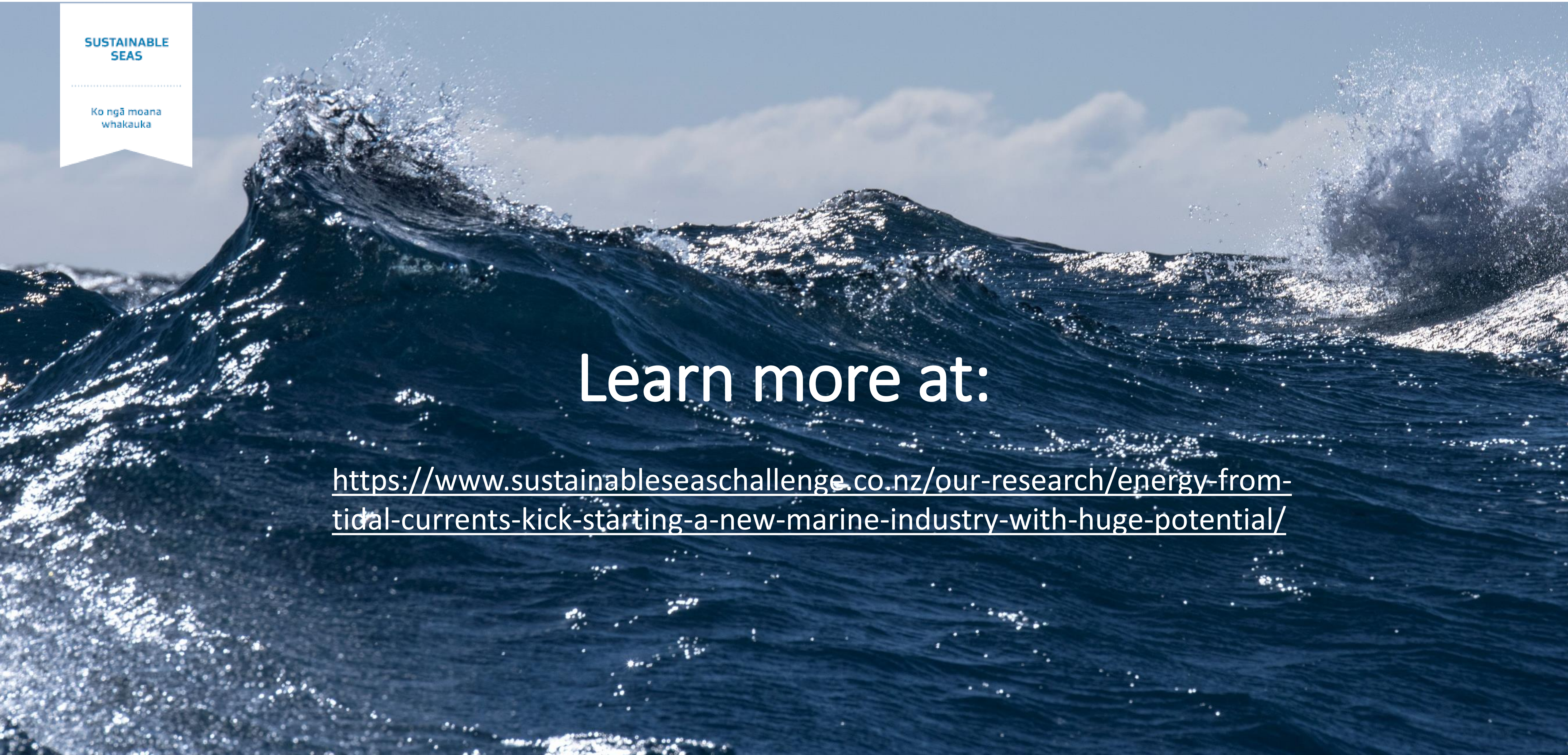

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