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The Business of Marine Energy

Oceania Room | Te Papa Tongarewa | Wellington

Realistic Power Output from Large Tidal Turbine Farms:

A tale of two NZ channels


Sea-Gen

1MW ? → 100 MW’s

Scaling Up Turbine Farms?

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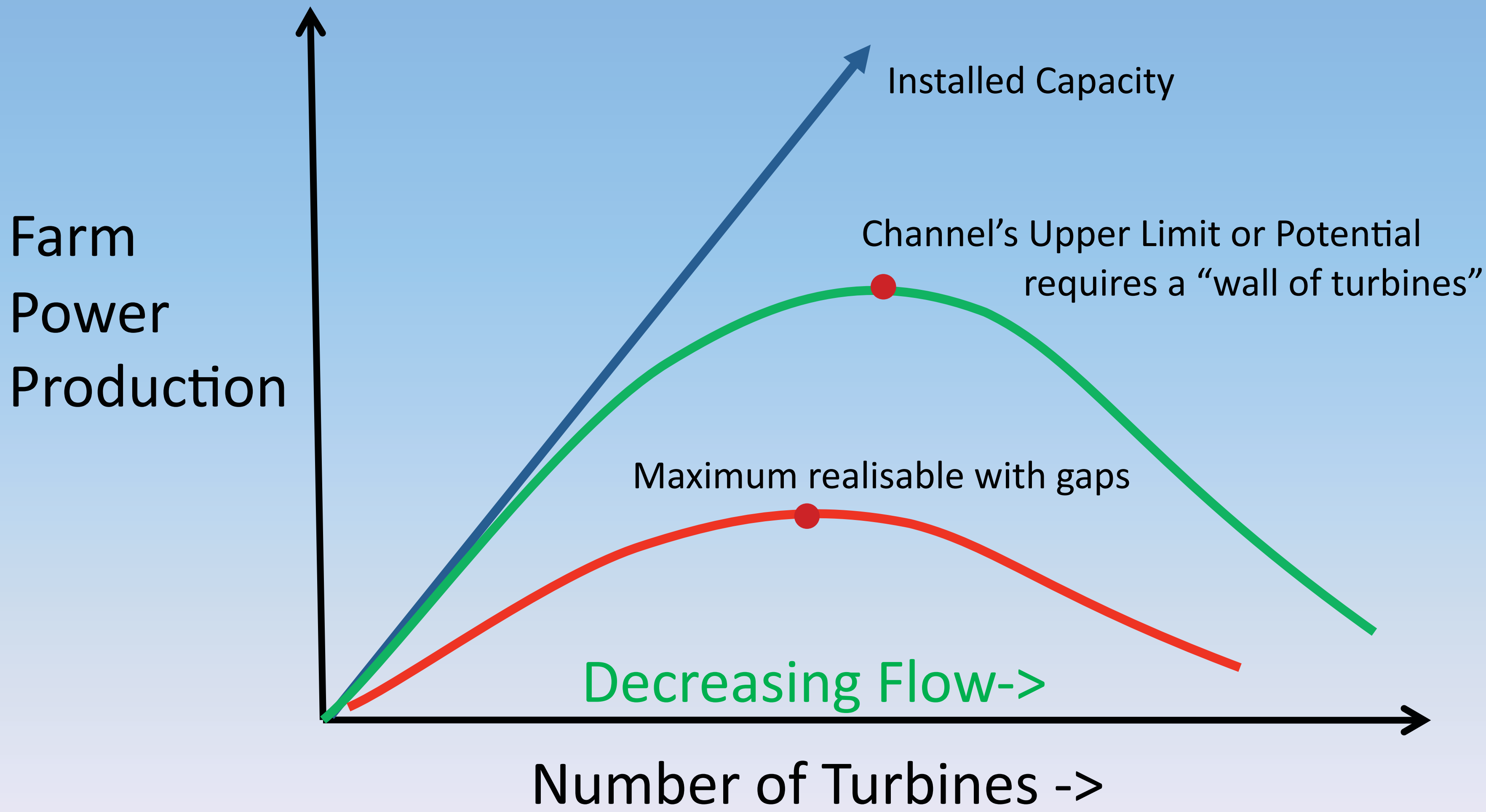
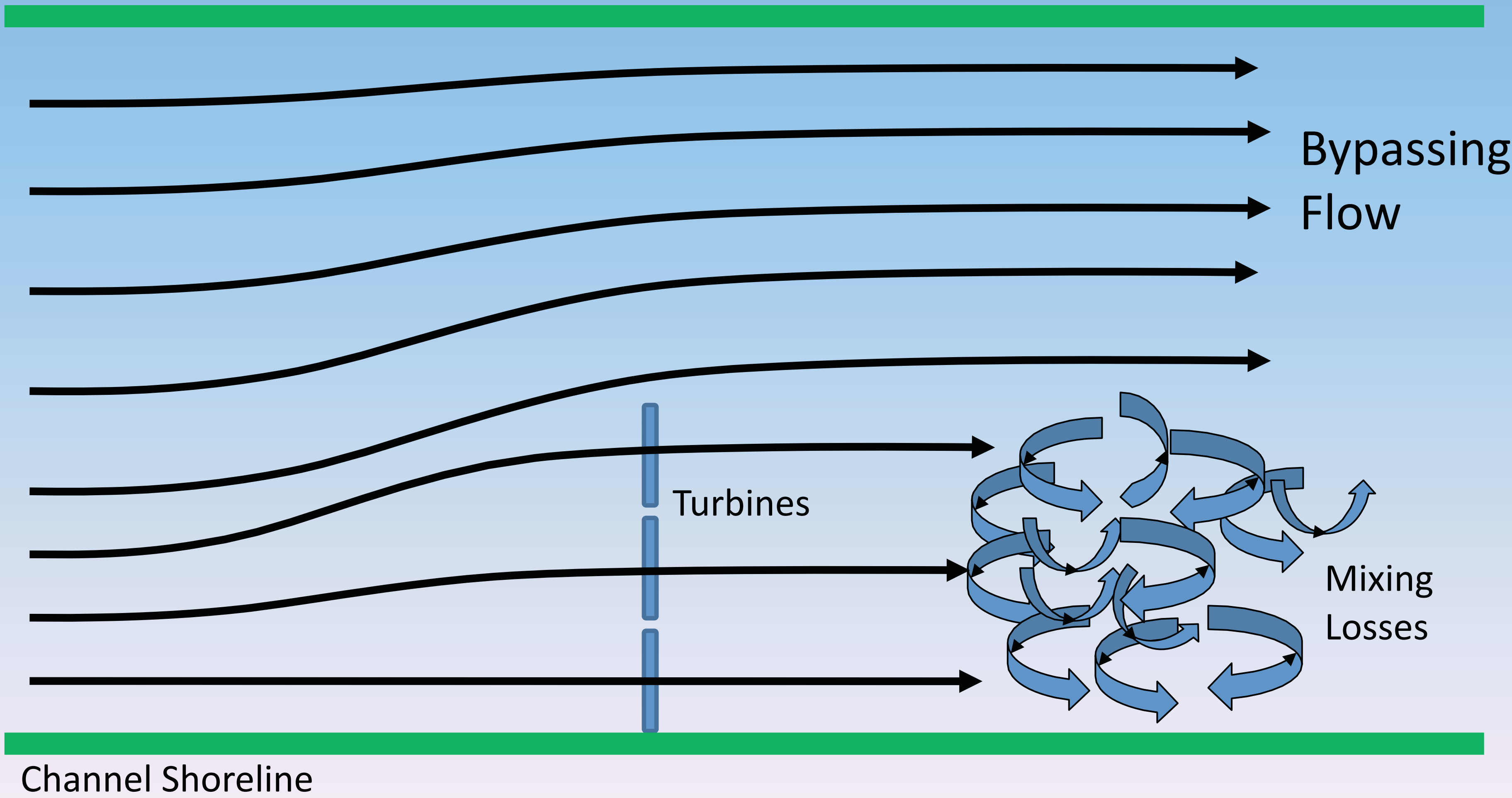
R. Vennell, Tuning turbines in a tidal channel, *Journal of Fluid Mechanics*, 2010.
R. Vennell, Tuning tidal turbines in-concert to maximise farm efficiency, *Journal of Fluid Mechanics*, 2011
R. Vennell, Estimating the Power Potential of Tidal Currents and the Impact of Power Extraction on Flow Speeds, *Renewable Energy*, in press

Upper limit for Production in Channels



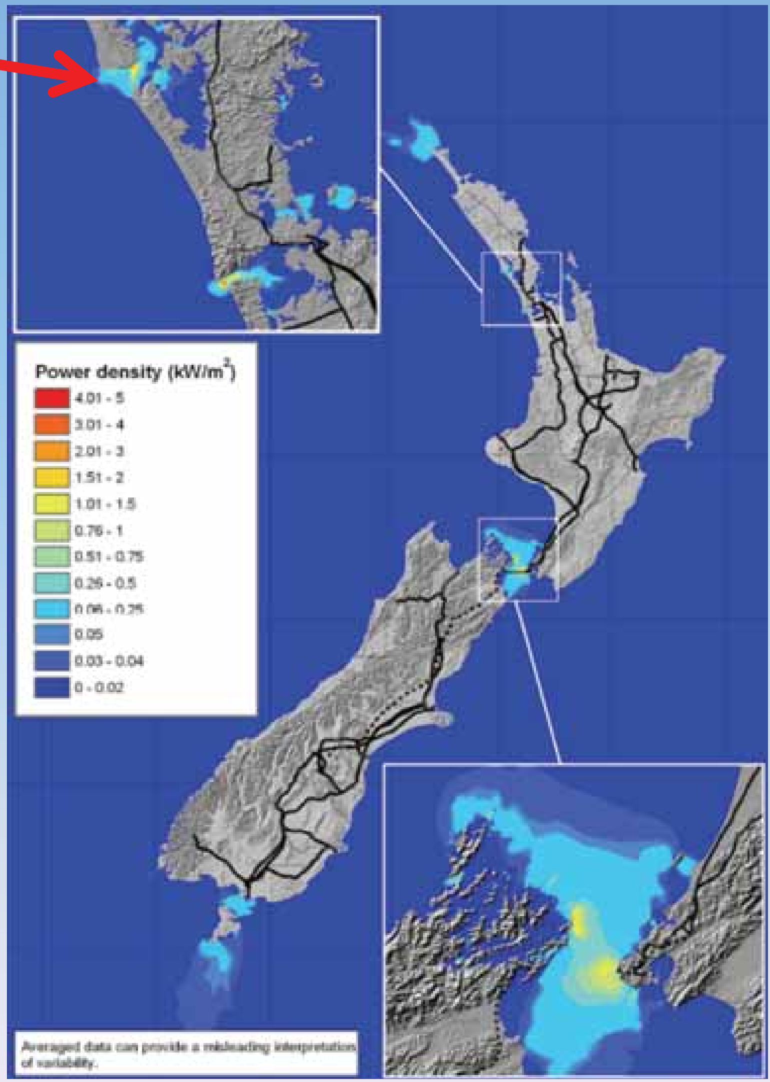
Flow will bypass turbines through any gaps needed for navigation!

Gaps to allow Navigation along Channel Bypassing flow and Mixing Losses



Two examples

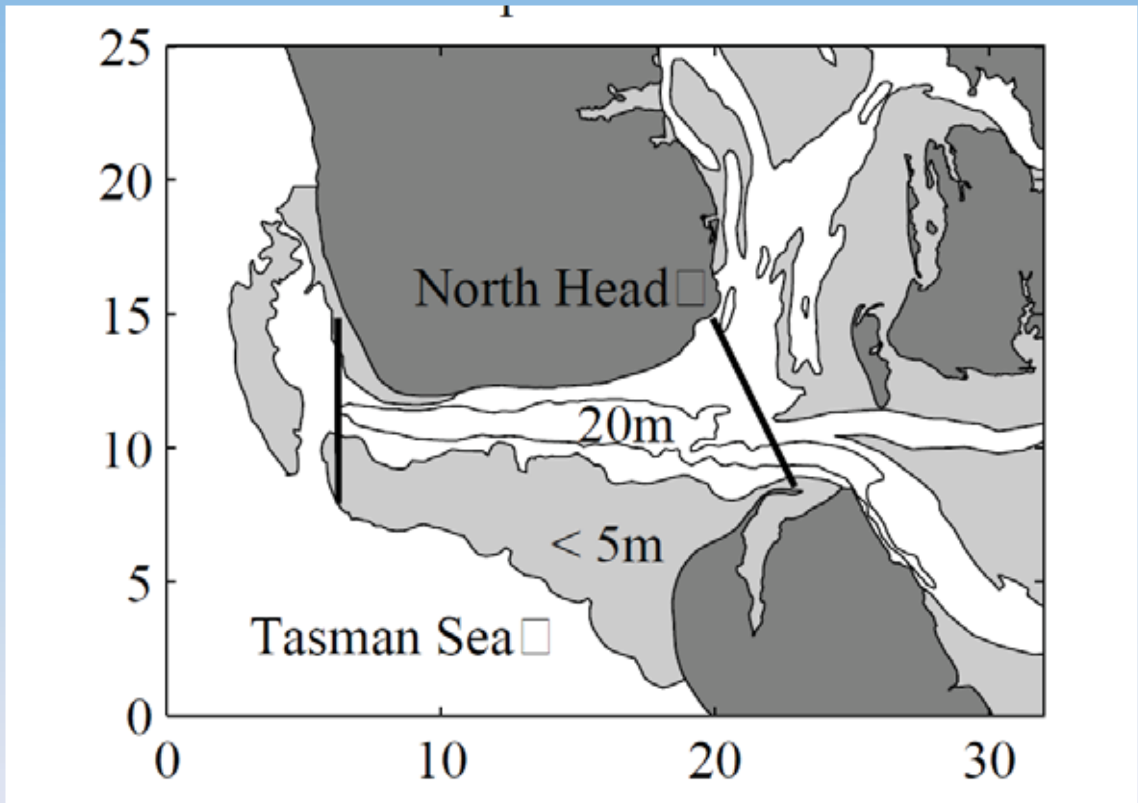
Kaipara Harbour



Cook Strait

EnergyScape, 2009

Kaipara Harbour



Channel

- 15 km long channel
- 25 m deep
- 2.5 km wide

Estuary

- 950 km^2
- 400km^2 dry at low tide
- 1.5-2.7m tidal range

Kaiprara Harbour Entrance

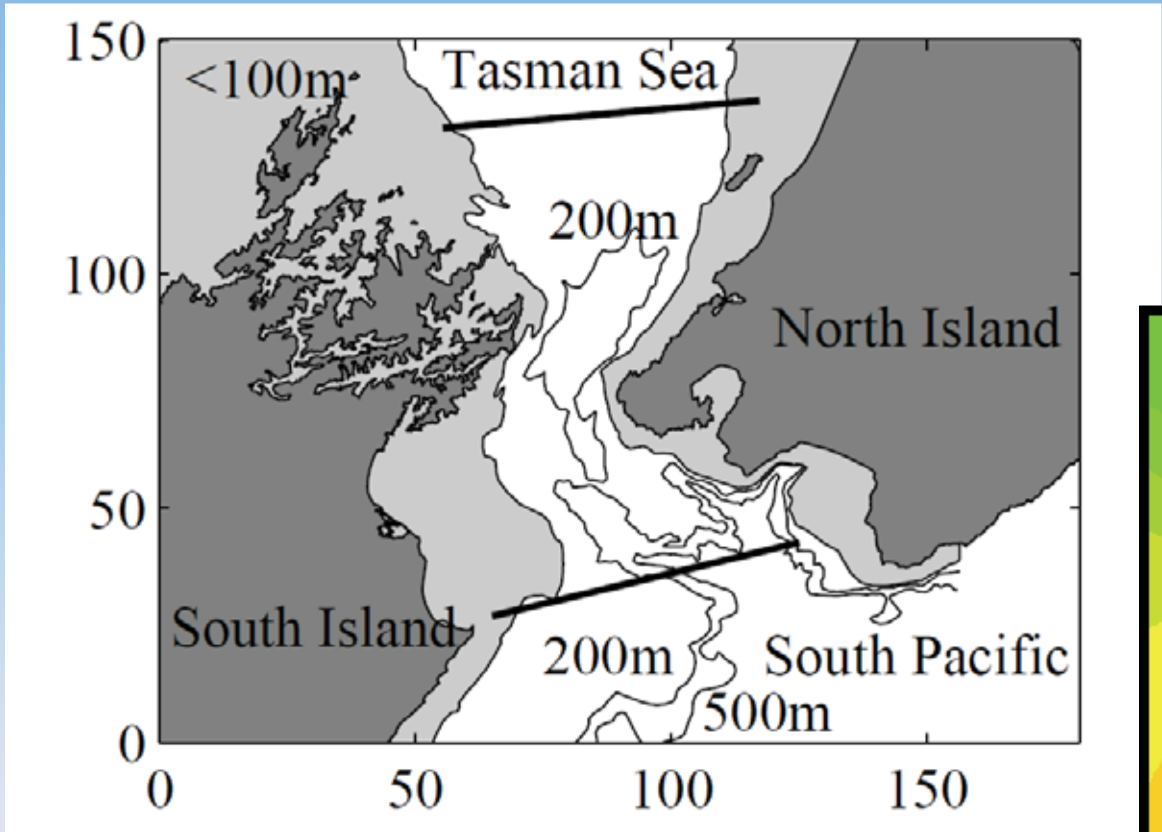
	At Peak Flow	Averaged over Tidal Cycle
Upper Bound or Potential	570 MW	240 MW
Requires Turbines to Fill Cross-section	250 turbines + 40% flow reduction	
Filling 10% of cross-section and 10 rows	100 MW	45 MW
Requires	250 turbines + 5% flow reduction	
Filling 30% of cross-section and 10 rows	300 MW	130 MW
Requires	740 turbines+ 17% flow reduction	

Based on 1.7m/s peak flows and 18m diameter turbine blades and assumes turbines are optimally tuned for the channel.

Power production will be smaller as these values as they don't allow for

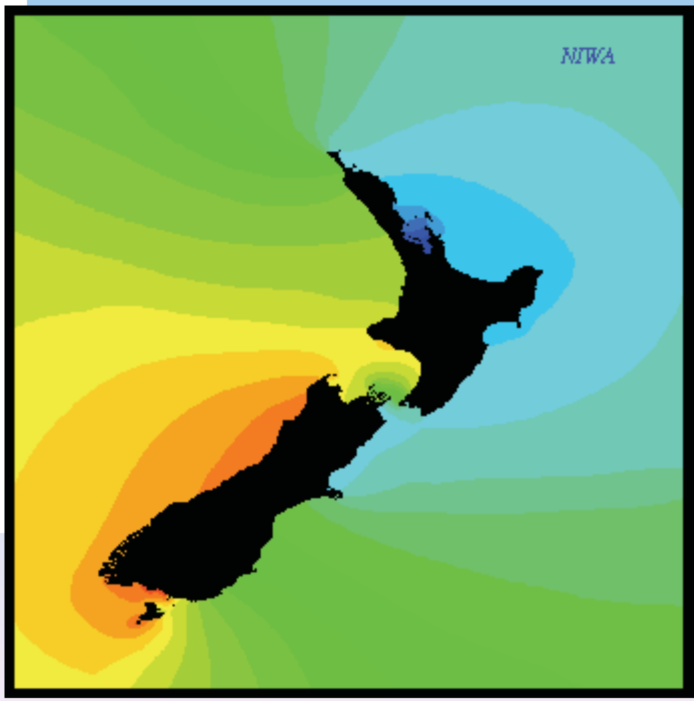
- Mechanical loses in gear boxes
- Electrical conversion and transmission losses
- Energy losses due to drag on turbine's support structure (?)
- Effects of upstream rows and their turbulence on turbine efficiency (?)
- Energy dissipation with the shallow Harbour due to bottom friction (?)

Cook Strait



Channel

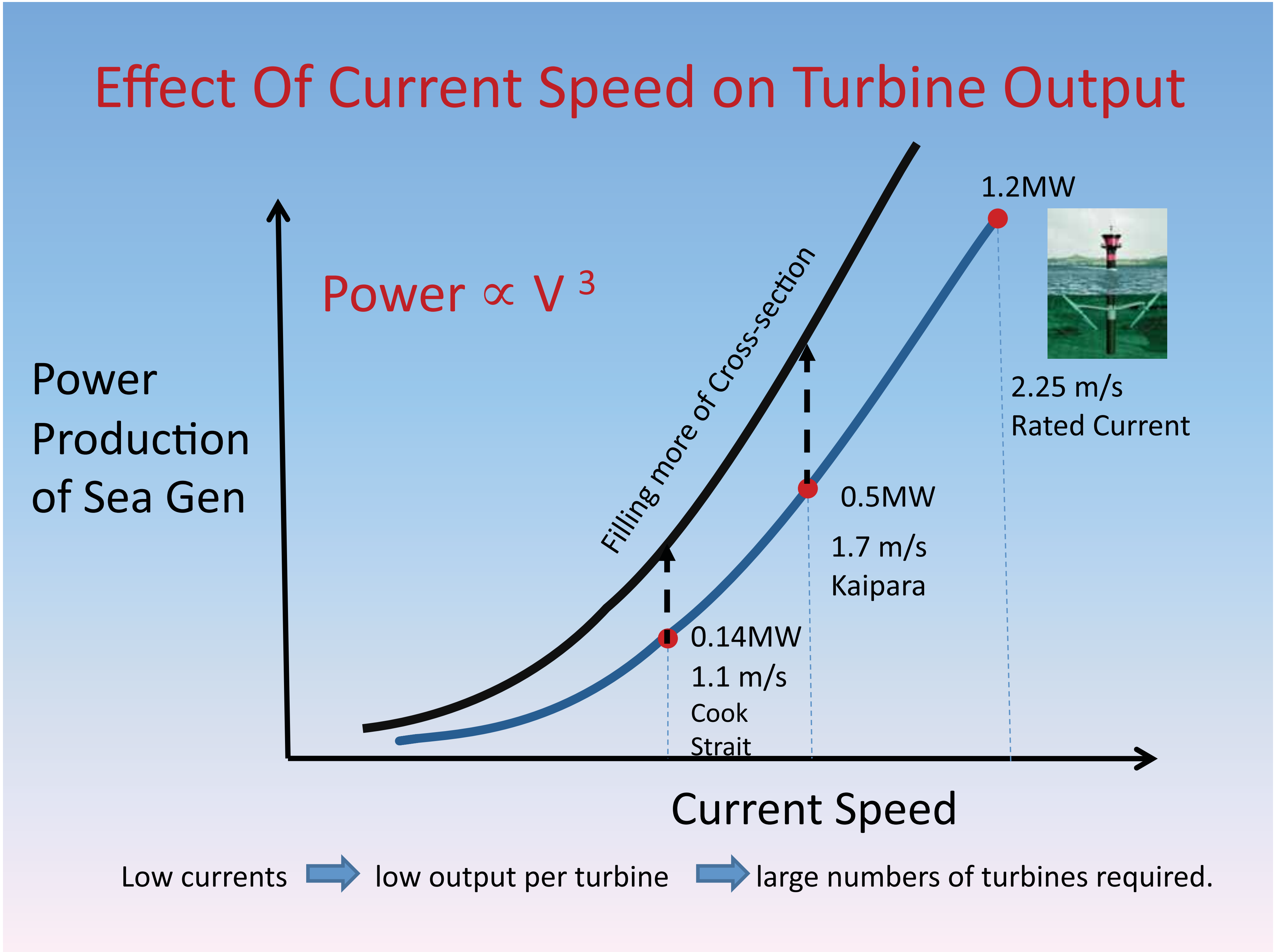
- 100 km long channel
- 150+ m deep
- 25 km wide



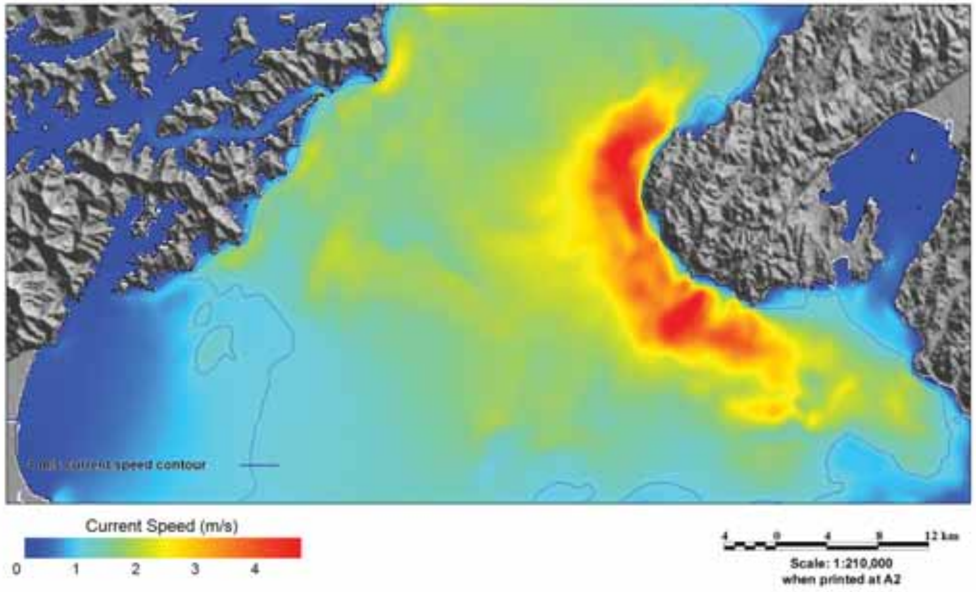
Cook Strait

	At Peak Flow	Averaged over Tidal Cycle
Upper Bound or Potential	36,000 MW	15,000 MW
Requires Turbines to Fill Cross-Section	15,000 turbines + 34% flow reduction	
Filling 10% of Cross-Section and 10 rows	1,800 MW	800 MW
Requires	15,000 turbines + 0.5% flow reduction	
Filling 30% of Cross-Section and 10 rows	8,300 MW	3,500 MW
Requires	44,000 turbines + 4% flow reduction	

Based on 1.1 m/s peak flows and 18m diameter turbine blades and assumes turbines are optimally tuned for the channel.


Effect Of Current Speed on Turbine Output
Power ∝ V 3
Power Production of Sea Gen
Filling more of Cross-section
1.2MW
2.25 m/s
Rated Current
0.5MW
1.7 m/s
Kaipara
0.14MW
1.1 m/s
Cook Strait
Current Speed
Low currents
low output per turbine
large numbers of turbines required.

Cook Strait Numbers Unduly Pessimistic



Peter McComb-
MetOcean Solutions

- Install in high flow regions to reduce turbine numbers
- These regions will move as a result, but should give higher flows that 1.1m/s cross-sectional average velocity.

Summary

- A compromise between Power Production and
  1) The fraction of the cross-section turbines are permitted to occupy
  2) An environmentally acceptable flow reduction

- For Kaipara, 250 18m diameter turbines give an average of
  240 MW if channel cross-section filled with turbines and a
  40% flow reduction
  45 MW if only 10% of cross-section filled and a
  5% flow reduction
- For Cook Strait low average flows mean large numbers of turbines are needed, however targeting high flow regions would require far fewer turbines and yield 1-2GW

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