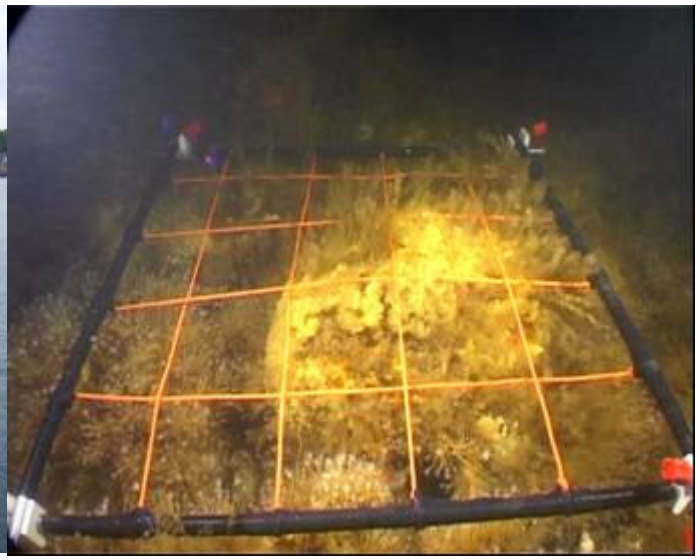

SeaGen Environmental Monitoring Programme: Biannual Update.
Version 1-SeaGen Biannual
Environmental monitoring July 2009 – Jan 2010.

MCT

21st April 2010

9S8562

ROYAL HASKONING

HASKONING UK LTD.
ENVIRONMENT

10 Bernard Street
Leith
Edinburgh EH6 6PP
United Kingdom
+44 (0)131 555 0506 Telephone
Fax
info@edinburgh.royalhaskoning.com E-mail
www.royalhaskoning.com Internet

Document title	SeaGen Biannual EMP update
Document short title	EMP update (Jan 2010)
Status	Version 1
Date	21st April 2010
Project number	9S8562
Client	MCT
Reference	9S8562/R/303719/Edin

Drafted by	Gemma Bedford and Frank Fortune	
Checked by	Frank Fortune	
Date/initials check	…….	…….
Approved by	Frank Fortune	
Date/initials approval	…….	…….

EXECUTIVE SUMMARY

The key elements / findings of this report are:

- Active sonar provides a conservative mitigation measure, replacing pile-based marine mammal observation and allowing for remote operation of SeaGen;
- Results of night time sonar operation indicate that sonar will continue to provide conservative mitigation during night time operation of SeaGen;
- Active sonar has triggered 19 precautionary shutdowns between July 2009 and February 2010 as a result of marine mammals coming within 50m of the turbine;
- No seal carcasses have shown signs of possible interaction with SeaGen;
- T-POD results indicated that SeaGen does not cause a barrier effect for harbour porpoise;
- Aerial surveys have shown no significant changes in seal use of haul out sites since installation of SeaGen;
- Benthic monitoring results strongly indicate that seabed changes are a result of natural variation and the benthic community has not been affected by the presence or operation of SeaGen; and
- Noise produced during operation of SeaGen is not within a range which could cause physical harm to marine mammals. High natural background noise as well as ongoing ferry noise, mean that habituation is likely to limit any potential effect on marine mammals.

CONTENTS

1 INTRODUCTION

1.1 Project History

1.1.1 Pre-installation

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

Over the same period MCT was also working with another consortium which in May 2003 successfully installed the 300kw SeaFlow "*proof of concept demonstrator*" device near Lynmouth, Devon. This subsequently created a requirement for a location suitable for the full scale precommercial demonstrator project (SeaGen).

After considering several possible locations, MCT selected Strangford Lough as the preferred location in November 2003 and submitted a FEPA application to EHS (now NIEA) in the same month.

Royal Haskoning Ltd was appointed in early 2004 to provide support to the EIA process. The scoping consultation 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 to accommodate necessary changes in installation methodology in February 2007, and again in February 2008.

1.1.2 SeaGen Installation

Installation of the moorings for anchoring the SeaGen deployment vessel commenced in February 2008 and was 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 achieved using the crane barge *Missing Link,* which was on location from mid April to late May 2008.

1.1.3 SeaGen Commissioning and Operation

Commissioning of SeaGen commenced in July 2008, culminating in full 1.2MW power generation to the grid in December 2008.

Since July 2008 SeaGen has achieved over 1500 hours of generation, delivering an energy output of over 1000 MW hours, greater than any other grid-connected marine device and leading to official recognition as a commercial power station. This success has resulted in SeaGen becoming the first marine renewable energy project to be accredited by the UK energy regulator OFGEM for ROCs (Renewable Energy Certificates).

Operation is continuing within the constraints of the FEPA license with the environmental monitoring programme results contributing to an adaptive management strategy where findings are periodically reviewed and improvements to the application of the FEPA restrictions are proposed.

The existing FEPA license covers the initial 5 year lease granted by the Crown Estate, which will result in SeaGen being decommissioned and removed in 2013.

1.2 SeaGen Description

SeaGen is a free stream tidal energy device that converts energy from tidal flow into electricity. The device 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 is, in turn, 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 approximately 9m above the average sea level (Figure 1.1). The twin rotors begin to generate electricity at a current speed greater than 1m/s. At a predetermined maximum tidal speed the rotors start to adjust their pitch to limit the maximum rotational speed to 14 RPM, resulting in a peak rotor tip speed of around 12m/s.

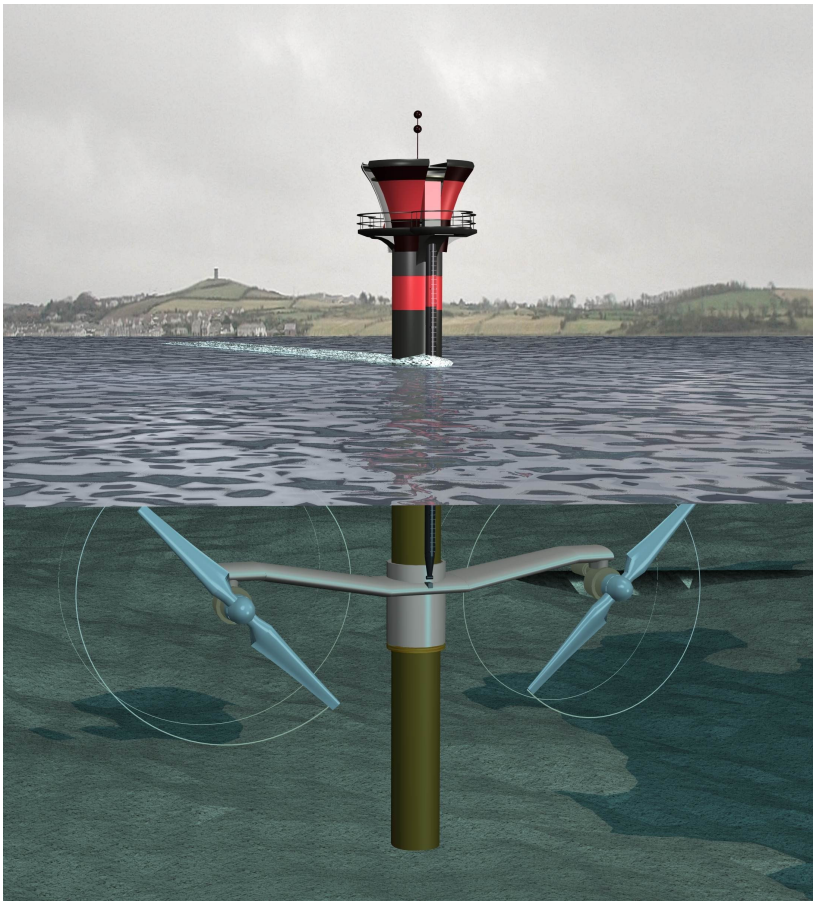

Figure 1.1 The SeaGen turbine, Strangford Lough, Northern Ireland.

Figure 1.1 shows the original SeaGen monopile installation concept which was modified to accommodate a change in installation platform in February 2008. The actual installation foundation is a four-footed structure, 18m by 12m in footprint area. Each corner of the foundation is supported on a 1m diameter pin pile. The base of the structure is raised approximately 2m above the seabed on pin piles, thus resulting in a much smaller seabed footprint than the original monopole design.

1.3 Environmental Monitoring Program

1.3.1 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 1.1) 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.

Table 1.1 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].	1. Post mortem evaluation of carcass stranding and assessment of cause of death.
	The turbine operates in such a way as to stop when marine mammals are within 50m from the rotors.	1. Assessment of the combined surface and sonar detection events with manual shutdown when a mammal is within 50m of turbine rotors. 2. 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 allow a precautionary shut-down to occur automatically.	1. Number of sonar detections and shut-down events.
	The SeaGen turbine does not present a barrier effect to the free passage of marine mammals through the Strangford Narrows.	1. Pile based marine mammal observations (ceased 21/08/09). 2. Active sonar operations allowing targets to be observed moving passed the turbine during periods of operation. 3. Land based visual observations pre- and post installation to examine any change in use of the area around the turbine. 4. Seal telemetry studies 5. T-POD measurements for harbour porpoise.
	Relative abundance of marine mammals in Strangford Narrows is not significantly[2] modified by the operation of the SeaGen turbine.	1. Number of marine mammals underwater recorded in close proximity (~ 50m) to the SeaGen turbine per hour 2. Wider contextual data from shore based observations.

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

[2] Further discussion is required to define 'significance' in this context. See discussion following this table.

Element	Objective	Measurement
	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.	1. Measurement of zone of audibility and zone of disturbance at full power operation. 2. Number of marine mammals underwater sighted in close proximity (~ 50m) to the SeaGen turbine per hour 3. 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.	1. Population estimates derived from aerial survey and set within the context of historical data. 2. 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[3] harbour seal haul out sites within the Strangford Lough SAC.	1. Haul out site seal numbers from aerial and boat-based survey. 2. 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.	1. Transit routes derived from telemetry data from the seal tagging programme. 2. Land based observations and pile based MMO data.
	The SeaGen turbine has no significant[2] effect on harbour seal movements through the Strangford Narrows	1. Harbour seal transit rates derived from telemetry data from the seal tagging programme.
	Harbour seals are not excluded[4] from important[3] foraging habitat or social areas within the Strangford Narrows as a result of the installation and operation of the SeaGen turbine.	1. Sightings frequency over space and time (from Shore-based visual operation) in pre-operational and post-operational periods). 2. Use of foraging habitat from telemetry data (i.e. amount of time spent foraging in different areas).

[3] Further discussion is required to establish the meaning of the term *important* when referring to areas of value for marine mammals. See discussion 'Environmental Risk Thresholds' which follows this table.

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

Element	Objective	Measurement
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.	1. 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[5] grey seal haul out sites within the Strangford Lough SAC.	1. 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.	1. Transit routes derived from telemetry data from the seal tagging programme. 2. Land based observations and pile based MMO data.
	Grey seals are not excluded[6] from important[3] foraging habitat or social areas within the Strangford Narrows as a result of the installation and operation of the SeaGen turbine.	1. 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.	1. Echolocation events/ detection positive minutes (presence/absence) from T-POD monitoring. 2. Sighting data from shore and pile based observers.
	The SeaGen turbine does not present a barrier effect to the free passage of harbour porpoises through the Strangford Narrows.	1. Echolocation events/ detection positive minutes between inner Lough, Narrows and outer Lough from T-POD monitoring. (Land based observations and MMO data should also contribute to the measurement of this element.)

[6] In this case, “exclusion” needs to pass the test of “significance”, See discussion following this table.

Element	Objective	Measurement
	Cetaceans not excluded from important foraging habitat or social areas within the Strangford Narrows as a result of the installation and operation of the SeaGen turbine	1. Sightings frequency (from shore-based visual observations) over space and time in pre-operational and post-operational periods. (T-POD 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	1. Sightings frequency of diving birds from shore- based visual surveys 2. 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.	1. Vessel- or bottom mounted ADCP measurement, as appropriate, of upstream and downstream flow character and turbulence signature. 2. 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.	1. 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.

Environmental Risk Thresholds

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 (Iain 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.

1.3.2 Biannual Reporting

This report provides an update of the environmental research activities currently being carried out since the previous biannual report in July 2009 as part of the SeaGen Environmental Monitoring Programme (EMP).

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

- **Baseline** (pre-installation): June 2005 – February 2008
- **Installation**: February 2008 – July 2008
- **Commissioning**: July 2008 – October 2008 (three months)
- **Operation**: October 2008 – ongoing

Report 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 and full recent progress reports are either provided in the Appendices or can be found in referenced literature.

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 4.1 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, three distinct phases of installation, commissioning and operation are recognised.

There are 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

This element provides 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 it 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 is occurring, but may also leave room for doubt when used to answer the key questions.
Low	The current data provide a poor or 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.

In addition to the Key Questions table the results, timescale, and expectation during the next reporting period are discussed for each aspect of the EMP.

2 MARINE MAMMALS

2.1 Shore-based marine mammal surveys

2.1.1 Results

Natural variability in the data collected during shore based marine mammal surveys provides low power to detect changes in abundances, as even large changes are within the potential for natural change. The power to detect change is greatest for harbour seals and a sudden drop in average seal abundance of 20% would be detectable with high probability (0.85) after 3 months of the current monitoring scheme.

Following analysis of the data no statistically significant changes have been determined.

A number of non-statistically significant trends have been identified and these indicate the following:

- A decrease in average relative abundance over time for harbour porpoise in the narrow, which supports the T-POD findings detailed later in section 2.5;
- Grey seal sightings peaked in 2008 relative to 2006, 2007 and 2009.
- Common seal sightings have remained relatively consistent over time, with a slight peak in 2009.
- Average sightings have been lower during operation of SeaGen.

Differences may be a result of natural variation, sampling variations or the limited amount of data during SeaGen operation, with the bulk of the data collected when SeaGen has not been operational.

2.1.2 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 significantly modified by the SeaGen turbine?	Installation	No	No	Medium
		Commissioning/ initial operation	No	No	Medium
		Operation	No	No	Medium
Q2	Does the SeaGen turbine have a significant effect on harbour seal movements through the Strangford Narrows?	Installation	No	No	Medium
		Commissioning/ initial operation	No	No	Medium
		Operation	No	No	Medium
Q3	Are harbour seals significantly excluded from foraging habitat or social areas within the Strangford Narrows as a result of the SeaGen turbine?	Installation	No	No	Medium
		Commissioning/ initial operation	No	No	Medium

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
		Operation	No	No	Medium

2.1.3 Timescale

- Survey data up to Oct 2009 has been analysed and the results reported here;
- November to December data were supplied by QUB to SMRU at the end of March; and
- January to March data will be supplied by QUB to SMRU by the end of April.

2.1.4 Expectations during the next reporting period

Shore based surveys will continue to be carried out 8 times per month during SeaGen operation. Watches are 3 hours in duration.

2.2 Pile-based Marine Mammal Observation

Roles and responsibilities[7]
Data collection: Royal Haskoning
Data analysis: Royal Haskoning and SMRU Ltd. (analysed alongside active sonar reporting).

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

2.2.1 Key Questions

	Key Question	Phase	Answer	Significant change from non-operational periods detected with current data?	Data confidence
Q4	Does operation of the SeaGen turbine have a significant effect on marine mammal sightings within the immediate waters of the	Installation	N/A	N/A	N/A
		Commissioning	No	N/A [8]	Medium

[7] Section 7.1.5, SeaGen EMP, (version 4, Royal Haskoning, May 2008)

	Key Question	Phase	Answer	Significant change from non-operational periods detected with current data?	Data confidence
	turbine?	Operation	No	N/A [8]	Medium

2.2.2 Results

In total, pile-based marine mammal observation has been undertaken for 469.01hrs (254.73hrs during SeaGen operation). Pile based observations began on the 8th July 2008 and ended on the 21 August 2009 (see Section 2.2.3). During this time 426 sightings of marine mammals were made within the observation grid from SeaGen (i.e. within approximately 200m in an upstream direction).

During the period of this reporting (since 10 July 2009) 112.78 hours of MMO pile-based survey have been completed, 90% of which were during operation. Table 2.1 shows the total number of sightings of each marine mammal species made within the observational grid (within approximately 200m upstream of the turbine) and the number of sightings in relation to survey effort (total sightings per hour).

Table 2.1 Sightings across whole observational grid

	All marine mammals	Common seals	Grey seals	Harbour porpoise
Total sightings	129	115	4	11
Total sightings per hour	0.28	0.25	0.001	0.02

Shutdown history

Table 2.2. Shutdown history from MMO and Active Sonar Operator (ASO) until pile based MMO removal on 21/08/09)

Date	Species	Age	Tidal State at sighting event	Twin/Single Rotor	Range seen by MMO	Behaviour	E-stop initiated by
13/07/2009	Common Seal	Adult	HW Slack ± 1 hr	Twin	30	Milling	MMO
13/07/2009	Common Seal	Adult	HW Slack ± 1 hr	None	85	Milling	ASO
16/07/2009	Common Seal	Pup	EBB	Twin	20	Drifting	MMO
27/07/2009	Common Seal	Adult	Flood	Single	120	Travelling	ASO
28/07/2009	Common Seal	Adult and	HW Slack ± 1 hr	Twin	70	Travelling	ASO

[8] The MMO dataset was collected during mitigation and was not designed to be statistically robust.

Date	Species	Age	Tidal State at sighting event	Twin/Single Rotor	Range seen by MMO	Behaviour	E-stop initiated by
		Pup					
28/07/2009	Common Seal	Adult and Pup	HW Slack ± 1 hr	Twin	80	Travelling	ASO
07/08/2009	Common Seal	Adult	HW Slack ± 1 hr	Twin	50	Dived	MMO
12/08/2009	Common Seal	Adult	Ebb	Twin	200	Drifting	ASO
13/08/2009	Common Seal	Adult	EBB	Twin	30	Milling / Drifting	MMO
13/08/2009	Common Seal	Adult	EBB	Twin	60	Milling	ASO

Sightings over different states of tide

Figure 2.1 shows the number of sightings made at different states of tide. Of the total 426 marine mammal sightings made throughout the duration of pile-based marine mammal observation there are clear peaks in the number of sightings at slack water, particularly high water slack.

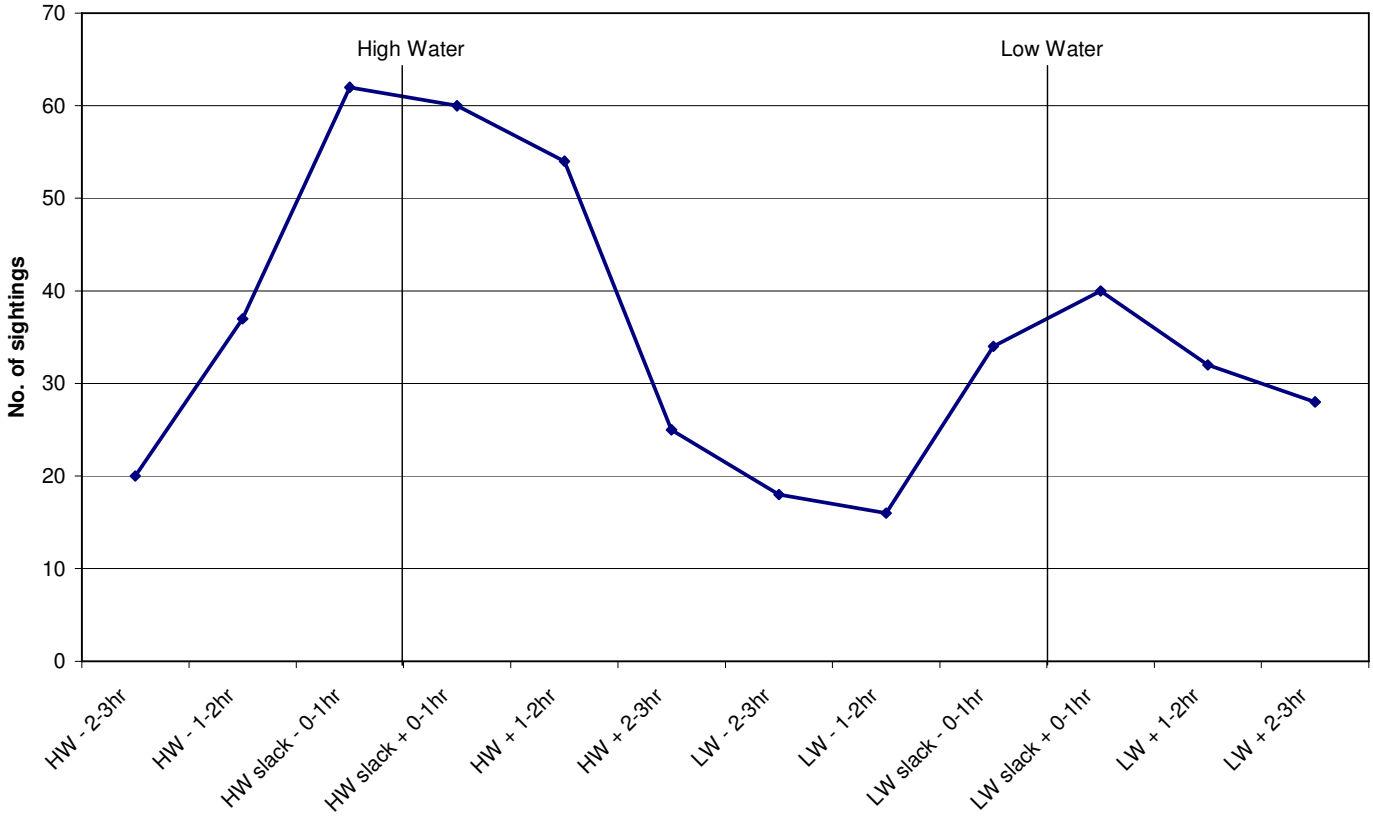

Figure 2.1. Number of marine mammal sightings made at different states of tide (between 08/07/08 and 21/08/09)

Sightings during operation and non-operation

Figure 2.2 shows the marine mammal sightings throughout the tidal cycle, both when the turbine was generating, and also when it was not in operation. Significantly more survey effort has been spent during turbine operation and so the 'turning' records are clearly higher, however both plots show similar patterns when compared with the state of tide. As a result it has been considered acceptable to use records collected both during turbine operation and non-operation while comparing MMO and ASO records.

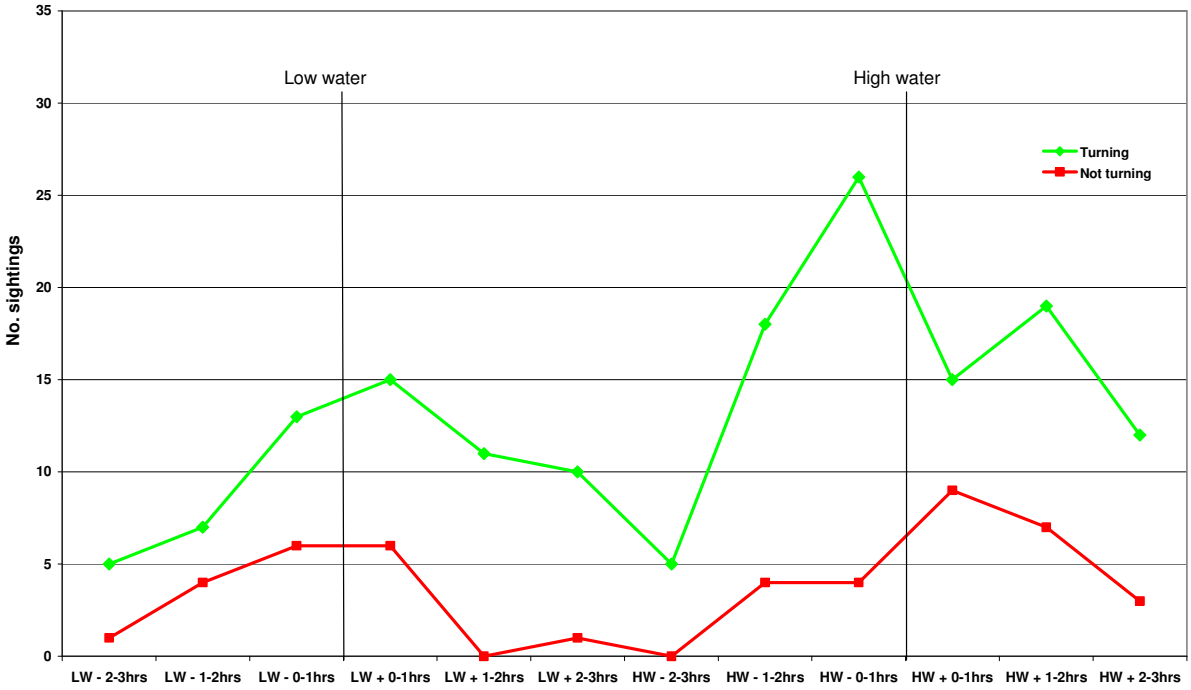

Figure 2.2. MMO sightings during SeaGen operation and non-operation

2.2.3 Timescale and Deliverables

MMO presence has worked well as a mitigation measure and has provided useful data about marine mammal activity since installation, enabling comparison with active sonar as mitigation. Following consultation within the Science Group it was agreed that there was sufficient evidence to allow the replacement of pile-based observation by manned active sonar (operated either from the turbine or remotely from the control room) as the key mitigation against collision of marine mammals with the turbine. The final day of MMO surveillance was on the 21/08/09.

2.3 Pile-based Active Sonar

Roles and responsibilities[9]:
Data collection and analysis: SMRU Ltd.

Rationale:
This system provides real time sub-surface sonar imagery of marine mammals and other large marine animals e.g. 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.

2.3.1 Key Questions

	Key Question	Phase	Answer	Significant change from non-operational periods detected with current data?	Data confidence
Q5	Can the active sonar system detect marine mammals within 50m of the turbine?	Installation	NA	NA	NA
		Commissioning	Yes	NA	Medium
		Operation	Yes	NA	Medium
Q6	Can the turbine stop before the travel path of a detected marine mammal brings it into a zone of possible injury?	Installation	NA	NA	NA
		Commissioning	Yes	NA	High
		Operation	Yes[10]	NA	High
Q7	Does marine mammal activity increase during night time?	Operation	No	NA	Low

2.3.2 Results

Between July 2009 and Feb 2010 225 targets were recorded on the active sonar. Of these 19 targets led to emergency shutdowns being initiated.

Active Sonar as the sole mitigation tool for protection of marine mammals

The active sonar continues to demonstrate that marine mammals (and other mobile targets e.g. debris and birds) can be detected in turbulent waters. Both marine mammals and 'other' targets move past the turbine in close proximity, however due to the current

[9] Section 7.1.3, SeaGen EMP, (version 4, Royal Haskoning (May 2008)
[10] During remote operation of the active sonar the turbine can be stopped rapidly by the Active Sonar Operator (ASO) in approximately 3 seconds.

requirement for precautionary turbine shutdowns it is not possible to determine how marine mammals would interact with the turbine during operation, although avoidance is expected.

Prior to removal of the pile-based MMO as mitigation, comparisons between MMO sightings and ASO targets were made and are shown in Figure 2.3. Both MMO and ASO records show clear peaks of activity around slack water, when the turbine is rapidly slowing.

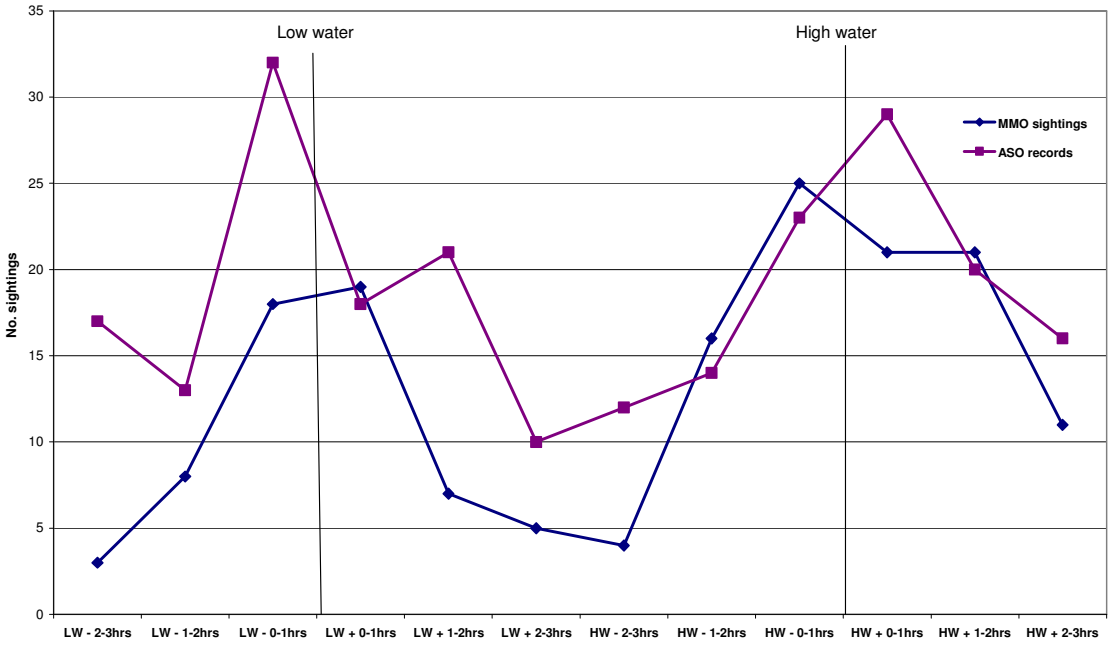

Figure 2.3 MMO sightings compared with active sonar targets between 08/07/08 and 21/08/09.

Extensive experience has now been gained in the use of active sonar. Key features, such as speed and nature of movement in relation to tidal direction, and these appear to provide an adequate basis for differentiating marine mammals from other targets.

Activity during SeaGen operation compared with non-operation

The tracks of all targets detected between July 2008 and July 2009 using the active sonar were plotted in X-Y coordinates in relation to the device to assess the underwater proximity of targets to the device. Results show that turbine activity (operational vs. non operational) did not significantly influence the track trajectories. However, it should be highlighted that sample sizes are relatively small and the method of analysis used here is relatively crude. Figure 2.4 shows the tracks from the upstream direction during flood and ebb tides.

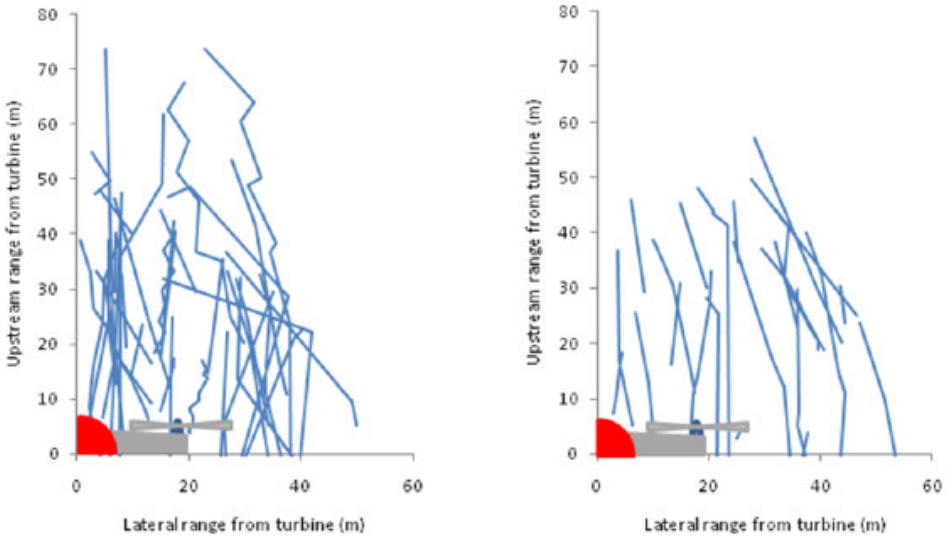

Figure 2.4 Tracks of confirmed marine mammals targets (before removal of pile-based MMO) upstream on the flood and ebb tide.

Night Time Active Sonar Operation

Between September and December 2009 116.1 hours of night time sonar data were collected when SeaGen was not in operation with a view to establishing the level of marine mammal activity in the vicinity of the device. The results, following analysis of the data, suggest that marine mammal activity was lower during night time however this contradicts the results of previous telemetry reporting which clearly showed increased activity during night time.

Analysis of the impact of season on the number of sonar targets suggest a higher number could be expected in the fourth quarter (October to December) and therefore seasonal differences are not expected to explain the difference between the telemetry and sonar night time results. However, the sonar is unable to accurately distinguish marine mammals from other targets such as birds and, as a result, patterns in marine mammal activity between night and day may be masked by other changes occurring between day and night, particularly the cessation of diving bird activity at night.

Active sonar continues to be a conservative form of mitigation and the use of active sonar during night time operation of SeaGen will continue to be effective throughout potential 24 hour operation.

2.3.3 Timescale

Active sonar operations will continue during all periods of SeaGen operation. Weekly reports will be produced outlining all targets which were potentially marine mammals, as well as listing all turbine shutdowns instigated by the Active Sonar Operator (ASO).

2.3.4 Expectations during the next reporting period

It is expected that SeaGen will begin 24/7 operation within the next reporting period.

Potential interaction with marine mammals will be mitigated by continuous active sonar observation throughout this period.

2.4 Marine Mammal Carcass Surveys

Roles and responsibilities[11]:
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 coastline[11] , 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.

2.4.1 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 mortalities occurred as a consequence of physical interaction with the SeaGen turbine?	Installation	NA	NA	NA
		Commissioning	No	N/A[12]	High
		Operation	No	N/A[12]	High

2.4.2 Results

QUB seal carcass surveys until the 5th March 2010 have found no carcasses.

No recent carcasses have been reported to NIEA. Previous post mortems have shown no link with the SeaGen turbine.

2.4.3 Timescale

QUB continues carrying out weekly carcass surveys and reports are produced as requested. A report would automatically be circulated following any carcass findings.

2.4.4 Expectations during the next reporting period

- NIEA will monitor and manage all stranding events. NIEA is responsible for responding to all reports of marine mammal strandings or carcasses and will collect, deliver carcasses for autopsy and maintain all records.

[11] Section 7.1.4, SeaGen EMP, Royal Haskoning (May 2008)
[12] No pre-installation surveys are available to provide a baseline for comparison with post-installation dataset.

- Post mortem continues to be carried out by a vet pathologist at Stormont.
- Weekly QUB carcass surveys will continue.

2.5 Passive Acoustic Monitoring (T-PODs)

Roles and responsibilities[13]
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 harbour porpoise activity (as a function of echolocation click events) in proximity to the SeaGen turbine.

2.5.1 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 Strangford Lough?	Installation	No	No[14]	Medium
		Commissioning	No	No[14]	Medium
		Operation	No	No[15]	Medium
Q10	Does the SeaGen turbine present a significant barrier effect to the free passage of harbour porpoises through the Strangford Narrows?	Installation	No	No	Medium
		Commissioning	No	No	Medium
		Operation	No	No[15]	Medium

2.5.2 Results

There are currently four T-PODs within the Narrows, and three T-PODs in the inner Lough.

Following analysis of T-POD data, no significant difference between porpoise detections during baseline and post-installation has been recorded in the inner Lough.

A decline in the overall detections within the narrows was recorded, and it is possible that this may indicate that the porpoise now pass through the narrows more quickly

[13] Section 7.1.3 SeaGen EMP (version 4, Royal Haskoning, May 2008)
[14] Average DPM per month showed no significant difference however DPM per day was significantly lower.
[15] Significant decreases in DPM were only recorded at the T-PODs which had been moved

and/or quietly. However, detailed analysis of each individual T-POD's data shows that only those on the east side of the narrows show a decline, with the site to the west remaining constant and the site to the north showing a significant increase in detections. The T-POD's to the east of the narrows were moved from their original position and this change in location is thought to be the cause of the decline in detections.

Despite the apparent changes in porpoise detection to the east of the narrows no significant difference between detections during SeaGen operation and non-operation has been observed within the Lough, indicating that SeaGen is not causing a barrier effect. This is supported by results from the T-POD stations to the north and south of the device which show no significant difference in detection rates.

Seasonal differences have remained similar throughout the 3 years studied. A lower level of detections per minute (DPM) have generally been recorded during May to July. This corresponds with the months which show peak births for harbour porpoise.

Operational data was only available from 8am to 6pm which is a period of naturally lower detections per minute and so comparisons between SeaGen operation and non-operation was based on data from within this time frame. Until SeaGen operates during the hours which have naturally higher DPM (22:00 to 01:00) SMRU Ltd remains unable to fully assess the potential for interaction.

2.5.3 Timescale and Deliverables

T-POD maintenance and data downloads will continue over the next 12 months and reporting on the results will be produced to feed into the biannual reports.

2.5.4 Expectations during the next reporting period

SeaGen is expected to begin 24/7 operations during the next reporting period, which will allow fuller assessment of potential displacement or barrier effects of the turbine on harbour porpoise.

2.6 Aerial Surveys

Roles and responsibilities[16]
Data collection: SMRU Ltd.
Analysis and reporting: SMRU Ltd.

Rationale
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.

[16] Section 7.1.6 SeaGen EMP (version 4, Royal Haskoning, May 2008)

2.6.1 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 significantly within the Strangford Lough SAC?	Installation	No	No	High
		Commissioning	No	No	Medium
		Operation	No	No	Medium
Q12	Has there been a significant change in the use of harbour seal haul out sites within the Strangford Lough SAC?	Installation	No	No	High
		Commissioning	No	No	High
		Operation	No	No	High

2.6.2 Results

It was not possible to undertake an August (moult) survey for harbour seals in 2009 due to equipment failure, a breeding season (July) survey was completed.

In Strangford Narrows the 2009 counts of harbour seals were similar to those recorded in 2006. However, 2008 showed higher numbers than other years for the narrows, in contrast to the wider survey area (Carlingford Lough to Belfast Lough) which showed an overall decline in seal numbers.

As in previous surveys, major concentrations were recorded in Strangford Lough and Strangford Narrows. In the month of July a slightly higher number of pups was recorded in 2009 within Strangford Narrows than was recorded in 2008 and in 2006.

Small numbers of grey seals were recorded in Strangford Narrows compared to harbour seals. In Strangford Narrows peak records were made in August 2007 and July 2009. However, numbers of grey seals on shore can vary widely from day to day during the summer months. Small numbers of grey seals breed within Strangford Lough with approximately 40 pups born annually (NIEA/NT data).

2.6.3 Timescale and Expectations during the next reporting period

Aerial surveys will be carried out during the 2010 breeding (July) and moult (August) seasons. Reporting will feed into the final 2010 biannual report.

2.7 Harbour Seal Telemetry

Roles and responsibilities[17] 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 post-installation phases of the SeaGen project.

2.7.1 Results

No additional tagging has occurred during this reporting period.

2.7.2 Timescale and Expectations during the next reporting period

A successful tagging deployment within Strangford Lough was carried out between 30th March and 9th April 2010. Reporting will feed into the final 2010 biannual report.

2.8 Noise impact on marine mammals of SeaGen during operation

During the 3rd and 4th November 2009 Kongsberg Maritime Limited measured the noise output from the SeaGen device at various fixed distances to the north and south of the turbine. Hydrophones were suspended from a boat to a depth of around 5m and the boat was allowed to drift with the current to minimise any noise caused by water moving over the hydrophones.

The noise produced by SeaGen when at a distance of 150m to the south and 311m to the north of the device was found to be at levels which will be perceived by common seals, grey seals and harbour porpoise to by similar to the noise emitted by the ferry when heard at 50m distance. At the mouth of Strangford Lough the movement of seabed substrata due to water turbulence produces greater noise than the turbine, which can be heard at 150m to the south and 311m to the north.

The noise levels discussed in the report are well below those which could cause hearing damage to a marine mammal following a single encounter. At 44m from the turbine strong avoidance reactions might be expected. However due to the existing high levels of noise in the Narrows caused by turbulence and the ferry, the effect of the turbine noise is likely to have little avoidance effect on the marine mammals.

[17] Section 7.1.7 SeaGen EMP (version 4, Royal Haskoning, May 2008)

3 BENTHIC ECOLOGY

3.1 Diver Surveys

Roles and responsibilities[18]
Survey coordination: QUB
Data collection and analysis: Irish Diving Contractors and Atlantic Marine Resources Ltd

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

3.1.1 Key Questions

	Key Question	**Phase**	**Answer**	**Significant change from baseline detected with current data?**	**Data confidence**
Q13	Is there a significant change in the broad benthic community structure that can be attributed to the turbine presence?	Installation	No	Yes[19]	High
		Commissioning	No	Yes[19]	High
		Operation	No	Yes[19]	High
Q14	Is there a significant change in abundance of dominant or characterising benthic species that can be attributed to the turbine presence?	Installation	No	Yes[19]	High
		Commissioning	No	Yes[19]	High
		Operation	No	Yes[19]	High

3.1.2 Results

Sampling times have been found to be the most significant factor regarding differences in benthic communities. Changes observed represent random spatial variation that encompasses disturbance, competition and succession. In general, all of the stations sampled have shifted in community structure in a manner that matches the reference station.

The objective of this monitoring program is to detect significant change that lies outside the range of natural variability of this habitat. It is clear that the monitoring is sufficient to detect change in these communities and that the changes observed appear to be gradual and in consistent with the reference station. There therefore appears to be no

[18] Section 7.4 SeaGen EMP (version 4, Royal Haskoning, May 2008)
[19] The statistically significant change indicated here is considered to be the result of natural variation, either through a seasonal cycle or as a consequence of a natural competition process between dominating species – see results section.

deleterious effect of the installation of SeaGen. The two years of sampling in 2008 and 2009 while the current turbine was operating at a very low level has provided a very robust baseline against which to assess future change once the turbine becomes fully operational.

3.1.3 Timescale and expectations during the next reporting period

No further data collection is currently planned. However, the Science Group will consider whether one further data set should be collected after a period of 24 hr operation, to be compared against 2008 / 2009 data.

4 ORNITHOLOGY

4.1 Shore based bird surveys

4.1.1 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 activities in the Strangford Narrows?	Installation	Unknown	Unknown	Unknown[20]
		Commissioning/ Operation	TBC	TBC	Unknown
Q16	Does SeaGen displace foraging diving birds from important areas within Strangford Narrows?	Installation	Unknown	Unknown	Unknown[20]
		Commissioning/ Operation	TBC	TBC	Unknown

4.1.2 Results

Records of position and activity of diving birds (in conjunction with marine mammal and basking shark surveys) have been collected each month since May 2005, although because survey methods were still being refined in 2005, data for that year have been omitted from analysis.

The University of Exeter (2010)[21] is undertaking analysis of the data detailed above, and this work is ongoing. Initial results indicate some minor statistically significant changes with regards to the distribution of certain species. However, there does not appear to be any biological significance to the changes observed.

SMRU Ltd is also currently carrying out further analysis of the data from May 2005 to October 2009 using a different approach to that deployed by Exeter University. Results will be available end of April 2010 allowing cross checking and comparison.

It is important to note that relatively few records used in either analysis came from the operational phase and so potential changes might not yet be fully apparent.

4.1.3 Expectations during next reporting period

Results from analysis of data will be available for reporting in the next biannual report.

Detailed ornithological data continue to be recorded within the standard shore-based surveys carried out by QUB[22].

[20] On review, current information / monitoring cannot answer this question. Specialist guidance is being sought through QUB.
[21] University of Exter (2010). The impacts of the SeaGen tidal turbine on the avian community of the Strangford Lough Narrows.
[22] Section 7.2 SeaGen EMP (version 4, Royal Haskoning, May 2008)

4.2 Acoustic Doppler Current Profiling (ADCP)

Roles and responsibilities[23]
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.

4.2.1 Key Questions

	Key Question	Phase	Answer	Significant change from baseline detected with current data?	Data confidence
Q15	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?	Installation	NA	NA	NA
		Commissioning	NA	NA	NA
		Operation	TBC	TBC	Unknown
Q16	If changes in the flow dynamics, scour patterns or turbulence do occur, have they caused a change in benthic community structure and function?	Installation	NA	NA	NA
		Commissioning	NA	NA	NA
		Operation	TBC	TBC	Unknown

4.2.2 Results

Results are awaited from post operation deployment and analysis data before and after deployment.

4.2.3 Timescale and expectations over the next reporting period

The remainder of the ADCP environmental monitoring work was scheduled to be completed during an 18 day period from 15th February 2010 in conjunction with two bottom-mounted ADCP's deployed upstream and downstream of the device. The two ADCP's were installed successfully on the 10/11th February.

The bottom mounted ADCP's were principally installed as part of the performance certification process of SeaGen (power versus water velocity curve) but importantly, were configured in such a way as to provide turbulence related characteristics as well.

Results should be available for inclusion in the next biannual report.

[23] Section 7.3 SeaGen EMP (version 4, Royal Haskoning, May 2008)

5 SUMMARY OF KEY QUESTIONS

Key Questions	Answer			Benthic ecology	ADCP	Seal telemetry	Aerial surveys	Passive acoustic	Carcass surveys	Active sonar	Pile based visual	Shore based visual
	Installation (February – July 2008)	Commissioning (July – September 2008)	Operation (October 08 – October 2010)									
Is marine mammal density and behaviour in Strangford Narrows significantly modified by the SeaGen turbine?	No	No	No			✓		✓				✓
Does the SeaGen turbine have a significant effect on harbour seal movements through the Strangford Narrows?	No	No	No [21]			✓						✓
Are harbour seals significantly excluded from foraging habitat or social areas within the Strangford Narrows as a result of the SeaGen turbine?	No	No	No [21]			✓	✓					✓
Does operation of the SeaGen turbine have a significant effect on marine mammal sightings within the immediate waters of the turbine?	N/A	No	No [21]									✓
Can the active sonar system detect marine mammals within 50m?	N/A	Yes	Yes							✓		
Can the turbine stop before the travel path of a detected marine mammal brings it into a zone of possible injury?	N/A	Yes	Yes							✓	✓	
Does marine mammal activity increase during night time?	N/A	N/A	Unsure[24]			✓		✓		✓		

[24] Results of the telemetry and passive acoustic monitoring indicate higher harbour seal and porpoise activity at night. Results of the active sonar indicate lower sighting rates of targets at night,

Key Questions	Answer			Benthic ecology	ADCP	Seal telemetry	Aerial surveys	Passive acoustic	Carcass surveys	Active sonar	Pile based visual	Shore based visual
	Installation (February – July 2008)	Commissioning (July – September 2008)	Operation (October 08 – October 2010)									
For all recorded stranding events, have any marine mammal mortalities occurred as a consequence of physical interaction with the SeaGen turbine?	N/A	No	No						✓			
Does the SeaGen turbine displace harbour porpoises from the Strangford Lough SAC?	No	No	No [21]					✓				✓
Does the SeaGen turbine present a significant barrier effect to the free passage of harbour porpoises through the Strangford Narrows?	No	No	No					✓				✓
Has the number of harbour seal adults and pups decreased significantly within the Strangford Lough SAC?	No	No	No				✓					
Has there been a significant change in the use of harbour seal haul out sites within the Strangford Lough SAC?	No	No	No				✓					
Does SeaGen present a barrier effect to the free passage of seals through the Strangford Narrows?	No	No	No			✓						✓
Does SeaGen have a significant effect on harbour seal movements through the	No	No	No			✓						✓

Key Questions	Answer			Benthic ecology	ADCP	Seal telemetry	Aerial surveys	Passive acoustic	Carcass surveys	Active sonar	Pile based visual	Shore based visual
	Installation (February – July 2008)	**Commissioning** (July – September 2008)	**Operation** (October 08 – October 2010)									
Strangford Narrows?												
Is there a significant change in the broad benthic community structure that can be attributed to the SeaGen turbine?	No	No	No	✓								
Is there a significant change in abundance of dominant or characterising benthic species that can be attributed to the SeaGen turbine?	No	No	No	✓								
Does the SeaGen turbine have a significant impact on seabird activities in the Strangford Narrows?	no impacts observed, statistical analysis ongoing	no impacts observed statistical analysis ongoing	no impacts observed statistical analysis ongoing									✓
Does SeaGen displace foraging diving birds from important areas within Strangford Narrows?	no impacts observed statistical analysis ongoing	no impacts observed statistical analysis ongoing	no impacts observed statistical analysis ongoing									✓
Has the SeaGen turbine significantly modified the flow dynamics, scour patterns or turbulence character of the Strangford Narrows?	N/A	N/A	No		✓							
If changes in the flow dynamics, scour patterns or turbulence do occur, have they caused a change in benthic community structure and function?	N/A	N/A	No[25]	✓	✓							

[25] Based on available data (awaiting ADCP results)

6 CONCLUSION

- The environmental monitoring programme implemented as a requirement of the SeaGen FEPA license has provided a robust methodology for monitoring and mitigating against the impacts of SeaGen on the environment of Strangford Lough.

- During the commissioning and operational phases, the opportunity to monitor the impact of the SeaGen turbine 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 must continue to meet on a regular basis to review the dataset and adapt the monitoring process as necessary.

- Further analysis of bird data is currently being undertaken, however, work to date suggests there have been changes to bird use of the narrows attributable to SeaGen, however, these are minor changes in distribution and are not of biological significance.