

Tidal Current Energy Conversion: Resource Issues

Ian Bryden

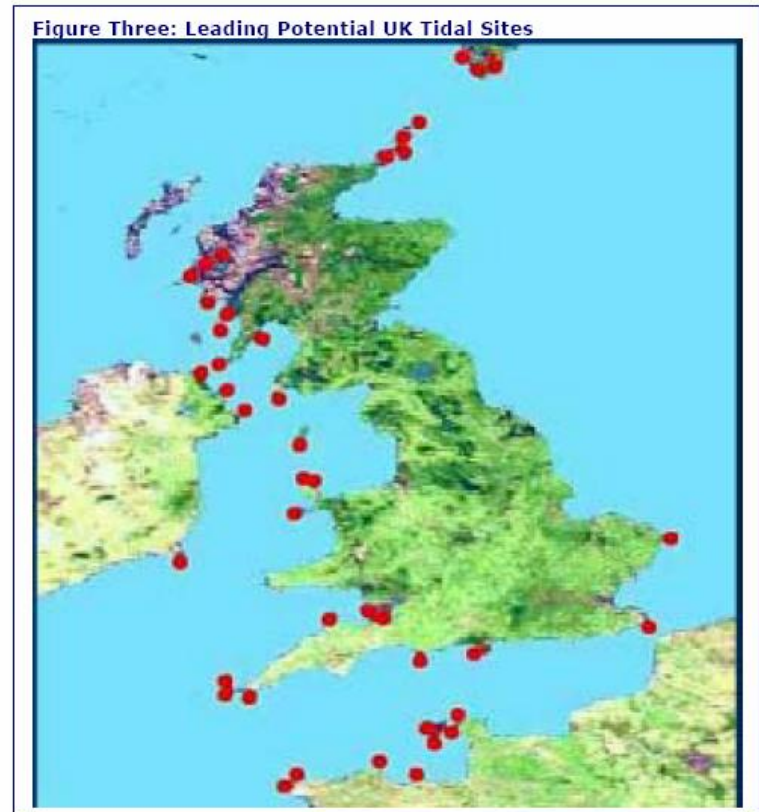
Centre for **R**esearch in **E**nergy and the **E**nvironment
The Robert Gordon University, Aberdeen

Resource Estimation in the FREDs(MEG) Report

- 10% of Scotland's electricity production can come from marine resources;
- we could see 1300 Megawatts of marine energy capacity installed in Scottish waters, increasing at a rate of 100MW per year;

Tidal Current

	2020 %	Rated MW	Annual Energy (GWh)
Pentland Firth	79%	1837	4827
Orkney	5%	115	303
Shetland	7%	153	403
West Highlands	3%	77	202
South West Scotland	7%	153	403
	100%	2336	6138



The “Old Approach”

- Draw parallels with wind energy
- Express resource capacity in terms of MW/unit area
- This approach neglects the hydraulic nature of tidal currents and can easily suggest a resource capacity which exceeds 100% of the actual

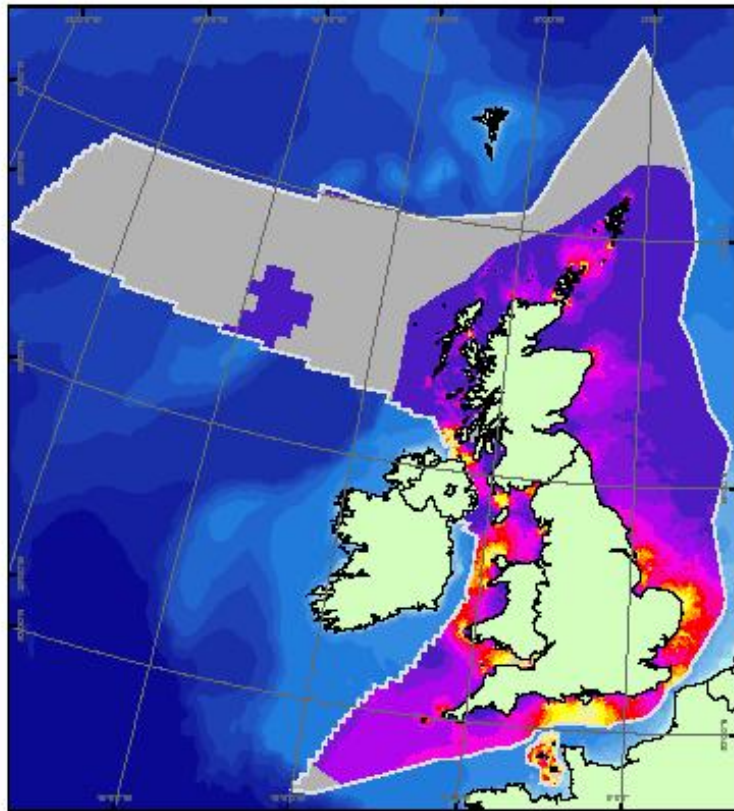
The “New Approach”

- Recognises that energy in tidal currents exists in the form of a flux of kinetic and potential energy
- Recognises that the “Raw” flux is, at best, a secondary indicator of resource capacity
- Potential of a site to deliver energy requires an understanding of the effective impedance of a channel or other location

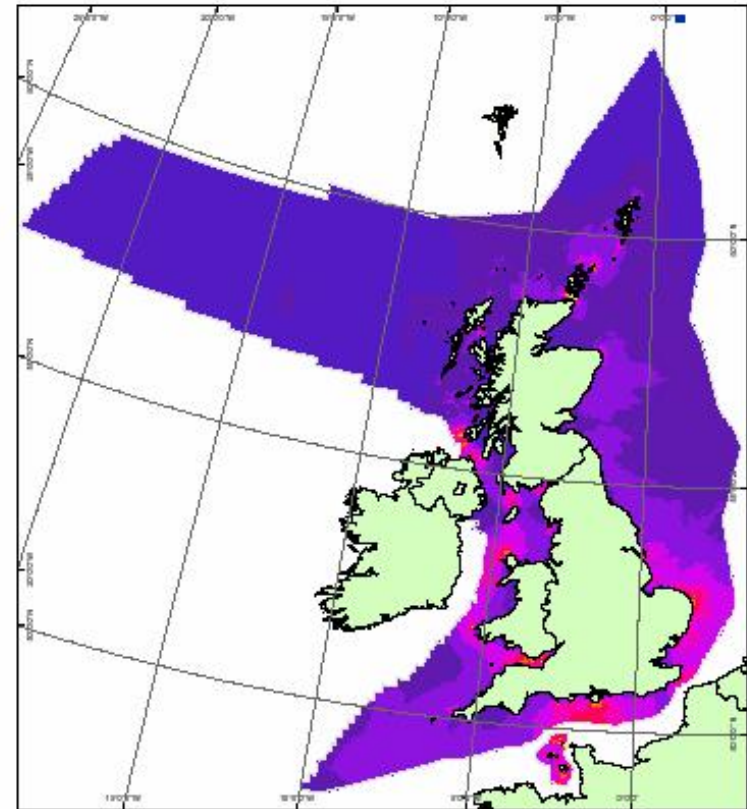


Using the "Flux" Approach we determine the mean energy flux across a chosen section

Tidal Current Energy Flux Density



<p>Power (kW / m²)</p> <ul style="list-style-type: none"> 20.01 - 50.00 10.01 - 20.00 5.01 - 10.00 0.01 - 5.00 5.01 - 6.00 4.01 - 5.00 3.01 - 4.00 2.01 - 3.00 1.51 - 2.00 1.01 - 1.50 0.51 - 1.00 0.26 - 0.50 0.11 - 0.25 0.06 - 0.10 0.01 - 0.05 0.00 	<p align="center">Mean Spring Tidal Power Density</p>
<p>Legend</p> <ul style="list-style-type: none"> UK Continental Shelf & Channel Island Territorial Sea Limit 	<p align="center">Atlas of UK Marine Renewable Energy Resources</p> <p><small>Notes:</small></p> <ol style="list-style-type: none"> 1. Model accuracy is less robust in areas closer than 100 km to land. 2. Total model based on daily predictions throughout one year. 3. Total power is calculated for the upper (50%) water column. 4. Total power is calculated per separate mile of vertical water column. 5. June 2008, Version 1.3 6. © Crown copyright. All rights reserved.
<p>Projection: Transverse Mercator BCRS 1984 UTM Zone 21 N</p> <p>Scale: 1:4,000,000 when printed A3</p> <p align="center">dti</p>	<p align="center">dti</p>

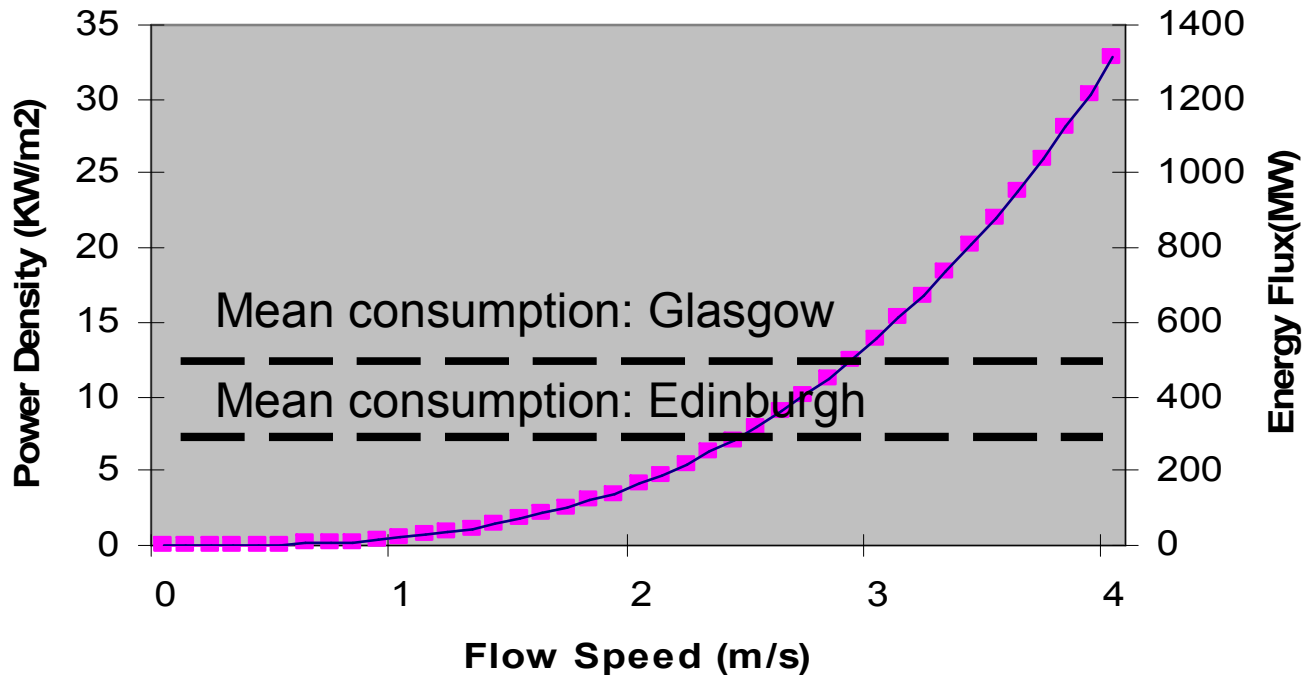


<p>Peak Flow - (m/s)</p> <ul style="list-style-type: none"> 4.01+ 3.51 - 4.00 3.01 - 3.50 2.51 - 3.00 2.01 - 2.50 1.75 - 2.00 1.51 - 1.75 1.26 - 1.50 1.01 - 1.25 0.76 - 1.00 0.51 - 0.75 0.26 - 0.50 0.11 - 0.25 0.00 	<p align="center">Peak Flow for a Mean Neap Tide</p>
<p>Legend</p> <ul style="list-style-type: none"> UK Continental Shelf & Channel Island Territorial Sea Limit 	<p align="center">Atlas of UK Marine Renewable Energy Resources</p> <p><small>Notes:</small></p> <ol style="list-style-type: none"> 1. Model accuracy is less robust in areas closer than 100 km to land. 2. Total model based on daily predictions throughout one year. 3. Total flow is calculated in metres per second. 4. Total power is calculated for the upper (50%) water column. 5. June 2008, Version 1.3 6. © Crown copyright. All rights reserved.
<p>Projection: Transverse Mercator BCRS 1984 UTM Zone 21 N</p> <p>Scale: 1:4,000,000 when printed A3</p> <p align="center">dti</p>	<p align="center">dti</p>

Influence of Flow Speed on Energy Flux in a Simple Channel

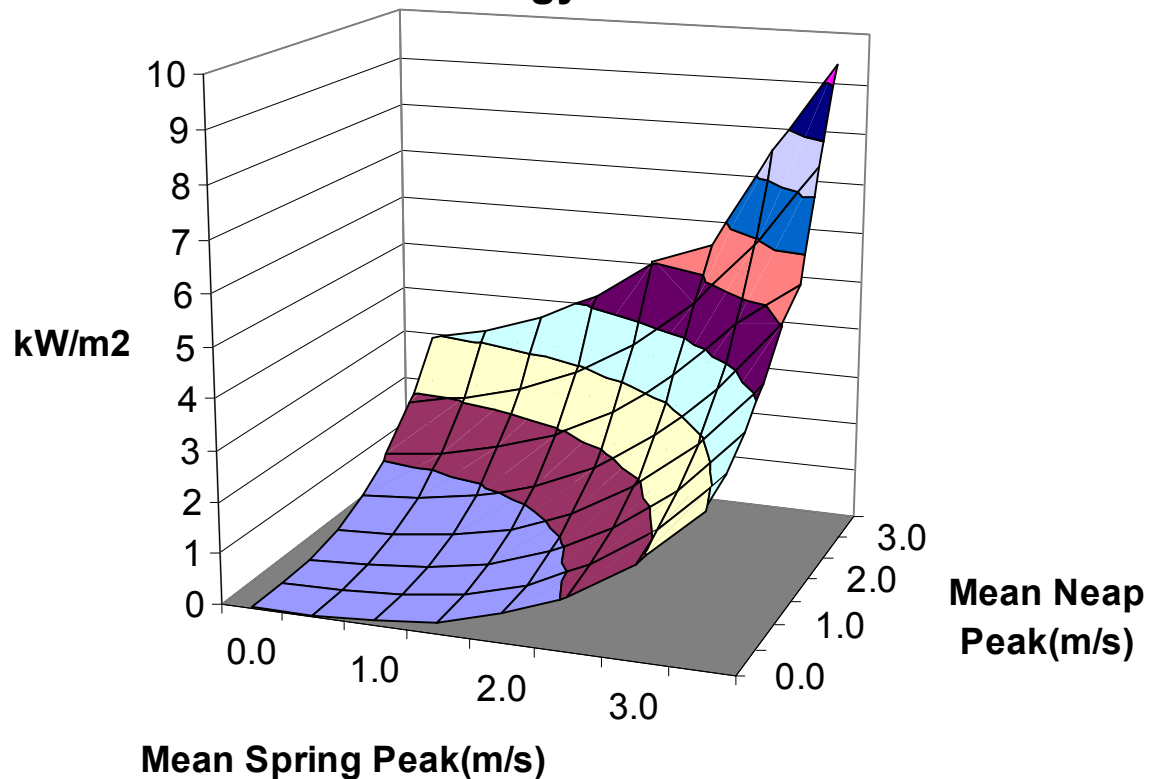
Channel Width	1000m
Channel Depth	40m

Influence of Flow Speed on Energy Flux



But: Influence of Flow Statistics

Influence of Tidal Statistics on the Mean Kinetic Energy Flux

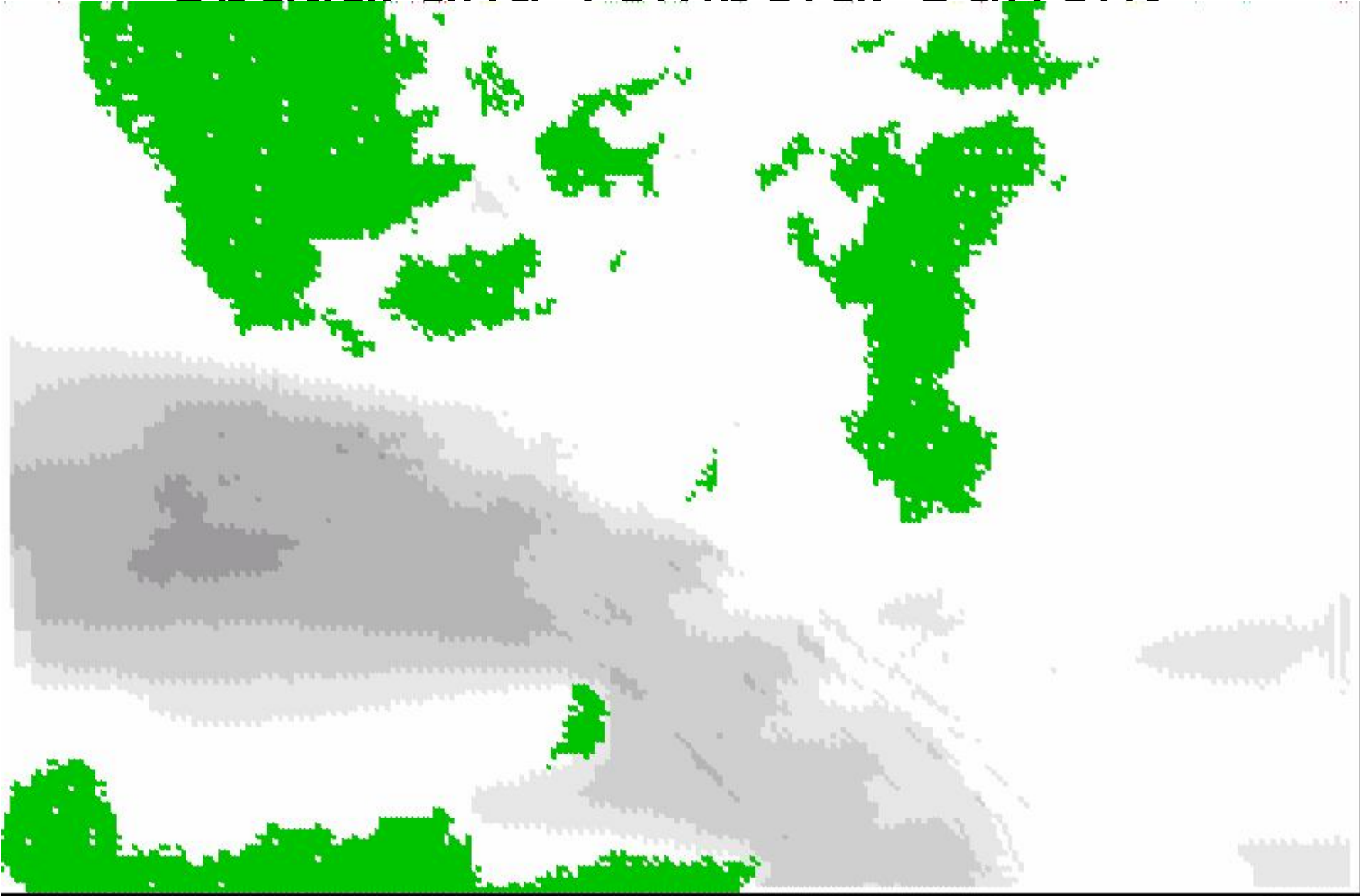


Obviously vital that the full tidal statistics are considered and not just the spring peak!

Assessment of Energy Flux at a Site Level

- Necessary to consider temporal variation over the semi-diurnal and spring/neap cycles
- Also necessary to consider the variation in current flow spatially
- In some sites, “Energy Hot Spots” may move between flood and ebb tides
- Need to identify regions of spatial stability for device installation

Spatial and Temporal Current

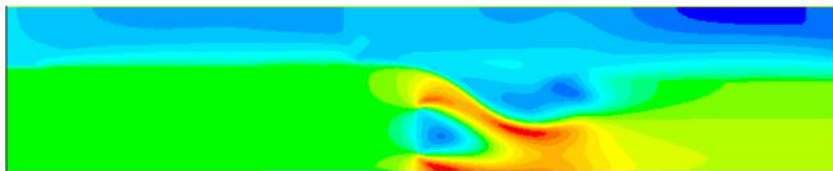
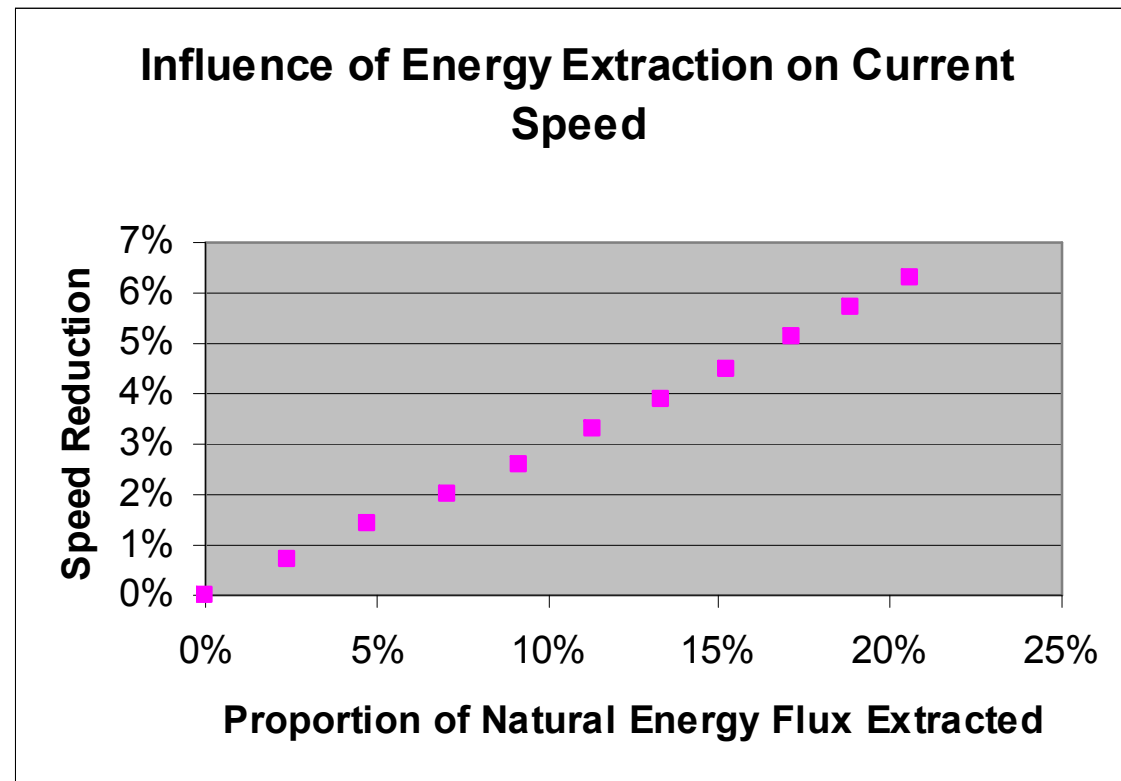


Identifying Limits to Extraction

The extraction of energy from a tidal flow will alter the underlying hydraulic nature of a tidal environment.

This will set limits to how much energy can be extracted without causing unacceptable changes

What those limits are will depend upon the site



Based on a simple 1 dimensional channel model

Other Factors

- Need to know depth limitations of technology type, so that comparative assessments can be made.
- Likely exclusions issues
- Still no comprehensive national resource assessment, including all constraint identification