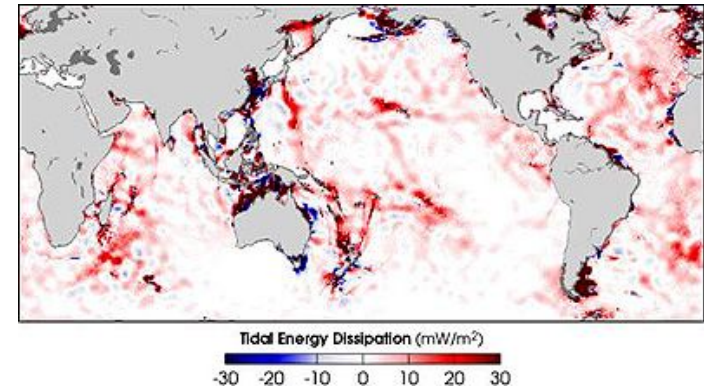


Analysis of Tidal Current Dynamics

Dr. Scott J. Couch
Institute for Energy Systems
University of Edinburgh



TOPEX/POSEIDON experimentally derived global tidal energy dissipation

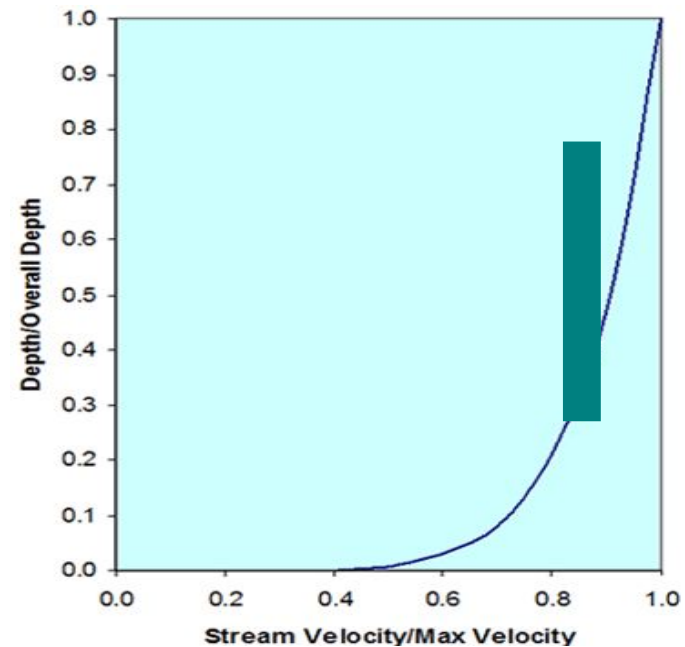
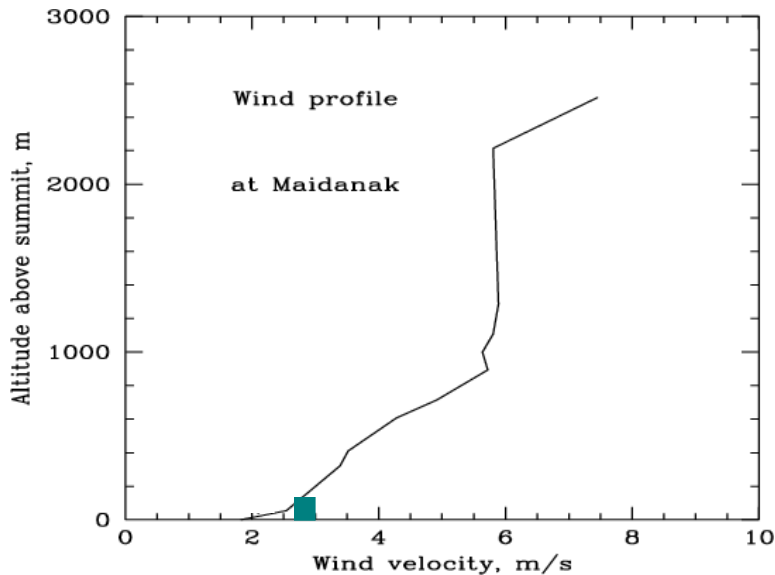


Supergen objective

“... to establish and calibrate methodologies that allow a greater understanding of the nature and magnitude of the recoverable, sustainable and deliverable marine energy resource.”

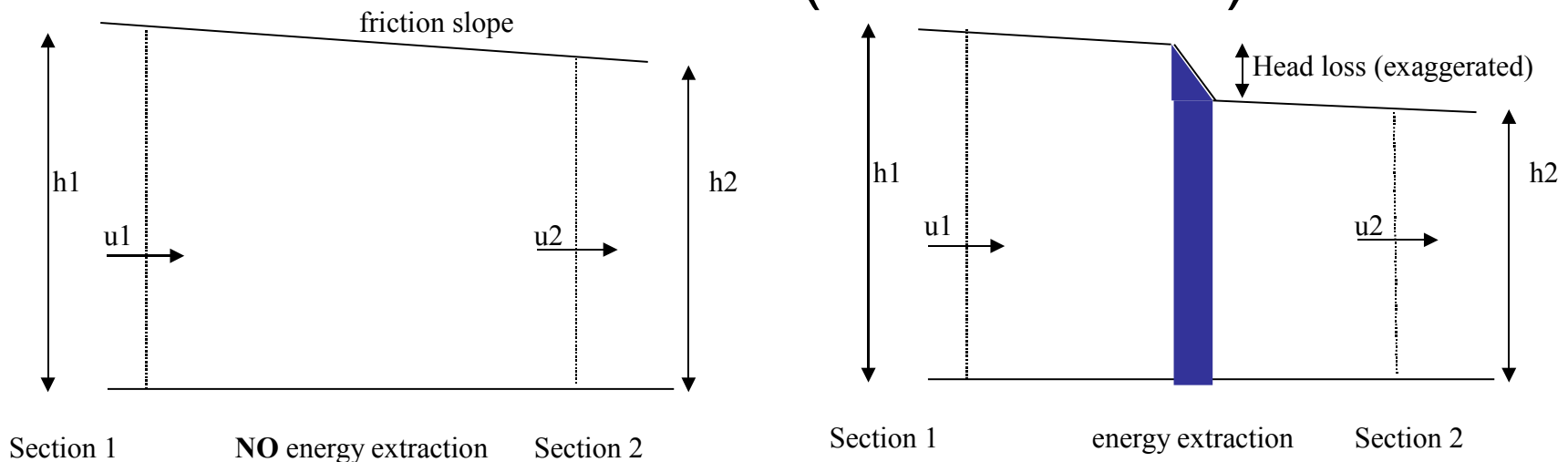
Where were we pre-Supergen

- Limited knowledge-base existed.
 - Most theories developed in analogy with the wind energy industry. How relevant is this?



Supergen step change (i):

- Impact of extraction: From 1-d analysis
 - **Old approach:** Closed stream-tube approach = reduction in kinetic energy downstream.
 - **New thinking:** In the presence of a free-surface kinetic energy **increases** downstream of the extraction site (the tidal case).



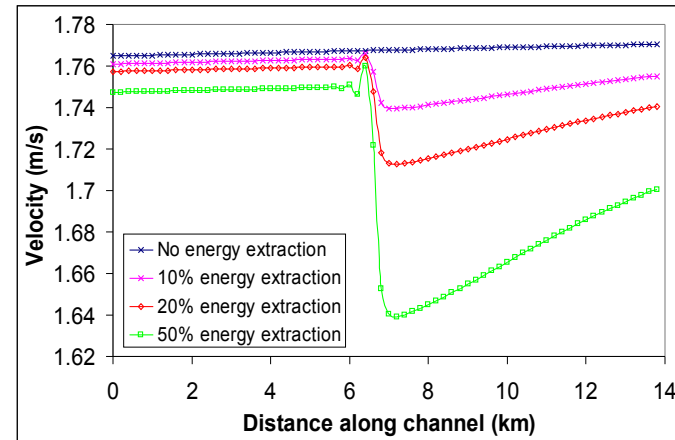
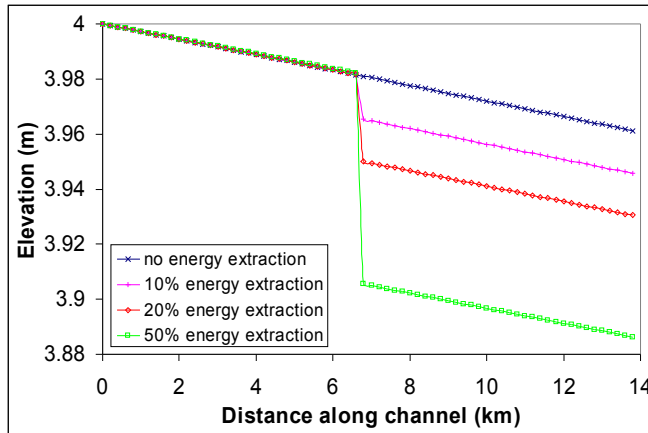


Supergen step change (i) contd.

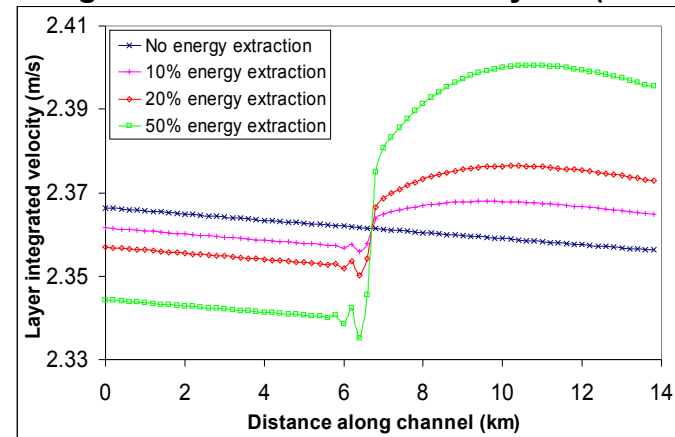
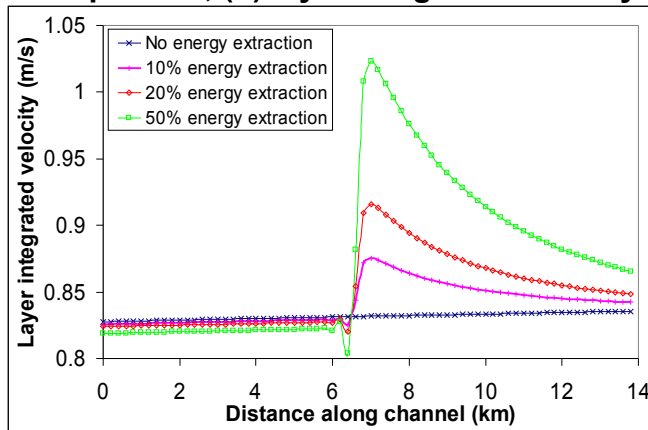
- Thinking only in terms of the kinetic energy component of the tidal system ignores the important dynamics:
 - Extracting energy at a discrete point reduces the overall kinetic energy in the system **by altering the surrounding pressure field**.
 - The kinetic energy in the system **downstream** of the extraction location is **higher** than **upstream**
 - Future analysis needs to think in terms of **total** as opposed to **kinetic** energy.

Supergen step change (i) contd:

- Impact of extraction: From 3-d analysis

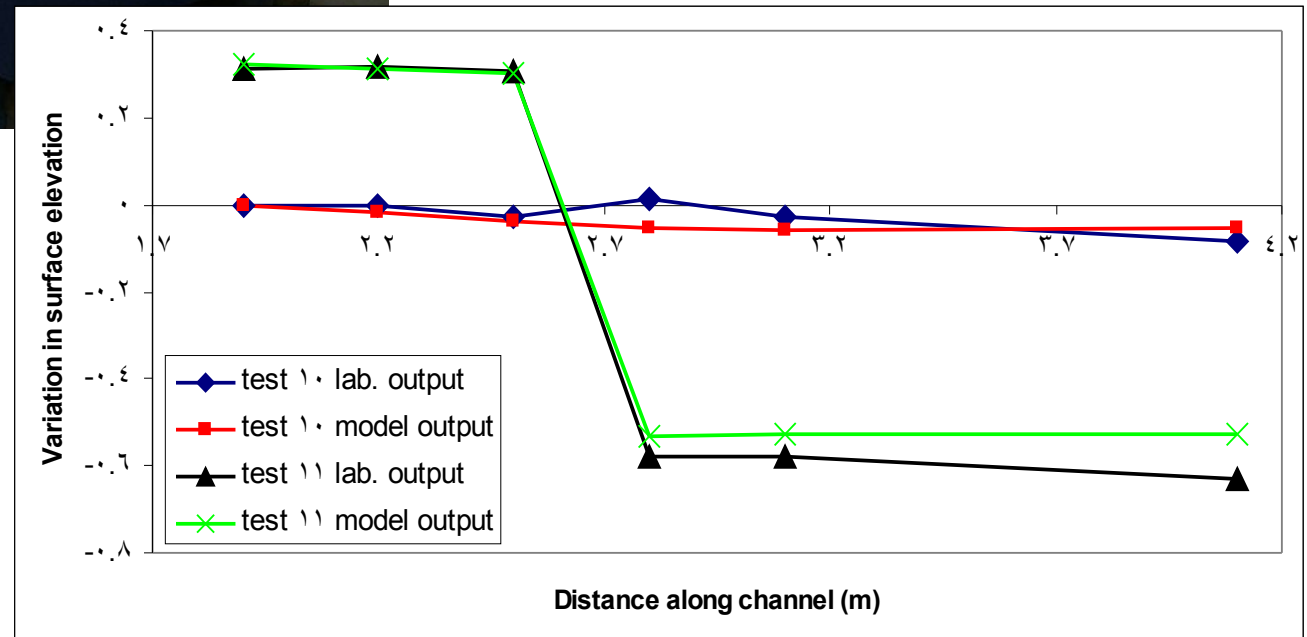
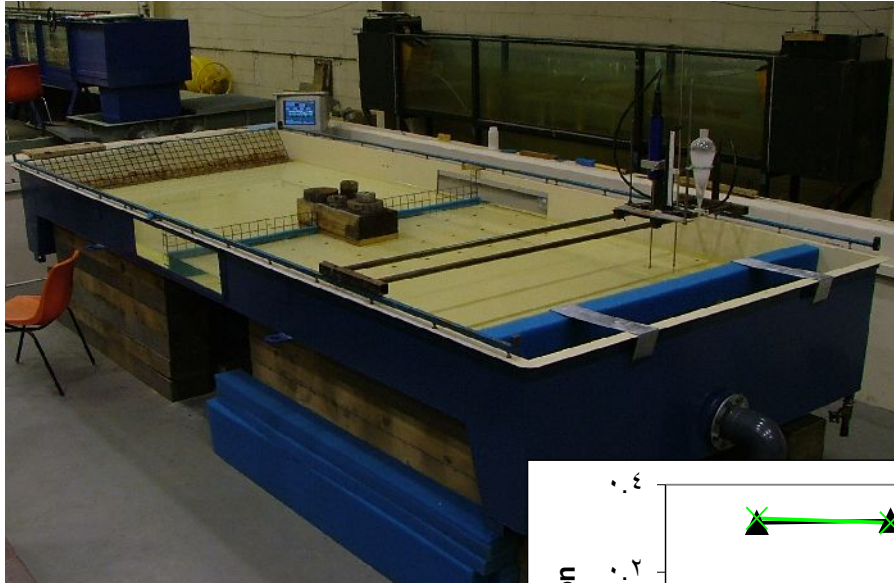


(a) elevation profiles, (b) layer integrated velocity profiles through the water column for σ -layer 5 (of 10).



Layer integrated velocity profiles through the water column, (c) σ -layer 1 (bottom), and (d) σ -layer 10 (top)

Laboratory validation:

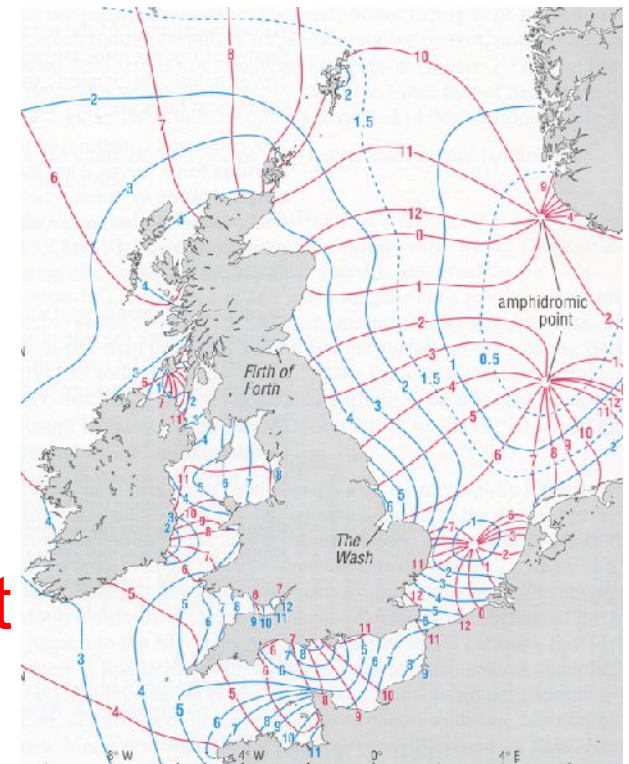


Supergen step change (ii):

- Not all tidal currents are the same!
 - Different mechanisms for driving strong currents have been identified:

- Hydraulic currents
- Tidal streaming
- Resonance

- Each mechanism has a different sensitivity to energy extraction



Supergen step change (iii)

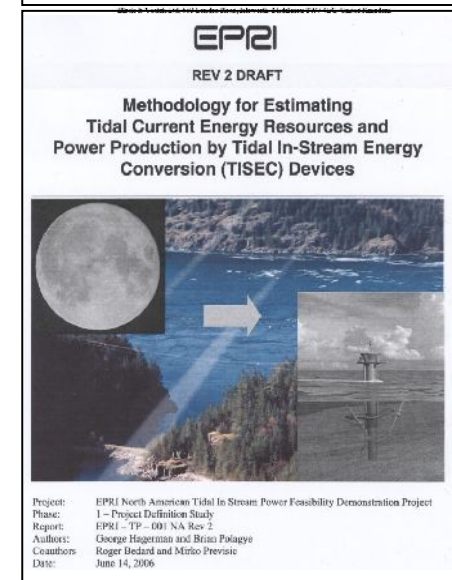
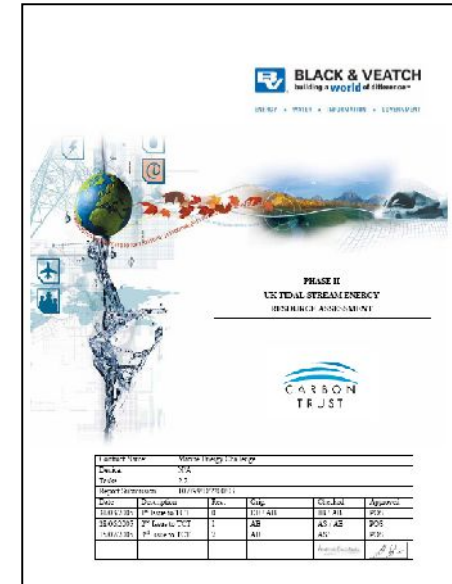
- Inadequacies of pre-Supergen resource assessments have been identified:
 - Think only in terms of kinetic energy.
 - No consideration of the impact of energy extraction.
 - No consideration of the impact on the larger tidal system (pressure gradient field).
 - Supergen has developed a robust methodology for resource assessment which addresses these issues.

Measurable impact

Significant impact of Supergen output is reflected by the direct adoption of methodologies, theories and conclusions from our work in recent major marine renewable publications.

Black & Veatch: “UK Tidal Stream Energy Resource Assessment” for the Carbon Trust Marine Energy Challenge.

Energy Power Research Institute: “Methodology for Estimating Tidal Current Energy Resources and Power Production by Tidal-in-Stream Energy Conversion (TiSEC) Devices”.



Future research questions?

- Need for monitoring of full-scale device operation to further inform research.
- Microscale effects: wake structure
- Macroscale effects: sensitivity to large-scale extraction.
- Need to use advanced understanding of physics to inform understanding of wider issues which will influence political and social attitudes.

Achievements

- A suite of 1-, 2-, and 3- dimensional numerical modelling tools have been developed to inform research.
- These modelling tools provide the first integrated approach to investigation of pre- and post-development resource assessment scenarios.
- A step change in understanding of the physical impact of energy extraction on the tidal system.
- The first recognition and attempts to study the varying sensitivity of the tidal energy resource to extraction dependent upon the underlying physics.



Thank you for your attention

Questions?