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Marine Current Turbine's SeaGen technology

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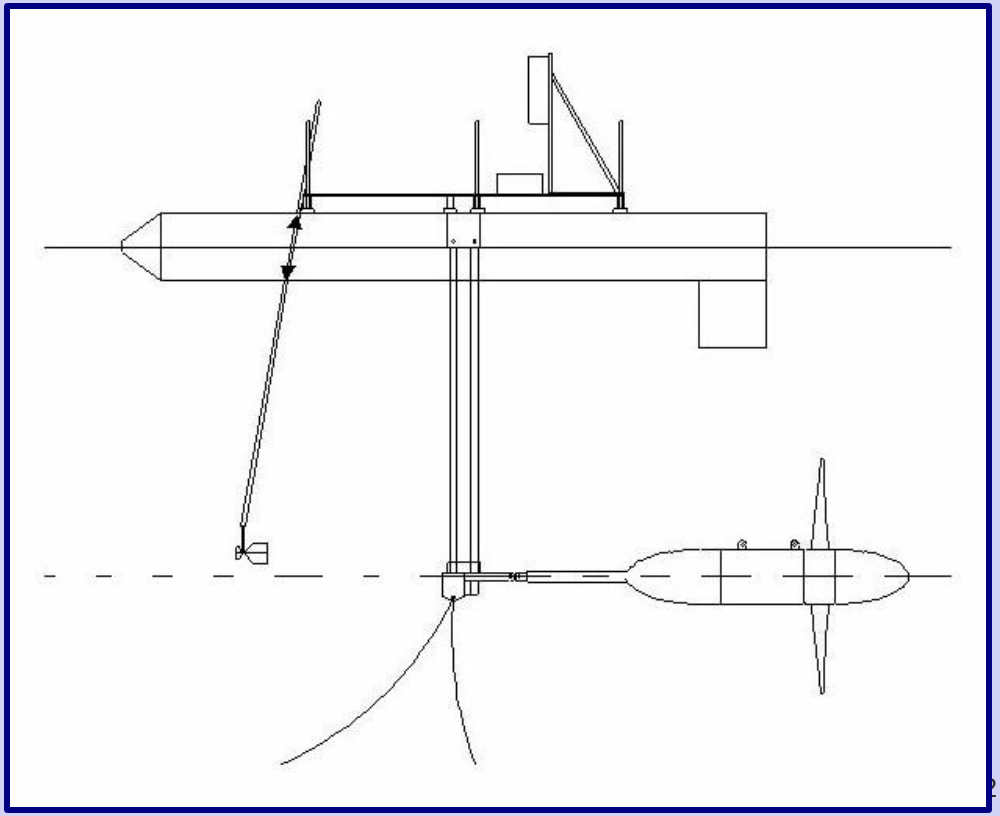
15kW Tidal Current Turbine (1994-5)

PROOF OF CONCEPT PROJECT

(IT Power. Scottish Nuclear & NEL)

Loch Linnhe, Scotland

World's first tidal current turbine



Seaflow installed 30 May 2003

rotor dia. 11m (= 95 sq.m.)
rated power 300kW @ 2.5m/s

World's first full-size, and only offshore tidal current turbine

Seaflow in typical conditions

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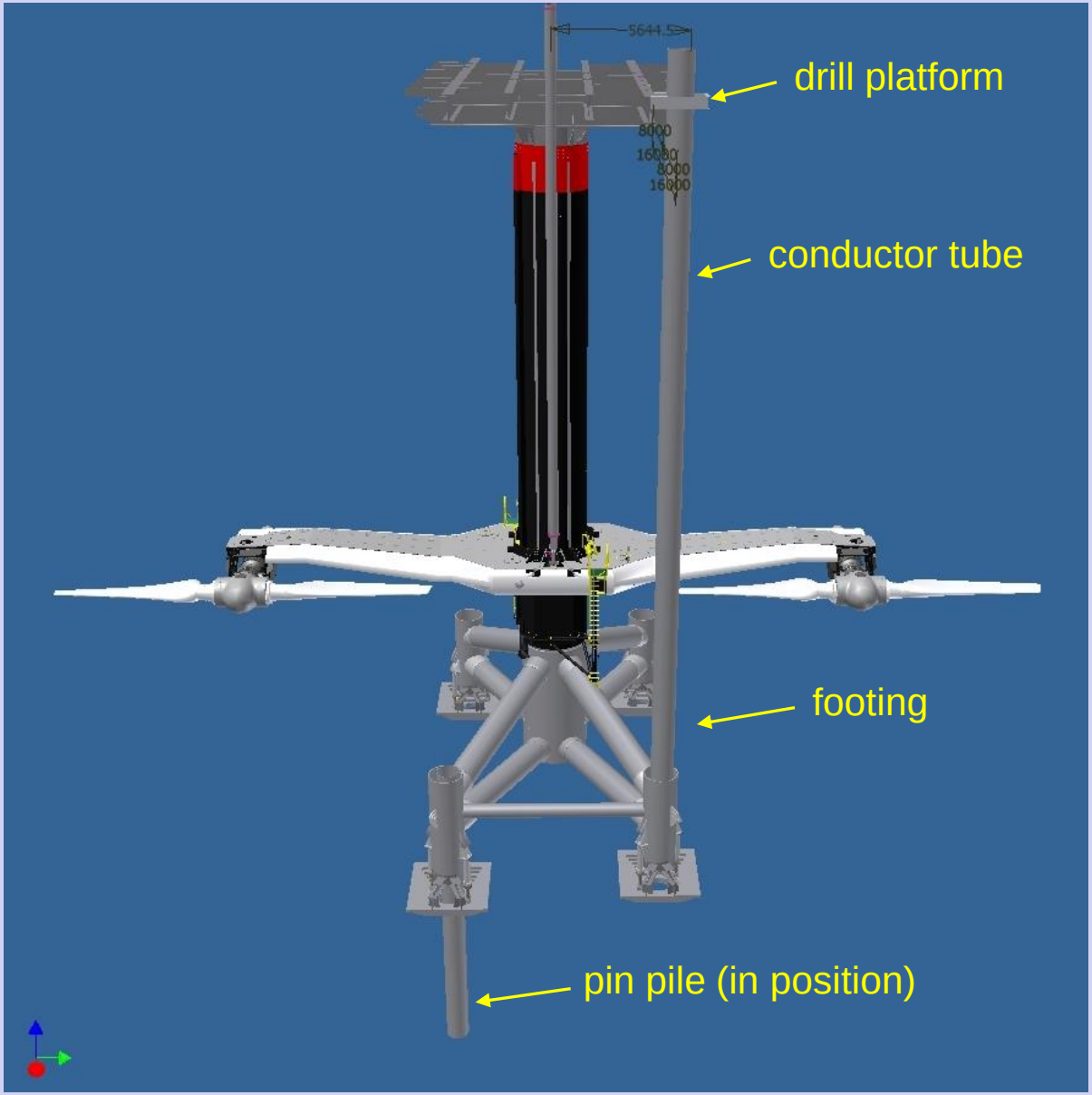
...and SeaGen in typical conditions

SeaGen Quadrapod

pin-pile installation method



Installation vessel for SeaGen

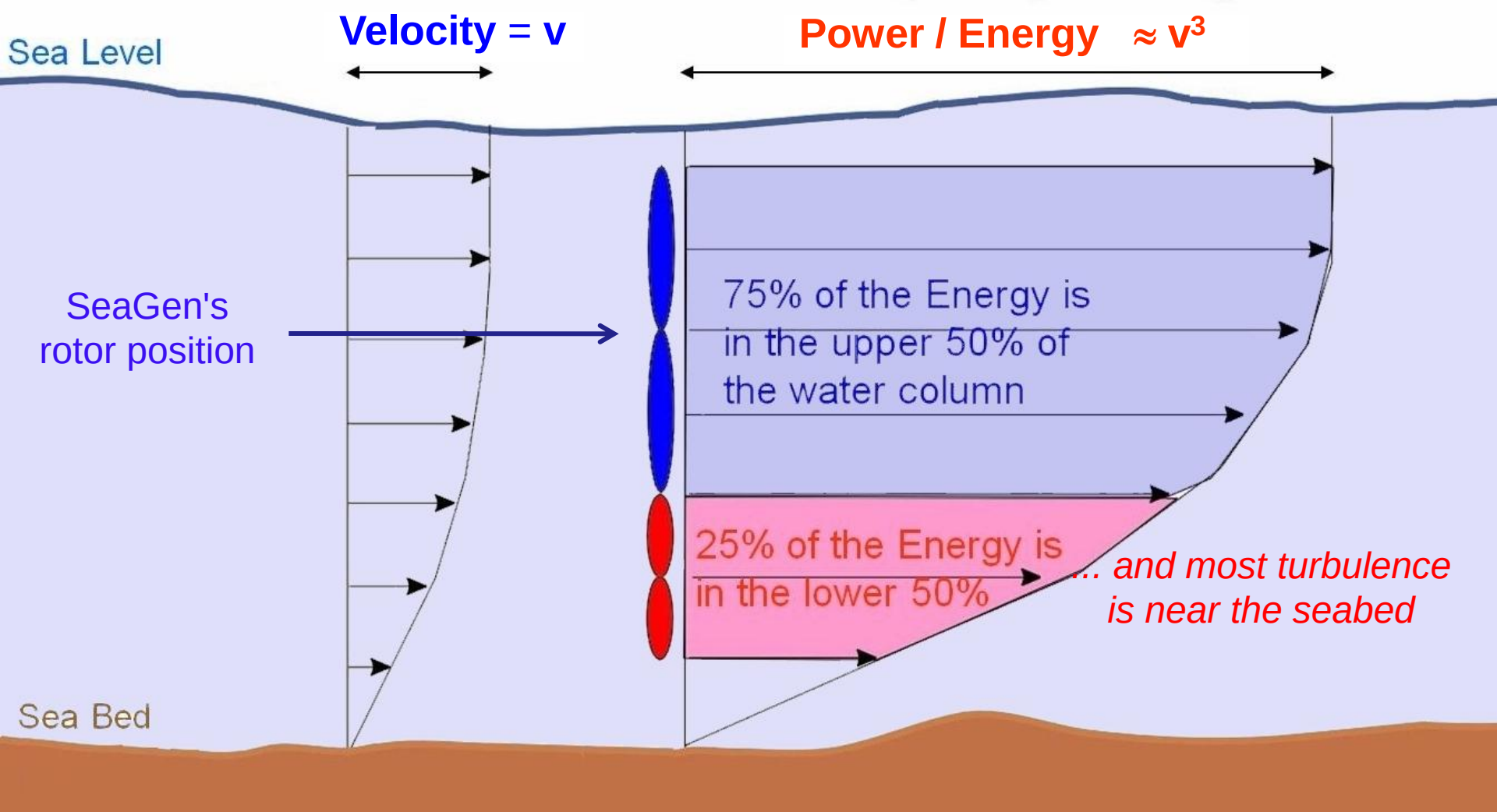
Drilling and Grouting Operations
- carried out from temporary work platform

SeaGen maintenance

most maintenance and repair functions can be completed rapidly, using no more than small service vessels: here shown fitting a new rotor blade

Position or rotors in water column:

most of the energy in a current is near the surface



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SeaGen tidal turbine – environmental mitigation and monitoring

ROYAL HASKONING

Frank Fortune

Technical Director

Royal Haskoning, Edinburgh

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Sea Mammal Research Unit

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Environmental Impact Assessment

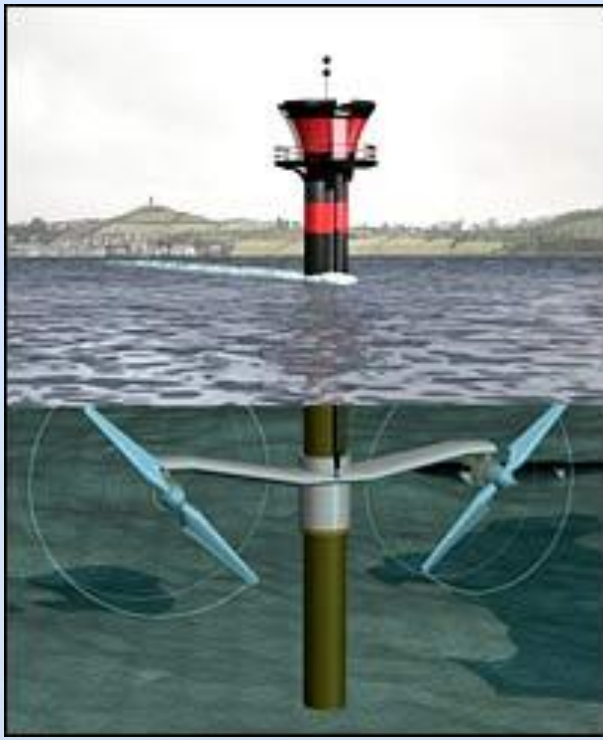
Uncertainty some potential impacts.

Common seals *Phoca vitulina*

1) Are the patterns of usage altered by the turbine installation and operation?
2) Are seals (or other large marine animals) being struck by the turbine rotors?

Reef (rocky and biogenic)

1) Does the installation and operation significantly affect the extent, quality or composition of seabed communities?



Licensing conditions - Mitigation

Environmental Monitoring Programme put in place alongside tiered mitigation.

Key elements of **mitigation** included:

- MMO presence on pile with ability to shutdown;
- Daylight operation only, initially;
- Experimental active sonar development as potential further tier of mitigation.

An **adaptive management** approach has been taken to operation of the device and the operation of the mitigation measures via advice of the SeaGen **Science Group** of regulators and independent advisors.

Mitigation - MMOs

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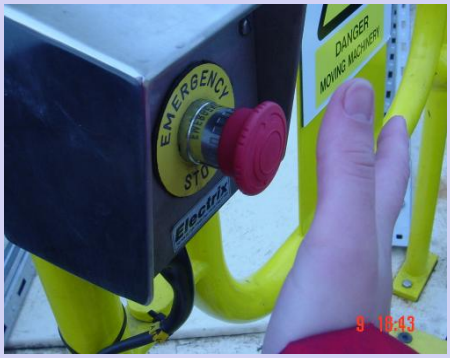
Mitigation - Pile-based MMO observations

- Sightings protocol using a spatial grid

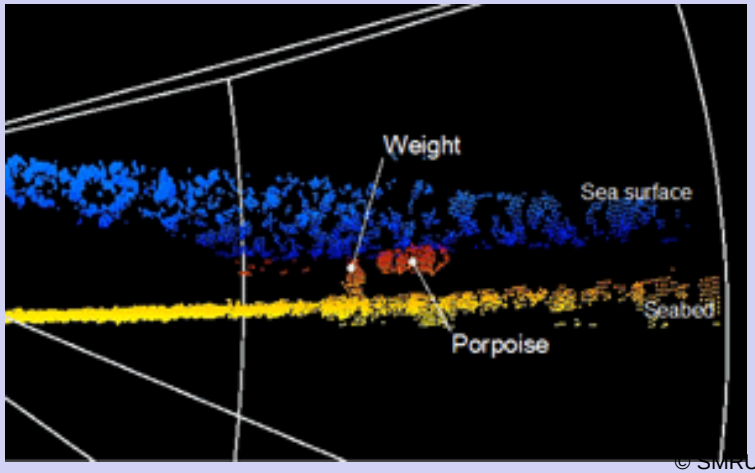
- Qualitative data on mammal activity and behaviour close to SeaGen

- Calibration element for the active sonar system.

- MMO surveys until September 2009 based on evidence that active sonar could provide conservative mitigation.



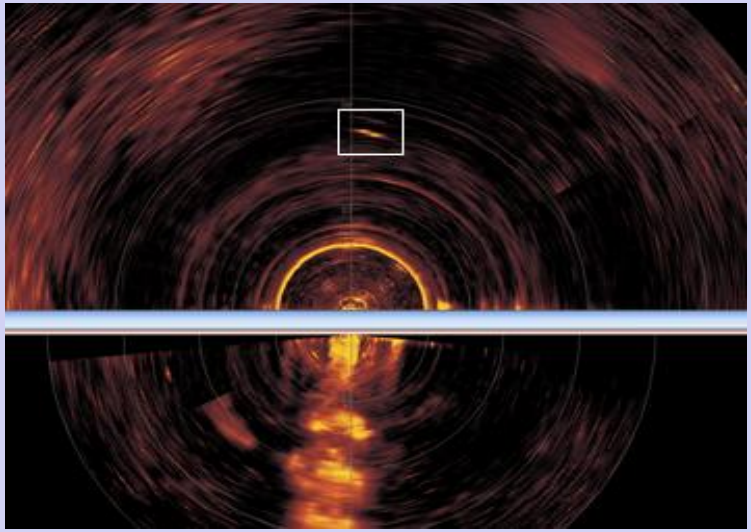
	Date	Species	SeaGen operational activity (twin/ single rotor)	Distance from turbine (m)	Behaviour	State of tide	E-stop initiated by?
1	08/07/2008	Common seal	Single	130	Drifting	Flood	MMO
2	06/10/2008	Common seal	Single	50	Drifting	Flood	MMO
3	07/10/2008	Unidentified target	Single	60	Travelling	Flood	ASO
4	15/10/2008	Common seal	Single	80	Drifting	HW Slack + 1 hr	MMO
5	15/12/2008	Common seal	Twin	50	Travelling	HW Slack + 1 hr	MMO
6	13/05/2009	Common seal	Single	40	Drifting	Flood [1]	MMO
7	27/05/2009	Common seal	Twin	40	Travelling	Flood [2]	MMO
8	27/05/2009	Common seal	Twin	80	Milling	Flood [3]	MMO
9	27/05/2009	Common seal	Twin	70	Travelling	Flood [4]	ASO
10	08/06/2009	Common seal	Twin	40	Travelling	Ebb	ASO
11	10/06/2009	Common seal	Twin	80	Drifting	HW Slack + 1 hr	MMO
12	22/06/2009	Common seal	Twin	38	Travelling	LW Slack + 1 hr	ASO
13	02/07/2009	Common seal	Twin	20	Travelling	Ebb	MMO
14	02/07/2009	Unidentified target	Twin	44	Travelling	Ebb	ASO
15	06/07/2009	Common seal	Twin	40	Travelling	Flood	MMO



Mitigation - Active sonar (SMRU)

Trail of real time sub-surface sonar imagery of seals, cetaceans and basking sharks close to the SeaGen.

Detection from 80m, well within initial revised shut down action distance of 50m, now reduced to 30m.



Low number of precautionary shutdowns (1 per 14.3 hours of operation).

Large degree of variability in track speeds and trajectories. Characteristics of tracks following the removal of the pile based MMO indicate that a number were likely not to be marine mammals.

No evidence of significant change in marine mammal activity at night in comparison to during daytime.

Monitoring

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Mammals

- Aerial surveys

- Harbour seal telemetry

- Shoreline surveys

- shore based vantage point surveys

- TPOD monitoring

Ornithology

- Shore based vantage point surveys

Benthic Ecology Monitoring

- Repeatable quadrat surveys

Mammals - Vantage Point Surveys

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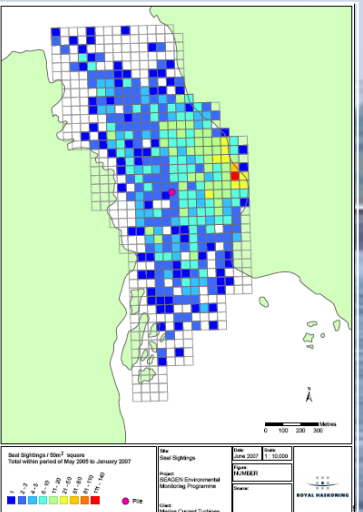
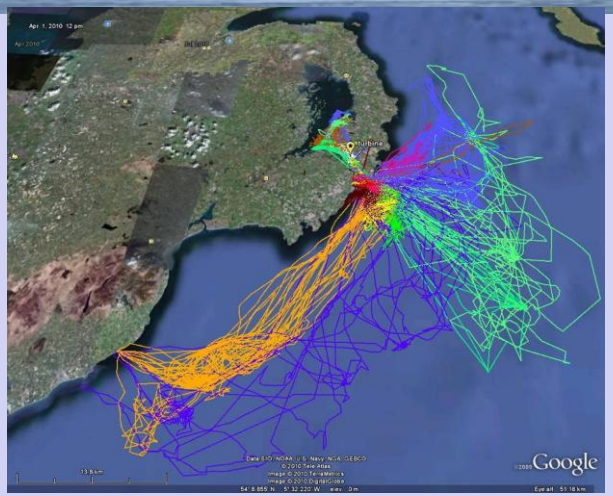
- Vantage point surveys since 2005 – ceased 2011;
- Time of day, tidal state and spatial location influences on data;
- The natural variability in the system under study is large
- Redistribution of common seals during turbine operation, no evidence for a decline in relative numbers during operation or on days when the turbine not operating.



Mammals – aerial and telemetry



Aerial survey – fixed wing infrared

- Trends in keeping with trends in the wider aerial survey area.

- Seals continue to haul out in Strangford Narrows near SeaGen.

Telemetry

- GSM tags

- 12 tagged 2006, 2008 and 2010

- No barrier effect

- Estimated that each seal in population may pass within 25m of SeaGen four times per year.

Mammals – shoreline surveillance and PAM

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Shoreline surveillance

- Incidental strandings: managed by NIEA

- Independent post mortem

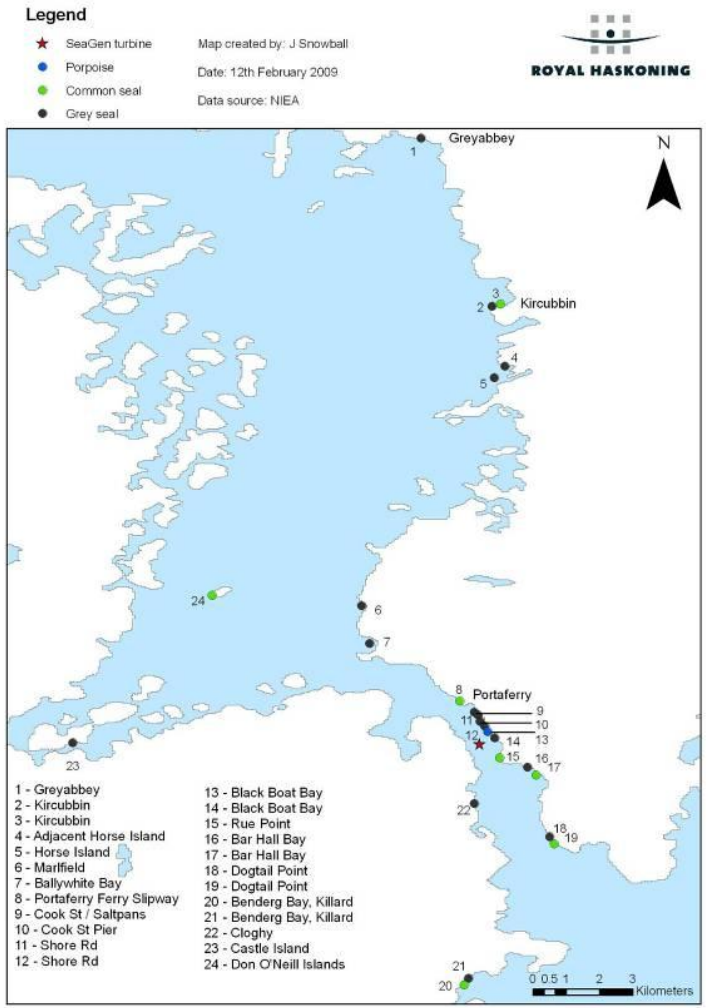
- No evidence of interaction with SeaGen turbine.

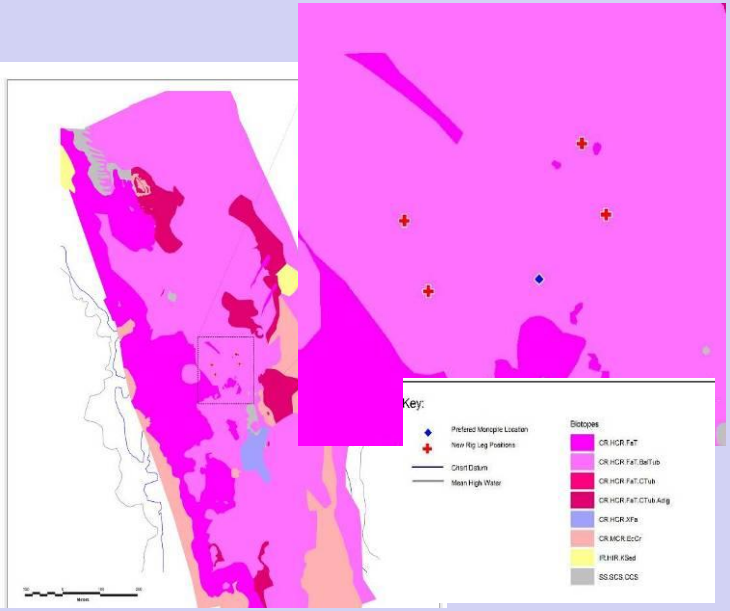
PAM – via T-PODs

- Harbour porpoise activity in proximity to SeaGen.

- No barrier effect

- Reaching limit of equipment life.

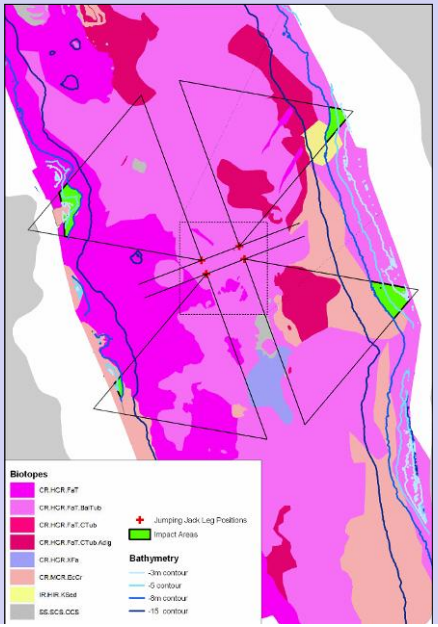




Monitoring - Benthic Ecology

Broad scale mapping and diver surveys have significantly increased our knowledge of the seabed in the Narrows in proximity to the turbine

Quantification of the potential footprint of the installation, operational and decommissioning phases



Fixed quadrat monitoring

Part of post installation licensing requirements

3 stations plus control

Observed changes minor and result of normal seasonal variation and natural species competition and succession.