



European User Symposium

ACDP Technology in Tidal Site Selection

openhydro
tidal technology

OpenHydro



OpenHydro

- ❑ Company formed 2004
- ❑ Open-Centre Turbine Technology
- ❑ 40 employees in Dublin and Greenore
- ❑ €52m raised to date
- ❑ Operational in 7 countries

Tidal Technology

European Marine Energy Centre (EMEC)

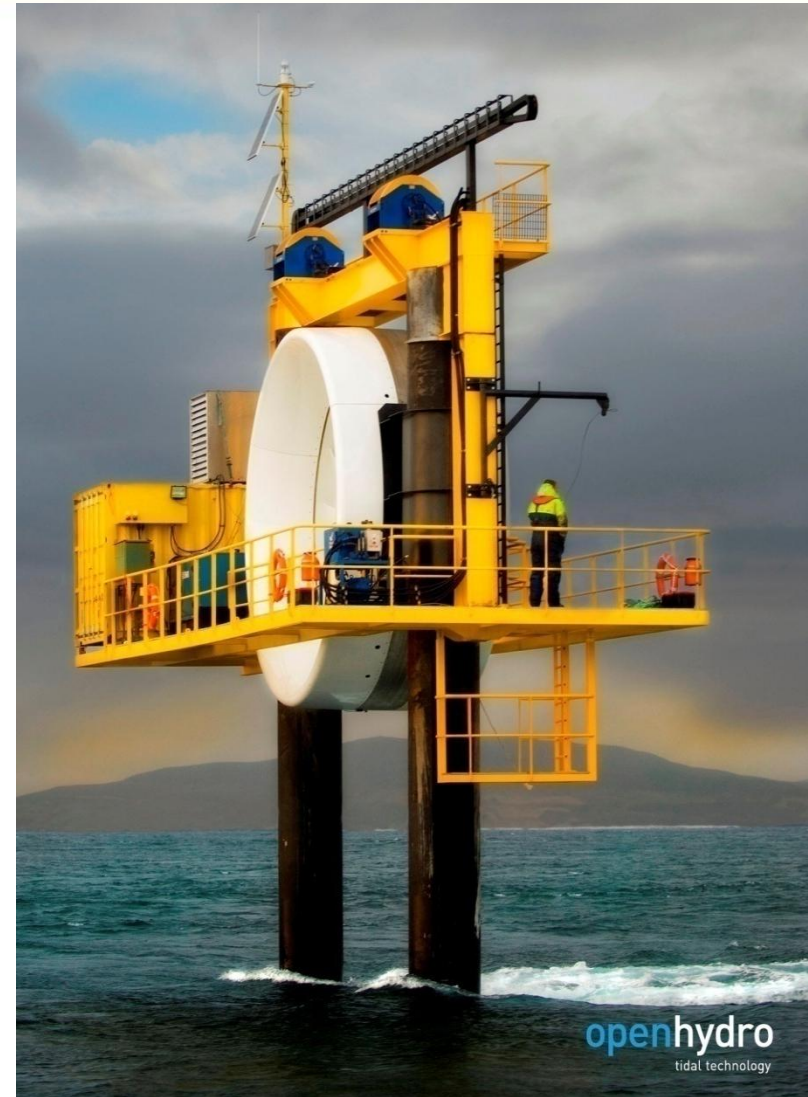
- ❑ Created by the UK & EU to support the Tidal & Wave industry; accredited marine laboratory.
- ❑ Global reputation as the centre for marine renewables.
- ❑ No 'soft option' with some of Europe's strongest tides (8.5 knots) and extreme weather climate (60° N).
- ❑ Politically driven allowing access and development options



Technology Development

Research Structure

- ❑ Installed at EMEC during 2006
- ❑ Continuous testing of 5 OCT-06 tidal turbines
- ❑ Grid connected May 2008



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OpenHydro Installer



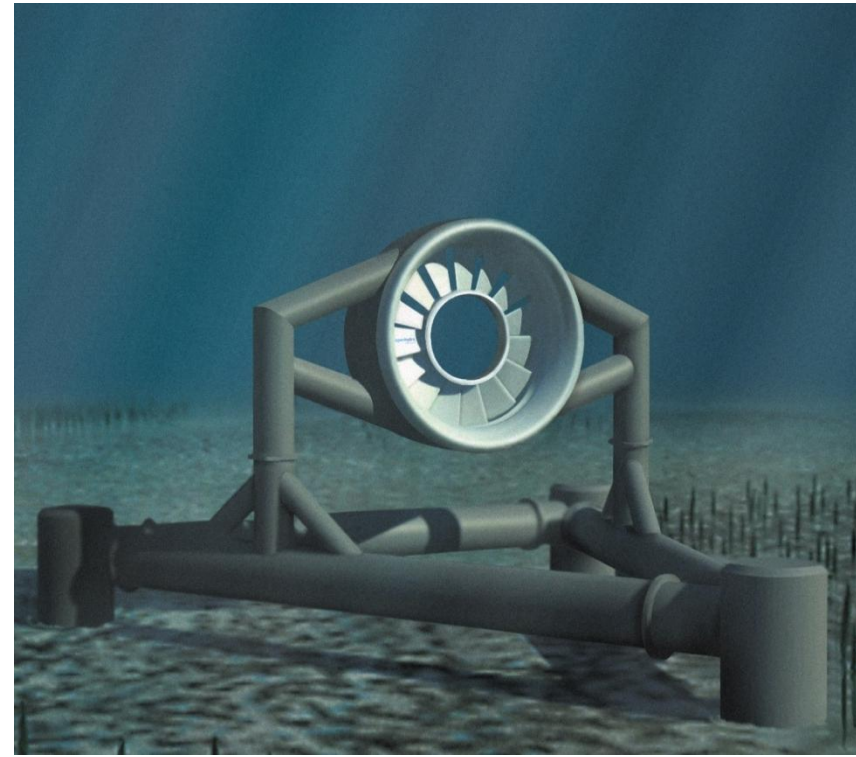
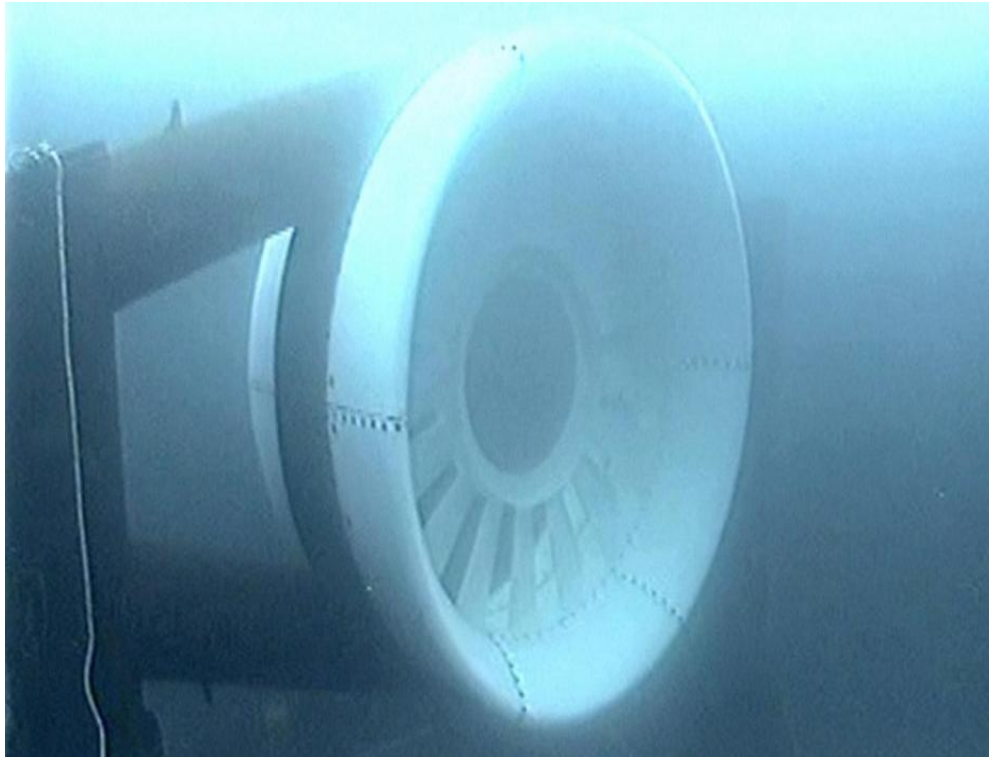
Subsea Installation



Subsea Installation

6m Subsea Base

- ❑ Commercial design is for turbines mounted directly on the seabed.
- ❑ During 2008, OpenHydro built and deployed its first seabed mounted turbine at EMEC



10m OpenCentre Turbine



Tidal Technology

FORCE

- ❑ 3 berth tidal test site – Bay of Fundy
Nova Scotia
- ❑ Strong tidal resource and political drivers

Tidal Demonstration Site



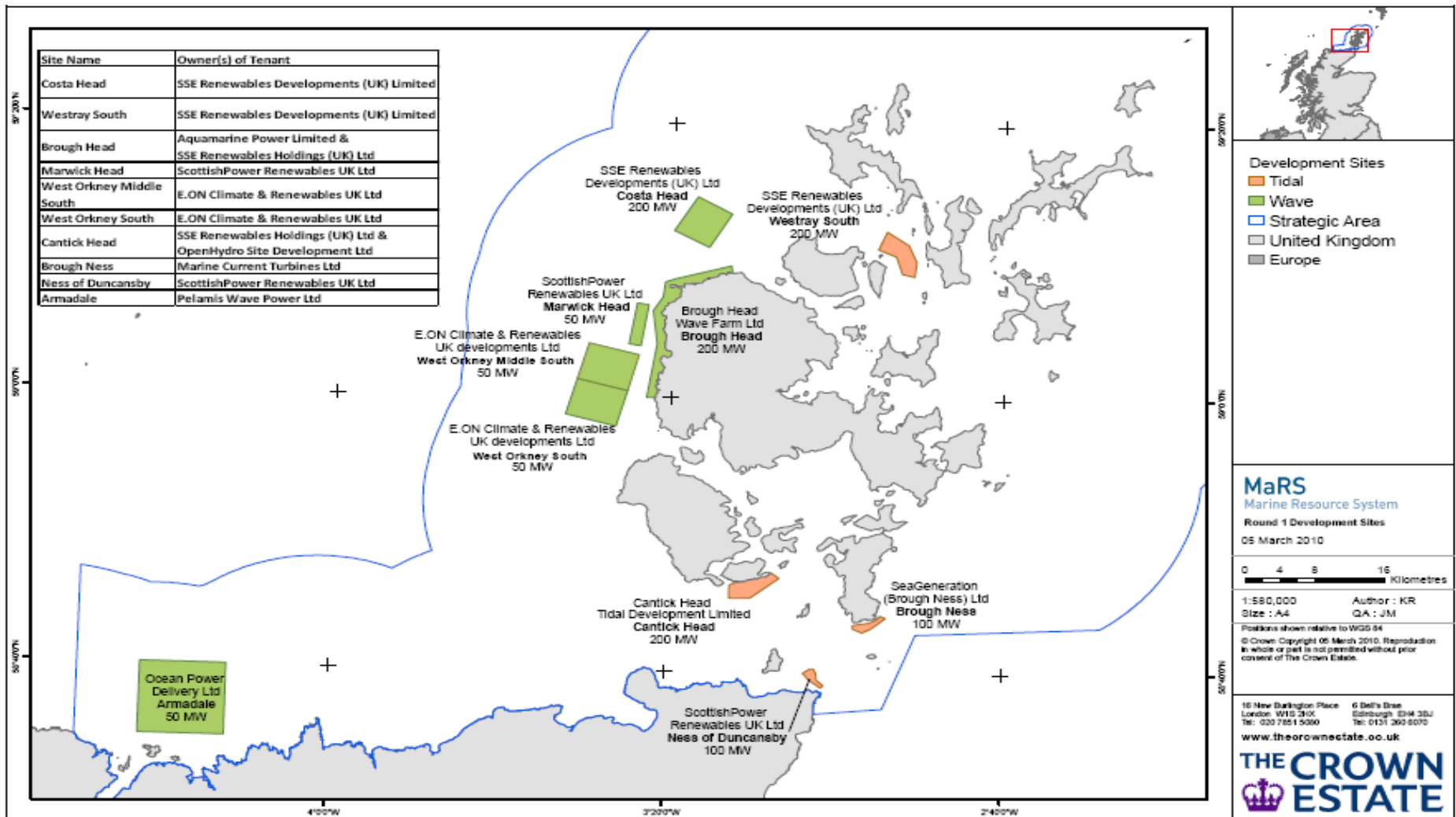
Commercial Developments



- ❑ OpenHydro commercial developments.

Scotland – Pentland Firth

Worlds First commercial scale licensing round

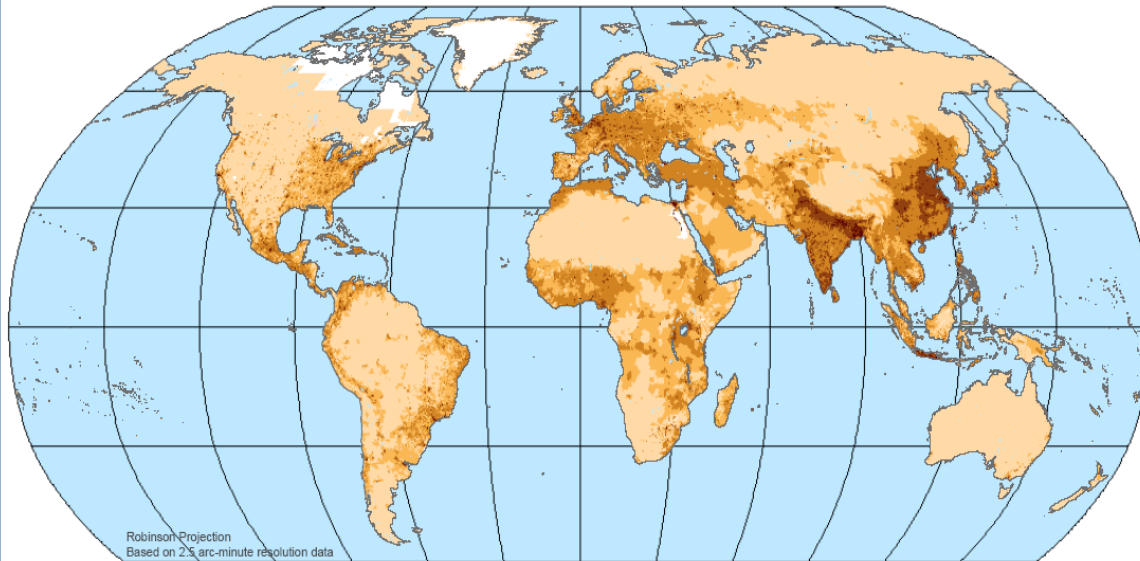


Tidal Energy

Global Tidal Stream Resource

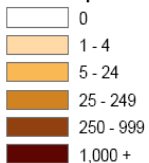
The World: Population Density, 2000

GPW [v3]



Gridded Population of the World

Persons per km²



Copyright 2005. The Trustees of Columbia University in the City of New York. Source: Center for International Earth Science Information Network (CIESIN), Columbia University, and Centro Internacional de Agricultura Tropical (CIAT), Gridded Population of the World (GPW), Version 3. Palisades, NY: CIESIN, Columbia University. Available at: <http://sedac.ciesin.columbia.edu/gpw>.

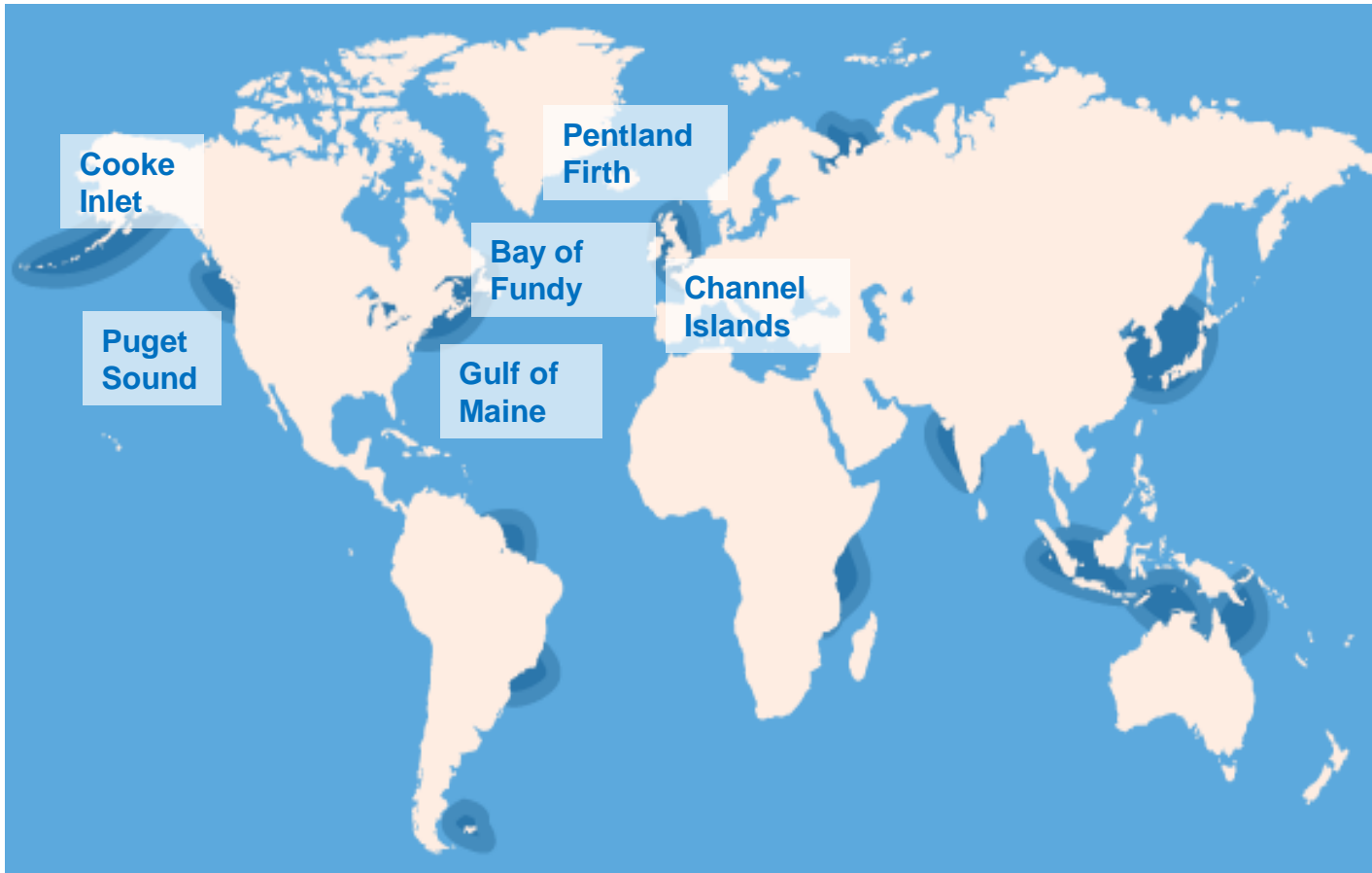
Opportunity

- ❑ 50TWh resources identified in Irish and UK waters
- ❑ 19.6TWh resources identified in US waters
- ❑ Potential for resource use, creation of an industry and economic gain HUGE

- ❑ An industry estimated to be worth €128bn in equipment sales.

Tidal Energy

Where in the world.....



Tidal Resource Assessment

OECD	Scale
Canada	Tier 1
UK	Tier 1
US	Tier 1
Japan	Tier 1
France	Tier 1
New Zealand	Tier 2
Australia	Tier 2
Falklands	Tier 3
Korea	Tier 3
Singapore	Tier 3
Ireland	Tier 3

TRANSITION	
China	Tier 1
India	Tier 2
Indonesia	Tier 2
Philippines	Tier 2
Brazil	Tier 2
Russia	Tier 3

DEVELOPING	
Guyana	Tier 2
Bangladesh	Tier 2
New Guinea	Tier 2
Burma	Tier 2
Tanzania	Tier 2

□ Global resources estimated between 450GW to 3TW

Tidal Energy

Why Tidal



	Predictability	Energy Density	No Visual / Noise Impact
Tidal	✓	✓	✓
Wave	-	✓	-
Wind	-	-	-
Bio Fuels	✓	-	-
Solar	-	-	-

Tidal Energy Projects

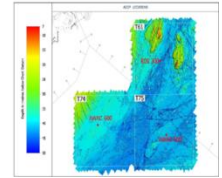
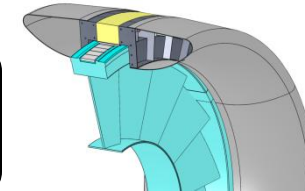
Initiation

Feasibility studies
Contracts
Site Development
Consultation



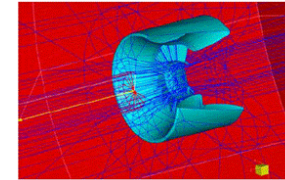
Development

ADCP
EIA
Design / Financials
Consultation



Pre-Construction

Turbine Manufacture
Turbine shipment
Power conversion procurement
Base manufacture



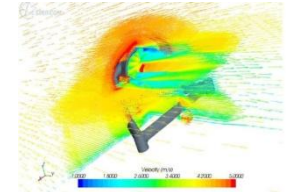
Construction

Turbine assembly / commissioning
Subsea cable installation
Post installation survey
Vessel resource deployment

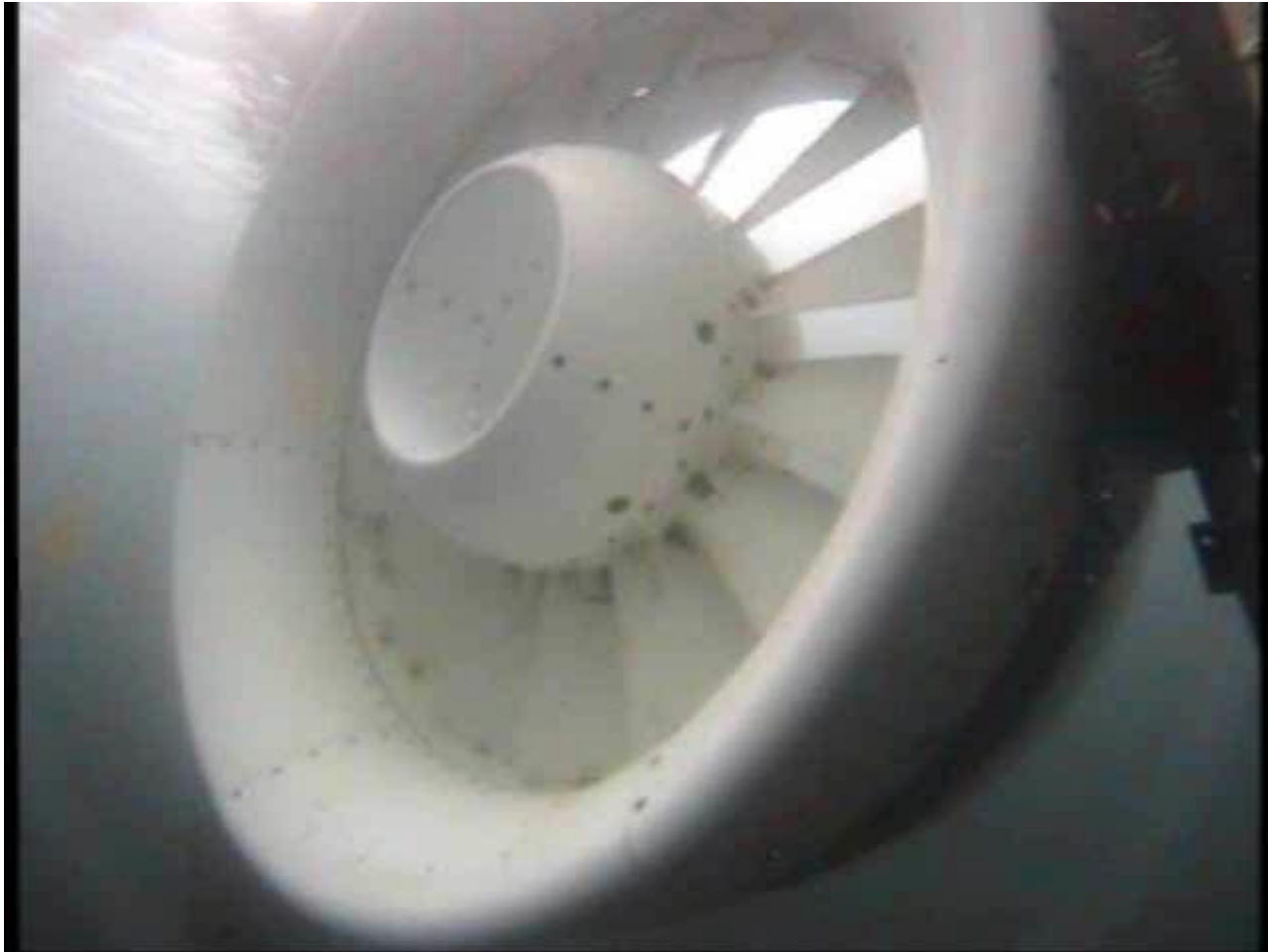


Operate

Monitoring
Maintenance
Component and replacement



ADCP Usage in Tidal Energy Projects



Tidal Energy

- Tidal Stream Power

- $P = \frac{1}{2} \cdot \rho \cdot A \cdot C_p \cdot V^3$

- Understanding Tidal Velocity:

- Electrical Design – power (proportional to V^3)
 - Structural Design – forces (proportional to V^2)

- Critical Parameter:

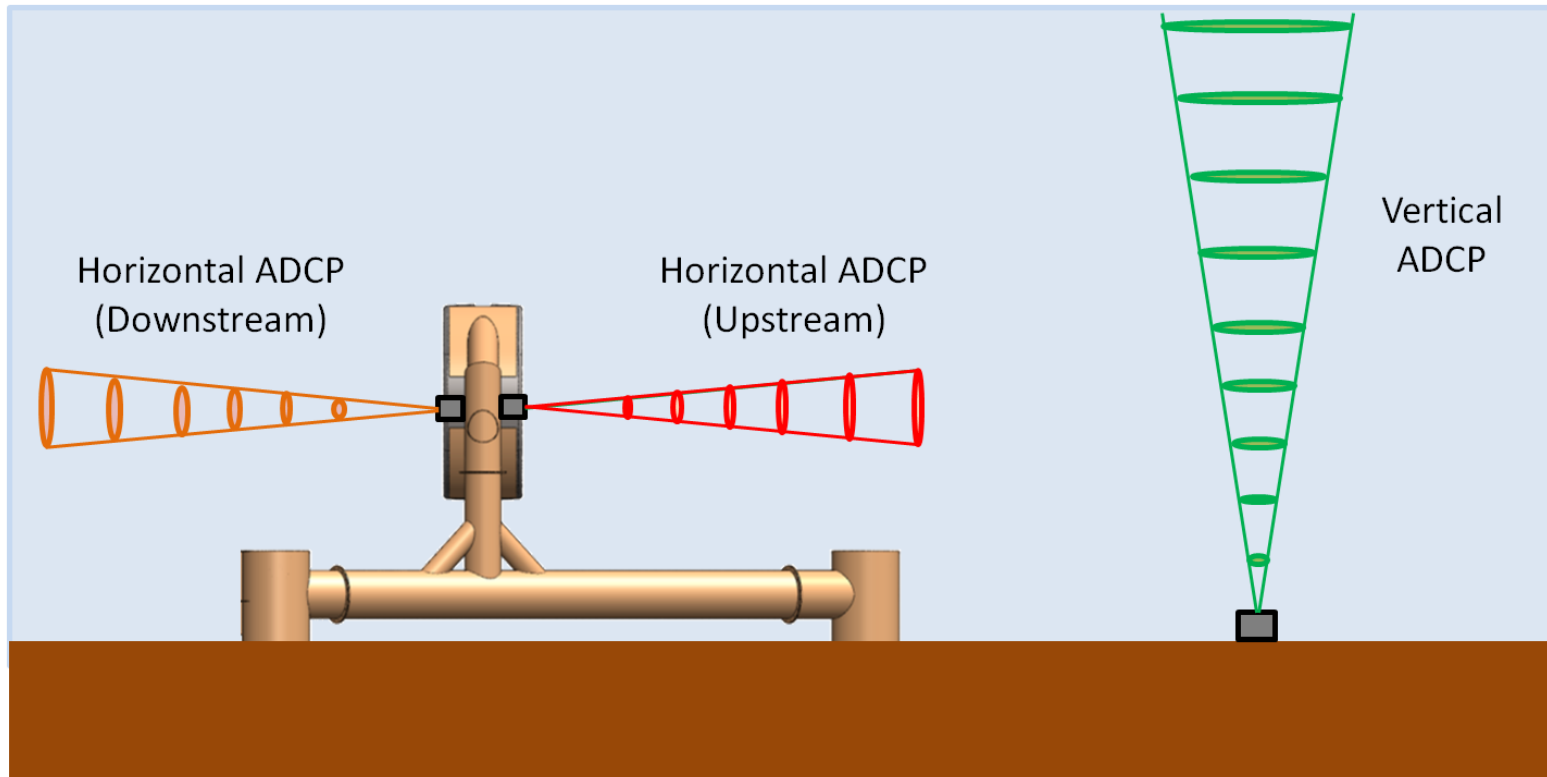
- 10% Velocity error
 - 21% Force error
 - 33% Power error

Installation Video



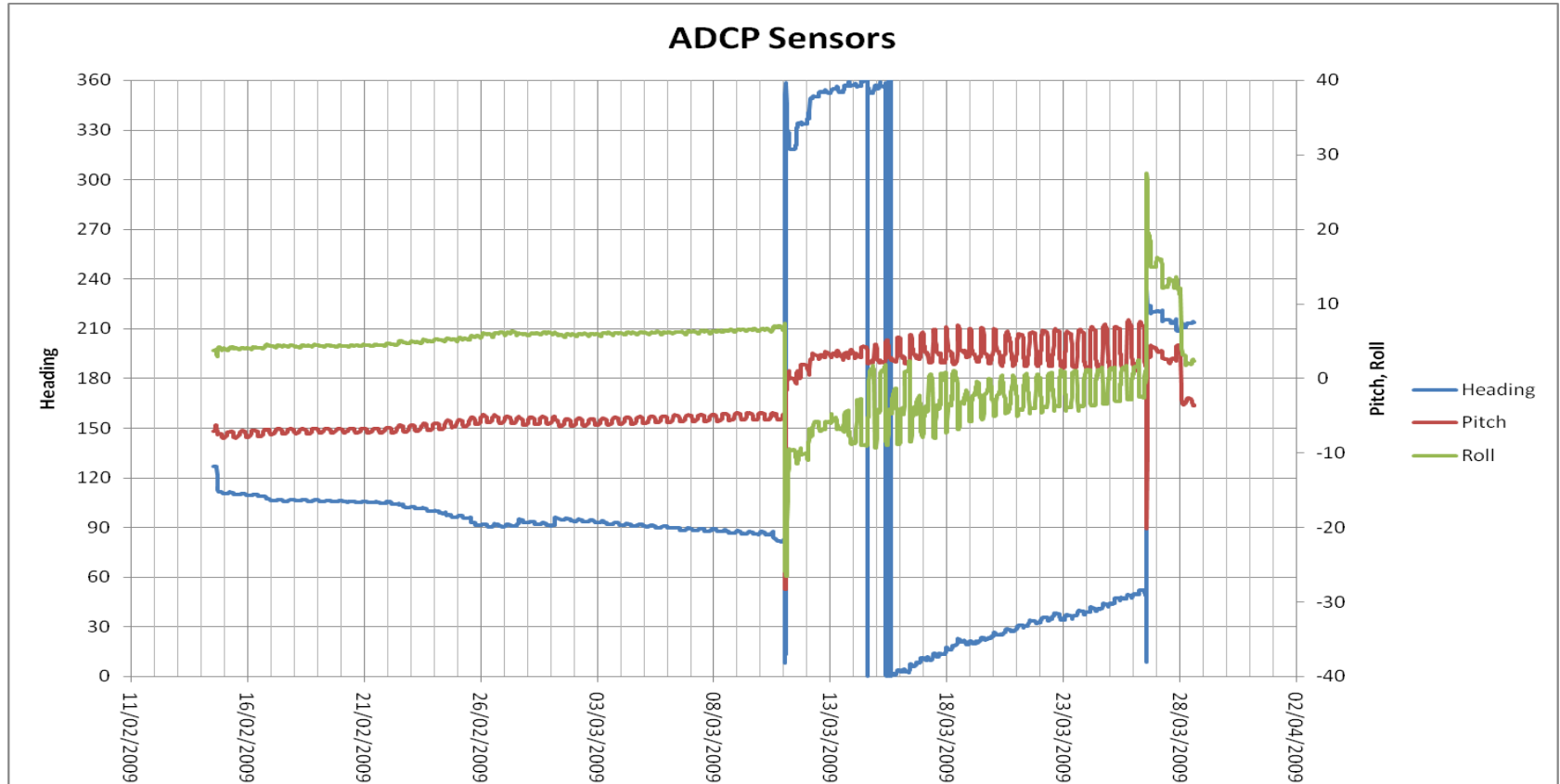
ADCP Surveys

- Stationary Surveys (Vertical ADCP)
- Real-time Monitoring (Horizontal ADCP)



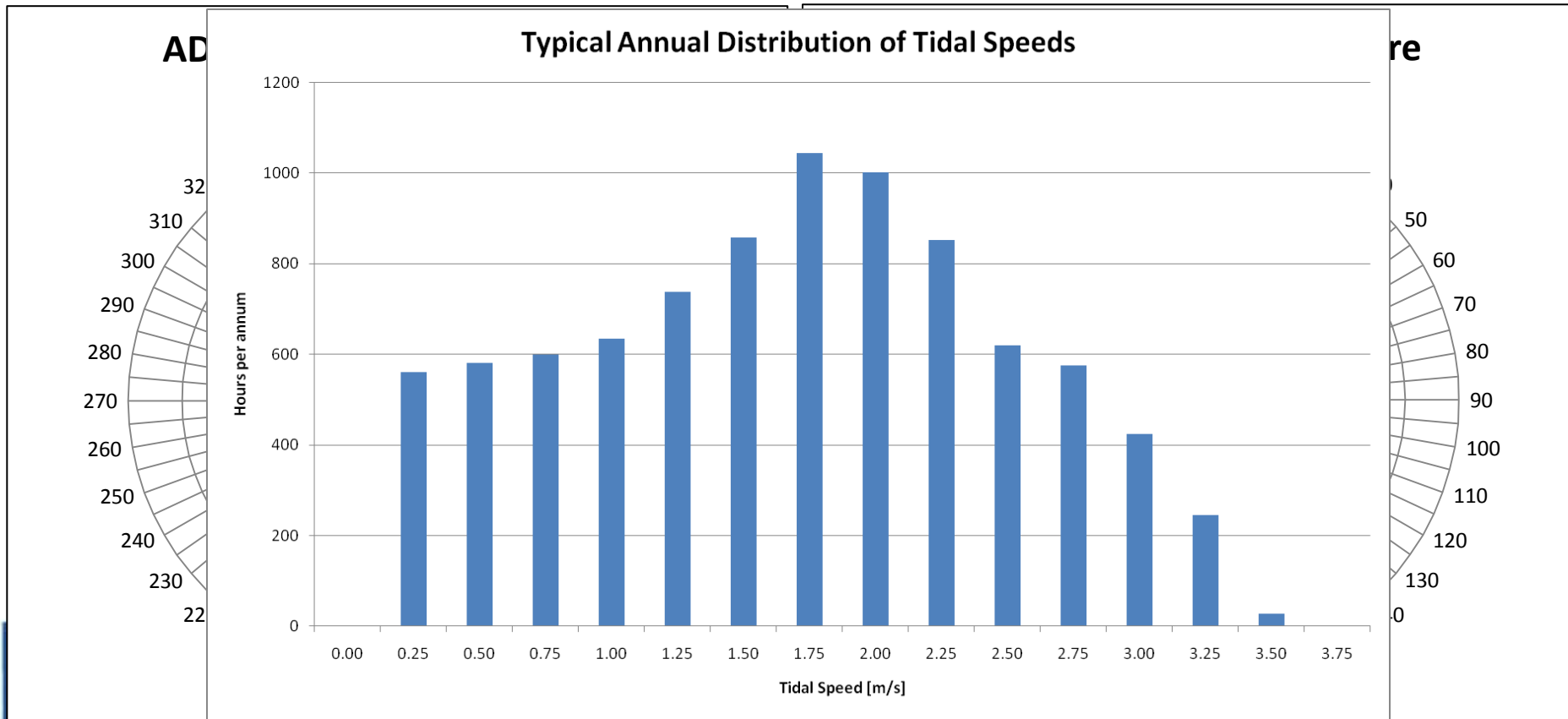
Standard Procedure

- Receive ADCP data
- Process for pitch / roll / heading



Standard Analysis

- Statistics:
 - Peak Flow – up to 5 m/s !
 - Flow Distribution
 - Directions - Tidal Rose

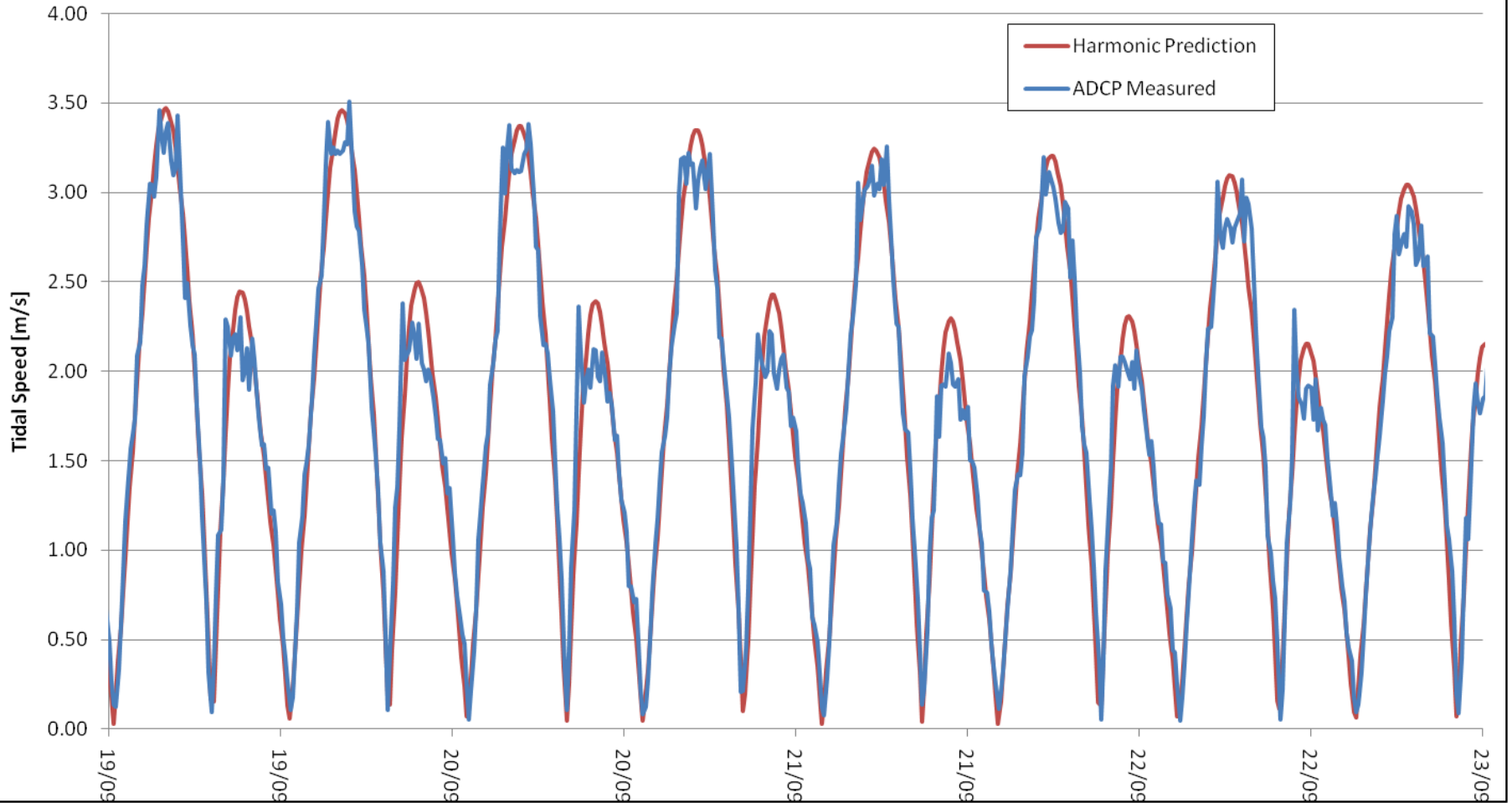


Harmonic Analysis

- Tidal Prediction
 - Take experimental data – project forward
- Why:
 - Energy prediction – economics
 - Power prediction – grid operations
 - Deployment operations – installation window
- Tidal Velocity is function of time
 - Harmonic analysis - mathematical treatment of limited experimental data to determine forcing function amplitudes and phases

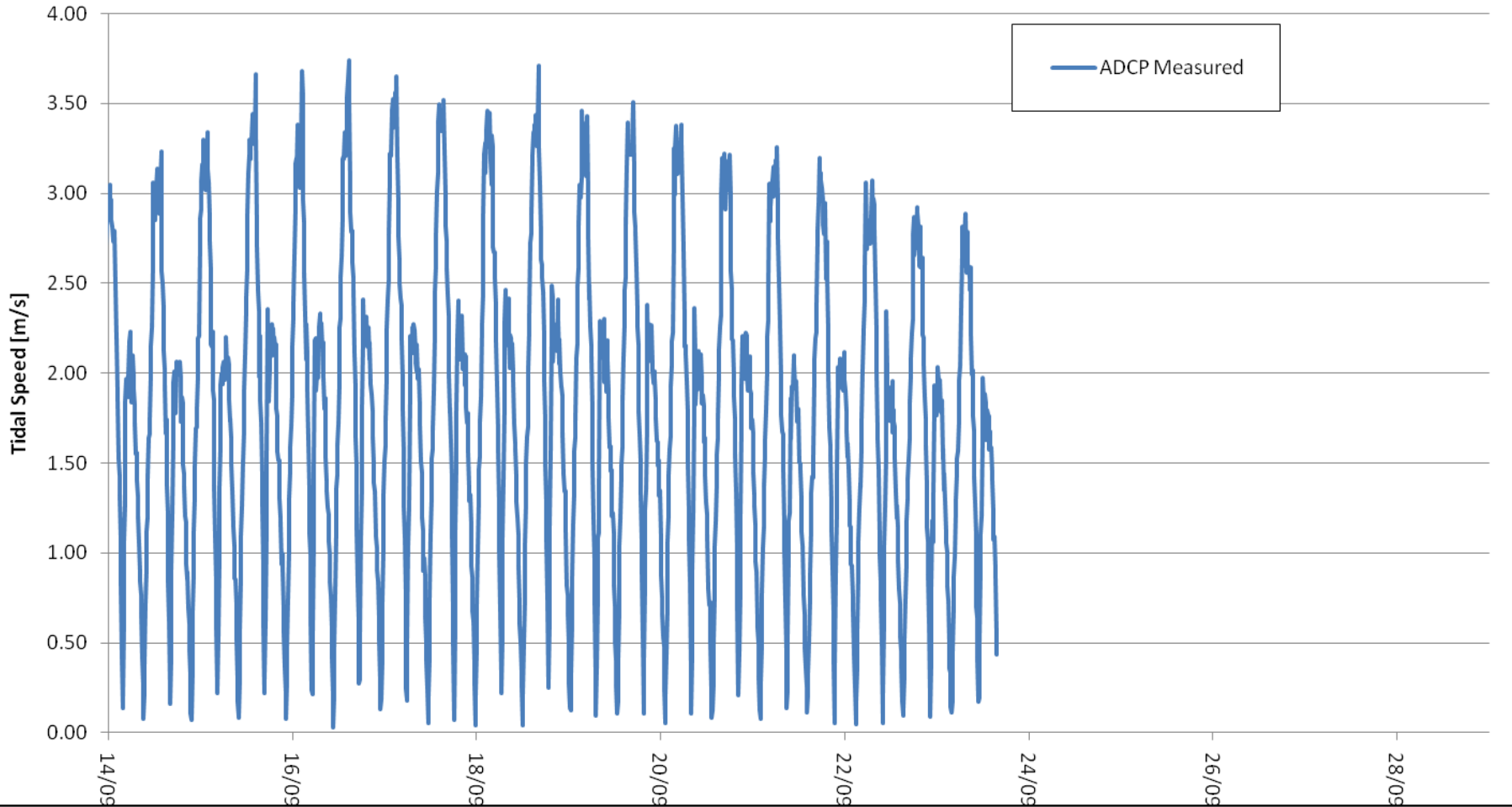
Harmonic Analysis

Tidal Harmonic Prediction



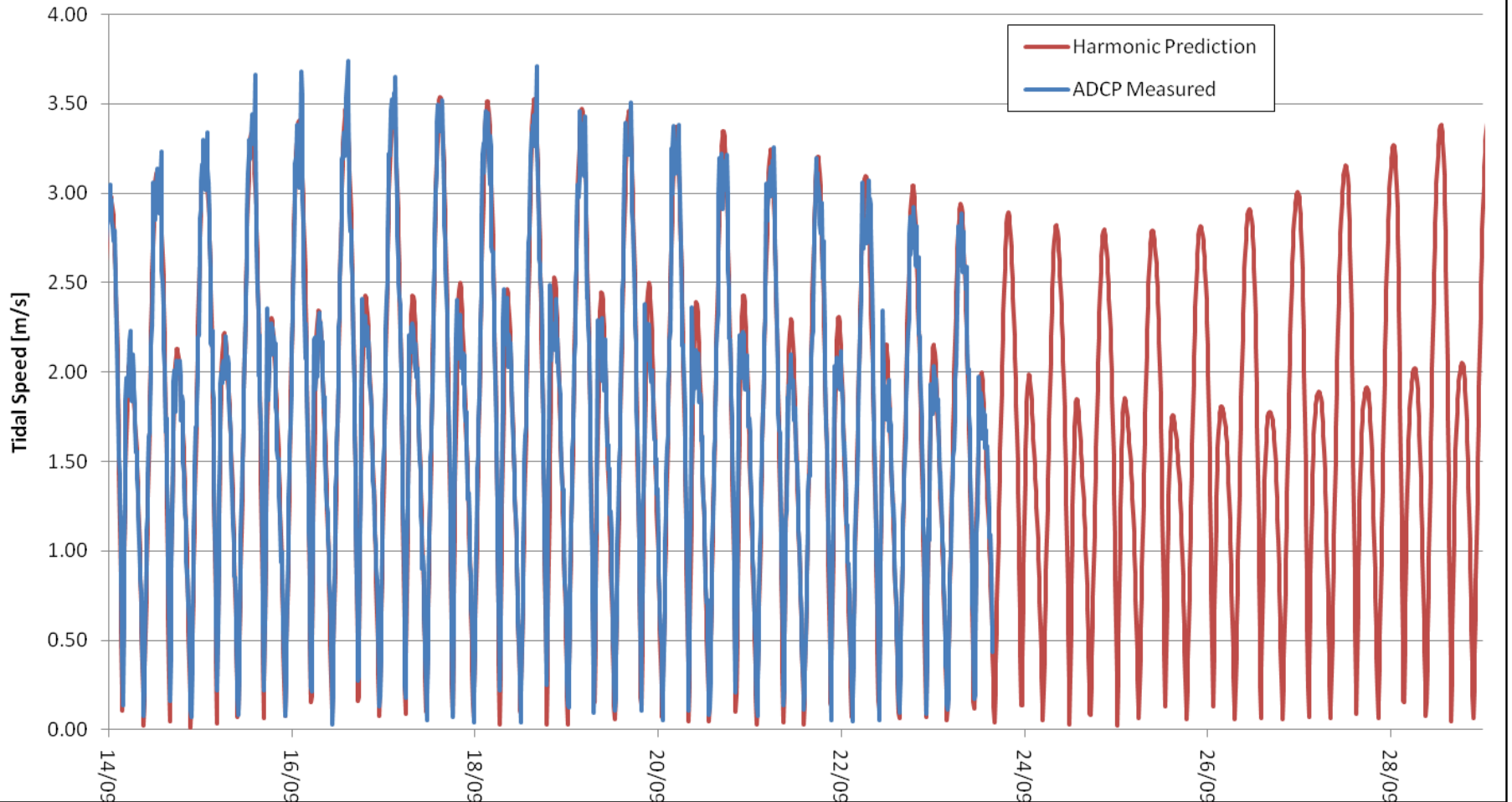
Harmonic Analysis

Tidal Harmonic Prediction



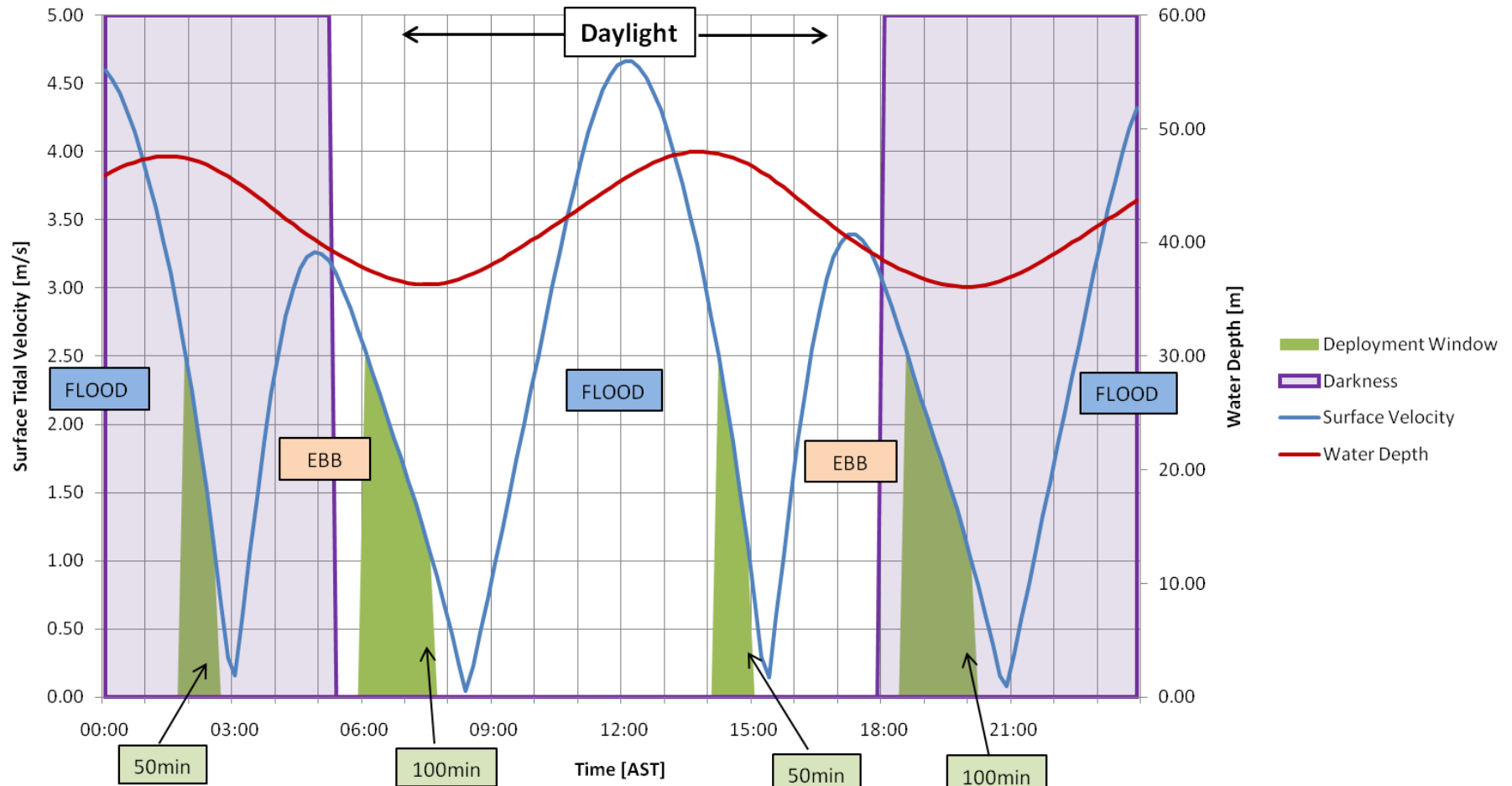
Harmonic Analysis

Tidal Harmonic Prediction



Sample Application: Deployment Planning

Predicted Surface Tidal Data



General Comments

- We need continuous measurements for 30 days minimum
- Stable Deployment
- Reliable Recovery Methods

Thank you
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