moray offshore renewables ltd

Developing Wind Energy In The Outer Moray Firth

Proposal:

Telemetry Study of Post-Smolt Emigration Behaviour

28/04/2015

edp renewables powered by nature

REPSOL

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Prepared by:	**Reviewed by:**	**Approved by:**	**Approved by (option):**
Dr Paula Low with comments from Brian Shaw (Spey Foundation), Martin Stemp (VS Aqua) and Donna-Claire Hunter (Marine Scotland)	Brian Shaw Donna-Claire Hunter Martin Stemp	Sarah Pirie	n/a

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1 The Proposal

MORL received Section 36 consents for the Telford, Stevenson and MacColl offshore wind farms in March 2014. Condition 30 of these consents reads as follows:

"*The Company must, to the satisfaction of the Scottish Ministers, participate in the monitoring requirements as laid out in the 'Scottish Atlantic Salmon, Sea Trout and European Eel Monitoring Strategy' so far as they apply at a local level (the Moray Firth). The extent and nature of the Company's participation is to be agreed by the Scottish Ministers in consultation with the MFRAG.*

Reason: To ensure effective monitoring of the effects on migratory fish at a local level (the Moray Firth)."

This document outlines MORL's proposal for a telemetry study of post-smolt emigration behaviour of salmon (*Salmo salar*) and sea trout (*Salmo trutta*), focussing on the direction of travel taken by smolts upon entry into the marine environment. The aim is to identify whether the post-smolts will travel along the coastline or swim directionally out to sea. In order to more fully understand any directional movements, the study will also look at the possibility of relationships with marine environmental parameters such as sea surface temperature, salinity and current speeds.

It is proposed that by undertaking this study, MORL will satisfy the above condition.

The study has been designed in collaboration with the Spey Foundation, Marine Scotland Science and with support from VS Aqua.

2 Technical Approach

Null hypothesis

H_0: Salmon and sea trout post-smolts show no common directional movement pattern as they exit into the marine environment from the River Spey.

Telemetry Equipment

For determining directional movements, smolts will be tagged using a VEMCO V7-69 kHz coded acoustic transmitter. The properties of this receiver are expected to be similar to the previous VR2W model receiver, which are as follows:

Property	Description
Dimensions	308mm x 73mm
Weight in air	1,190g
Power supply	1 x 3.6V lithium D cell battery
Battery life	c. 15 months
Receive frequency	69 kHz standard
Maximum depth	500m

Table 1: VR2W model receiver parameters

In accordance with Marine Scotland Science tagging protocols, the use of this transmitter will require that smolts to be tagged are a minimum size of 135mm.

VEMCO VR2AR receivers will be used to detect tagged smolts. Properties of this receiver are as follows:

Property	Description
Diameter	7mm
Weight in air	1.4-1.8g
Power output (dB)	136
Battery life (90 second delay)	200 days

Table 2: VEMCO VR2AR receiver parameters

Study Population

The salmon and sea trout population of the River Spey have been selected as the subjects of this study.

The Spey Foundation have studied the salmon population extensively. There is 40 years of data collection from the Spey Dam where 50,000 smolts have been caught using a fixed trap. Since 2005, 65,000 smolts have been caught using Rotary Screw Trap studies (see Table 3 below).

Location	Years of data collection
Lower Spey mainstem	2005 – 2008
River Tromie	2009-2013
River Truim	2010 – 2013
River Avon	2014
River Fiddich	2014

Table 3: River Spey Rotary Screw Trap Studies 2005-2014

The following table provides an overview of the percentage of the salmon smolts from tributary populations, expected to exceed the 135mm threshold for tagging.

Site	Maximum	Minimum	Mean	Number of Years of data collected
Spey mainstem	21%	11%	17%	4
Tromie	13%	5%	8%	5
Truim	5%	4%	4%	4

Table 4: Summary of River Spey salmon smolt populations expected to exceed 135mm

Sea trout are also known to use the River Spey and its tributaries for breeding. Therefore, the study will include the tagging of sea trout, in order to identify any potential differences in behaviour between the two species.

Study Design

The smolt capture and tagging programme is expected to be undertaken between April and July 2017, in order to ensure the study accounts for any yearly variation in the timing of the start of the smolt run. The exact start date will be agreed in collaboration with the Spey Foundation.

Smolts will be captured using a 6ft Rotary Screw Trap. Work identifying the exact location of the deployment of the trap will be identified by the Spey Foundation. It is currently anticipated that the trap will be located approximately 10km upstream from the river mouth.

Marine Scotland Science have advised that a maximum of 100 salmon smolts and 50 sea trout smolts should be tagged. The tagging work will be done by appropriately qualified and experienced Marine Scotland Science personnel, under the relevant Home Office licences and using the standard Marine Scotland Science protocols. It is anticipated that a recovery box will be used to monitor post-surgery survival before release.

One or two receivers will be deployed in the lower reaches of the river in order to monitor survival rates of tagged smolts. However, the main array of receivers will be located within the marine environment in proximity to the mouth of the River Spey. In order to minimise the risk that tagged smolts will be swept through the array by water flows, ABPmer are carrying out a desk study to assist with identifying the likely geographical points where smolt swimming behaviour will be the dominant force in determining smolt direction. The scope of work of this study is attached in Appendix A. This desk study will influence the provisional pattern for the receiver array, as described below. It is currently anticipated that this desk study will be supported using a drifter study led by the Scottish Association of Marine Science. The scope of work of this study is attached in Appendix B and is currently being reviewed by the project team. The results of the drifter study will inform the final choice for the receiver array.

It is highlighted that Marine Scotland Science are coordinating the National Salmon Strategy and have the remit of ensuring coordination of all ongoing salmon projects. Therefore, their advice on the final array pattern will also be critical for determining the final array configuration.

It is estimated that approximately 50-60 receivers will deployed in the main array. The timing of this work will be between February and March 2017 and is likely to be led by the Spey Foundation and another party, to be confirmed. There are two potential configurations for the receiver array, which are both described below.

- A VEMCO positioning system (VPS) array is illustrated in the figure below. This array pattern would be configured in a grid which allowed the triangulation of the position of tagged salmon as they moved through the array. An estimated calculation based on a VPS study area using 8 x 8 receivers (64 receivers) assuming 200m spacing would mean a VPS coverage area of c. 1400x1400m. The VPS array would be positioned directly outside the river mouth and would have the advantage of identifying any behaviour smolts show upon exit into the marine environment – e.g. acclimatisation behaviour. The other advantage of this array pattern is that there will be sufficient coverage to capture directional information should a receiver fail.

Figure 1: VEMCO positioning system (VPS) array configuration

- A double-arc formation is illustrated in the figure below. This array pattern would be configured in two double arcs, with the first arc potentially within 500m of the river mouth and the second arc at several kilometres from the river mouth. The exact distances would be determined based on the number of receivers obtained by the project and the final distances between each receiver when in the field. Initial spacing will be based on 200m between receivers, thus allowing redundancy should a receiver fail. The advantage of this array pattern is the ability to determine the location of tagged smolts at increasing distance from the river mouth, thus inferring the probable direction of travel in the very early stages of migration.

Figure 2: Double arc array configuration

For both array patterns, a short range testing study would be required to determine the final spacing of receivers and with respect to the VPS array, the final configuration of the array. This testing is expected to be carried out between December 2016 and March 2017.

Equipment to monitor relevant environmental parameters will also be deployed within the array. At least one current profiler will be used to monitor current speeds at appropriate depth(s) within the array. In addition, temperature and salinity tags will be attached to chosen receivers in the array.

It is anticipated that the receivers will be actively logging tag transmissions from April 2017 until at least 2 weeks after the final tags have been deployed. The retrieval date for receivers will be agreed with the project team, using local expertise and assessment of other similar studies. If possible, the receivers will be left *in situ* for the entire duration of the study to avoid any impacts on the geographical positioning of the array that could affect the results of the study. A check on the location of receivers may be undertaken during the first couple of weeks of the study.

Data Analysis

It is anticipated that Marine Scotland Science personnel will undertake the analysis of the data.

The data collected from the receivers will allow Geographical Information Systems mapping of individual smolts, providing visual representations of the movements through the array. If a VPS array is used, this will allow statistical analysis of pathway choice.

Dispersion modelling, utilising the Marine Scotland Oceanography Group Scottish Shelf model will be used to assess whether post-smolts show a preference for direction of travel when emerging into the marine environment and whether this is correlated to environmental variables.

3 Risks to Project Success

Risk	Mitigation
Number of smolts to be caught for tagging.	Rotary Screw Trap to be located where the number of smolts caught can be maximised.
Loss of tags/death of tagged fish.	Tag a sufficient number of smolts.
Tags not recorded going through array/data lost due to multiple tags transmitting at the same time to a single receiver.	Array needs to be have sufficient units but also spaced closely enough. This will be determined using an in-water pre-study. The study can be designed by using particular tag setting configurations to minimise the chance of overlapping transmissions being an issue.
There is a risk that local noise levels require a smaller distance between receivers than expected with consequences for data quality or budget.	Noise/receiver analysis prior to study commencement.
There is a risk of acoustic receivers being lost to due to a number of factors including problematic coastal conditions, storms, acoustic receiver failure or shipping.	Assessment of coastal hydrography to inform location and design of moorings. Use of proven landing systems. Timing of deployment. When choosing deployment locations, consider metocean locations, third party use (shipping / fishermen) and the potential for agreements with fishermen.
Restricting receivers to coast only will miss migration path taken.	Review once we know how many units – but we can suggest that the coastal path is the main hypothesis so we test this first and make assumptions about nil result.
No directional movement is recorded (i.e. all directions are found to have smolts).	The use of a VPS array will identify the track of tagged animals through the array. An alternative approach might be to add additional “curtains” or “gates” or receivers up or downstream of the VPS array, or at other important locations, to detect presence/absence of tagged fish if they pass through those gates. Tag sufficient number of smolts. Ensure units at sufficient distance from river mouth. Expectation modelling to determine probable direction.

BOWL offshore export cable is expected to be installed in 2017, which may cause disturbance to smolts from construction work, affecting their behaviour.	Discuss timings of work activities with BOWL.
Staff resources to manage and carry out the work are critical and any loss of key staff would cause project failure.	Personnel will be drawn from Spey Foundation, Marine Scotland Science and EDPR and/or a contractor working on behalf of EDPR.

4 Project Summary Timeline

	2015					2016					2017				
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Jan	Feb	Mar	Apr	May	Jun	Q3	Q4
Stage Gates															
MRFRAG approval	★														
Home Office licence		★													
Contract for Difference				★											
Key Project Tasks															
Hydrographic assessment	■														
Kick-off meeting			✦												
Drifter study					■										
Project finalisation						✦									
Licence applications						■									
Procurement						■	■								
Range testing trials							■	■	■						
Receiver array deployment									■	■					
Rotary Screw Trap deployment										■					
Smolt tagging											■	■	■		
Receiver retrieval														✦	
Data analysis														■	■

Appendix A: Hydrographic desk study scope of work

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Our ref: P.11754/155/DOL

Dr. Paula Low
Moray Offshore Renewables Limited
4th floor 40 Princes Street
Edinburgh
EH2 2BY

19 February 2015

Dear Paula

COASTAL PROCESSES REVIEW TO INFORM SPEY RIVER SALMON SMOLT MONITORING

Thank you for your recent enquiry, please find our proposal attached. We trust that this addresses your requirements.

If you have any questions or comments, please contact David Lambkin.

Yours sincerely
for ABP Marine Environmental Research Ltd

Stephen Hull
Technical Director

shull@abpmer.co.uk

Background

Moray Offshore Renewables Limited (MORL) is a wind farm developer with consent secured to develop a site in the outer Moray Firth, north-east Scotland. ABPmer has worked together with MORL to develop and deliver various background (baseline) and Environmental Impact Assessments (EIA) relating to marine physical processes that were used as evidence in securing the consent for this development.

To address a condition of the consent, MORL is planning a study of salmon smolt behaviour at the mouth of the Spey River, located on the central southern coast of the Moray Firth. Some details have been provided to ABPmer regarding the presently proposed design of the study. In summary:

- The study will aim to take place in the months March to June, 2016;
- Salmon smolts will be trapped in the Spey River, tagged with small acoustic tags, and then released back into the river;
- The movement of individual tagged smolts will be subsequently monitored by an array of around 50-60 acoustic transmitter/receivers, located relatively nearshore in an arc surrounding the mouth of the Spey River; and
- The measurements will aim to record smolt behaviour such as the duration of time spent in or near to the mouth of the river, and the direction and speed of travel of the smolts from the river into the marine environment.

The optimal positioning of the transmitter/receiver devices is the subject of ongoing discussion. It is considered at this time that the devices should be located a sufficient distance from the mouth of the river, that the speed of the river water plume is likely less than the swimming speed of the smolts, so that observations are most likely to reflect active (deliberate), rather than passive movement and behaviour. Patterns of local tidal currents and naturally present gradients in seawater temperature or salinity may also be relevant to this discussion and the final design of the device array.

Approach and Scope

An initial desk based review of the relevant physical processes will be undertaken to inform the discussion about the transmitter/receiver device array design. The review will provide summary details and estimates of key relevant physical fluvial and marine environmental features, namely:

- Typical discharge rates/velocities for the Spey River;
- Typical patterns of tidal behaviour in the Moray Firth at the mouth of the Spey River, including the range of water levels, current speeds, directions and relative duration and timing of flood and ebb periods;
- Patterns of morphology (and changes in morphology) in the mouth of the Spey River, which may affect the patterns of river discharge into the marine environment; and
- General or estimated patterns of temperature and salinity gradients in the local vicinity of the Spey River mouth and in the wider Moray Firth

Descriptions of tidal and river processes will utilise the body of knowledge and the numerical modelling results previously developed for MORL as part of the EIA and related studies. The review will also be

informed by a more site specific online literature search and ideally also with reference to suitable historical gauging data for the Spey River and/or tidal current observations, if and where available.

The assessment of river discharge plume dimensions and local patterns of temperature or salinity will be undertaken as a semi-quantitative desktop exercise for this desktop review. Patterns will be informed by general hydrodynamic literature and theory and the actual resulting dimensions will be estimated with reference to the typical Spey River discharge rates, local tidal behaviour and Spey River mouth morphology.

On the basis of the completed review, advice will also be developed as to whether more accurate information could be provided by further studies, e.g. additional local data collection, analyses or numerical modelling. It is understood that there is an opportunity for such data collection in the summer months this year, if needed.

The review will focus on the key physical parameters (listed above) as these appear to be most relevant to salmon smolt behaviour at the point that they transition from a fresh to a salt water environment. The review will not include significant detail or reference to previous studies of salmon smolt behaviour *per se,* beyond that which is considered necessary to inform the scope of the work.

Deliverables

The desktop review will be provided as a short technical note or report in ABPmer format, as a digital pdf document. One draft will be provided for comment prior to the final being issued.

Timescale and Cost

[Removed from this version].

Stephen Hull
19 February 2015

Appendix B: Drifter Study Scope of Work

Quotation for Drifter Deployment

For

EDP Renewables

March 2015

Commercial details redacted

SAMS Research Services Ltd., Malin House, European Marine Science Park, Oban, Argyll, PA37 1SZ

Phone: +44 1631 559000 **Email:** info@srsl.com **Web:** www.srsl.com

Quotation Title	Quotation to EDP Renewables for deployment and retrieval of drifters in the River Spey
Quotation Number	01603

Revision History

Revision	Changes	Date
A	Draft issue for internal review	24th March 2015
B	Draft re-issued after costs restructuring to include boat charter	26th March 2015
FINAL	Issued to EDP Renewables	27th March 2015
R1	Reissued with commercial details redacted	10th April 2015

	Name & Position	Signature	Date
Author	**Peter Taylor, Environmental Consultant**		24th March 2015
Checked	**Alan Stewart, Proposals Manager**		26th March 2015
Approved	**Alan Stewart, Proposals Manager**		26th March 2015

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1 PROJECT OUTLINE

1.1 Project Background

EDP Renewables approached SAMS Research Services Limited (SRSL) through one of its consultant scientists, Fraser MacDonald. SRSL was asked, in confidence, to provide a quotation for the characterisation of the dominant current direction, water mixing and oceanographic conditions at the mouth of the River Spey to improve EDP Renewables understanding of the prevailing conditions in that location. This understanding will aid the successful placement of a sensor array at the mouth of the River Spey in 2016 to allow the tracking of Atlantic salmon (*Salmo salar*) smolts as they migrate from the Spey into the North Sea.

1.2 Documents received from EDP Renewables

EDP Renewables provided SRSL with two files: a report authored by ABPmer, titled “P11754 Spey Salmon Coastal Processes (for comment)(2).docx” with the section “Timescale and Cost” redacted, and the power point presentation “Spey salmon study outline – confidential” indicating EDP Renewables motivations behind the requirements for this study. Both files were provided in confidence to SRSL and SAMS Group, of which SRSL is a member. All personnel involved in this project have agreed that any data gathered will be the property of EDP Renewables and will not be published as research in academic journals without the express permission of EDP Renewables.

2 INTRODUCTION TO SRSL

2.1 Summary of SRSL's service provision capability

Established in 2002, SRSL provides specialist marine consultancy and survey services under-pinned by cutting-edge science. SRSL's mission is to enable its clients to understand and mitigate the risks involved in industry interaction with the marine environment.

SRSL provide environmental consultancy services to clients in the Mining, Renewable Energy, Oil and Gas, Aquaculture and Nuclear sectors. SRSL has been contracted by several leading companies in the Renewable Energy industry to perform EIA's in various locations. In addition, we provide consultancy & research to many of the UK's key government agencies including Marine Scotland, SNH, SEPA, JNCC, Cefas and FSA.

Since 2009 SRSL has experienced significant growth by focussing on key market segments and investing in organisational development for client delivery and market expertise to ensure that clients receive a high quality service. All SRSL's projects are planned by a professional Programme Manager who oversees a team of dedicated Project Managers, each of whom are focussed specifically on client delivery. SRSL's Quality Management System is being continually developed by a dedicated Quality Manager. Accreditations have already been gained for service provisions in ISO: 17025, we are working towards ISO: 9001.

SRSL's Health & Safety policy ensures mandatory adoption of HSE procedures by all staff to ensure risk management procedures are observed. All of SRSL's work is fully assessed for safety in advance, with risk assessments and safe methods of work produced as necessary and briefed to project teams.

In addition to dedicated commercial project staff, SRSL has full access to a further 150 research staff within the SAMS group who can be contracted under dedicated service level agreements to ensure timely delivery. As part of the Marine Alliance for Science and Technology for Scotland (MASTS) community, our reach can be extended to further access another 500 researchers working across a diverse portfolio of relevant projects throughout Scotland.

SRSL is wholly owned by the SAMS Group. Founded in 1884, the Scottish Association for Marine Science (SAMS) is one of the oldest oceanographic institutes in the world and is committed to increasing the knowledge and stewardship of the marine environment through research, education, maintenance of research infrastructure and knowledge transfer. Research activities encompass the entire breadth of marine science and are often multidisciplinary in nature. Organised in four departments: Physics, Sea Ice and Technology; Biogeochemistry and Earth Sciences; Ecology and Microbial and Molecular Biology, SAMS' core strategic research programme is "Oceans 2025", in which it collaborates with six other UK marine science organisations.

3 PROJECT TEAM AND RELEVANT EXPERTISE

3.1 Project Team

SRSL's proposed project team comprises a multi-disciplinary group of scientists who will be led by Dr Andrew Dale

- Dr Andrew Dale (Oceanographer and mathematical modeller)
- Karen Wilson (Glider pilot and sensor technician)
- Bernard Hagan (Electronic Engineer)
- Dr Christopher Allen (Environmental Consultant and Project Manager)

Short Curricula Vitae of suggested team members outlining their experiences and their competences can be found in Appendix A.

Please note: *SRSL reserves the right to substitute any team member with suitably experienced equivalents at any time.*

3.2 Specific Experience relating to Renewable Energy and Salmon Development

- SRSL conducted a baseline study in Northern Ireland to determine the impact of a proposed offshore renewable energy development on Cetaceans and Basking Sharks
- SRSL deployed neutrally buoyant underwater drifters to detect the acoustic and electromagnetic signals generated by offshore energy developments off Orkney
- SRSL was commissioned to provide a detailed report identifying best practice in the design of offshore renewable infrastructure with regards the generation of electromagnetic and acoustic noise underwater
- SRSL and SAMS were key partners in a pan-European project, EquiMar, which had the aim of identifying key protocols for the Environmental Impact Assessment of marine energy converters
- SRSL delivered a detailed bathymetric map of a coastal area identified for potential offshore renewable development using multi-beam sonar
- SRSL provided an operational noise assessment for a tidal turbine on a pile-mounted test structure.
- SRSL provided encounter risk monitoring for an offshore renewables development in an area proven to be frequented by cetaceans and basking sharks, contributing to the EIA for the development and aiding collision mitigation
- A report was written for a large Aquaculturist examining the potential ecological impacts of a fish farm, proposed for development in a sensitive area and identified as requiring specialist components to the Environmental Impact Assessment.
- SRSL undertook a two year project examining the interaction of fish, birds and marine mammals with an offshore renewables development and the underwater noise generated by the development. We were regularly requested by the client to represent them at regulatory meetings and during public consultations.
- SRSL undertook a study of benthic and demersal ecology prior to a wind-farm development off Islay, the study involved benthic ecologists, geologists, biogeochemists and fisheries ecologists as well as oceanographic expertise

Some highlights from our relevant experience can be found in Appendix B.

4 PROJECT PLAN AND PRICE QUOTATION

4.1 Project Plan

SRSL will undertake a survey of the prevailing oceanographic conditions at the mouth of the River Spey by releasing drifters into the water approximately 200m upstream from the river mouth. The drifters are only slightly buoyant and will drift down the river and into the Moray Firth with minimal influence from the wind. They will record their position using a GPS tracker throughout the experiment and will also record water temperature as they drift to a position not less than 500m from the mouth of the Spey. They will then be retrieved and the data stored will be downloaded.

The release experiment will be conducted using 5 separate drifters, released at different points in the river to ensure that representative data is collected during the experiment. The release experiment will be conducted a minimum of 4 times, at different tidal states and covering a complete tidal cycle over 12 hours, to build a representative understanding of the prevailing conditions at the river mouth.

Each drifter will be approximately 70cm in length and will sit vertically in the water with only ~10cm above the water surface. Fins on the bottom of the drifter will ensure that they drift in the prevailing currents, collecting position data as they move. In addition to location data, the drifters will collect temperature data. However, this will be collected at one depth point only for each drifter, limiting the inferences that can be made about conditions in the deeper water. Therefore, at each drifter release time additional data will be collected.

A sensor measuring conductivity, temperature and density (a “Castaway” CTD) will be hand-lowered into the water, to record salinity and temperature against water depth in a vertical profile of the water and will then be pulled out by hand. Each point will be located using GPS and a transect of CTD casts will be conducted from the river into the Moray Firth, directly out from the coastline. Depending on the results of this transect, a second transect may be conducted perpendicular to the river mouth, in parallel with the shore (although this will have to be wave and weather dependant). This data will aid the interpretation of the salinity and temperature data recorded by the drifters as they move from the river mouth.

The data captured will be collated and a report of SRSL’s findings will be presented to EDP Renewables as quickly as possible after the data collection phase, with the aim of submitting the report within 4 weeks of data collection.

4.2 Price Quotation

Section deleted from this version at request of Paula Low, EDP Renewables.

4.3 Recommendations

SRSL understands that the scope for this project is constrained by available budget and has tailored the experiment accordingly. It should be noted, however, that the project described in section 4.1 provides a snapshot, at a pre-agreed date, of the water mixing and current directions around the mouth of the River Spey. Although this will provide accurate data for varying tidal conditions on the day, it will not necessarily provide representative data for differing flow rates from the river, which can vary widely. It is recommended that a further study is undertaken in conditions different to those which prevail during the first study. Subject to agreement with EDP Renewables, SRSL can quote for such additional work, which will provide a greater insight to the prevailing conditions at the mouth of the Spey across different tidal and river discharge rates.

The SRSL drifters cannot currently record salinity as they drift out of the Spey and into the Moray Firth. They could be adapted to include salinity recording, but to do so would mean that the data collection phase would be delayed until Autumn, rather than during late April, early May as requested by EDP Renewables. If salinity tracking is needed, EDP Renewables should advise at the earliest opportunity. This would involve additional cost to SRSL for equipment purchase and modification.

5 APPENDIX A – CURRICULA VITAE

Andrew Dale

Consultant in Numerical Modelling

Andrew.Dale@sams.ac.uk

Dr Andrew Dale is a physical oceanographer with expertise in combining observational and modelling approaches to MetOcean hydrodynamics. He specialises in tidal currents and deep-ocean mixing, working up from relatively small scales to characterise how physical processes (internal waves, gravity currents, eddies and turbulence) affect larger scale environments as diverse as the deep ocean and the coastal waters of western Scotland.

EXPERTISE

Physical oceanography.

Theory and models, with an emphasis on processes at regional and coastal scales, especially in the context of Western Scotland.

Mechanisms and implications of horizontal dispersion and its impact on biological systems.

Internal waves and tides.

QUALIFICATIONS

1996 PhD Oceanography, University of Wales, UK.

1990 BSc Mathematics (First Class), University of Durham, UK.

EMPLOYMENT HISTORY

2006-	**Lecturer In Marine Modelling**, The Scottish Association For Marine Science, Oban
1990	**Graduate Research Assistant**, Unit For Coastal And Estuarine Studies, School Of Ocean Sciences, University Of Wales, Bangor,
2006 (Jun-)	**Data Scientist** (Short-Term), British Oceanographic Data Centre, Liverpool.
2000-2005	**Research Associate**, College Of Oceanic And Atmospheric Sciences, Oregon State University, USA.
1997-2000	**Research Associate** (Postdoctoral), College Of Oceanic And Atmospheric Sciences, Oregon State University, USA.

SELECTED PROJECT EXPERIENCE

MIDAS: Managing Impacts of Deep-Sea Resource Exploitation (EC FP7, 2013-2016).

GREAT RACE: Survey of the Gulf of Corryvreckan using Autonomous Underwater Vehicle and arrays of satellite-tracked drifters to characterise eddies, turbulence and mixing (2010-2013), partners with Marine Scotland (NERC-funded).

ASIMUTH: Applied Simulations and Integrated Modelling for the Understanding of Toxic Algal Blooms (EC FP7, 2010-2013).

ECOMAR: Ecosystem of the Mid-Atlantic Ridge at the sub-polar front and Charlie-Gibbs Fracture Zone (NERC-funded).

SELECTED PUBLICATIONS

Dale, A. C., & Inall, M. E., 2015. Tidal mixing processes amid small-scale, deep-ocean topography. Geophysical Research Letters. DOI: 10.1002/2014GL062755.

Turnewitsch, R, Falahat, S, Nycaner, J, Dale, A, Scott, R, Furnival, D, 2013. Deep-sea fluid and sediment dynamics—Influence of hill-to seamount-scale seafloor topography. Earth-Science Reviews 127:203-241.

Abell R.E., Brand, T., Dale, A.C., Tilstone, G.H., Beveridge, C., 2013. Variability of particulate flux over the Mid-Atlantic Ridge. Deep- Sea Research II: Topical Studies in Oceanography. 98:257-268.

Dale AC, Boulcott P and Sherwin TJ. 2011 Sedimentation patterns caused by scallop dredging in a physically dynamic environment. Marine Pollution Bulletin 62(11):2433-2441

Read J, Pollard R, Miller P and Dale AC. 2010 Circulation and variability of the North Atlantic Current in the vicinity of the Mid-Atlantic Ridge. Deep-sea Research Part I-oceanographic Research Papers 57-3:307-318

Dale AC, Barth JA, Levine MD and Austin JA. 2008 Observations of mixed layer restratification by onshore surface transport following wind reversal in a coastal upwelling region. Journal Of Geophysical Research Vol. 113:C01010

Dale AC, Levine MD, Barth JA and Austin JA. 2006 A dye tracer reveals cross-shelf dispersion and interleaving on the Oregon shelf. Geophysical Research Letters 33(3):L03604

Karen Wilson

AUV Techincian

karen.wilson@sams.ac.uk

EXPERTISE

UUV Operations.

Oceanographic instrumentation maintenance and deployment.

Participation in expeditions.

QUALIFICATIONS

BSc (Hons.) Marine Science with Arctic Studies.

Miss Karen Wilson is a graduate of the University of the Highlands and Islands and has worked as an aircraft engineer, with specific expertise on electronic systems, testing and fault diagnostics, both for the Royal Navy and the private sectors.

She has used this knowledge of electronic systems to work as an electronics assistant in delivery of SIMBA units for SRSL and has also crewed the SRSL Research Vessel, Calanus.

After graduating, Karen became a member of the Scottish Marine Robotics Facility and the North Atlantic Glider base, working with, performing maintenance upon and programming Autonomous Underwater Vehicles (AUVs) and Gliders, as well as piloting gliders on deployments of several months in duration.

EMPLOYMENT HISTORY

2014-present	Autonomous Underwater Vehicle Technician, SAMS
2010-2014	Undergraduate Student. SAMS.
1998-2010	Aircraft Engineer. Royal Navy, Vector Aerospace.

RESEARCH PROJECT INVOLVEMENT

Extended Ellett Line Cruise, from Iceland to the North East Atlantic collecting a time series of oceanographic data
Fisheries support research cruise in the Arctic in 2013
FASTNEt - Fluxes Across Sloping Topography of the North East Atlantic
OSNAP – Overtiurning in the Subpolar North Atlantic Program
NACLIM – Assessment of Decadal Climate Forecasts.

Bernard Hagan

Electronics Engineer

Bernard.Hagan@sams.ac.uk

EXPERTISE

Design and construction of bespoke circuit boards

Design and construction of acoustic sensors for various applications

Maintenance and construction of SRSL's fleet of oceanographic sensors, AUVs and Gliders.

QUALIFICATIONS

Time-served apprenticeship in Electronics Engineering, GEC Telecommunications

Bernard is an Electronics Engineer with a wide background in development and maintenance of electronic sensors, batteries, design verification of control systems and the design and manufacture of bespoke circuit boards. His career has spanned with the Ministry of Defence, bespoke systems design for individual clients, sub-sea electronics for the oil and gas industry and sensor development for acoustics systems.

At SRSL he works as part of a dedicated team to design, build and develop bespoke marine sensing tools and provide maintenance on existing systems throughout the range of sensors capability available to clients.

SELECTED EMPLOYMENT HISTORY

- 2009-Present Electronics Engineer, SAMS Group
- 2004-2009 Senior Hardware Engineer, Qinetiq
- 2000-2004 Principle Engineer, Raytheon Systems
- 1997-1998 Electronics Design Engineer, Sunvic Controls
- 1995-1996 Technical Director, BH Systems
- 1981-1994 Technical Design Engineer, Wood Group, MoD & others
- 1975-1981 Electronics Engineer Apprenticeship, GEC Telecommunications

Christopher Allen

Environmental Consultant and Project Manager

Dr Christopher Allen is a marine ecologist with a broad background in oceanography. Prior to his appointment with SRSL, Christopher worked as a Senior Marine Biologist undertaking environmental surveys of the marine environment for a wide variety of industries, including governmental organisations. He has particular expertise in planning and conducting marine environmental surveys, data interpretation and report writing and marine mammal observations.

EXPERTISE

Marine Environmental Surveys

Data interpretation and report writing

Morphological taxonomy

Marine mammal observations

Molecular biology and phylogenetics

Population genetics

QUALIFICATIONS

First class Masters of Oceanography

PhD- 'The ecology of the intertidal crab Dotilla Intermedia' Southampton University

SELECTED PROJECT EXPERIENCE

- Mapping priority marine features within the Clyde Sea area using environmental data from a range of different methods, Scottish Natural Heritage.
- Baseline surveys for various offshore renewable energy projects including offshore wind farm sites in the Irish Sea, and tidal turbine projects off Alderney.
- Designing scientific diving survey methods for environmental monitoring and baseline surveys in the Isles of Scilly and Falmouth SAC, Natural England.
- Environmental monitoring, and data analysis of marine aggregate dredging areas on behalf of MarineSpace Ltd
- Various aspects of the MCZ scheme, including offshore and deep water sites, on behalf of CEFAS and JNCC.

NOTABLE EXPERIENCE

- Senior Marine Biologist, Seastar Survey Ltd., responsible for management, assessment and training of junior staff members. Project Management, client liaison and preparing tender bids.
- Species page author, Encyclopaedia of Life, for the Census of Marine life (ChEss) project. Compiling descriptions of marine organisms from deep sea chemosynthetic environments.
- Sampling programme member and teaching packs developer, EU Tsunami Impacts (TILS) project, in the Laem Son area of Thailand.

SELECTED PUBLICATIONS AND REPORTS

- **Allen CJ**, Clark PF, Paterson GLJ, Hawkins LE, Aryuthaka C (2011). A new record of *Dotilla intermedia* De Man 1888 (Brachyura: Ocypodidae) from Thailand. *Marine Biodiversity Records* 4 e11.
- **Allen CJ**, Paterson GLJ, Hawkins LE, Hauton C, Clark PF, Aryuthaka C (2010) Zonation on tropical sandy beaches: a case study using *Dotilla intermedia*. *Marine Ecology Progress Series* 408: 97 – 107
- **Allen, C.**, Axelsson, M. & Dewey, S. (2014). Community analysis of benthic grab and video data from offshore MCZs. *A report to JNCC by Seastar Survey Ltd.,* 170 pages.
- **Allen, C.**, Axelsson, M. & Dewey, S. (2014). Analysis of a subset of video and still data from deep-water surveys. *A report to JNCC by Seastar Survey Ltd.,* 50 pages.
- **Allen, C**., Axelsson, M., Doran, J., & Dewey, S. (2014). Survey of marine features within the Luce Bay and Sands Special Area of Conservation (SAC). *Scottish Natural Heritage Commissioned Report Number. No. 738.*
- **Allen, C.**, Axelsson, M. & Dewey S. (2013). JNCC Marine Survey Scotia 1013S Pobie Bank Reef cSAC Benthic Sample Analysis. *A report to JNCC by Seastar Survey Ltd.,* 110 pages.
- **Allen, C**., Axelsson, M. & Dewey S. (2013). Areas 396 and 435: Benthic Monitoring Survey 2013. *A report to MarineSpace Ltd. by Seastar Survey Ltd.,* 239 pages

6 APPENDIX B – RELEVANT EXPERIENCE

SRSL
Specialist marine consultancy and survey services

Customer Case Study

SRSL Undertake Environmental Assessments for West Islay Tidal Energy Farm

Project Summary

Customer: DP Marine Energy Ltd

Industry: Renewable Energy

Location: Scotland, UK

Objective:
Bird and Marine Mammal Surveys (2 years of observations), Underwater Noise Measurements and Fish Studies (including fisheries liaison) Environmental Statement chapters (Mammals and Fish).

Outcome:
SRSL successfully completed the contract. Responsibilities were extended to include client representation and regulatory liaison activities. SRSL successfully authored the relevant ES chapters on time and budget for the submission of the full ES to Marine Scotland.

Fish, Bird and Marine Mammal Surveys, Underwater Noise and Environmental Statement, West Islay Tidal Energy Farm, DP Marine Energy Ltd (DPME), 2011-13

Renewable energy developer DPME and partner DEME Blue Energy Ltd, propose to develop a phased 400MW tidal stream project off the island of Islay on the South West Coast of Scotland. DPME has so far been awarded an agreement for a Commercial Lease of 30MW by The Crown Estate. The EIA has been submitted to Marine Scotland.

To this end SRSL have successfully concluded a 2-year baseline survey campaign for marine birds and mammals and have recently completed underwater noise surveys at the site. The SRSL project team are assessing potential impacts on marine mammals by combining information on the characteristics of the underwater environment, with the noise output of the proposed devices and the risk of animals encountering a turbine. SRSL are also conducting commercial and natural fish baseline studies and fisheries liaison activities.

Lucy Greenhill, Renewable Energy Services Manager at SRSL, comments: "This project is testament to the experience and ability of the SRSL survey personnel to operate in challenging metocean environments. Our unique location combined with careful project management allowed our team to maximise the use of available weather windows, ensuring that we achieved a robust baseline for our client, DP Energy".

> *"SRSL is a key consultant to the West Islay Tidal Energy Project, developing scientifically defensible methodologies for assessing environmental impacts* - ***Clodagh McGrath, DP Energy Ireland Ltd***"

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Customer Case Study

Baseline Surveys and Specialist Advice on Seals, Basking Sharks and Cetaceans, Marine Harvest (Scotland) Ltd, 2013

Project Summary

Customer: Marine Harvest

Industry: Aquaculture

Location: Scotland, UK

Objective:
To provide Specialist Advice on Seals, Basking Sharks and Cetaceans to support consent application for a new fish farm development.

Outcome:
SRSL carried out desktop studies and field surveys to assess the nature of any 'significant' impacts and advised Marine Harvest on best-practice methodologies and mitigation approaches to support their application.

In 2013, Marine Harvest Scotland Ltd announced a plan to invest around £80 million by 2016 in the growth of their business, in an effort to meet growing global demand for farmed salmon, and create more sustainable jobs in rural communities. As part of this strategy, a licence application was proposed for a new fish farm development off the west coast of Scotland. Marine Harvest was thus required to consider the potential ecological impacts of the proposed fish farm. SRSL was subsequently contracted to undertake a specialist assessment of the potential impact of the development on large macrofauna including cetaceans, basking sharks and seals, to support the planning application. The assessment addressed the statutory requirements of the planning process with regard to impacts on sharks and marine mammals, addressing the issues raised by regulators during scoping.

SRSL presented the occurrence of species in the area, using the most recent information available, in order to predict what effects the development might have. SRSL's strong research base enabled mitigation options to be discussed in detail to ensure the best possible outcome for all parties. Examples of impacts that were assessed include injury and disturbance due to noise and presence of vessels and activities, displacement leading to habitat exclusion and barrier effects, collision risk with maintenance vessels, acoustic impacts from acoustic deterrent devices (ADDs) and potential cumulative impacts. Mitigation measures were presented to form the basis of a best practice approach to be adopted by Marine Harvest.

> *"Marine Harvest (Scotland) Ltd is extremely satisfied with the service provided by SRSL; this professional and competent team with strong links to aquaculture has the flexibility to meet the needs of a developing industry* ***– Peter MacDougall, Marine Harvest***

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Customer Case Study

First encounter-risk model to be submitted as part of an EIA in Scotland; produced by SRSL

Project Summary

Customer: MeyGen Ltd

Industry: Renewable Energy

Location: Scotland, UK

Objective:
SRSL were commissioned to develop and deliver an encounter-risk model for the MeyGen tidal stream project. The model would run baseline data provided by other consultants and would address issues relating to collision risks associated with the proposed tidal development.

Outcome:
Assessment of environmental impacts on marine mammals is a contentious area for any tidal energy development. Encounter-risk modelling (ERM) from SRSL has successfully broken new ground and was well received by MeyGen. The modelling was included in the Phase 1 EIA submitted in 2012.

SRSL design and implement marine mammal encounter-risk modelling for the MeyGen tidal stream project's Environmental Impact Assessment.

Marine mammals are more reliant on sound than on visual cues for responding to the presence of marine renewable devices. The balance between avoidance and evasion responses to devices will depend on the distances from which the animals will be able to perceive the devices, and their subsequent behavioural reactions. Marine renewable devices therefore have a potential range of ecological implications. They extend from no impacts, to the potential removal or injury of individuals and if rates are sufficiently high, to declines in populations. If avoidance responses occur then habitat exclusion is possible while if structures provide foraging opportunities then positive exploitation may occur. If there are significant collision concerns then methods of mitigation are desirable.

The SRSL encounter-risk model was the developed in discussion with Marine Scotland and was run and modified a number of times in the light of changes to parameters by the client. Findings were discussed in a technical report and later included in the Phase 1 EIA submitted in 2012.

> *"MeyGen Ltd. is extremely pleased with the support and unique services SRSL provided for the MeyGen Tidal Energy Project marine mammal encounter risk modelling. SRSL continue to show their dedication to the project following the consent application"*
> ***– Ed Rollings, MeyGen Ltd***

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Customer Case Study

Benthic environmental surveys and fish population studies for Islay Offshore Wind Farm Wind Farm Site

Project Summary

Customer: Scottish and Southern Energy Renewables

Industry: Renewable Energy

Location: Scotland, UK

Objective:
SRSL were commissioned to develop and deliver fish population studies and benthic surveys at the Islay wind farm site

Outcome:
Assessment of environmental impacts on fish and fisheries is a contentious area for any offshore renewables energy development. Baseline surveys from SRSL were well received by SSER on time and budget despite challenging conditions.

Contracted by Scottish and Southern Energy Renewables (SSER), SRSL, has successfully completed the management and delivery of baseline benthic surveys and fish population studies and at the Islay wind farm site.

SSER was granted exclusivity by the Crown Estate in 2009 to develop a 690MW offshore wind farm 13km off the west coast of Islay. The acquisition of site-specific environmental data is fundamental to SSER's Environmental Impact Assessment for the proposed development. SRSL were commissioned to carry out natural and commercial fish population studies, in addition to a sampling campaign for sediment and marine organisms living on the seafloor.

To date, SRSL has delivered consultancy services and field surveys for 8 renewable energy developments in Scotland, and has recently completed a 2-year marine mammal survey campaign for DP Marine Energy Ltd at their proposed tidal energy farm, also situated off Islay.

Lucy Greenhill, EIA & Consenting Manager at SRSL, comments: "We are delighted to have successfully completed these environmental surveys off the west coast of Islay. This is testament to the experience and ability of the SRSL survey personnel to operate in challenging metocean environments. Our unique location combined with careful project management allowed our team to maximise the use of available weather windows, ensuring that we achieved a robust and defensible baseline for our client, SSER".

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