

SeaGen Environmental Monitoring Programme: Biannual Update.

Version 5

Covers environmental monitoring June 2005 – November 2008.

12th February 2009



ROYAL HASKONING

HASKONING UK LTD. ENVIRONMENT

10 Bernard Street Leith Edinburgh EH6 6PP United Kingdom +44 (0)131 555 0506

Telephone Fax E-mail Internet

info@edinburgh.royalhaskoning.com www.royalhaskoning.com

Document title	SeaGen Biannual EMP update
Document short title	EMP undate (February 2009)
Status	Version 5
Date	12th February 2009
Project name	
Project number	9S8562
Client	Marine Current Turbines
Reference	9S8562/R/303519/Edin

Drafted by	Graham Saunders,	Jennifer Snowball and Frank
	Fortune	
Checked by	Graham Saunders	
Date/initials check		04/02/09
Approved by	Frank Fortune	
Date/initials approval		26/12/08

CONTENTS

1	EXECUTIVE	SUMMARY	1							
2	SEAGEN PROJECT HISTORY									
3	INTRODUCTION									
4	OPERATION	JAL OBJECTIVES	3							
5	REPORTING	G FORMAT	9							
6	MARINE MA	MMALS	11							
	6.1	Shore-based marine mammal surveys	11							
	6.1.1	Key Questions	11							
	6.1.2	Results	11							
	6.1.3	Timescale and deliverables	12							
	6.1.4	Expectations During Next Reporting Period	12							
	6.2	Pile-based Marine Mammal Observation	13							
	6.2.1	Preliminary Results	13							
	622	Timescale and deliverables	14							
	6.3	Pile-based field trails of active sonar	15							
	631	Key Ouestions	15							
	632	Boculte	15							
	633	Timoscalo	16							
	624	Expectations During Next Penerting Period	10							
	6.J.		10							
	0.4	Marine maninal carcass surveys	10							
	0.4.1	Rey Questions	10							
	0.4.2	There are a second seco	18							
	6.4.3		18							
	6.4.4	Expectations during next reporting period	19							
	6.5	Passive Acoustic Monitoring (TPODs)	20							
	6.5.1	Key Questions	20							
	6.5.2	Interim results	20							
	6.5.3	Timescale	21							
	6.5.4	Expectations During Next Reporting Period	21							
	6.6	Aerial surveys – breeding and moult seasons 2008	22							
	6.6.1	Key Questions	22							
	6.6.2	Interim results	22							
	6.6.3	Timescale	23							
	6.6.4	Expectations During Next Reporting Period	23							
	6.7	Harbour seal telemetry	24							
	6.7.1	Key Questions	24							
	6.7.2	Interim results	24							
	6.7.3	Timescale	25							
	6.7.4	Expectations During Next Reporting Period	25							
7	ORNITHOLO	DGY	26							
	7.1	Shore-based bird surveys	26							
	7.1.1	Key Questions	26							
	7.2	Pile-based bird surveys	27							
	7.2.1	Key Questions	27							

Page

8	BENTHIC	CECOLOGY	28
	8.1.1	Key Questions	28
	8.1.2	Results	29
	8.1.3	Timescale	29
	8.1.4	Expectations During Next Reporting Period	29
9	ACOUST	IC DOPPLER CURRENT PROFILING (ADCP)	30
	9.1.1	Key Questions	30
	9.2	Velocity Measurements	30
	9.2.1	Preliminary Results	30
	9.3	Turbulence Measurements	31
	9.3.1	Preliminary Results	31
	9.3.2	Timescale and deliverables	31
10	POST IN	STALLATION REPORTING	32
11	SUMMAF	ΥY	34
12	APPEND	ICES	1

1 EXECUTIVE SUMMARY

Key elements / findings of this report are:

- Shore based marine mammal survey shows no evidence for a disturbance during installation or a change in underlying relative seal abundance in the area;
- MMO and shore based observation data suggest low incidence of seal and porpoise sightings in the central portion of Strangford Narrows;
- Active acoustic sonar can detect marine mammals, diving birds and other targets (debris etc), with cross referencing with marine mammal observers (MMOs) suggesting 16% of targets are marine mammals;
- No seal carcasses submitted for post-mortem examination to date have exhibited signs of possible interaction with SeaGen;
- TPOD data indicated lower DPM during installation, but there was no significant difference between baseline and operational DPM in the Narrows;
- Aerial surveys detected more pups in 2008 than 2006;
- Seal telemetry shows no evidence of changes in haul out behaviour, transit rates, time in the Narrows and time spent close to SeaGen between 2006 and 2008;
- Benthic ecology indicates no change attributable to SeaGen operation.

2 SEAGEN PROJECT HISTORY

In 2002 DETI initiated a project to review the tidal resource in Northern Ireland and the potential locations to deploy commercial tidal arrays. Marine Current Turbines Ltd (MCT) were involved with this project along with the consulting engineers Kirk McClure Morton Ltd.

Within the timeframe for this project, MCT were working with another consortium that installed the 300kw SeaFlow "*proof of concept demonstrator*" project near Lynmouth, Devon in May 2003 and was subsequently looking for test locations for the full scale precommercial demonstrator *SeaGen* project.

In 2003, MCT evaluated several other potential locations to deploy SeaGen, but selected Strangford as the preferred location in November 2003 and subsequently submitted a FEPA application to NIEA in the same month.

Royal Haskoning Ltd were appointed in early 2004 to provide support to the EIA process. The scoping process was completed in mid 2004, and the EIA commenced late 2004. The final EIA was submitted in July 2005, with the initial FEPA license being granted in December 2006. These were revised for variations in installation methodology in February 2007, and again in February 2008.

SeaGen Installation

Installation of the moorings for anchoring the installation vessel commenced in February 2008 and were completed in March 2008. The SeaGen structure was positioned on the seabed on April 2nd 2008 by the crane barge *Rambiz*. Drilling for the pin piles, grouting and completion of assembly was supported by the crane barge *Missing Link*, which was on location from mid April to late May 2008.

SeaGen Commissioning and Operation

Commissioning of *SeaGen* commenced in July 2008, culminating in full power 1.2MW output power being generated to the grid in December 2008.

Operation is continuing within the constraints of the FEPA license with the environmental monitoring programme results being used to adapt the operational restrictions.

The existing FEPA license covers a 5 year temporary installation period, which will result in *SeaGen* being decommissioned and removed in 2013.

SeaGen Description

SeaGen is a free stream tidal energy device that converts energy from tidal flow into electricity. SeaGen comprises twin 16m diameter rotors connected to a generator through a gearbox, with a rotor system supported on the end of a cross beam. The cross beam in turn is supported by a 3m diameter pile. The cross beam can slide vertically up and down the pile to allow access to the rotors, generator and gearbox for servicing and inspection, thus minimising the requirement for diver intervention.

The top of the pile is circa 9m above the average sea level, Figure 1. The twin rotors will begin to generate electricity once the tide runs faster than 1m/s. At a predetermined maximum tidal speed the rotors start to pitch to limit the maximum rotational speed to 14 RPM, resulting in a peak rotor tip speed of circa 12m/s.



Figure 1 The SeaGen turbine, Strangford Lough, Northern Ireland.

Figure 1 shows the original SeaGen monopile installation concept which was varied in February 2008. The actual installation foundation is a four footed structure circa 18m and 12m dimensions rectangular in footprint, each corner of the foundation is supported on a circa 1m diameter pin pile. The whole bottom of the structure is above the seabed by circa 2m. Thus the revised installation has a lower footprint on the seabed.

3 INTRODUCTION

This report provides an update of environmental research activities currently being carried out as part of the SeaGen Environmental Monitoring Programme (EMP) and spans the period June 2005 to November 2008.

This report provides a comparative analysis of environmental data collected during the baseline period (pre-installation), installation, commissioning and initial operation of the SeaGen turbine:

Analysis of data collected during the commissioning and operational period, July 2008-October 2008, has been interpreted with caution. Given the limited rotational activity during this period, real operational effects will not be understood until SeaGen reaches at least semi-continuous or continuous operation.

4 OPERATIONAL OBJECTIVES

The SeaGen environmental mitigation with the associated research programme is designed to:

- Detect, prevent or minimise environmental impact attributable to the turbine installation and operation and;
- Provide an ongoing monitoring strategy to determine any immediate or emerging adverse impacts on the habitats, species and physical environment of Strangford Lough.

In support of this, the research programme is focused on ensuring that the status of the important ecological elements most likely to be influenced by the presence of the turbine is established and monitored by credible scientific methods. To provide a transparent and logical direction for the research and monitoring programme, a series of management action-specific or "operational" objectives have been developed which are also intended to act as a framework for the environmental reporting.

Strangford Lough has been identified as a site which supports internationally important examples of particular marine and coastal habitat and species features and has accordingly been given the dual status of a European Special Area of Conservation (SAC) and a European Special Protected Area (SPA). Three of the site features have been identified as potentially vulnerable to activities and impacts associated with the installation of the SeaGen turbine.

Accordingly, key overarching objectives for the SeaGen mitigation programme are that: *the presence of the turbine does not have a significant detrimental impact on*:

- (a) the integrity of the breeding harbour seal population;
- (b) the abundance, diversity, integrity and extent of the benthic biological communities associated with the submerged rocky reefs;
- (c) the population of breeding seabirds

The Operational Objectives (Table 3.1) provided below establish the means by which the overarching objectives are to be achieved, alongside further measures for species which carry additional protected status. This table is derived from the EMP task matrix used to focus discussion of operational objectives at recent Science Group meetings.

Table 4.1 Operational Objectives for the SeaGen Environmental monitoring	
and mitigation programme	

Element	Objective	Measurement
Marine Mammals (General)	No marine mammal mortalities occur as a consequence of physical interaction with the turbine rotors ¹ .	 Post mortem evaluation of carcass stranding and assessment of cause of death.
	The turbine operates in such a way as to minimise turbine rotation when marine mammals are within an agreed distance from the rotors.	 Assessment of the combined surface and sonar detection events with manual shutdown when a mammal is within 50m of turbine rotors. Post mortem evaluation of carcass stranding and: assessment of cause of death.
	Establishment of an active sonar system which detects marine mammals at sufficient range from the turbine to	 Number of sonar detections and shut- down events. (See footnote 2)
	allow a precautionary shut- down to occur automatically ² .	
	The SeaGen turbine does not	1. Quantitative tocal follows of marine

¹ The circumstances and significance of any mortality will be investigated by the SeaGen Science Group, see Appendix C, EASMP, Royal Haskoning 2008)

² SMRU advises that with technology currently available, the rate of detection is at least 50% in the surface zone (2-3 m) where sonar systems have poorest coverage. The rate at greater depths (which lie directly in the path of the turbine) will most probably be higher and could approach 100%. When there are objects at depth the identity cannot be verified visually at the surface. In these circumstances it is possible to build higher levels of precaution into the shut-down procedures so that shut-down will happen at lower detection threshold values. This will result in increased numbers of unnecessary shut-downs (because of false positive detections) but increasing experience of operating the turbines, including tuning the sonar operations and interpretations, will gradually lead to reductions in false positive detections.

Element	Objective	Measurement
	present a barrier effect to the free passage of marine mammals through the Strangford Narrows.	mammals past the turbine during periods of operation and non-operation using active sonar.2. Land based visual observations pre and post installation to examine any change in use of the area around the turbine.
	Relative abundance of marine mammals in Strangford Narrows is not significantly ³ modified by the operation of the SeaGen turbine.	 Number of marine mammals underwater recorded in close proximity (~ 50m) to the SeaGen turbine per hour Wider contextual data from shore based observations.
	Sub-surface noise generated by the turbine does not cause a level of disturbance to marine mammals sufficient to displace them from areas important for foraging and social activities.	 Measurement of zone of audibility and zone of disturbance at full power operation. Number of marine mammals underwater sighted in close proximity (~ 50m) to the SeaGen turbine per hour Sightings frequency per hour watched within grid squares close (within ~ 50m) to the SeaGen turbine.
Marine Mammals: harbour seals	The number of harbour seal adults and pups does not decrease significantly as a result of the installation and operation of the SeaGen turbine.	 Population estimates derived from aerial survey and set within the context of historical data. Population distribution and haulout behaviour from telemetry data. (Number of harbour seals using the Lough based on boat counts from NIEA can also supplement these data)
	The SeaGen turbine does not cause a significant change in the use of important ⁴ harbour seal haul out sites within the Strangford Lough SAC.	 Haul out site seal numbers from aerial and boat-based survey. Population distribution and haulout behaviour from telemetry data. (Number of harbour seals using the Lough based on boat counts from NIEA can also supplement these data)
	The SeaGen turbine does not present a barrier effect to the free passage of harbour seals through the Strangford Narrows.	 Transit routes derived from telemetry data from the seal tagging programme. Land based observations and MMO pile data.
	The SeaGen turbine has no significant ³ effect on harbour	1. Harbour seal transit rates derived from telemetry data from the seal tagging

³ Further discussion is required to define 'significance' in this context. See discussion following this table.

⁴ Further discussion is required to establish the meaning of the term important when referring to areas of value for marine mammals. See discussion following this table.

Element	Objective	Measurement
	seal movements through the Strangford Narrows	programme.
	Harbour seals are not excluded ⁵ from important ⁴ foraging habitat or social areas within the Strangford Narrows as a result of the installation and operation of the SeaGen turbine.	 Sightings frequency over space and time (from Shore-based visual operation) in pre-operational and post- operational periods). Use of foraging habitat from telemetry data (i.e. amount of time spent foraging in different areas).
Marine mammals: grey seals	The number of grey seal adults and pups does not decrease significantly as a result of the installation and operation of the SeaGen turbine.	 Population estimates derived from aerial survey and set within the context of historical data. (Number of grey seals using the Lough based on boat counts from NIEA can also supplement these data)
	The SeaGen turbine does not cause a significant change in the use of important ⁶ grey seal haul out sites within the Strangford Lough SAC.	 Haul out site seal numbers from aerial and boat-based survey. (Number of harbour seals using the Lough based on boat counts from NIEA can also supplement these data)
	The SeaGen turbine does not present a barrier effect to the free passage of grey seals through the Strangford Narrows.	 Land based observations and MMO pile data.
	Grey seals are not excluded ⁷ from important ⁴ foraging habitat or social areas within the Strangford Narrows as a result of the installation and operation of the SeaGen turbine.	 Sightings frequency over space and time (from Shore-based visual operation) in pre-operational and post- operational periods).
Marine mammals: cetaceans	The SeaGen turbine does not displace harbour porpoises from the Strangford Narrows and the adjacent Strangford Lough SAC.	 Echolocation events/ detection positive minutes (presence/absence) from TPOD monitoring. Sighting data from shore and pile based observers.
	The SeaGen turbine does not present a barrier effect to the	 Echolocation events/ detection positive minutes between inner Lough, Narrows

In this case, "exclusion" needs to pass the test of "significance", See discussion following this table. 5

⁶ Further discussion is required to establish the meaning of the term important when referring to areas of value for marine mammals. See discussion following this table.

In this case, "exclusion" needs to pass the test of "significance", See discussion following this table.

Element	Objective	Measurement
	free passage of harbour porpoises through the	and outer Lough from TPOD monitoring.
	Strangford Narrows.	should also contribute to the measurement of this element.)
	Cetaceans not excluded from important ⁴ foraging habitat or social areas within the Strangford Narrows as a result of the installation and operation of the SeaGen turbine	 Sightings frequency (from shore-based visual observations) over space and time in pre-operational and post- operational periods. (TPOD data can also supplement this as clicks can be associated with feeding behaviour).
Seabirds	The SeaGen turbine does not injure or displace foraging diving birds from important areas within the Strangford Narrows	 Sightings frequency of diving birds from shore- based visual surveys Sightings frequency/hour watched of diving and rafting birds within the pile- mounted observational grid area.
Hydrodynamics	The installation and operation of the SeaGen turbine will not impede or modify the flow dynamics, scour patterns or turbulence character of the Narrows in such a way that will cause a change to benthic community structure.	 Vessel- or bottom mounted ADCP measurement, as appropriate, of upstream and downstream flow character and turbulence signature. Diver video survey for scour effects.
Benthic hard communities	The installation and operation of the SeaGen turbine will have no significant impact on the abundance, diversity and integrity of the benthic communities within the Strangford Narrows.	 Benthic species abundance at re- locatable video sample stations at a range of distance intervals from the turbine installation.
Adaptive Management	Mitigation measures are regularly reviewed for effectiveness, consistency and suitability and they are modified or revised where changes are considered to provide increased benefit. (Subject to consultation and the terms of the FEPA licence).	1. Assessment of effectiveness at regular Science Group meetings.

In developing these objectives a requirement has been identified for further discussion and subsequent agreement on how the term 'biologically significant' should be determined or defined for the purposes of conservation management. For

example, SMRU has suggested that a level of >50% change from baseline in seal movements might be a reasonable measure of a potentially significant change (lain Boyd, pers. comm. December 2008). There then remains a need to demonstrate that this level of change can be attributed to a turbine operation effect. The present set of measurements, in addition to considering the broader context of national trends in distribution and abundance, should provide a framework around which significant change can be determined and applied in the SeaGen monitoring programme.

Similarly, the use of the term 'important' when referring to sites of value for marine mammal foraging, social interaction or hauling out also requires further consideration and definition. The results of NIEAs ongoing site condition monitoring programme should also provide a valuable contribution to establishing important areas in this context.

5 REPORTING FORMAT

The following sections constitute an evaluation of the progress of all of the elements of the SeaGen Monitoring programme. To allow an "at-a-glance" assessment of progress each section contains summary interpretation of the results and other main aspects of each programme. The more detailed descriptive components, together with methodological information are either provided in the Appendices or can be found in referenced recent reports.

The summary interpretation sections include the following:

Key Questions

For each monitoring or mitigation element one or more key questions are presented. These are directly linked to the operational objectives presented in Table 3.1 and are the critical concerns which the monitoring programmes are specifically designed to address. Our ability to be able to answer the key questions at this time is largely indicated by the sections on detection of change and data confidence (see below).

In addressing the key questions the two distinct phases of installation and commissioning/operation are recognised. In some cases the key questions are only applicable to a single phase of the programme and a return of 'not applicable' (NA) is indicated where this is the case.

There a four possible answers to the key question. In addition to the positive or negative responses an answer of 'unsure' is used where the monitoring results are ambiguous, where there is an element of methodological doubt, when no data are available or the analysis has not been completed or submitted. 'Not possible' is used when no data are available for the period in question.

Significant Change Detection

An indication of whether a statistically significant change has, or has not, been detected. In addition, two other reporting options are provided. In instances where there are indications of change, but methodological doubts, or issues over data confidence introduces uncertainty, an 'unsure' result is reported. Where the monitoring data are plainly unable to provide a level of resolution that will allow a measurement of change, or have not yet been collected, the status is indicated as 'not possible'.

As indicated in Section 4, issues over the determination of what constitutes 'significant' change remain to be addressed within the broader SeaGen monitoring strategy. In this report, where such issues arise, these are briefly explained in the results section.

It is also important to point out that the detection of significant change does not necessarily signify an undesirable effect of the turbine installation. In many cases, perhaps most, we may simply be detecting a natural and cyclic variation related to seasonal or longer-term fluctuations, or even wider changes initiated by other influences such as climate change. If this is thought to occur a brief evaluation is included in the results section.

Data Confidence

Data confidence refers to the ability of the data to provide a reliable indicator of change and answer the key questions. It is largely an expression of the broad quality status of the presently held dataset.

Four categories are used to define data confidence:

High – The current data provide a good reflection of the element(s) being measured, are highly likely to provide an indication of change if is occurring and will directly answer the key questions.

Medium – The current data provide a broad reflection of the element(s) being measured, may provide a sufficient level of resolution to detect change if it occurring, but may also leave room for doubt when used to answer the key questions.

Low – The current data provide a poor and possibly inaccurate reflection of the status of the monitored element(s), are unlikely to be of sufficient power to reliably detect even large changes and cannot presently be used to answer the key questions.

Unknown – The current data have not yet been analysed, or are still undergoing collection.

Data confidence is, in many cases, likely to be linked to the frequency or time period over which the data have been collected and it is anticipated that monitoring programmes demonstrating a reduced level of confidence will improve with increased data collection.

Results

A brief summary of the results to date are provided in this section.

Timescale and Deliverables

An indication of the tasks achieved within this reporting period and an associated timeline.

Expectations During Next Reporting Period

An indication of the tasks expected to be undertaken within the next six monthly reporting period.

6 MARINE MAMMALS

6.1 Shore-based marine mammal surveys



Roles and responsibilities⁸

Data collection: Queen's University Belfast (QUB) Data analysis: SMRU Ltd.

Rationale

The outputs of this surveillance provide a robust preinstallation baseline dataset of the number of sightings of a species over space and time which can be compared with numbers of sightings during the postinstallation phase on a like-for-like basis.

6.1.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q1	Is marine mammal density and behaviour in Strangford Narrows	Installation	No	No	Medium
	SeaGen turbine?	Commissioning/ operation	No	No	Medium
Q2	Does the SeaGen turbine have a significant effect on harbour seal	Installation	No	No	Medium
	Narrows?	Commissioning/ operation	No	No	Medium
Q3	Are harbour seals significantly excluded from foraging habitat or social areas within the Strangford	Installation	No	No	Medium
Q3	Narrows as a result of the SeaGen turbine?	Commissioning/ operation	No	No	Medium

6.1.2 Results

Key findings from SMRU Ltd analysis of shore based marine mammal observation data (SMRU Ltd report appended) are:

 Models were fitted to the data to determine both the significance and type of relationship, between the environmental variables and sightings rates for both seals and porpoises. The time of day, tidal state (phase, ingoing/outgoing), and spatial location all proved significant. There were also long-term trends evident at both a daily and monthly resolution;

⁸ Section 7.1.5, SeaGen EMP, (version 4 Royal Haskoning, May 2008)

- There was no evidence for disturbance during installation and there was no evidence for a change in underlying relative seal abundance in the area during times of lower activity;
- The natural variability in the system under study is large, even after accounting for the systematic changes associated with the environment under current conditions;
- Simulation studies suggest low power for the current monitoring scheme (and subsequent analysis) to detect changes in the average abundance of porpoises. A sudden drop in average porpoise abundance of 50% would be detectable with a probability of 0.75 after 6 months of the current monitoring scheme. This is an improvement on the previous assessment (SMRU, 2007)⁹ which indicated detection with a probability of 0.18 after 7 months of effort.
- Simulation studies suggest better power for the current monitoring scheme (and subsequent analysis) in detecting changes in the average abundance of seals. For example, a sudden drop in average seal abundance of 50% would be detectable with high probability (0.88) after 1 month of the current monitoring scheme. Drops in average seal habitat usage of <20% would only be detected with probability 0.5 after 6 months of monitoring.

6.1.3 Timescale and deliverables

Current status

Pre-installation baseline			Installation			Commissioning				Operating Year 1										
May '05 - Sept '07	Oct	Nov	Dec	Jan '08	Feb	Mar	Apr	Мау	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '09	Feb	Mar	Apr	May

Analysis completed: dataset analysed by SMRU Ltd.

Raw data processed: raw sightings data transcribed by QUB

Raw data collected: sightings data collected by QUB

6.1.4 Expectations During Next Reporting Period

- Ongoing observations and data processing;
- Correlation with baseline;
- Review correlation and adapt monitoring process as necessary;
- Expected to continue for at least 2 years post installation (up to April 2010) but could be terminated earlier if the regulator considers that the monitoring is providing no additional benefit; and
- Required for at least one year post decommissioning

⁹ SMRU (2007). Strangford Lough: updated report on use of visual observation data. August 2007. SMRU, St Andrews.

6.2 Pile-based Marine Mammal Observation



<u>Roles and responsibilities¹⁰</u> Data collection: Royal Haskoning Data analysis: Royal Haskoning and SMRU Ltd. (analysed alongside active sonar reporting).

<u>Rationale</u>

This surveillance programme ensures that the appropriate mitigation procedures are undertaken during the commissioning programme and provides temporal and spatial distribution of large marine megafauna (including marine mammals) which transit the Narrows in proximity to the pile.

	Key Question	Phase	Answer	Significant change from none operational periods detected with current data?	Data confidence
Q4	Does operation of the SeaGen turbine have a significant effect on	Installation	NA	NA	NA
	marine mammal sightings within the immediate waters of the turbine?	Commissioning/ operation	Unsure	Unsure	Medium

6.2.1 **Preliminary Results**

Harbour and grey seals

Both anecdotal evidence from the weekly MMO Field Reports and GIS mapping of visual sightings data indicate that there is a low level of seal activity within the central portion of the Strangford Narrows compared to the sides (Figure A, Appendix V), with an average of 0.61 harbour seal sightings per hour watched within the observational grid.

To date, there has been a low incidence of grey seal sightings in close proximity to the turbine (Figure B, Appendix V), with an average of 0.16 sightings per hour watched.

Porpoises

There have been a low number of harbour porpoise sightings from the visual surveys (Figure C, Appendix V), with a mean of 0 sightings (maximum 0.28) per hour watched. MMOs noted an average of 2 surfacing for each encounter, with animals travelling rapidly through the centre of the Narrows (approximately 150m from the turbine) during periods of peak tidal flow.

¹⁰ Section 7.1.5, SeaGen EMP, (version 4, Royal Haskoning, May 2008)

6.2.2 Timescale and deliverables

Current status



The initial proposal was to be present for 90 days during operational and nonoperational periods in parallel to the active sonar monitoring, but this duration is adaptive and will be reviewed by the Science Group and the regulator. Positional and behavioural data collected by the MMO is analysed alongside the active sonar data in order to compare the surface and subsurface tracks of the animals and determine how many sightings were missed by the active sonar.

Pile-based mitigation is currently planned to run up until the end of the commissioning period in February 2009 and for specific periods thereafter as prescribed by the Science Group.

6.3 Pile-based field trails of active sonar



Roles and responsibilities¹¹: Data collection and analysis: SMRU Ltd.

Rationale:

This system provides real time sub-surface sonar imagery of marine mammals and basking sharks within 80m of the SeaGen turbine. The main objectives are to increase detection capabilities and examine the behavioural reactions of large marine animals to the turbine both in operation and while shut down.

6.3.1 Key Questions

	Key Question	Phase	Answer	Significant change from none operational periods detected with current data?	Data confidence
Q6	Can the active sonar system detect marine mammals within 50m of the	Installation	NA	NA	NA
	turbine and shut down the turbine automatically?	Commissioning/ operation	Yes	NA	High
	Can the turbine reduce rotation to a	Installation	NA	NA	NA
Q7	safe speed before the travel path of a detected marine mammal brings it into a zone of possible injury?	Commissioning/ operation	Yes	NA	High

The turbine can be rapidly manually 'switched off' on detection of a potential marine mammal. Such detections may also include a large proportion of false positives. Once the shutdown button has been engaged, the SeaGen turbine goes from full rotation to complete shutdown in approximately 3 seconds.

At present the system appears to detect close to 50% of targets identified on the surface by MMOs directly upstream. Because we know that sonar systems will not work well at detecting objects in the surface layer (2-3 m), the probability of detection at depths beyond 3m is likely to be much greater than at the surface.

6.3.2 Results

Key findings of the study to date are summarised below and the full report is appended.

¹¹ Section 7.1.3, SeaGen EMP, (version 4, Royal Haskoning (May 2008)

- Small marine mammals (and other mobile targets, birds, debris etc.) can be detected in a tidally turbulent water column in real time;
- 137 moving objects were detected using the active sonar and comparison with sightings by the MMO confirmed that only 16% of objects were marine mammals;
- Directly upstream of the turbine the percentage of visual sightings that were detected using the sonar was less than half (46.7%) the sightings of marine mammals made by the MMO. It is possible that some of the objects detected by the sonar were marine mammals that were not detected by the MMO;
- Both confirmed marine mammals (and 'other' objects) moved past the turbine in relatively close proximity.
- It is not currently possible to determine whether there were differences in marine mammal behaviour during periods when the turbine was operating and when it was inactive;
- The sonar used in this study would require further development to produce a reliable and efficient mitigation tool.
- It is unclear why a relatively high proportion of marine mammals are not detected;
- Some of the object features identified in this study (e.g. speed, movement in relation to tidal direction etc) appear to provide the basis for differentiating marine mammals from other targets (including other wildlife species).
- The current system employed relies on manual intervention to invoke a shut down and further development is required for an automated system.

The difficulty encountered by the sonar system in operation in the surface 2-3 m of water is thought to be due to the large amount of turbulence and entrained air in that portion of the water column. It is important to note that this portion of the water column lies above the area within which the SeaGen turbine rotates. This problem is well documented for acoustic ocean studies in general and also applied in the case of the ADCP surveys carried out for the EMP. Despite the difficult conditions in the surface layers the sonar is able to detect close to half of the sightings made by the MMOs and it is reasonable to assume that the degree of detection below the surface layers, where turbulence and entrained air are less, is considerably higher than half.

6.3.3 Timescale

Current status

Pre-installation baseline	Installation	Commissioning	Operating Year 1			
May '05 - Oct Nov Dec Jan Sept '07 '08	b Mar Apr May Jun	Jul Aug Sep Oct Nov	Dec Jan Feb Mar Apr May '09			

Analysis completed: dataset analysed by SMRU Ltd.

Raw data processed: raw data processed by SMRU Ltd.

Raw data collected: manual observation period by SMRU Ltd.

6.3.4 Expectations During Next Reporting Period

- Further monitoring during periods of operation; and Evaluation of alternative automated systems -
- -

6.4 Marine mammal carcass surveys¹²



Roles and responsibilities¹³: Surveys: QUB Reporting: QUB

Rationale:

Following Task 1, Section 10 of the SeaGen EASMP a programme of shoreline surveillance, covering a pre-defined area of the Strangford Narrows and immediate coastline¹³, is carried out throughout the first year of commissioning and operation. Any seal carcasses discovered within the surveillance area is subjected to a post-mortem by a Vet Pathologist to determine whether the cause of death is likely to have resulted from collision with the SeaGen turbine.

6.4.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q8	For all recorded stranding events, have any marine mammal	Installation	NA	NA	NA
	mortalities occurred as a consequence of physical interaction with the SeaGen turbine?	Commissioning/ operation	No	Unsure ¹⁴	High

6.4.2 Preliminary Results

- All common and grey seal carcasses found within the study site have been post-mortemed by a Vet Pathologist at Stormont.
- No carcasses have been detected which show evidence of interaction with SeaGen, for survey results refer to Table D, Appendix I.

6.4.3 Timescale

Current status

Full details, including positional information of stranding events for the period from July 2008 to January 2009 are available in Appendix 1.

¹² Marine mammal carcass recording is supplemented by details of stranding events currently managed and collated by NIEA.

¹³ Section 7.1.4, SeaGen EMP, Royal Haskoning (May 2008)

¹⁴ No pre-commissioning surveys are available to provide a baseline for comparison with postcommissioning dataset.

Currently, no post mortem evidence for any carcasses is suggestive of interaction with the SeaGen turbine.

6.4.4 Expectations During Next Reporting Period

- Further monitoring during periods of operation

6.5 Passive Acoustic Monitoring (TPODs)



Roles and responsibilities¹⁵ Data collection: SMRU Ltd. Data analysis and reporting: SMRU Ltd.

Rationale

The T-POD is a self contained submersible unit deployed at various locations within Strangford Lough to provide continuous data on porpoise activity (as a function of echolocation click events) in proximity to the SeaGen turbine.

6.5.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q9	Does the SeaGen turbine displace harbour porpoises from the	Installation	No	Yes ¹⁶	High
	Strangford Lough?	Commissioning/ operation	No	No	High
	Does the SeaGen turbine present a	Installation	No	No	High
Q10	significant barrier effect to the free passage of harbour porpoises through the Strangford Narrows?	Commissioning/ operation	No	No	High

There are ccurrently four TPODs within the Narrows, and three TPODs in the inner Lough. TPOD failure and loss has contributed to low recording success, with a loss of approximately 220 days worth of data. Further data collection is required to determine if a possible change pre and post installation is present.

6.5.2 Interim results

Key findings include:

- Detection Positive Minutes (DPM) per day were considerably lower within the Narrows during installation compared to the baseline periods (pre- and post installation);
- Average DPM per day recorded in the Narrows during installation and 2nd baseline (April, May and June 2008) were significantly lower than the average DPM from 2006 and 2007 in the equivalent months;

¹⁵ Section 7.1.3 SeaGen EMP (version 4, Royal Haskoning, May 2008)

¹⁶ Detection Positive Minutes (DPM) remained similar during all periods within the inner Lough. However, compared to baseline, there was lower DPM within the Narrows during installation.

- There was no significant difference in the average DPM per month recorded during the baseline and operational phases in the Narrows or the Inner Lough.
- DPM per day were similar during all periods in the Inner Lough.
- Changes in the number of DPM could be a result of a decrease in the number of animals using an area, animals spending less time within an area or the same number of animals echolocating less often than previously.
- Data being collected over the next few months is required to determine if post installation detections have returned to levels similar to 2006 and 2007.
- Lower DPM observed in 2008 than previous years may be a result of interannual variation in porpoise use of the site.

6.5.3 Timescale

Current status

To date, analysis has been completed on all TPOD data collected between April 2006 and September 2008 (SMRU Biannual report, appended). Further data collection is ongoing.

Pre-installation baseline					Installation			Commissioning					0	Operating Year 1						
April '06 - C Sept '07	Oct	Nov	Dec	Jan '08	Feb	Mar	Apr	Мау	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '09	Feb	Mar	Apr	Мау

Analysis completed: dataset analysed by SMRU Ltd.

Raw data processed: raw data processed by SMRU Ltd.

Raw data collected: TPOD data downloaded by SMRU Ltd.

6.5.4 Expectations During Next Reporting Period

- Further monitoring during periods of operation

6.6 Aerial surveys – breeding and moult seasons 2008



<u>Roles and responsibilities</u>¹⁷ Data collection: SMRU Ltd. Analysis and reporting: SMRU Ltd.

<u>Rationale</u>

The aim of the aerial surveys is to determine the overall numbers of harbour seals and the location of their haul-out sites between Carlingford Lough and Belfast Lough, including Strangford Lough.

6.6.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q11	Has the number of harbour seal adults and pups decreased	Installation	No	No	High
	significantly within the Strangford Lough SAC?	Commissioning/ operation	No	No	High
	Has there been a significant	Installation	No	No	High
Q12	change in the use of harbour seal haul out sites within the Strangford Lough SAC?	Commissioning/ operation	No	No	High

The data show considerable variation, suggesting that natural change may be considerable. In addition, definition of the terms "significant" and "important" is required if the questions are to be answered.

6.6.2 Interim results

- Moult surveys in 2006 and 2007 show similar counts of harbour seals over the whole survey area;
- An approximate 8% decline was observed between 2007 and 2008;
- Within Strangford Lough and Narrows the number of hauled-out harbour seals was variable both within and between years.
- In 2008 the breeding season adult counts for the Lough and Narrows were higher than in 2006, unlike all other sub-regions. The pup counts also increased, as they did in other regions.
- Overall more pups were counted in relation to adults in 2008 than in 2006;
- Grey seals are much less abundant in the survey area than harbour seals and numbers counted within each sub-region are variable within and between years;
- There has been a general increase in numbers of grey seals since 2002.

¹⁷ Section 7.1.6 SeaGen EMP (version 4, Royal Haskoning, May 2008)

6.6.3 Timescale

Current status

Successful breeding season (13th July) and moult (27th August) surveys were carried out in 2008. These surveys were completed over the usual area (Carlingford Lough to Bangor).

Pre-installation baseline						Installation			Commissioning				0	Operating Year 1								
	May '06 - Aug '07	Sept	Oct	Nov	Dec	Jan '08	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '09	Feb	Mar	Apr	May

Analysis completed: dataset analysed by SMRU Ltd.

Raw data processed: raw data processed by SMRU Ltd.

Raw data collected: data collected by SMRU Ltd.

6.6.4 Expectations During Next Reporting Period

Post-installation moult and breeding season surveys in 2009 (subject to progress of SeaGen operation programme)

6.7 Harbour seal telemetry



Roles and responsibilities¹⁸ Data collection: SMRU Ltd. Data analysis and reporting: SMRU Ltd.

Rationale

The aim of the GSM tagging is to provide a description of the movements of harbour seals in relation to the Strangford Lough Narrows and wider coastline. Seal tracks are used to assess the extent to which movements have changed during the pre- and postinstallation phases of the SeaGen project.

6.7.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q13	Does SeaGen present a barrier effect to the free passage of seals	Installation	No	No	High
	through the Strangford Narrows?	Commissioning/ operation	No	No	High
	Does SeaGen have a significant	Installation	No	No	High
Q14	effect on harbour seal movements through the Strangford Narrow?	Commissioning/ operation	No	No	High

Twelve harbour seals were tagged with GPS/GSM tags in March 2008, adding to the data collected from 12 seals tagged in 2006. The data appear good and reliable, but, the ability to detect change is reduced by the large variation in behaviour between animals. In addition, definition of the term "significant" is required to answer the second question.

6.7.2 Interim results

Key findings from the SMRU biannual report (appended) are:

- In 2008, as in 2006 there was considerable inter-individual variability, but consistency within individuals;
- Some individuals travelled to distant haul out sites (outside Strangford Lough and Narrows) which is evidence that seals in Strangford Lough/Narrows are not ecologically isolated from the remaining North Ireland population;
- There was no evidence for a change in haul out behaviour, transit rates, time spent within the Narrows and time spent within the SeaGen buffer, between 2006 to 2008; and
- Many seals clearly foraged outside Strangford Lough and the Narrows.

¹⁸ Section 7.1.7 SeaGen EMP (version 4, Royal Haskoning, May 2008)

6.7.3 Timescale

Current status

Pre- installati baseline	Pre- Installation installation baseline 2006 Eab Mar Ann May Jun					Con	Commissioning									Ope Yea	Operating Year 1			
2006 Tagging	Feb 08	Mar 08	Apr 08	May 08	Jun 08	Jul 08	Aug 08	Sep 08	Oct 08	Nov 08	Dec 08	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May

NB tags deployed in March 2008 collected data until August 2008

Analysis completed: dataset analysed by SMRU Ltd. Raw data processed: raw data processed by SMRU Ltd. Raw data collected: data collected by SMRU Ltd.

6.7.4 Expectations During Next Reporting Period

- Post-installation tag deployment in March 2009 (subject to progress of SeaGen operation programme).

7 ORNITHOLOGY

There are two sets of ornithological data currently collected: shore based observation undertaken by QUB; and pile based observation undertaken by MMOs during pile based marine mammal observation. The analysis of these data has not been agreed by the Science Group at time of writing. Analysis of ornithological data will be discussed at the next Science Group and an agreed approach sought.

7.1 Shore-based bird surveys

7.1.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q15	Does the SeaGen turbine have a significant impact on seabird	Installation	Unsure	Unsure	Unknown ¹⁹
	activities in the Strangford Narrows?	Commissioning/ operation	Unsure	Unsure	Unknown
	Does SeaGen displace foraging	Installation	Unsure	Unsure	Unknown ¹⁹
Q16	diving birds from important areas within Strangford Narrows?	Commissioning/ operation	Unsure	Unsure	Unknown

Detailed ornithological data continues to be recorded within the standard shorebased surveys carried out by QUB²⁰.

The rationale for analysis of these data and comparison with pile based survey results is to be determined.

¹⁹ On review, current information / monitoring cannot answer this question. Specialist guidance is being sought through QUB..

²⁰ Section 7.2 SeaGen EMP (version 4, Royal Haskoning, May 2008)

7.2 Pile-based bird surveys



Roles and responsibilities Data collection: Royal Haskoning

Rationale

MMO survey protocol includes a standardised method for recording surface behaviour of diving birds and ducks in proximity to the SeaGen turbine.

7.2.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q17	Does presence and operation of the SeaGen turbine have a significant	Installation	NA	NA	NA
	50m of the structure?	Commissioning/ operation	Not possible	Not possible	Unknown

Data continues to be collected. The rationale for analysis of these data and comparison with shore based survey results is to be determined. External advice is being sought through QUB.

The immediate, qualitative assessment of the pile based observer suggests there is no apparent impact on seabirds.

8 BENTHIC ECOLOGY



Roles and responsibilities²¹

Data collection and analysis: QUB and Irish Diving Contractors. Survey coordination and data analysis: QUB and

Survey coordination and data analysis: QUB and Atlantic Marine Resources

Rationale:

The monitoring programme objective is to detect broad change in the benthic community structure (e.g. abundance shifts in dominant or characterising species) that may arise from increased sedimentation, changes in scour or flow pattern, or through direct physical damage

8.1.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q18	Is there a significant change in the broad benthic community structure	Installation	No	Yes	High
	installation?	Commissioning/ operation	Unsure	Not Possible	High
Q19	Is there a significant change in abundance of dominant or characterising benthic species that	Installation	No	Yes	High
	can be attributed to the turbine installation?	Commissioning/ operation	Unsure	Not Possible	High

Note: significant change is considered to be the result of natural seasonal variation – see results section.

The status of the seabed close to the turbine has presently been assessed on the basis of two sample time points; the first a pre-installation survey in March/April 2008, followed by a post-installation survey in July 2008. The video sample methodology is explained in Appendix IV. No post-operation surveys have been undertaken as yet, and therefore an assessment of change over this period is currently not possible.

The high quality of the diver-collected video data has provided an unexpectedly detailed record of the biological communities at each of the four re-locatable sample stations, with over 60 species identified. There is, however, a high degree of natural species dominance, by a small number of species, notably the hydroids *Sertularia cupressina*, and *Tubularia* spp. and the sponges *Halichondria* sp. and *Esperiopsis fucorum*.

²¹ Section 7.4 SeaGen EMP (version 4, Royal Haskoning, May 2008)

8.1.2 Results

- The Reference and 20 m stations have undergone a slight increase in mixed faunal turf (mainly bryozoans) with an appearance of amphipod tubes on *Sertularia*;
- In the 150 m and 300 m stations there has been a similar increase in bryozoan cover, but with increased encrusting red algal cover;
- The changes across all stations are broadly similar in nature; and
- The dominant species (hydroids and sponges) in March continue to dominate in July.

All of the current data support a conclusion that the presently observed changes are relatively minor and are a result of *natural seasonal variation*.

8.1.3 Timescale

Current status

Ins	talla	tion	I		Со	ommissioning					Operating Year 1														
F	М	Α	М	J	J	Α	s	0	Ν	D	J	F	М	Α	М	J	J	Α	s	0	Ν	D	J	F	М
80	08	08	80	08	08	80	80	80	80	08	09	09	09	09	09	09	09	09	09	09	09	09	10	10	10

Analysis completed: dataset analysed by QUB (Atlantic RMS Ltd.)

Raw data processed: raw data processed by QUB (Atlantic RMS Ltd.)

Raw data collected: data collected by QUB (Irish Divers)

8.1.4 Expectations During Next Reporting Period

Due to the extended installation time, the original survey schedule has slipped. This has resulted in the 6-Month post-installation sampling point falling at a time corresponding to a known natural seasonal reduction in the abundance of some of the characterising fauna, particularly the Hydrozoa. For this reason the next sampling is delayed until March 2009, effectively providing a one-year comparative interval with the pre-installation samples. The subsequent scheduled +13 Month and +18 Month post-installation sample points is also be reviewed and revised accordingly.

9 ACOUSTIC DOPPLER CURRENT PROFILING (ADCP)



Roles and responsibilities²² Data collection: QUB Data analysis and reporting: QUB

Rationale:

The aim of the ADCP monitoring is to identify and quantify changes in the water flow characteristic imparted into the Narrows by the tidal turbine in operational mode.

9.1.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q20	Has the SeaGen turbine modified the flow dynamics, scour patterns	Installation	NA	NA	NA
	or turbulence character of the Strangford Narrows in such a way to have caused a change in benthic community structure?	Commissioning/ operation	Unsure	Unsure	High

It should be noted that a significant change in the benthic community structure may indicate a response to a change in the flow pattern. However, the relationship between these changes will only be able to be made by association.

The study is not able to answer the question relating to flow dynamics until SeaGen operates in semi-continuous or continuous mode for a reasonable length of time and a benthic sampling programme of appropriate timescale is completed.

Benthic sampling around the pile feet approximately three months after installation of the pile indicated no scour effects and recolonisation of the small areas of the seabed affected by installation operations.

9.2 Velocity Measurements

9.2.1 Preliminary Results

- Detailed ship-mounted ADCP surveys of the area around the SeaGen turbine showed the expected pattern of tidal flow in the Strangford Narrows with a northward flow on the flood tide and a southward flow on the ebb;
- Local eddy flow patterns were recorded on the shallow margins;
- The zone of maximum flow on the flood tide was constrained to the deeper part of the main channel; this pattern was less evident on the ebb tide, possibly owing to the local alignment of the Narrows; and

²² Section 7.3 SeaGen EMP (version 4, Royal Haskoning, May 2008)

• Maximum current velocities of 4.65 m s-1 were recorded on the spring flood tide with comparable values of 3.10 m s-1 during the neap flood tide.

9.3 Turbulence Measurements

9.3.1 Preliminary Results

- It was not possible to obtain data of sufficient quality to allow quantification of turbulent flow velocity components from ship-based ADCP measurements.
- Required data will be obtained from standard bottom-mounted ADCP deployments prior to full commissioning of the turbine.

9.3.2 Timescale and deliverables

- Studies are to be completed in 2009.

10 POST INSTALLATION REPORTING

Reporting will focus on the key questions identified. Table 8.1 below restates those questions and identifies the route by which it is proposed they are addressed.

Monitoring Programme Compo									npon	ents		
Key Questions	A	Answer			ys	etry	eys	oustic	ırveys	ar	visual	ed visual
	Installation	Commissioning / operation	Benthic ec	ADCP	Bird surve	Seal telem	Aerial surv	Passive ac	Carcass st	Active son	Pile based	Shore base
Is marine mammal density and behaviour in Strangford Narrows significantly modified by the SeaGen turbine?	NO	NO				~		~				>
Does the SeaGen turbine have a significant effect on harbour seal movements through the Strangford Narrows?	NO	NO				~						>
Are harbour seals significantly excluded from foraging habitat or social areas within the Strangford Narrows as a result of the SeaGen turbine?	NO	NO				~	~					~
Does operation of the SeaGen turbine have a significant effect on marine mammal sightings within the immediate waters of the turbine?	NA	UNSURE									¢	>
Can the active sonar system detect marine mammals within 50m of the turbine and shut down the turbine automatically?	NA	YES								>		
Can the turbine reduce rotation to a safe speed before the travel path of a detected marine mammal brings it into a zone of possible injury?	NA	YES								>	>	
For all recorded stranding events, have any marine mammal mortalities occurred as a consequence of physical interaction with the SeaGen turbine?	NA	NO							>			
Does the SeaGen turbine displace harbour porpoises from the Strangford Lough SAC?	NO	NO						~				>
Does the SeaGen turbine present a significant barrier effect to the free passage of harbour porpoises through the Strangford Narrows?	NO	NO						~				>
Has the number of adult seals and	NO	NO					~					

Table 10.1 Key questions and associated monitoring activities

	Monitoring Programme Components											
Key Questions	Answer				eys	netry	veys	coustic	surveys	nar	d visual	sed visual
	Installation	Commissioning / operation	Benthic e	ADCP	Bird surv	Seal telen	Aerial sur	Passive a	Carcass s	Active so	Pile base	Shore bas
pups decreased significantly within the Strangford Lough SAC?												
Has there been a significant change in the use of harbour seal haul out sites within the Strangford Lough SAC?	NO	NO					>					
Does SeaGen present a barrier effect to the free passage of seals through the Strangford Narrows?	NO	NO				>						>
Does SeaGen have a significant effect on harbour seal movements through the Strangford Narrow?	NO	NO				>						~
Does the SeaGen turbine have a significant impact on seabird activities in the Strangford Narrows?	UNSURE	UNSURE			>							
Does SeaGen displace foraging diving birds from important areas within Strangford Narrows?	UNSURE	UNSURE			>							
Does presence of the SeaGen turbine have a significant impact on seabird activity within 50m of the structure?	UNSURE	UNSURE									~	
Is there a significant change in the broad benthic community structure that can be attributed to the turbine installation?	NO	NOT POSSIBLE	*									
Is there a significant change in abundance of dominant or characterising benthic species that can be attributed to the turbine installation?	NO	NOT POSSIBLE	~									
Has the SeaGen turbine modified the flow dynamics, scour patterns or turbulence character of the Strangford Narrows in such a way to have caused a change in benthic community structure?	NA	UNSURE		>								
If changes in the flow dynamics, scour patterns or turbulence do occur, have they caused a change in benthic community structure and function?	NA	UNSURE		>								

11 SUMMARY

The environmental monitoring programme implemented as a requirement of the SeaGen FEPA license has provided a robust methodology for generating a sound environmental baseline.

During the commissioning phase, the opportunity to monitor the impact of the installed SeaGen device in both operational and non operational modes has been used to generate significant post installation data to compare with the baseline.

The data gathered both pre and post installation is considered to be of high quality and integrity.

NIEA and the Science Group meet on a regular basis to review the data set and adapt the monitoring process as necessary.

12 APPENDICES

Appendix I

SEAL CARCASS SURVEYS

SEAL CARCASS SURVEYS

METHOD

The area of search for carcass surveys is limited to four potentially receptive bays in Strangford Lough Narrows and the immediate outer coastline:

- Ballyhornan Bay;
- Mill Quarter;
- Benderg Bay;
- Ballyhenry Bay.

Surveys have been carried out towards the end of every month between June and August during which time no seal carcasses were recorded (see Table 4.1 below).

Due to the lack of significant turbine activity following the end of August (generally less than a few minutes per week) and increased public reporting of seal carcasses after that time, as a result of enhanced public awareness of the significance of seal carcasses in the area, the decision was taken to put beach surveys for carcasses on hold until major turbine commissioning commenced. After the end of August, it appeared that carcasses were either reported directly or indirectly to QUB or NIEA staff; arrangements were made for the removal of carcasses from the shore to the Pathology Laboratory generally within hours

For more information on the survey methodology and site details of these locations refer to Table 12.1, Appendix I.

It should be noted that the key data from carcasses used in the monitoring programme comes from pathology analysis. Carcasses are examined to determine if a possible link between the cause of death and the turbine could be present. Quantitative data about the number of carcases detected cannot be used as pre installation data are not available.

This survey is to be carried out weekly for the first three months that the turbine blades are turning (the commissioning phase).

Equipment: Handheld GPS; Mobile telephone; List of positions; OS map; Surgical gloves; Surgical mask; Binoculars; and Spray paint Inspections are to be made from the observation points described in Table 8.1.

Table 12.1 Site details and description of carcass survey protocol

Beach	Location
Ballyhornan Bay	• At the small promontory just north of Gilpin Harbour (59208 41658), check the small bay to the south and the west shore

	 of Guns Island. At the gate pull-in (59299 41850), look north up the main sweep of Ballyhornan On the coast road, pull in at stile (59330 42199) and from the stile look north, below and south At the lay-bye above the north end of the beach (59700 42747) walk est. 15m down the path to beach and look north and south
Benderg Bay	Verbal consent from the owner for DB to use road to access (60451 43481) by vehicle, weekly to the end of September. Climb gate, walk path across Reserve (est. 500 m) to vantage point (60583 43219), look north and south.
Mill Quarter	Due to parked vehicles and vegetation growth these are variable
Ballyhenry Bay	 At the lay-bye adjacent to the Walter rock (58776 51186), look north At the passing space on the south side of Ballyhenry bay (58574 51601), look north and south On the wide verge on the north side of Ballyhenry Bay (57962 51879), look north and south South of Ballyhenry Island (57777 52001) walk to the strand line and look north and south At the notice board at the start of the causeway to Ballyhenry Island (57587 52166) look south.

Observation points have been selected to give views of the entire shore with the majority of vantage points on the public roadside. Any seals seen are to be noted and checked (from a distance) for status. If dead or injured seals are found, these are to be reported through the Science Group protocol. Injured seals are to be reported to Exploris as soon as possible; carcasses are to be marked with spray paint for recovery and post-mortem examination.

PRELIMINARY RESULTS

Table 12.2 Results and progress of seal carcass surveys undertaken by QUB between June and
 August 2008. NS = No significant blade activity. Data source: D Birkett (QUB)

Date	Turbine Activity	Survey Area	Survey Area							
		Ballyhenry	Ballyhornan	Mill	Benderg					
		Bay	Bay	Quarter	Bay					
Week of June 23	NS									
Week of June 30	NS	none	none	none	none					
Week of July 07	NS									
Week of July 14	NS									
Week of July 21	NS									
Week of July 28	NS	none	none	none	none					
Week of August 04	NS									
Week of August 11	NS									
Week of August 18	NS									
Week of August 25	NS	none	none	none	None					

Since the SeaGen turbine was installed in early July 2008, the Environmental Action and Safety Management Plan (EASMP - Version 3, June 2008) has been

successfully reporting and managing any marine mammal strandings that have occurred within the Strangford Narrows and immediate coastline (Task 2, Section 10, EASMP).

Table 12.3 and Figure 1 provide further details of these strandings, the resulting actions carried out by the EASMP response team and the results of any post mortem investigations carried out.

Table	12.3	Marine	mamma	l carcasses	found	inside	Strangford	Lough	or	on	the	Co.	Down	Coast
betwee	en Clo	oghy an	d St. Johr	ns Point betw	ween Ju	ly 200	8 and Janua	ary 2009). Da	ata	soui	rce: l	NIEA	

Date Found	Location Found	Species*	Sex	Age	Action Taken	Postmortem Summary
19/07/2008	Black Boat Bay	Porpoise	N/D	Adult	Carcass measured and insitu photographs taken off the animal. This carcass was not sent for PM.	N/D
03/08/2008	Shore Road Portaferry	G	М	PUP	Carcass collected and taken to Exploris. FEPA team called and taken to PM	No evidence of trauma. The findings suggest this pup died from starvation
08/08/2008	Cloghy	G	F	ADULT	Reported by Exploris, collected for PM same day by contractors.	PM result, pregnant female mature adult, no signs of trauma.
22/08/2008	Shore Road Portaferry	G	М	PUP	Collected by contractors. PM results:consistent with starvation.	No evidence of trauma.
28/08/2008	Ben Deargh Beach	С	М	PUP	Removed for PM by NIEA STAFF. Results indicate starvation	Markedly autolytic but there was no evidence of trauma. Findings consistent with starvation
08/09/2008	Killard, Benderg Bay	G	М	PUP	Removed for PM by NIEA STAFF. Results indicate starvation	No evidence of trauma. The findings suggest this pup died from starvation
11/09/2008	Portaferry Ferry Slipway	С	Μ	PUP	QUB contacted. Removed same day for PM.	No evidence of ante mortem trauma.Cause of death not established
22/09/2008	Record incomplete	G	U	PUP	QUB contacted.Removed same day for PM	Cause of death not established
22/09/2008	Marlfield	G	F	Immature	QUB contacted. Removed same day for PM.	No evidence of ante mortem trauma.Cause of death not established
25/09/2008	Greyabbey	G	F	PUP	QUB contacted. Removed same day for PM.	Head cut off. No evidence of trauma in rest of carcass.
30/09/2008	Rue Point, Strangford Narrows	С	М	Not Given	QUB contacted. Removed same day for PM.	No evidence of ante mortem trauma.
30/09/2008	Don O'Neill Island	С	F	ADULT	Removed for PM by NIEA STAFF.	No evidence of ante mortem trauma.Cause of death not established
30/09/2008	BlackBoat Bay	G	F	PUP	QUB contacted. Removed same day for PM.	No evidence of ante mortem trauma.Cause of death not established
07/10/2008	Dogtail Point	G	F	PUP	QUB contacted. Removed same day for PM.	Head cut off at the caudal neck. Spine also cut through.No evidence of ante mortem trauma elsewhere in the carcass
10/10/2008	Cook Street Pontoon	G	М	PUP	QUB contacted. Removed same day for PM.	No evidence of ante mortem trauma.
11/10/2008	Bar Hall Bay	G	М	ADULT	QUB contacted. Removed same day for PM.	Evidence of mono-filament net entanglement.
13/10/2008	Dogtail Point	С	М	ADULT	QUB contacted. Removed same day for PM.	Heavily decomposed however no evidence of ante mortem trauma.
20/10/2008	Barr Hall Bay	С	F	ADULT	Removed for PM by NIEA STAFF.	No evidence of trauma
20/10/2008	Castle Island	G	F	PUP	QUB contacted. Removed same day for PM.	Head had been cut off. No evidence of trauma elsewhere in the carcass, not possible to comment on whether there had been antemortem trauma to the head
26/10/2008	Kircubbin	С	F	Not Given	QUB contacted. Removed same day for PM.	Cause of death not established but drowning plausible. Seal had been cut around the base of the neck.
27/10/2008	Kircubbin	G	М	PUP	QUB contacted. Removed same day for PM.	Cause of death not established but drowning plausible. Seal had been cut around the base of the neck.
27/10/2008	Ballywhite Bay	G	F	PUP	Removed for PM by NIEA STAFF.	Cause of death not established but drowning plausible
29/10/2008	Horse Island	G	М	PUP	QUB contacted. Removed for PM. Only lower abdomen recoverable	Carcass cut around circumferance by sharp knife.
29/10/2008	Adjacent Horse Island	G	F	PUP	QUB contacted. Removed for PM. Only lower abdomen recoverable	Carcass cut around circumferance by sharp knife.
10/11/2008	Cook street / Salt Pans	G	F	PUP	QUB contacted. Removed for PM.	Drowning cause of death. No evidence of trauma



Figure 2 Marine mammal carcasses found inside Strangford Lough or on the Co. Down Coast between Cloghy and St. Johns Point between July 2008 and January 2009. Data source: NIEA

APPENDIX II

SMRU BIANNUAL REPORT

APPENDIX III

BENTHIC ECOLOGY

BENTHIC MONITORING

METHOD

Four relocatable sample stations have been established by installing Ultra Short Baseline (USBL) transceivers. Three are located in-line with the rotational axis of the east turbine at 20m, 150m and 300m down/upstream to the south-east (approx.) of the turbine installation. A further single reference station is installed approximately 50m to the ENE of the turbine structure. The location of the sample stations relative to the turbine installation are shown in Figure 1.

Video Sample Method in Detail

1. General video record stations

A general video record is taken at three locations. These are:

- (i) The seabed at the central point of the quadrapod, beneath the turbine structure
- (ii) The seabed around the south-east leg of the quadrapod
- (iii) The seabed around the north-eastern installation platform anchor point

Stations (i) and (ii) have been selected as representative stations for possible turbine structure impacts. Station (iii) has been selected as a proxy to monitor the impact of the four anchor points. Previously obtained video has established that this station is likely to be the most vulnerable to physical damage as it contains a dense epifaunal community of sessile and long-lived species.

At each of these stations a diver obtains no less than 30 seconds of video footage within a 2m range of installation structures (where present) taking care to include obvious non-natural effects. For station (i) an area $2m \times 2m$ (depending on visibility) is documented. A direction which best represents the dominant seabed community is selected and noted by the diver and a slow video sweep of not less than 90° (from left to right) and taking not less than 30 seconds is made.



Figure 1. Schematic showing video sampling stations (not drawn to scale)

2. Detailed (quadrat) video sampling stations

A more detailed video sampling strategy is employed at the four stations where the USBLs are secured. Each USBL is marked to allow diver orientation of a $0.5m \times 0.5m (0.25m^2)$ quadrat. The quadrat is placed to the north-east or north of the USBL, unless the topography of the seabed does not present a suitable surface for quadrat deployment within a 2.5m straight line distance. If the seabed is assessed as not suitable for quadrat deployment to the NE or N, then a new direction is selected and a means put in place in which a returning diver is able to repeat the quadrat sampling in the same position and direction.

Once a direction has been selected and noted, five adjacent quadrats are recorded by rolling the quadrat in the designated direction. Each of the five quadrat placements require three video sequences to be taken:

- (i) A sequence taken from vertically above the quadrat, attempting to include all of the quadrat area in the field of view. The video sequence is of 10 20 second duration and matches the orientation of all other sequences where appropriate.
- (ii) A sequence taken from an angle of approximately 45° , attempting to include all of the quadrat in the video frame, or a slow pan to incorporate all of the area if visibility or camera lens restrictions prevents a single image. The video sequence is of 10 20 second duration and matches the orientation of all other sequences where appropriate.
- (iii) A sequence taken from vertically above (or as close as possible), concentrating on the 10cm x 10cm sub-divisions within the quadrat. The video sequence includes a pause at each of the subdivisions of no less than two seconds to allow a high quality image freeze suitable for taxonomic identification and enumeration. The track of the video sequence (Figure 2) is orientated in the same way for all quadrats and throughout all sampling visits,

The combined video time for all of the above tasks is approximately 1min. 30sec. for each quadrat and a total time for the completion of all quadrats at any station is approximately 7 - 8 minutes, not including diver orientation and setting-up time.

In addition to the detailed video, a short contextual pan sequence (left to right) of no less that 30 seconds, covering approximately 90° and including the quadrat area is taken from a point close to the USBL.



Figure 2. Video sequence orientation and direction of successive deployment of 0.5m x 0.5m quadrat.

RESULTS

The establishment of fixed re-locatable monitoring stations was completed in March, 2008 and the collection of video quadrat data for the turbine pre-installation time point was achieved in the same month.

Pre-installation Monitoring

The biological communities for all of the stations were broadly typical of Strangford Lough tide-swept habitats and were dominated by a hydroid turf with extensive sponge and bryozoan cover. The dominant species at all stations were *Sertularia cupressina* and *Tubularia* sp. with a variable, but generally high degree of cover of *Esperiopsis fucorum, Halichondria* (cf) *bowerbanki* and bryozoan turf. In total, more than 60 species were identified from the video footage.

Multi-dimensional Scaling (MDS) ordination of the community data (Figure 3) confirmed that most stations were broadly similar, but indicates that there is a weak but significant difference, confirmed by use of the PRIMER Analysis of Similarities (ANOSIM) routine, separating the Reference stations from the others. Subsequent examination of the raw data suggests that there may be subtle overall species

abundance differences, but that the bulk of the segregation of the Reference samples is due to the wide variability between the Reference station quadrats.



Figure 3 Non-Metric Multi-dimensional Scaling (MDS) ordination of all pre-installation video quadrats. Abundance data are standardised and arcsine transformed. (Stations indicated as follows: R = Reference, 20 = 20 m, 150 = 150 m, 300 = 300m). The distance between any two station numbers indicates how similar, in terms of species and abundance, they are. Shorter distances indicate greater similarity, more distant quadrat samples indicate greater dissimilarity.

The slight Reference station dissimilarity, while unfortunate, is a problem commonly encountered when establishing marine monitoring programmes. The assignment of suitable 'control' or 'reference' areas of seabed for comparison with potentially impacted areas is notoriously difficult, since the seabed is topographically complex and the associated habitats and biota will therefore be patchily distributed. This non-uniform distribution is likely to be reflected in relatively small samples such as the quadrats used here.

The subtle differences detected are not considered a cause for concern, since all of the dominant species in the other stations are similarly dominant in the reference station samples and an examination of coincident change, beyond that of natural variation and succession, across all sample stations is still possible. Nevertheless, an addition USBL-marked station beyond the zone of possible impact has been established at 600m and will be surveyed at the 6-month post-installation visit.

One-Month Post Installation

Post-turbine installation sampling was completed in July 2008, successfully repeating the methodology employed for pre-installation sampling.

A MDS comparison of the pre- and post installation video samples show a degree of spatial segregation, providing an indication of possible biological community change between May and June of 2008 (Figure 4).



Figure 4 Non-Metric Multi-dimensional Scaling (MDS) ordination of pre- and post-installation video quadrats (B = before/pre-installation, P = post-installation). Abundance data are standardised and arcsine transformed.

The stress value, an indication of the reliability of the plot, is considered relatively high in Figure 4, suggesting that, although the broad segregations are probably valid, the detail should not be considered an accurate representation of station similarities.

A MDS plot of the means of the species abundance for the five quadrats from each stations Figure 5 provide a considerably more reliable plot, confirming that there has been a statistically significant shift in biological community structure in **all** of the stations between March and July 2008.



Figure 5 Non-Metric Multi-dimensional Scaling (MDS) ordination of mean species (five quadrats) abundance for each sample station, pre- and post-installation sampling (B = before/pre-installation, P = post-installation). Abundance data are standardised and arcsine transformed.

A further detailed examination of the difference in community composition across sample times indicates the following:

- the Reference and 20 m stations have undergone a slight increase in mixed faunal turf (mainly bryozoans) with an appearance of amphipod tubes on *Sertularia*;
- there has been a similar increase in bryozoan cover in the 150 m and 300 m stations, but with increased encrusting red algal cover;
- the changes across all stations are broadly similar in nature;
- the dominant species (hydroids and sponges) in March continue to dominate in July

All of the current data support a conclusion that the observed changes are relatively minor and are a result of *natural seasonal variation*.

APPENDIX IV

ADCP REPORT

APPENDIX V

PILE-BASED MMO METHODOLOGY

METHOD

A Marine Mammal Observer (MMO) has been present on the turbine during all periods of rotation throughout the commissioning and operational period.

Between 2nd July and 5th November 2008, 172 hours of survey effort has been undertaken by the team of MMOs and for much of this time these surveys have been coordinated alongside the active sonar monitoring.

The application of a simple observational grid across the observer's field of view has allowed the survey team to record the surface behaviour and travel patterns of marine mammals within 200m of the SeaGen turbine.



Figure 12.3

Figure 12.4

Figure 12.3: MMO looking upstream through observational grid (the grid can be adjusted depending on the surveyors height and state of tide), Figure 4.2: approximate coverage of observational grid

PRELIMINARY RESULTS





÷









9S8562/R/303519/Edin