Spiorad na Mara Offshore Wind Farm

Offshore Project

Environmental Impact Assessment Report

Appendix 12.2: Consultation on Atlantic salmon underwater noise assessment and associated data analysis, Volume 2c

Document Reference No.: SNM-SNM-PAC-APP-1122

Date: February 2026

Quality Control Page

Document details	
Document title	Offshore Project Environmental Impact Assessment Report
Document subtitle	Appendix 12.2: Consultation on Atlantic salmon underwater noise assessment and associated data analysis
Document Reference No.	SNM-SNM-PAC-APP-1122
Date	February 2026
Version	1.0
Author	WSP
Client Name	Spiorad na Mara Limited Ltd

Document history						
Version	Revision	Issued	Checked	Approved	Date	Comments
1.0	A	WSP	WSP	SnM Ltd	February 2026	Final for submission

Contents

List of Tables

List of Plates

1 INTRODUCTION

1.1 OVERVIEW

1.1.1.1 This appendix of the Environmental Impact Assessment Report (EIAR) presents the evidence base and technical analyses that inform the assessment of potential underwater noise impacts on Atlantic salmon for the Spiorad na Mara Offshore Wind Farm (hereafter referred to as the 'Offshore Project'). In addition to documenting the consultation undertaken with MD-LOT, NatureScot and MD-SEDD, the appendix brings together the key baseline inputs requested and refined through that engagement, this includes the rod-catch and stock-assessment analyses, and the smolt swim-speed evidence review. These datasets and interpretations form part of the wider fish ecology baseline that supports **Chapter 12: Fish Ecology, Volume 2a** of the EIAR and underpin the modelling assumptions, assessment parameters and mitigation measures developed for Atlantic salmon. This appendix accompanies **Chapter 12, Volume 2a** of the EIAR.

1.1.1.2 This appendix should be read in conjunction with the project description provided in **Chapter 3: Project Description, Volume 1a** and the relevant parts of the following chapters and appendices:

- **Chapter 12, Volume 2a;**
- **Appendix 12.1: Fish Ecology Baseline, Volume 2c;**
- **Appendix 12.3: Overview of Percussive Piling Fish Ecology Mitigation, Volume 2c.**

1.1.2 PROJECT BACKGROUND

1.1.2.1 Spiorad na Mara Limited (hereafter referred to as 'the Applicant') is proposing to develop the Project. The Project is an offshore wind farm (OWF) that will consist of up to 60 fixed-bottom wind turbine generators (WTGs).

1.1.2.2 The Project will include both offshore and onshore infrastructure. This Offshore EIAR supports the application for the offshore components of the Project as outlined in **Chapter 1: Introduction, Volume 1a**. The offshore components of the Project (the Offshore Project) includes all infrastructure and activities located seaward of Mean High Water Springs (MHWS) within the Array Area and Offshore Cable Area of Search (OCAS) (**Figure 1.2: Offshore Project Location, Volume 1b**). Further detailed information is provided in **Chapter 3, Volume 1a**.

1.1.2.3 The Offshore Project is situated off the northwest coast of Isle of Lewis/*Eilean Leòdhais* and the Array Area is located approximately 5-13 km offshore and is approximately 161 km^2 in size. It will comprise WTGs, foundations, Offshore Cables, Offshore Substation Platform (OSP) (if required), and Landfall. The Array Area combined with the OCAS is defined as the Offshore Project Boundary. The water depths across the Turbine Area range from 37 m-67 m with the southwest corner of the

Array Area reaching 72 m. The proposed WTGs and fixed foundations will be located within a Turbine Area of approximately 140 km^2, within the Array Area.

1.2 PURPOSE OF THIS APPENDIX

1.2.1.1 Atlantic salmon *Salmo salar* were identified as a key receptor for assessment in relation to potential underwater noise impacts during construction. Given the location of the Offshore Project, adult and juvenile Atlantic salmon are expected to migrate in proximity to the development during downstream migrations (adult and juveniles) and upstream (return) migrations to natal rivers (adults only). In addition, 2 European Sites designated for Atlantic salmon, North Harris Special Area of Conservation (SAC) and Langavat SAC, were identified as requiring consideration within the Report to Inform Appropriate Assessment (RIAA). Further baseline information on the presence and distribution of Atlantic salmon across the Offshore Project area is provided in Section 4.4 of **Appendix 12.1, Volume 2c**.

1.2.1.2 Consultation was therefore required with statutory consultees to agree the approach for the assessment of impacts on Atlantic salmon. This appendix documents the consultation undertaken in relation to Atlantic salmon and underwater noise (Section 2), and presents the additional analyses that were requested, developed, or refined as part of that process (Section 3 and 4). This appendix includes the following technical outputs, which were either recommended by consultees or developed collaboratively through consultation:

- Salmon rod catch data and stock baseline review used to inform the impact assessment (Section 3);
- Smolt swim speed literature review (Section 4).

1.2.1.3 The Appendix is supported by the following annexes:

- **Annex 12.2.1: Slide deck: underwater noise assessment on Atlantic salmon (25/07/2025);**
- **Annex 12.2.2: Underwater noise salmon impact assessment meeting (10/10/2025);**
- **Annex 12.2.3: Median numbers of fish in rivers in the Loch Roag salmon fishery district area based on stock assessment.**

2 CONSULTATION

2.1.1.1 A number of consultation meetings were undertaken with Marine Directorate – Licensing Operations Team (MD-LOT), NatureScot, and Marine Directorate - Science, Evidence, Digital and Data (MD-SEDD) regarding the assessment of underwater noise (UWN) impacts on Atlantic salmon.

2.1.1.2 2 key meetings were held, and are summarised below.

2.2 ATLANTIC SALMON MEETING (25/07/2025)

2.2.1.1 The purpose of this meeting was to support engagement with NatureScot and MD-SEDD regarding the assessment of potential underwater noise impacts on Atlantic salmon and to seek their advice and confirmation on key aspects of the evidence base and assessment approach. The objectives of the consultation were to:

- Discuss Atlantic salmon ecology, migration behaviour, and the baseline information required to inform the assessment;
- Agree the approach to the EIAR for underwater noise impacts on Atlantic salmon;
- Confirm the approach to the RIAA, including the treatment of connectivity between the Offshore Project and SACs designated for Atlantic salmon.

2.3 UNDERWATER NOISE SALMON IMPACT ASSESSMENT MEETING (10/10/2025)

2.3.1.1 The purpose of this meeting was to provide NatureScot and MD-SEDD with an update on the assessment of underwater noise impacts on Atlantic salmon following the July meeting and the feedback received. The engagement focused on presenting updated baseline information, confirming modelling parameters, and discussing preliminary assessment outputs to ensure continued alignment with regulatory expectations. The specific objectives were to:

- Provide an update on adult Atlantic salmon baseline information derived from the rod-catch and stock assessment analysis;
- Present the underwater noise modelling parameters applied and the updated model outputs;
- Outline the preliminary EIAR findings for impacts on Atlantic salmon;
- Discuss measures proposed to minimise potential effects.

2.3.1.2 Slide decks and meeting minutes from these meetings are provided in full in **Annex 12.2.1**, along with earlier versions of the information later presented in Section 3 (Salmon Rod Catch and Stock Assessment) and the information presented in Section 4 (Smolt Swim Speed Review). These documents were shared with stakeholders during the meetings and submitted for comment.

2.3.1.3 Several requests for agreement and input from MD-LOT, NatureScot, and MD-SEDD were made during these presentations. Key discussion points, comments received, and how these have been addressed are summarised in **Table 2-1**. This table also includes ongoing feedback on the documents provided as part of the consultation meetings.

Table 2-1 Applicant's assessment queries and stakeholder responses received through consultation meetings

Request	Comment	Response/where this is addressed
Atlantic salmon meeting 25/07/2025		
The Applicant sought confirmation that the key migration windows for Atlantic salmon are as follows: **Smolts**: April-May (2-week window) **Adults**: May-August (peak June-July) **Kelts**: October-May	MD-SEDD advise that Malcolm *et al.* (2015) should be consulted to determine the sensitive window when large numbers of smolts are likely to be in the coastal zone. MD-SEDD also advise that local information on smolt movements should be considered. MD-SEDD advise that the migration of all life stages of Atlantic salmon should be considered in the assessment.	All life-stages of Atlantic salmon have been considered in the assessment (refer to Section 12.8.3 of **Chapter 12, Volume 2a**). A migratory window from April-October has been applied to encompass movements of all life stages, with peak periods refined as described below. The smolt migration window used for assessment and development of mitigation is now 13 April-25 May (inclusive) as per Malcolm *et al.* (2015). As Malcolm *et al.* 2015 study is over 10 years old, the Applicant may choose to update the scientific understanding of smolt movements. If progressed, this will be done by completing a smolt monitor study prior to the planned construction works to better understand the smolt migration period for the Langavat SAC. Further details regarding this commitment are provided in Section 3.4.2 of **Appendix 12.3, Volume 2c**.

Request	Comment	Response/where this is addressed
		01 April and 25 May (Section 12.6 of **Chapter 12, Volume 2a**; **Appendix 12.1, Volume 2c**, and **Appendix 12.3, Volume 2c**), with no specific assumption regarding the duration of the migration window. A conservative assumption was made that all age classes of adult fish are present in coastal waters (and therefore at risk of effects from percussive piling noise) for 4 weeks prior to the month in which they were recorded in their natal rivers. Further detail on this approach is provided in Section 3.7.
Diel (daily) activity patterns of emigrating smolts show increased movement during periods of darkness. The Applicant sought MD-SEDD and NatureScot's view of diel (daily) activity patterns of post-smolts emigrating from natal rivers.	MD-SEDD advise that salmon post smolt movements should not be confined to either day or night. MD-SEDD advise that smolts do not show a diel pattern once in the marine environment, the data presented by the Applicant in the meeting supports this with tagged fish detected within the array area at most hours of the day.	No assumption of diel migration has been applied across the Offshore Project. The assessment does not restrict post-smolt movements to day or night periods; modelling and impact evaluation assume fish may be present at any time.
Nearshore coastal movement corridors are considered important for migrating Atlantic salmon, as they provide a key pathway for adults returning to their natal rivers. The Applicant identified a 1.5 km coastal corridor as a suitable representation of this nearshore movement route and proposed its use as an assessment threshold	MD-SEDD are not clear on how the proposed 1.5 km migratory corridor will be used in the assessment. The data presented by the Applicant shows at least 39% of smolts detected leaving the SAC were detected on the Array Area which is outside a 1.5 km migratory corridor. No information is available on the coastal corridors of Adult salmon although tagged adult Atlantic salmon	The assumption of a 1.5 km migratory corridor has been removed from consideration. The distance between the noise impact contours for temporary threshold shift in relation to percussive piling within the Array Area, and the coastline of the Hebrides/*Innse Gall* is discussed in

Request	Comment	Response/where this is addressed
for considering potential impacts on returning adult Atlantic salmon. The Applicant requested MD-SEDD and NatureScot's views about any assumption with regards to this coastal movement corridor for Atlantic salmon.	from Armadale have been shown to migrate considerable distances from shore. Scottish Marine and Freshwater Science Vol 6 No 16: Genetic Assignment of Marine-caught Adult Salmon at Armadale to Region of Origin. A coastal corridor is likely to extend for many kilometres from shore.	Section 12.8.3 (paragraph 12.8.1.102) of **Chapter 12, Volume 2a**. A precautionary approach was adopted with respect to impacts from TTS on adult Atlantic salmon migrating from the north along the coastline of the Hebrides/*Innse Gall*, with the assessment concluding that effects may be significant without secondary mitigation.
The Applicant requested MD-SEDD and NatureScot's views on the suitability of using the Temporary Threshold Shift (TTS) onset contour as a precautionary threshold (186 dB re 1 μPa^2 s SELcum, per Popper *et al.,* 2014), and as a proxy for behavioural effects.	MD-SEDD confirmed that TTS threshold (186 dB re 1 μPa^{2}s SELcum) is to be used in the assessment.	TTS threshold has been used within the assessment (**Chapter 12, Volume 2a**).
The Applicant enquired whether MD-SEDD and NatureScot would support adopting a more realistic scenario in the noise model, specifically, modelling a swimming fish rather than stationary fish, to better reflect migratory behaviour, instead of relying solely on TTS-based thresholds.	In response to the information shared following the July meeting (via email, on 16 September 2025), MD-SEDD clarified that a dual assessment approach for both stationary and swimming behaviours will be used in the EIAR/Habitat Regulations Appraisal (HRA) assessment. A swim speed of 1.2 BL/s will be used for modelling in ensonified environments with a swim speed of 4.4 BL/s for sustained swimming in periods of behavioural avoidance. MD-SEDD are content with this approach.	Confirmed that a dual-assessment approach has been adopted for post-smolt modelling in the EIAR/HRA for the moving receptor model. 2 scenarios within the moving model were applied: **No behavioural avoidance (unensonified environment)**: 1.2 BL/s, reflecting typical migration speeds in ensonified environments. **Behavioural avoidance (sustained swimming)**: 4.4 BL/s (≈0.604 $m \cdot s^{-1}$), based

Request	Comment	Response/where this is addressed
		on sustained swimming capability during behavioural response. Further detail is provided in Section 4.
The Applicant sought confirmation of alignment with the following interpretation of determining impact significance: **Magnitude**: spatial extent, duration, reversibility, and timing of the effect. **Sensitivity**: species' tolerance, adaptability, and recoverability, including auditory sensitivity. **Magnitude** reflects ecological consequence (e.g. disruption to migration, recovery time), not just the extent of the noise at that level. **Assessment Matrix**: Sensitivity and magnitude are combined to determine significance of effect (per Chartered Institute of Ecology and Environmental Management (CIEEM) 2018 guidance). **Clarification**: Spatial and temporal considerations can influence both magnitude and sensitivity assessments.	MD-SEDD advise that the protected status of Atlantic salmon should be considered (e.g. Atlantic salmon are a qualifying interest in the designated Special Areas of Conservation within the proposed development area) in addition to the significant declines in the wild Atlantic salmon populations over recent years and the reclassification of global populations of Atlantic salmon, by the International Union for the Conservation of Nature (IUCN), from Least Concern to Near Threatened.	The assessment methodology considers the protected status and conservation importance of Atlantic salmon when determining receptor value, which is considered when defining sensitivity. Receptor value acts as a modifier for sensitivity in the impact assessment. As outlined in Section 12.5 of **Chapter 12, Volume 2a**), nature conservation status is used to define 'Value,' incorporating legal protection, ecological significance, and socio-cultural importance. Atlantic salmon has been assigned a 'High' value in the EIAR to reflect its qualifying interest in SACs within the development area, recent population declines, and its IUCN reclassification to Near Threatened.
Due to lack of available density data for Atlantic salmon, the Applicant proposed 2 options as a proxy to quantify the proportion of the Atlantic salmon population that could potentially be affected by the construction activity:	MD-SEDD agree on the use of Option 2 proxy within the assessment	Option 2 (temporal assessment) was used within the assessment as described in Section 3, and presented in Section 12.8.3 of **Chapter 12, Volume 2a**.

Request	Comment	Response/where this is addressed
Option 1: Spatial Assessment • Divides fish stock by area; • Assumes even distribution (not realistic as doesn't account for migratory behaviour); • Not preferred. **Option 2: Temporal Assessment** • Uses average migrating fish per day; • Reflects seasonal/daily movement; • Preferred method. The Applicant requested feedback or alternative perspectives that NatureScot and MD-SEDD may wish to offer on this approach.		
The Applicant sought MD-SEDD and NatureScot's advice on whether salmon from North Harris SAC could enter/exit via Loch Roag.	MD-SEDD and NatureScot clarified that while there is a hydrological connection between the 2 SACs, it is not suitable for salmon movement.	No connectivity between Atlantic salmon populations in the 2 SACs has been assumed in the assessment.
The Applicant sought NatureScot and MD-SEDD view on proposed temporal mitigation for Atlantic salmon, specifically the avoidance of percussive piling during peak migration periods	MD-SEDD advise that all proposed mitigation measures should be presented in a mitigation plan as part of the EIAR application. MD-SEDD and NatureScot noted with regards to temporal mitigation that where precise migration timing cannot be predicted, developers may need to avoid the entire sensitive window for migration, unless real-time monitoring can refine it. Highlighted the key	A mitigation plan for percussive piling, including both spatial and temporal mitigation, has been prepared and is provided as **Appendix 12.3, Volume 2c**. In relation to temporal mitigation, percussive piling in the zone closest to the coast (see below under spatial mitigation) would be limited to September and October.

Request	Comment	Response/where this is addressed
	need to consider timing of construction activities around key migration periods.	Percussive piling will only take place during the Percussive Piling Programme (**Appendix 12.3, Volume 2c**), i.e. to avoid the period when smolts will be undertaking outward migrations. The Applicant may choose to undertake a dedicated study (prior to construction commencing) to understand if the Percussive Piling Programme could be extended into April/May. The purpose of this study would be to provide further information on the timing of smolt emigration through Loch Roag/*Loch Ròg*. Further details of this study are provided in Section 3.4.2 of **Appendix 12.3, Volume 2c**.
The Applicant sought NatureScot and MD-SEDD view on proposed spatial mitigation for Atlantic salmon, specifically the sequencing percussive piling to avoid sensitive areas (e.g. near river mouths or known migratory corridors).	MD-SEDD and NatureScot, in relation to spatial mitigation encouraged the investigation into whether piling in certain parts of the array would have less impact and could prioritised during sensitive periods.	Spatial mitigation has been considered as part of the percussive piling approach. In summary, spatial mitigation comprises dividing the Percussive Piling Area of the Turbine Area in which percussive piling would occur into the 2 zones. Percussive piling in the zone closest to the coast (purple) would be limited to September and October. In the outermost zone (orange), percussive piling will not take place during the period during April and May when post

Request	Comment	Response/where this is addressed
		smolts are undertaking outward migrations. Further details on spatial prioritisation are provided in **Appendix 12.3, Volume 2c**.
The Applicant sought NatureScot and MD-SEDD view on proposed construction scheduling mitigation for Atlantic salmon, specifically the sequencing of percussive piling activity to avoid sensitive areas (e.g. near river mouths or known migratory corridors) or times (e.g., consideration of daylight vs night-time percussive piling).	NatureScot advised that Atlantic salmon are present in the Array Area at all times of day, making this mitigation (scheduling of piling at night) less effective.	No assumption of daylight vs night-time presence within the Offshore Project Boundary has been applied. The assessment does not restrict post-smolt or adult fish movements to day or night periods; modelling and impact evaluation assume fish may be present at any time.
The Applicant sought opinion on whether potential additional measures proposed during the meeting were necessary, and if there were any further mitigation measures stakeholder's would recommend that the Project could consider.	NatureScot and MD-SEDD recommended including principles for adaptive mitigation in a future Piling Mitigation Plan, allowing for real-time monitoring to inform construction timing.	In the absence of data, the Applicant has proposed not to undertake percussive piling during the smolt emigration period. To further understand of smolt emigration, the study described above will be undertaken to provide further information on the timing of smolt emigration through Loch Roag/*Loch Ròg*. Should the smolt monitoring study indicate that they migrate in a shorter temporal window, the Applicant would revise the Percussive Piling Programme accordingly in consultation with MD-LOT (**Appendix 12.3, Volume 2c**).
The Applicant sought NatureScot and MD-SEDD view on compensation for Atlantic salmon, if mitigation could not fully avoid adverse effects on site integrity.	NatureScot noted that compensation would be a last resort and is not well established for salmon in Scotland/*Alba*.	The Offshore RIAA concluded that with the secondary mitigation measures proposed for percussive piling (discussed above and presented in **Appendix 12.3, Volume 2c**) no

Request	Comment	Response/where this is addressed
		Adverse Effect on Integrity (AEOI) are considered likely (see **Offshore RIAA**).
Comments on Technical Note – Atlantic Salmon Post Smolts Swim Speeds (August 2025)		
The Applicant requested MD-LOT/MD-SEDD to provide an indication of their position on the proposed Atlantic salmon smolt speed provided in the Atlantic salmon smolt swim speed review (provided in Section 4). The Atlantic salmon smolt swim speed review concluded by presenting the mean body length of the tagged post smolts using a 4.4 body lengths per second swim speed to derive a mean swim speed of 0.604 ms^{-1}.	M. Newton (NatureScot representative) noted that a commonly used swim speed for post-smolts in literature (including Newton *et al*, 2021) is 1.2 body lengths per second/ 0.165 m s^{-1} swim speed (not 4.4 body lengths per second / 0.604 ms^{-1} swim speed). NatureScot advised that a precautionary approach should use the lower available estimated swim speed. To take account of fish behaviour we would suggest using one of the slower swim speeds to how represent	The Atlantic salmon smolt swim speed review (provided in Section 4) has been revised to clarify the distinction between migration speed and swim speed and to address behavioural assumptions under noise exposure. Migration speeds reported in the literature (0.07-0.46 m s^{-1}) are based on fish not exposed to percussive pile-driving noise; using these values in noise-affected areas implies that fish exhibit little or no avoidance behaviour (see Section 4). Accordingly, the assessment employs a dual-scenario approach, using modelling outputs based on a swim speed with no behavioural response to noise, alongside outputs based on a swim speed that incorporates a behavioural response: **No behavioural avoidance (unsonified environment)**: a sustained swim speed of 1.2 body lengths per second (BL s^{-1}) equivalent to 0.165 m s^{-1} based on recorded swim speeds of the Grimersta River post-

Request	Comment	Response/where this is addressed
	the post smolt fish are likely to traverse the Array Area, which is unlikely to be in a straight line at a swim speed of 0.604 m s^{-1} (4.4 body lengths per second).	smolt during the tracking study (**Annex 12.1.3, Appendix 12.1, Volume 2c**) was used. Noise modelling results using this swim speed was found to be similar to the outputs of the stationary receptor model. **Behavioural avoidance (sustained swimming):** 4.4 body lengths per second (≈0.604 m s^{-1}), based on sustained swimming capability. Although outputs from noise modelling using the 2 swim speeds are presented within Section 12.8.4 of **Chapter 12, Volume 2a** the precautionary principle is applied when determining the significance of effect. A such, the most conservative swim speed of 0.165 m s^{-1} (1.2 body lengths per second) is applied to represent a precautionary exposure duration. The higher swim speed model outputs (0.6 m s^{-1}, 4.4 body lengths per second and 1.5 m s-1) are presented to contextualise more realistic behavioural responses for these species, but it is not used to determine significance.

Request	Comment	Response/where this is addressed
		Further rationale for this approach is provided in Section 4.
Underwater Noise Salmon Impact Assessment Update Meeting 10/10/2025		
The Applicant requested feedback from stakeholders on the proposed modelling parameters and secondary mitigation measures that the Project is considering. **<u>Modelling parameters</u>** • Variable maximum hammer energy: 3 zones of maximum hammer energy, reducing toward the south; • Maximum daily piling up to 5.5 hours over a 24-hour period. **<u>Secondary mitigation</u>** **Spatial mitigation** - sequencing the piling programme to ensure that the 1.5 km coastal migration zone is outside the TTS zone during the most sensitive months for the inward migration of adult salmon from June to August, and outward migration of smolt in April and May. Piling at Locations 2 to 5 could be programmed to take place in September/October when approximately	NatureScot questioned whether pulling the TTS contour away from the coast by 1.5 km is sufficient to allow migration.	The assumption of a 1.5 km migratory corridor has since been removed from consideration. The distance between the noise impact contours for temporary threshold shift in relation to percussive piling within the Array Area, and the coastline of the Hebrides is discussed in Section 12.8.3 of **Chapter 12, Volume 2a**.
	MD-SEDD enquired why designated piling zones (purple, green, orange) for secondary mitigation run in the opposite direction to the zones designated for different hammer energies. MD-SEDD questioned whether there is value in targeting areas that require lower hammer energy during peak migration periods, as opposed to focusing solely on maintaining a coastal migration corridor.	The variable hammer energy approach was initially designed to allow greater distance between the TTS contour and the mouth of Loch Roag. As secondary mitigation measures were developed, the focus shifted to creating a coastal corridor for migration. The finalised secondary mitigation, in which there will be no percussive piling during the spring period to avoid the smolt migration period; a restriction on percussive piling in during the summer period; and incorporation of quiet periods into the programme to minimise impacts on adult salmon is considered to be sufficient to mitigate

Request	Comment	Response/where this is addressed
80% of adult salmon are estimated to have migrated through coastal waters. **Temporal mitigation** - maintaining daily quiet periods throughout the piling programme in all areas of the Array Area. Particularly important for piles that are being driven during September and October period when outward migrating kelts may be present. The percussive piling area was divided into zones, each with its own spatial and/or temporal mitigation requirements: **Orange Zone** • Piling can occur April-October; • Consideration of continuous quiet period during June and July. **Green Zone** • Piling can occur April l-October; • Consideration of continuous quiet period during April and May. **Purple Zone** • Piling can only be undertaken in September and October; • Consideration of continuous quiet period during September and October.		significant adverse effects (for further details see **Appendix 12.3, Volume 2c**).
	MD-SEDD noted that using lower hammer energies might require longer piling durations, potentially increasing the temporal exposure risk for migrating salmon. MD-SEDD enquired whether the trade-off between hammer energy and piling duration had been analysed, and whether a shorter, higher-energy piling event might be preferable to a longer, lower-energy one.	Choice of hammer energy and percussive piling duration is influenced by site-specific ground conditions, which will be determined by detailed pre-construction surveys. Modelling assumed a maximum of 5.5 hours for pin piles/4.5 hours for casings of percussive piling per day, with higher hammer energies expected to require less time. The Applicant acknowledges that this trade-off is important and will further explore installation options as more geotechnical data becomes available and detailed design is undertaken.
	MD-SEDD suggested that quiet periods could be made adaptive, for example, extended following river spate events that trigger mass smolt migration. MD-SEDD enquired about the feasibility of adjusting piling schedules in response to real-time environmental cues.	While this approach could provide more targeted protection for migrating fish, its feasibility would depend on the ability to monitor river conditions and coordinate with construction logistics. The proposed spatial and temporal mitigation described above was considered to be a more practical and robust approach to minimising impacts on migrating salmon.
	MD-SEDD enquired whether the quiet periods between piling events are sufficient, and whether longer quiet	The current construction plan includes quiet periods built into the construction sequencing. Acknowledged that the longer

Request	Comment	Response/where this is addressed
	periods during peak migration windows would be more effective.	the quiet period, the better for fish migration, but this must be balanced with construction needs.
	NatureScot suggested that, given the April-October piling window, it would be beneficial to maximise the amount of quiet time during the peak smolt migration period in April and May.	The secondary mitigation strategy includes a restriction on percussive piling during the peak migration during April and May. A daily 12-hour quiet period will also be incorporated into the percussive piling programme during key sensitive periods to ensure fish seeking to migrate through the Array Area are subject to a reduced impact. The Applicant may choose to undertake a dedicated study (prior to construction commencing) to understand if the Percussive Piling Programme could be extended into April/May. The purpose of this study would be to provide further information on the timing of smolt emigration through Loch Roag/*Loch Ròg*. Further details of this study are provided in Section 3.4.2 of **Appendix 12.3, Volume 2c**.
	MD-SEDD enquired whether there could be better phasing of piling activities in relation to ground conditions and the amount of piling required in	Choice of hammer energy and percussive piling duration is influenced by site-specific ground conditions, which will be determined by detailed pre-construction surveys. Phasing

Request	Comment	Response/where this is addressed
	particular areas, to further reduce risks to migrating salmon.	will be optimised as more site data becomes available and detailed design is undertaken.

3 SALMON ROD CATCH AND STOCK BASELINE REVIEW

3.1.1.1 As agreed with MD-LOT, MD-SEDD, and NatureScot (refer **Table 2-1**) the EIAR considers the potential impact on adult Atlantic salmon by understanding the proportion of the population that could be potentially affected by the construction activity. This section describes the approach for estimating the proportion of adult Atlantic salmon returning to rivers within the zone of influence (ZOI) of the Offshore Project that would be exposed to underwater noise impacts. The Atlantic salmon baseline conditions are described in **Appendix 12.1, Volume 2c**.

3.1.1.2 An analysis has been undertaken of baseline information comprising rod catch data (Section 3.4) and stock assessments (Section 3.5), both compiled by Marine Scotland. Methods and data sources are described in Section 3.3. The numbers and proportions of adult Atlantic salmon in the period in which data is available (May to September for the rod catch data; full calendar year for stock assessments) are compared across the 2 data sets as well as the adequacy of the data considered to support the assessment. As requested by NatureScot/MD-SEDD, limitations in the analysis and gaps in the data set are described in Section 3.8.

3.2 STUDY AREA

3.2.1.1 The Diadromous Fish Study Area is shown on **Plate 3-1** and is presented as **Plate 2-1** of **Appendix 12.1, Volume 2c**. Atlantic salmon are believed to pass through the ZOI during migrations into rivers on the west coast of the Hebrides/*Innse Gall* and whilst foraging in coastal waters. Tagging studies have demonstrated that smolts move through the ZOI during their outward migrations. Rod catch data and stock estimates for Atlantic salmon for rivers along the west coast of the Isle of Lewis/*Eilean Leòdhais* have been used to inform the baseline for the assessment of impacts on Atlantic salmon populations within vicinity of the Offshore Project (**Table 3-1**).

Plate 3-1 Fish Ecology Study Area – comprising the Marine Fish Study Area, Diadromous Fish Study Area and Basking Sharks and Ocean Sunfish Study Area (as per Plate 2-1 of Appendix 12.1, Volume 2c)

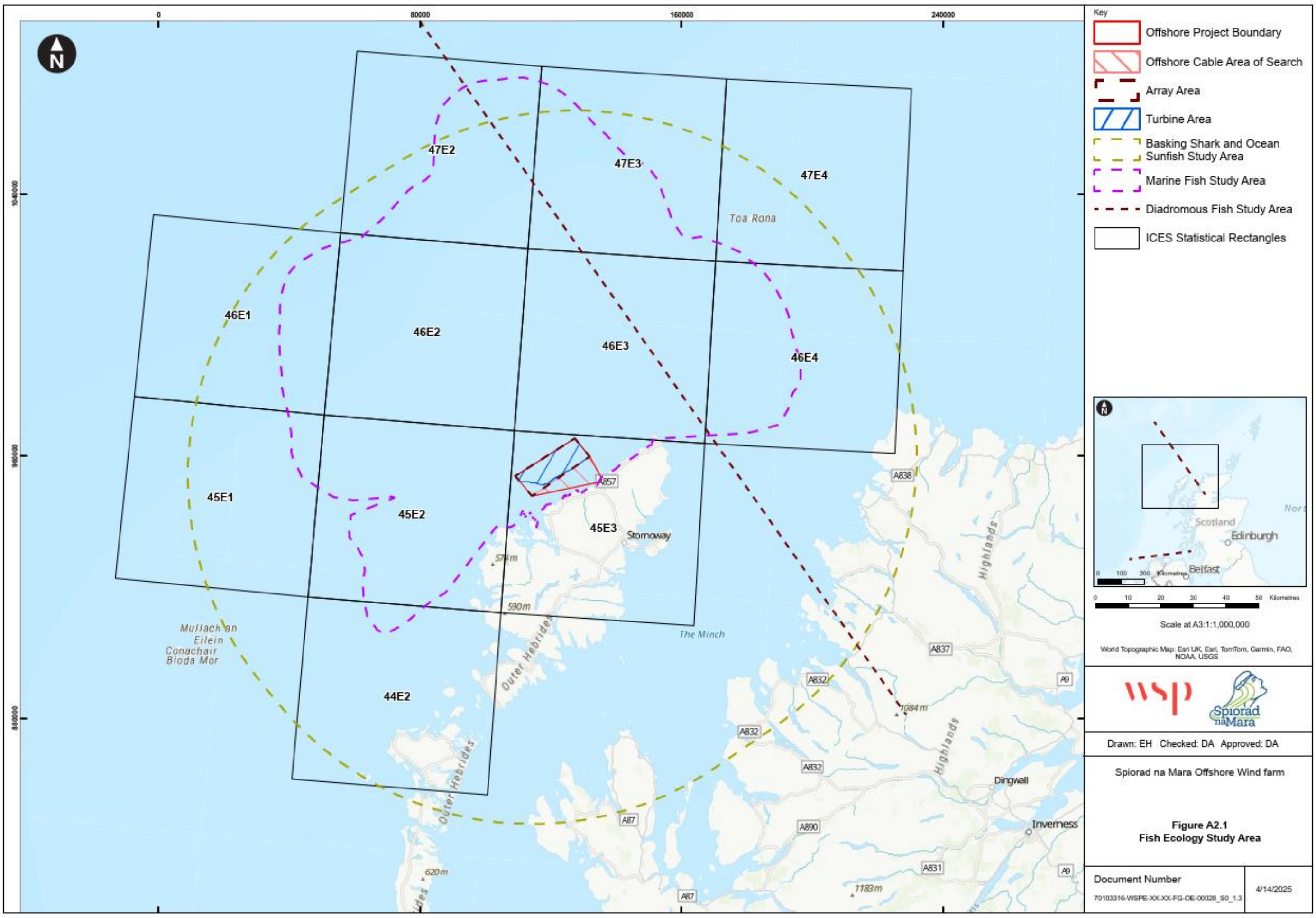


Table 3-1 Stock assessment areas and river systems included in the rod catch data analysis

Atlantic salmon Fishery District Area	**Stock Assessment Area**	**River(s)**
Loch Roag	River Barvas	River Barvas/Bharabhais
	River Carloway/*Càrlabhagh*	River Carloway/*Càrlabhagh*
	River Blackwater (Lewis)	River Blackwater/*An t-Uisge Dubh*
	Langavat SAC	River Grimersta
	Loch Morsgail system	Loch Morsgail system
	Mhor a' Ghlinne Ruaidh and Geisiada	River Glenroe
		Loch Geisiadar system
	Forsa River (Lewis)	River Forsa
	Caslabhat and Tamanabhaigh	River Caslabhat
		River Tamanabhaigh
Resort/Fincastle	North Harris	River Miavhaig
		Amhuinnsuidhe
		Leosavay River
		Big Head River/*Cheann Mòr*
		Loch a' Ghlinne system
Fincastle	River Laxdale (Harris)	River Laxdale
	Loch Steisavat system	Loch Steisavat system
Mullanageren	North Uist Lochs	Loch Grogary system
		Loch nan Geireann system
		Loch Sgealtair system
	Horisary River	Horisary River
Howmore	Howmore and Loch Bi	Howmore River
		Loch Bi system
	Kildonan and Loch a' Bharp	Loch a' Bharp system
		Loch Kildonan system

3.3 DATA SOURCES AND APPROACH TO ANALYSIS

3.3.1.1 A preliminary analysis of rod catch data collated by Marine Scotland (Marine Scotland, 2014) for the period 2011-2023 was undertaken to determine whether it could be used to estimate the monthly proportions of fish recorded in rivers across the angling season (i.e. between May-September). The analysis covered data for all rivers within 5 Atlantic Salmon Fishery District Areas on the west coast of the Hebrides/*Innse Gall* (**Table 3-1**). The angling season for most salmon rivers in Scotland/*Alba* is from May-September and therefore rod catch data is available only for these months.

3.3.1.2 Stock assessment data used to support the management of sustainable Atlantic salmon fisheries under the Atlantic Salmon Conservation Regulations 2016 was also analysed. The first step undertaken in the stock assessment process is to convert rod catch data to numbers of returning Atlantic salmon using correction factors based on flow and monthly variations in angling efficiency (Section 3.5).

3.3.1.3 The limitations of both data sets in accurately reflecting the timing of adult salmon returns are discussed in Section 3.7.

3.4 APPROACH TO PRESENTING AND SUMMARISING THE ROD CATCH DATA

3.4.1 OVERVIEW

3.4.1.1 Rod catch data for multi sea-winter (MSW) and one sea-winter (1SW) Atlantic salmon (2011-2023) were collated for each of the identified stock assessment areas (**Table 3-1**). Released and retained counts were summed to give combined total counts for both MSW and 1SW Atlantic salmon populations. Absolute abundance estimates can be unreliable because they may be influenced by variation in fishing effort. Monthly proportions were therefore calculated allowing the analysis to focus more on the timing of returns as opposed to absolute numbers. The analysis focused on the pattern of fish returns for the months of May to September in which rod catch data is available. It is acknowledged that this is likely to underestimate the returns during the period from October-April which includes the period in which MSW fish are believed to return.

3.4.1.2 For each year of available data, monthly proportions were first calculated by dividing the number of Atlantic salmon caught in each month by the total catch for that migratory period. These proportions were then summarised across years using means and medians. The findings are discussed in the following sections.

3.4.2 FINDINGS AND RANKED MONTHS OF ARRIVAL

3.4.2.1 Analysis of the mean monthly return proportions highlights seasonal patterns for both 1SW and MSW Atlantic salmon populations (**Plate 3-2**). Collectively for 1SW Atlantic salmon, the returns are concentrated between July and September, with August displaying the highest overall mean proportion (0.31), followed by July (0.28), and then September (0.23). Returns in June (0.07) and May (0.00) were negligible

3.4.2.2 For MSW Atlantic salmon, a slightly different overall pattern is observed (**Plate 3-3**). Returns begin earlier in the season during May (0.06), and then increase monthly in a linear sequence, with the highest proportion recorded in September (0.26). As for the 1SW fish data, returns were much lower in June (0.11) than July-September.

Plate 3-2 Mean monthly return proportions for 1SW population summed across 13 years (2011 to 2023) for all sites (1SW fish).

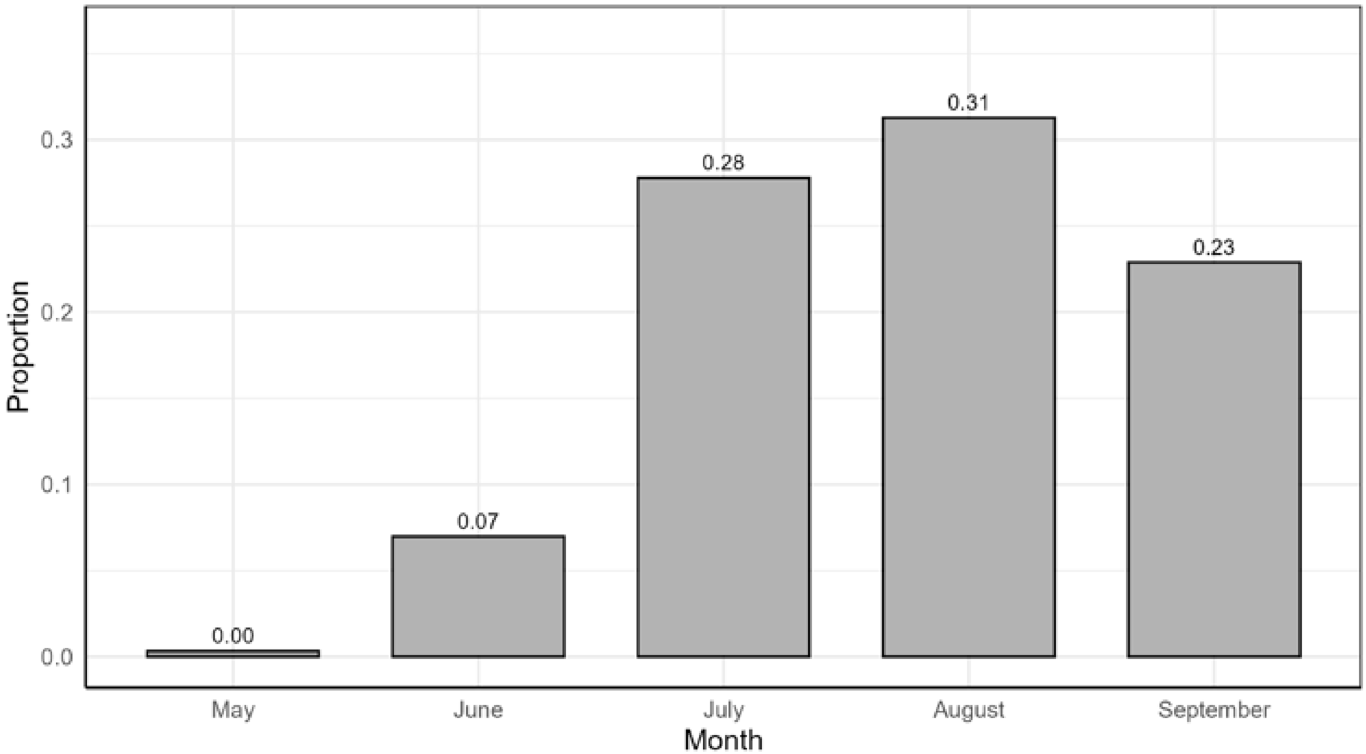
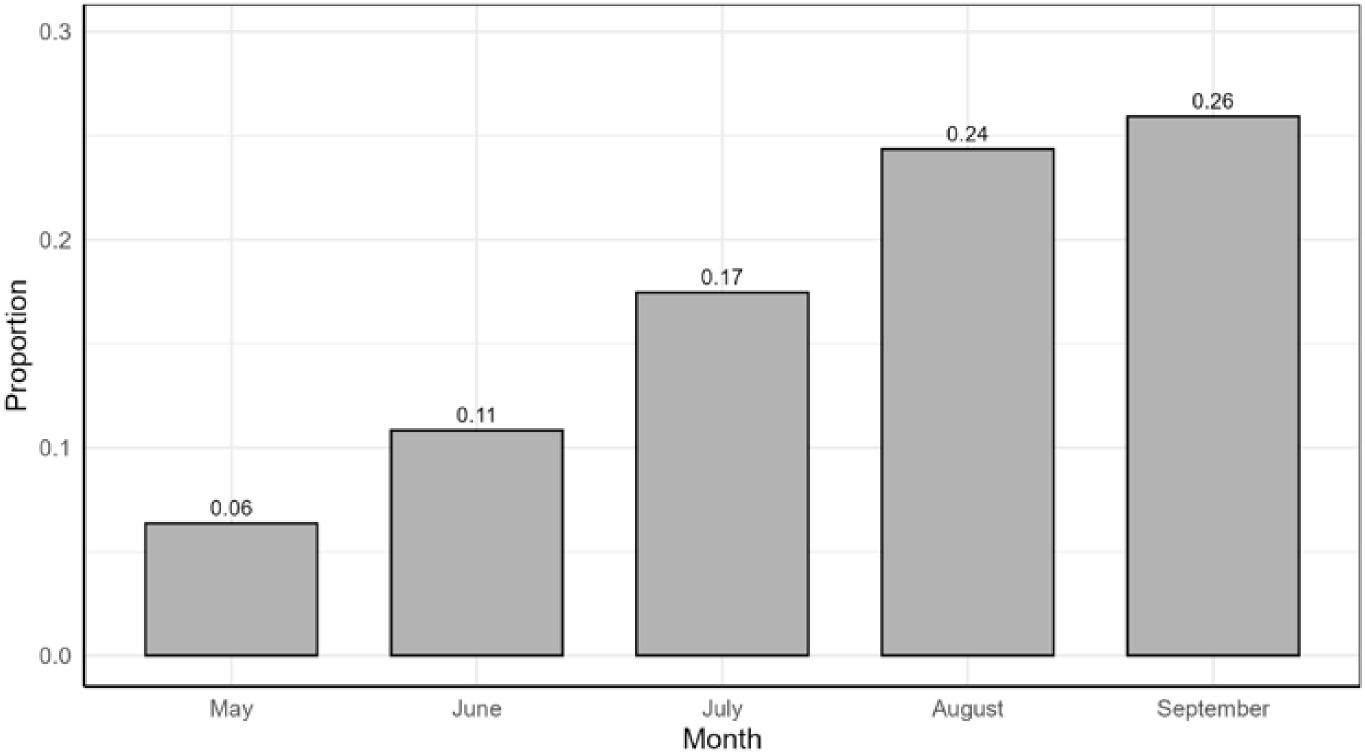


Plate 3-3 Mean monthly return proportions for MSW population summed across 13 years (2011 to 2023) for all sites (MSW fish).



3.5 STOCK ASSESSMENT DATA

3.5.1 METHODS

3.5.1.1 Stock assessments are undertaken to support the sustainable management of fisheries. In the context of Atlantic salmon rivers in Scotland/*Alba,* assessments are undertaken by spatial units referred to as stock assessment areas. An egg requirement (the numbers of eggs required to produce sustainable salmon stocks) is set for each area, and an annual assessment undertaken to determine whether the egg requirement has been met. The assessment comprises 5 steps:

- Step 1: Converting reported rod catch to number of returning Atlantic salmon;
- Step 2: Converting number of returning salmon to number of spawning female Atlantic salmon;
- Step 3: Converting number of spawning females to number of eggs;
- Step 4: Calculating egg requirement to maintain sustainable Atlantic salmon population;
- Step 5: Determining number of eggs compared with the egg requirement to maintain the salmon population in each stock assessment area.

3.5.1.2 For the purposes of this analysis, only Steps 1 and 2 have been considered. The conversion of rod catch data to returning Atlantic salmon is achieved using the relationship between catch data and counts for those Scottish rivers with counters on their lower reaches (referred to here as reference rivers). For Atlantic salmon stock assessments this comprises 9 Scottish mainland rivers; the Awe/*Uisge Abha*, Beauly/*Abhainn nam Manach*, Dee/*Uisge Dhè* (Kirkcudbrightshire), Helmsdale/*Abhainn Ilidh*, North Esk/*Easg Thuath*, Tummel/*Uisge Theimheil*, Tweed, Spey/*Uisge Spè* and Ugie. In most cases count data are obtained from fish counters, except for the Tweed and Spey/*Uisge Spè* where counts are based on the recapture of Atlantic salmon caught in nets at the bottom of the river, or radio tagged, released and recaptured by rod fishers.

3.5.1.3 For the purposes of the stock assessment the relationship between catches and counts has been modelled using a series of predictor variables from which a correction factor (CF) has been derived. The relationship between catch and count:

- Changes between months where, for a given count, catches are lower during the summer than during the spring/autumn;
- Uses flow to account for changes in angling conditions with Atlantic salmon shown to be more catchable in higher flows than in low flow conditions. For example, out of 100 fish entering a river during June it is estimated that 4 would be caught in low flow conditions compared to 7 in normal flows and 11 in high flow conditions.

3.5.1.4 Step 2 of the stock assessment has been used to provide an insight into the seasonal pattern of returns for the various age classes of fish.

3.5.1.5 The modelling approach used to derive correction factors in the stock assessment includes a method for estimating stock outside the angling season (i.e. between October/November and March[1]. Count data for October-December from 6 of the 9 Scottish mainland rivers with fish counters was compared with the counts from the final month of the angling season (i.e. September) and a proportion calculated. The proportions were considered to be sufficiently consistent across the 6 river systems that they could be applied to rivers without counters. For example, for rivers where the fishing finishes at the end of October and the proportion of November to October counts was 0.75 a stock estimate of 100 fish in October would produce a stock estimate of 75 fish in November (100 x 0.75). Pre-season estimates (January onward) were undertaken using a similar procedure but using stock estimates from the first full month of the fishing season rather than the last.

3.5.2 RESULTS

3.5.2.1 Only rivers within the Loch Roag/*Loch Ròg* salmon fishery district area (River Barvas/*Bharabhais*; River Carloway/*Càrlabhagh*; Langavat SAC; River Blackwater/*An t-Uisge Dubh*; Loch Morsgail; Mhor a' Ghlinne Ruaidh and Geisiada; River Forsa, and Caslabhat and Tamanabhaigh) have been included in the analysis since the populations associated with these rivers are considered the most likely to be affected by percussive piling for the Offshore Project. For the purposes of the assessment the assumptions regarding the proportion of the population impacted by percussive piling in the Loch Roag/*Loch Ròg* salmon fishery district area will be applied to the other river systems.

3.5.2.2 **Plate 3-4** to **Plate 3-11** show how the converted maximum, minimum and median numbers of fish estimated to be entering the river systems within the Loch Roag/*Loch Ròg* salmon fishery district area between April and November from 2020-2024. The converted numbers of fish are referred to as 'Estimated stock' on the y-axis.

[1] Estimating Abundance of Adult Salmon

Plate 3-4 River Barvas/*Bharabhais*

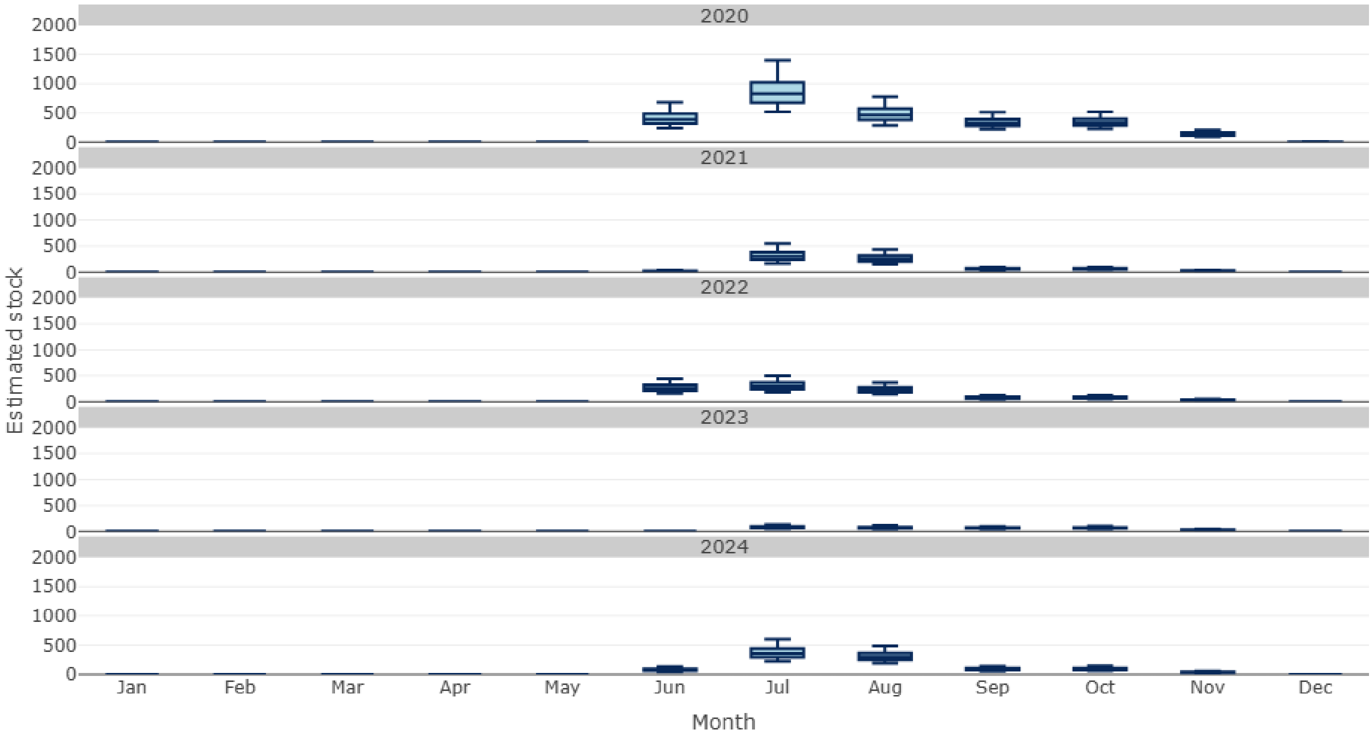


Plate 3-5 River Carloway/*Càrlabhagh*

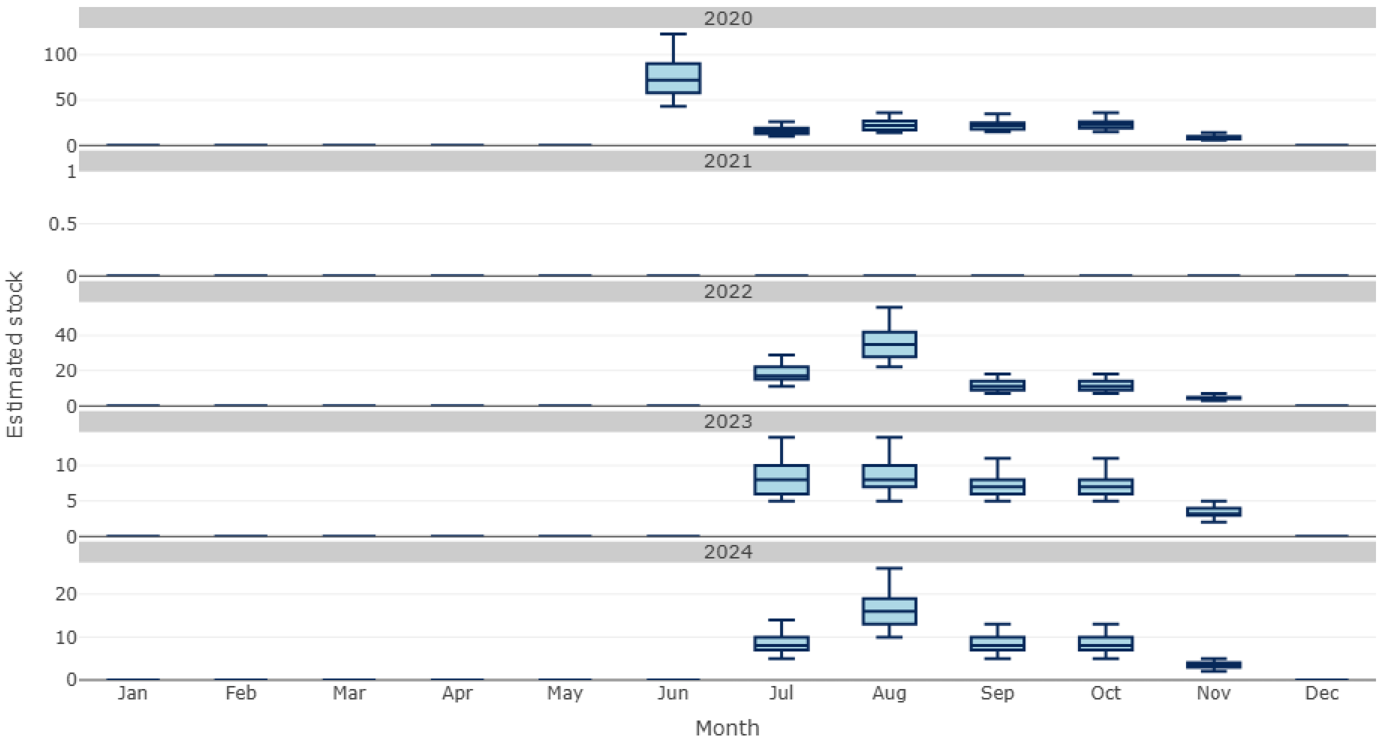


Plate 3-6 River Blackwater/*An t-Uisge Dubh*

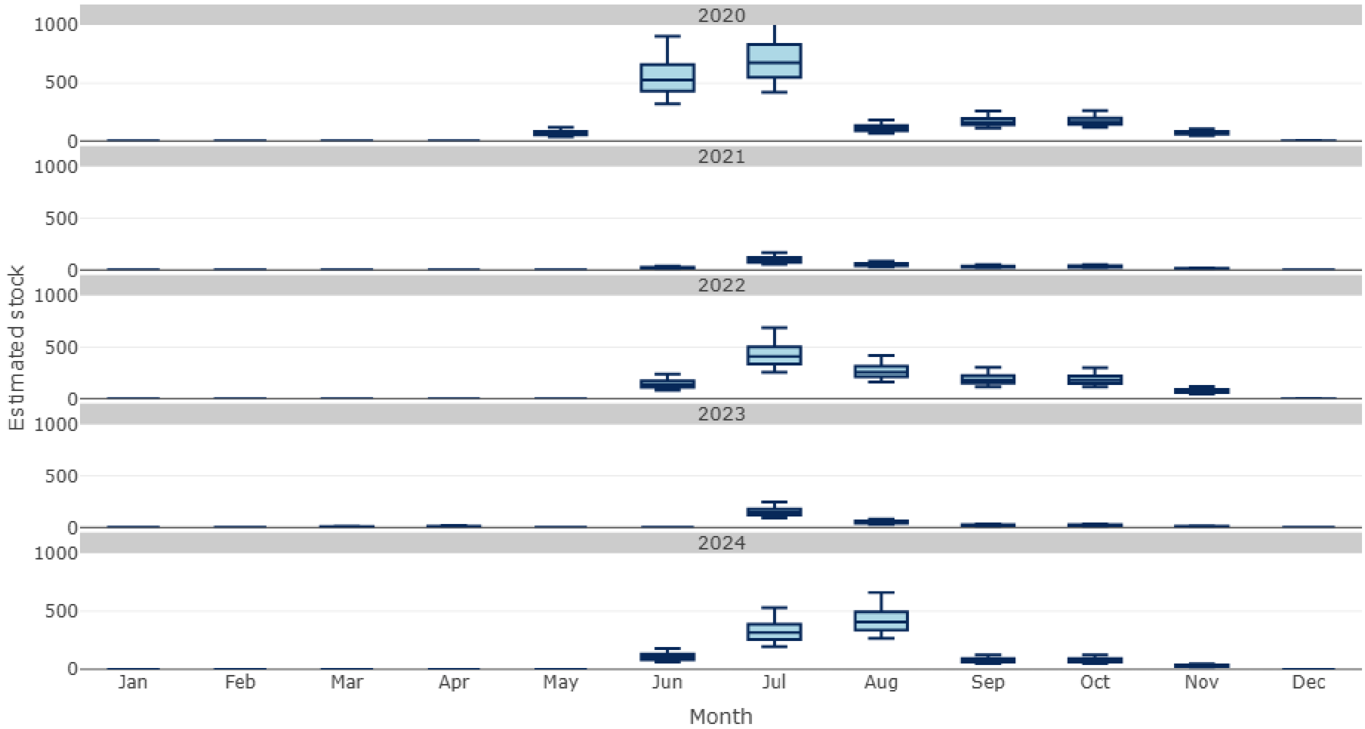


Plate 3-7 Langavat SAC/River Grimersta

Plate 3-8 Loch Morsgail system

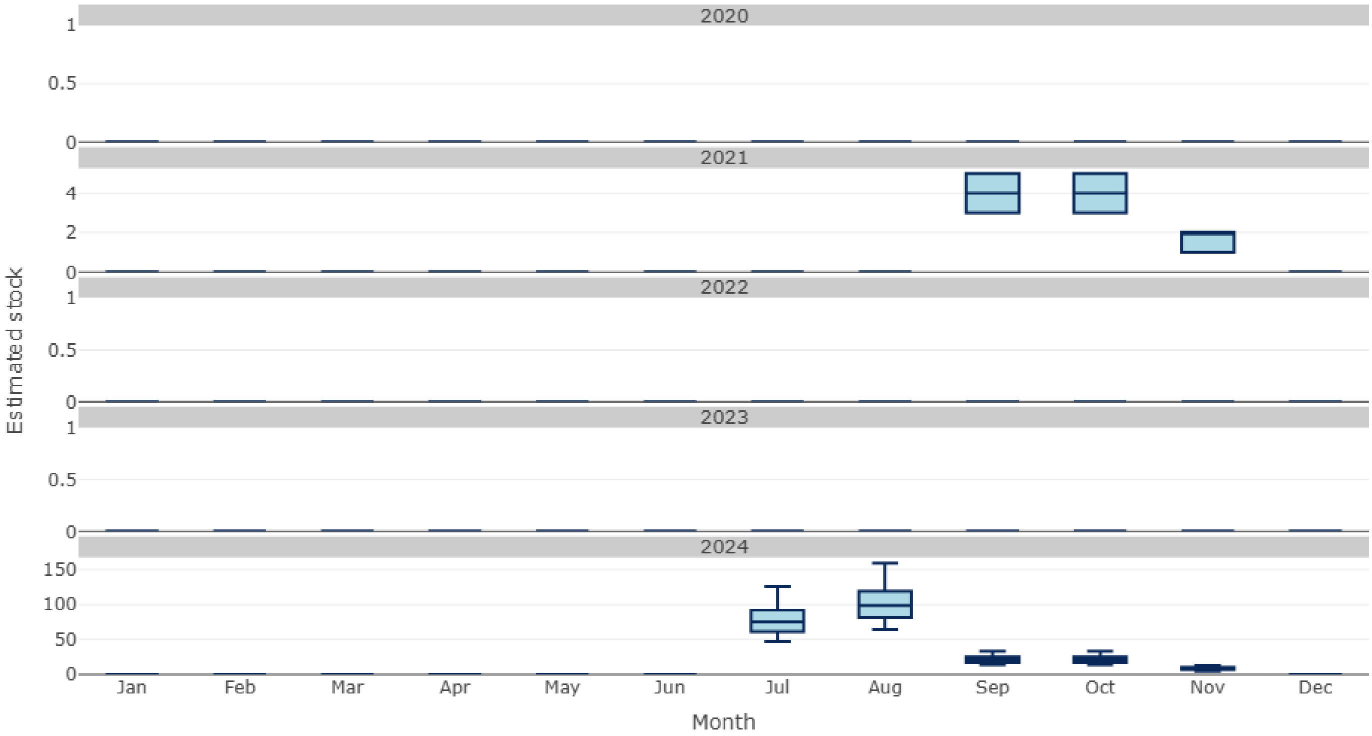


Plate 3-9 Mhor a' Ghlinne Ruaidh and Geisiada

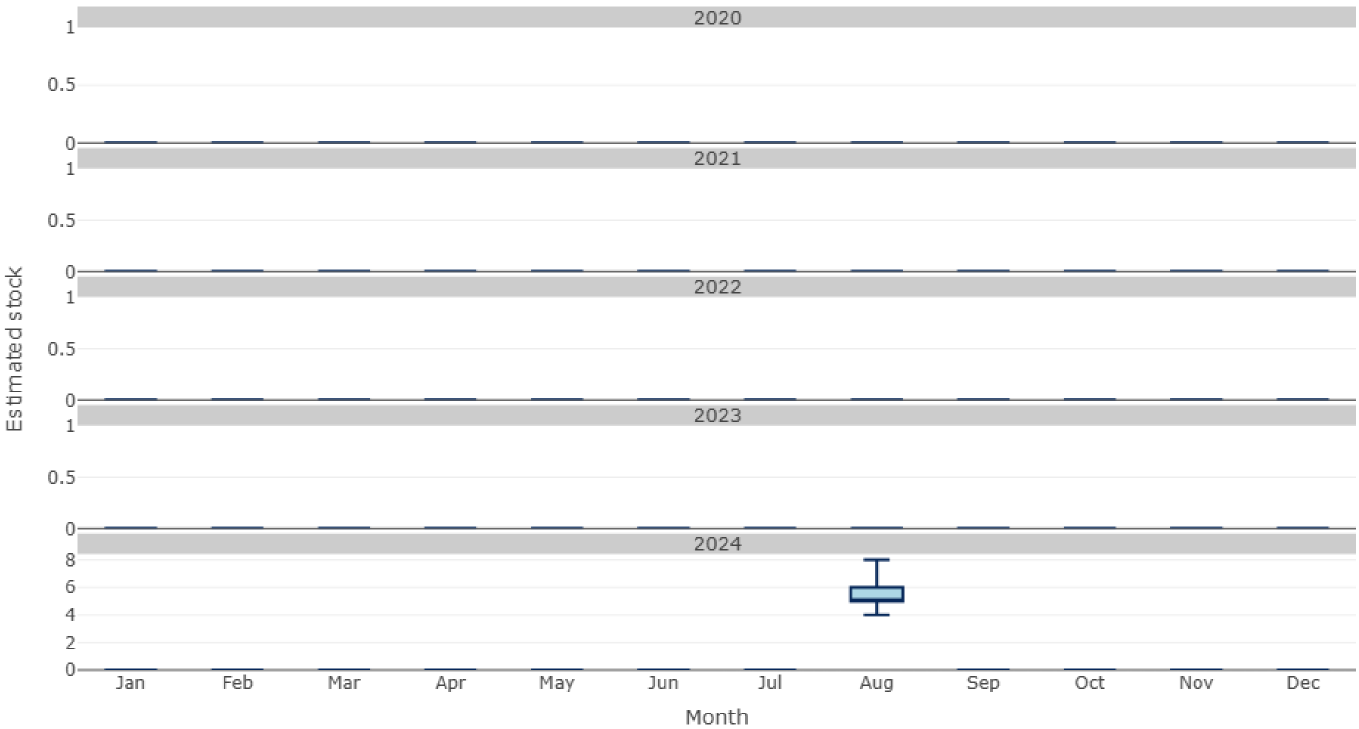


Plate 3-10 Forsa River

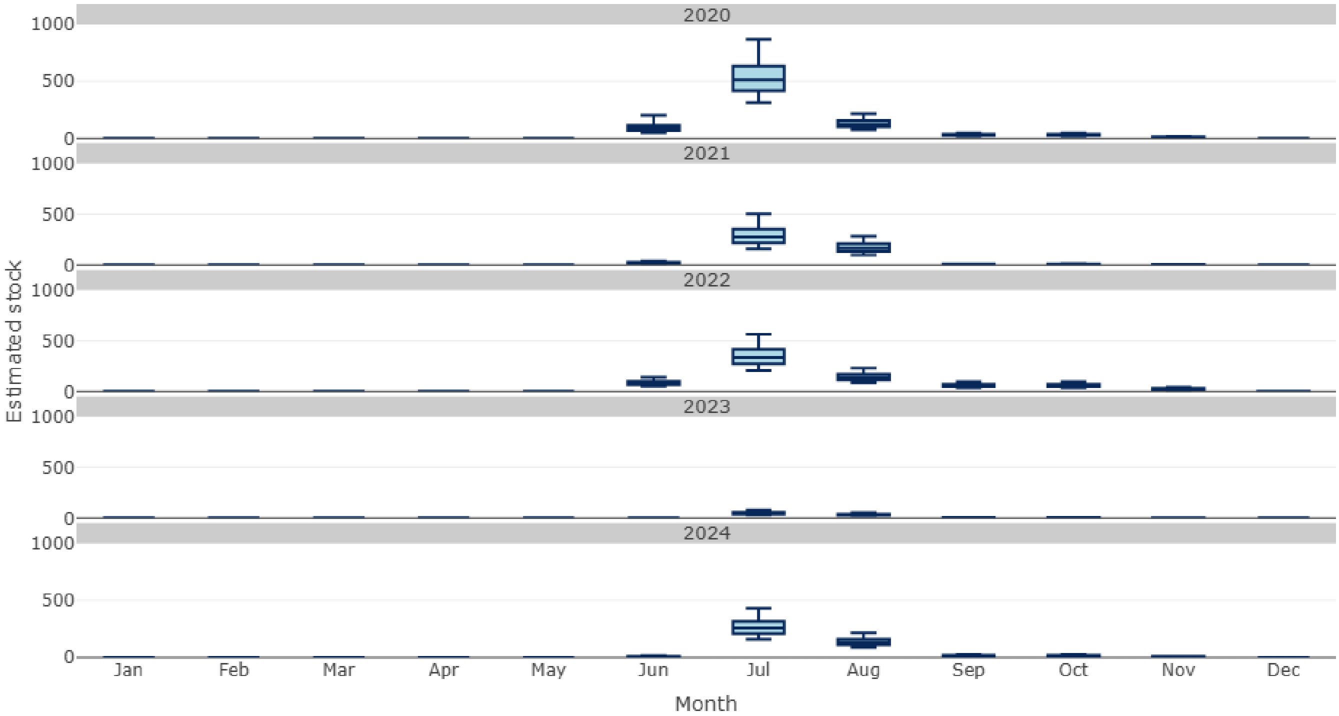
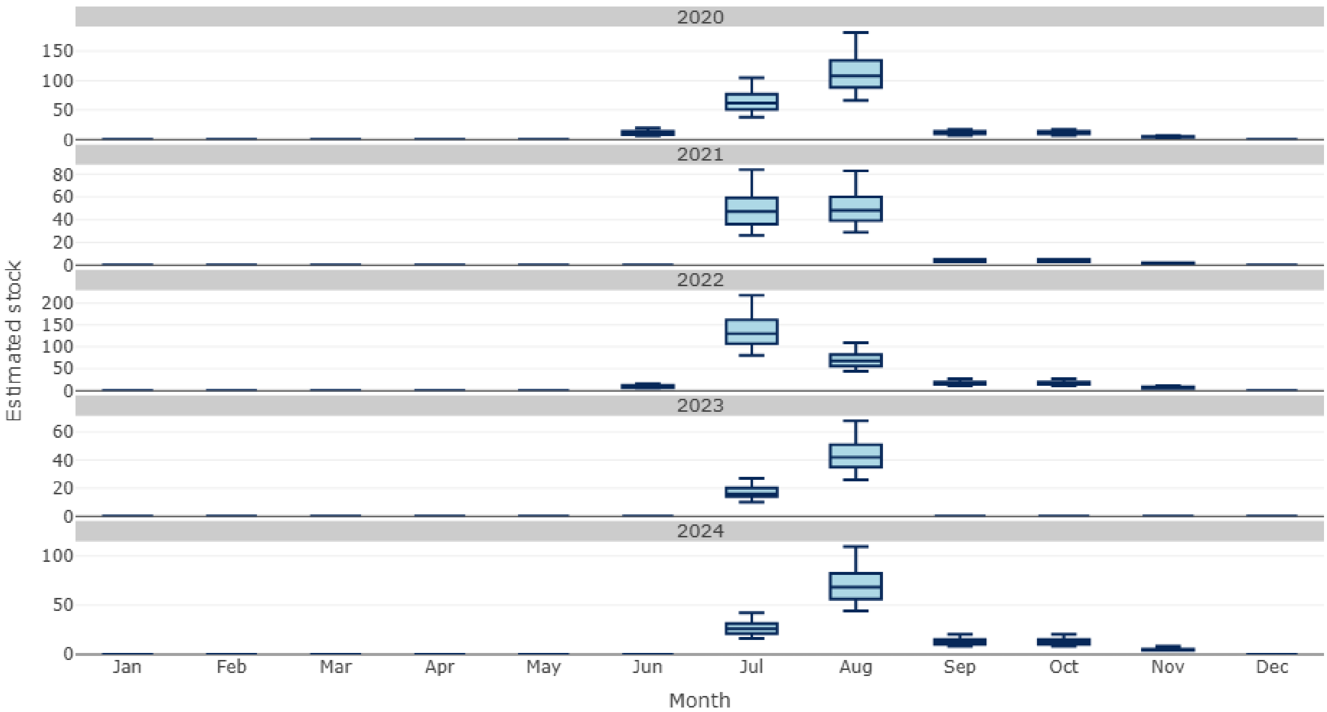


Plate 3-11 Caslabhat and Tamanabhaigh



3.5.2.3 Of the 8 river systems Langavat SAC (River Grimersta) had the highest stock estimate (total stock estimate of fish across all months over 5 years = 19,159; **Plate 3-7**) with estimates for the other river systems ranging between 739 and 5,418. The highest stock estimate across all river systems occurred in July, with the second highest predominantly falling in August with the exception of the Langavat SAC where the second highest was June.

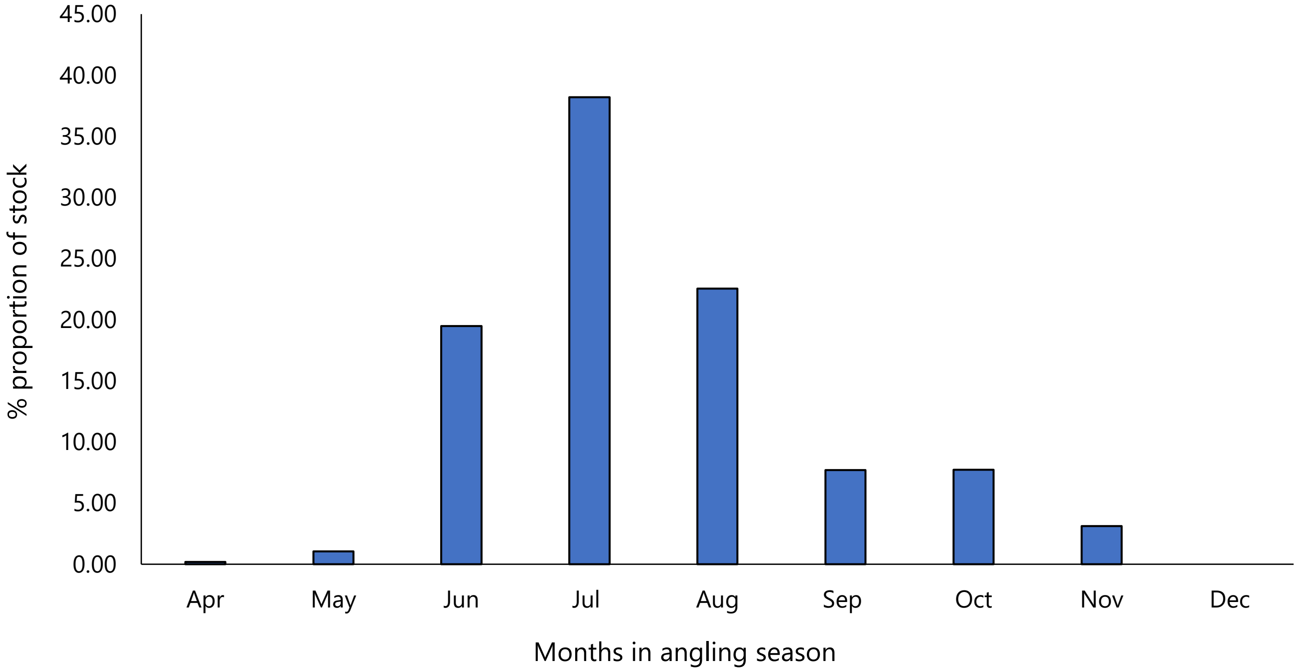
3.5.2.4 For each of the rivers with data for all 5 years (River Bravas/*Bharabhais*; River Blackwater/*An t-Uisge Dubh*; Langavat SAC; Forsa River, and Caslabhat and Tamanabhaigh) monthly medians (April-December) were extracted for the years 2020-2024 and summed. These were also expressed as percentage monthly medians summed across all years (**Annex 12.2.3**). In most cases there are only stock estimates over 0 from May or June-November, with estimates dropping to 0 in December. However, on the River Blackwater/*An t-Uisge Dubh* a small stock estimate was also recorded for April which is likely to be a reflection of the approach to estimating stock outside the angling season (paragraph 3.5.1.1 to paragraph 3.5.1.5).

3.5.2.5 To provide an overall estimate of adult salmon entering the Loch Roag/*Loch Ròg* system monthly medians for the years 2020-2024 have been summed and a percentage proportion of the median relative to the total median value has been calculated (% all rivers combined) (**Table 3-2** and **Plate 3-12**). These values will be used in the assessment as an estimate of the proportion of the adult population present in rivers for the period between April and December. The approach to estimating the proportion of adult fish present in coastal waters is covered in Section 3.7.

Table 3-2 Median stock assessment by month summed across 5 years (2020 to 2024)

River	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River Bravas/*Bharabhais*	0	0	78	301	252	76	77	30	0
River Blackwater/*An t-Uisge Dubh*	11	65	105	315	108	77	77	31	0
River Grimersta/Langavat SAC	0	0	952	1,444	848	301	301	123	0
Forsa River	0	0	82	278	132	16	16	6	0
Caslabhat and Tamanabhaigh	0	0	0	47	68	11	11	5	0
Summed median across all rivers	**11**	**65**	**1,217**	**2,385**	**1,408**	**481**	**482**	**195**	**0**
% all rivers combined	**0.18**	**1.04**	**19.49**	**38.20**	**22.55**	**7.70**	**7.72**	**3.12**	**0.00**

Plate 3-12 Graph showing percentage proportion of stock by month within the angling season for all rivers in Loch Roag/*Loch Ròg* stock assessment area

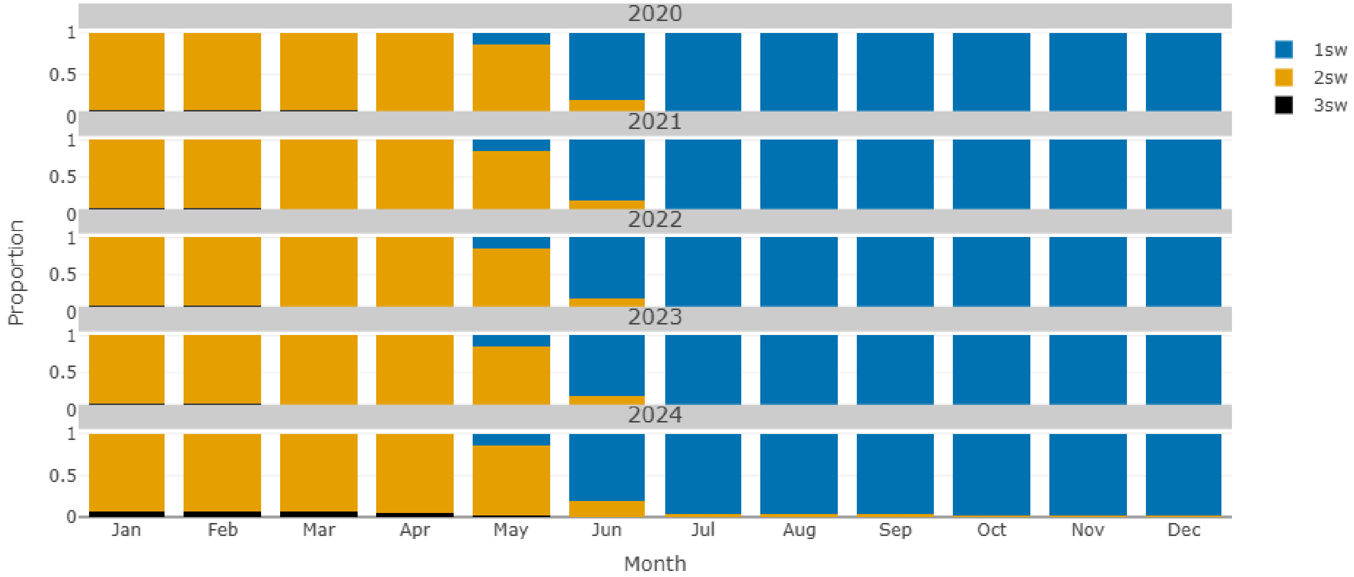


3.6 SEASONAL VARIATION IN AGE CLASS

3.6.1.1 To ensure a robust assessment of impacts on the adult population it is also necessary to consider individual age classes of fish due to their differing reproductive output. For example, MSW fish are known to produce significantly greater numbers of eggs than 1SW fish due to their larger body size, and therefore contribute disproportionately to the sustainability of the population. Although the converted rod catch data combines age classes, Step 2 of the stock assessment (i.e. converting number of returning salmon to number of spawning female Atlantic salmon) presents age classes for returning female fish as proportions from January-December (**Plate 3-13**). For all rivers the small number of MSW (2SW and 3SW) fish enter the rivers from January-April. In contrast, the analysis of rod catch data (Section 3.4; **Plate 3-2** and **Plate 3-3**) suggests that MSW fish return to their natal rivers in spring and summer with the proportion increasing steadily from May and peaking in September. Fish returns outside the angling season are calculated in the stock assessment based on an analysis of the fish counter data from the 9 Scottish mainland rivers.

3.6.1.2 2SW fish represent the largest proportion between January and May. From June-December 1SW are the predominant age class.

Plate 3-13 Proportion of spawners by month

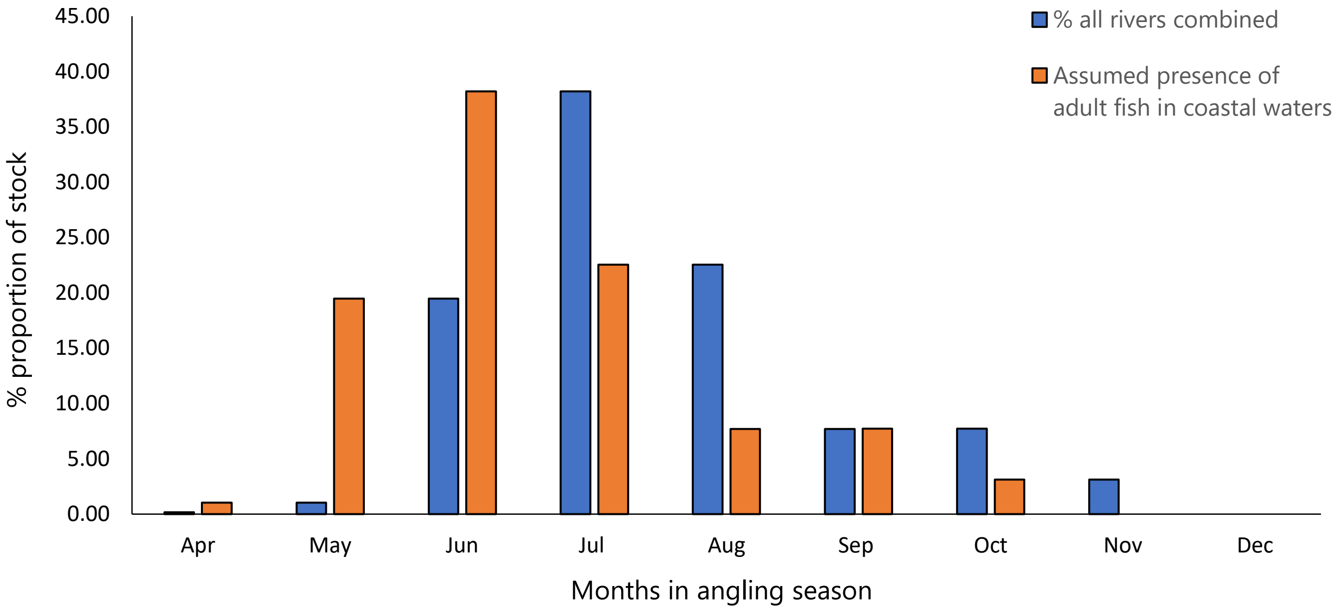


3.7 APPROACH TO ASSESSMENT

3.7.1.1 The construction noise impact assessment will include consideration of the likely proportion of the estimated stock that will be exposed to underwater percussive piling noise during their inward migration given the April-October percussive piling period. Since the stock assessment data relates to fish recorded within rivers, an assumption will need to be made regarding the timing and duration of the period in which fish will be passing through coastal waters on their inward migration.

3.7.1.2 For the purposes of the EIAR assessment a conservative assumption will be made that all age classes of fish are present in coastal waters (and therefore at risk of effects from percussive piling noise) for 4 weeks prior to the month in which they were recorded in their natal rivers. For example, based on the median returns summed across all rivers (**Table 3-2**) 19.5% of the adult stock were present in the rivers in June. For the assessment it would be assumed that this proportion of fish are present in coastal waters from beginning of May, peaking at 38.2% in June, and declining to 22.5% in July and 7.7% in August (**Plate 3-14**).

Plate 3-14 Proportion of adult salmon assumed to be in coastal waters by month based on stock assessment data



3.7.1.3 A proportion of the adult population may make outward migrations during the spring and remain in coastal waters for a prolonged period, with the potential to pass through ensonified area more than once. In the LaHave River (Canada), a study found that some kelts remained in the estuary for up to 5 weeks before migrating out to the ocean (Hubley *et al.,* 2008).

3.7.1.4 Based on the stock assessment data almost all of the population (99.82%) may pass through the ensonified zone between April and October at least once during their inward migration, with the outward migrating kelts potentially passing through twice or more in consecutive years. This is based on a conservative assumption that fish do not follow a coastal migration pathway. In a study of tagged Atlantic salmon from the Miramichi River in Canada Strøm *et al.* (2017) found that individuals were generally associated with surface waters and spent >67% of the time in the upper 10 m of the water column, with migrations tending to occur in shallower coastal areas along the Labrador Shelf. The proportion of fish entering during months outside the proposed percussive piling months of April-October may also be underestimated due to inaccuracies in the correction factors used in the stock assessment for months outside the angling season. MSW fish, which represent less than 1% of the population by number, but contribute a significant proportion of eggs, are unlikely to pass through the ensonified zone since their migrations occur between January and March.

3.8 LIMITATIONS OF DATA SETS

3.8.1.1 The following limitations have been identified:

- Limited data points in the rod catch, and therefore stock assessment data for most river systems;
- Rod catch returns could have been under or over reported;
- Fishing effort is not standardised across years and there is no effort data for fishing. That means if 100 fish are caught in June and 100 in July the number of fish the model predicts returning will be the same for each month (after general correction factors for month and flow are applied) regardless of whether the fishing effort in July was double that of June. This assumption is also made between years and is unrealistic. If the fishing effort is double for the same returns, then there are likely fewer fish in the river;
- Although the stock assessment method attempts to model returns in months outside the angling season, it is a proportionate estimate based on the last month of the angling season (for October-December) and the first month of the season (for January-March). It is unlikely to be accurate, and most importantly, it underestimates the number of MSW fish entering the system during the winter months;
- The characteristics of the 9 reference rivers used as proxies in the model may not accurately reflect Hebridean river systems. For example, the Langavat SAC includes multiple lochs and understanding of migrating Atlantic salmon in loch systems is poorly understood;
- Related to the above the weighting of the co-variates used in the stock assessment model may not be accurate for Hebridean rivers and therefore correction factors may be inaccurate. For example, the catchability of salmon in loch dominated systems may be different from other rivers;
- Rod catch data indicates that MSW fish peak in September (**Plate 3-3**) whereas they are known to enter river systems between January-March. This reflects the bias in the rod catch data in favour of angling activity. The correction factors in the stock assessment allow for this but there is still likely to be an error in the figures which cannot be accounted for;
- There is limited evidence for the period in which fish are migrating through coastal waters prior to entering their natal rivers. The estimate of 1 month is likely to be over precautionary.

3.9 CONCLUSIONS

3.9.1.1 An analysis of raw rod catch and stock assessment data was undertaken to support an estimate of the proportion of the adult Atlantic salmon population that would pass through the zone impacted by percussive piling noise during their inward migrations. 13 years of raw rod catch data (2011-2023) and 5 years of stock assessment data (2020-2024) were accessed via the Marine Scotland website. The analysis of raw rod catch data covered 5 salmon fishery district areas on the west coast of the Hebrides/*Innse Gall* and focused on the pattern of returns by month and whether the monthly returns data for individual age classes (1SW and MSW) is normally distributed. For 1SW Atlantic salmon, the returns are concentrated between July and September, with a peak in August. Returns begin earlier in the season during May (0.06), and then increase monthly in a linear sequence, with the highest proportion recorded in September. For MSW returns begin earlier in the season during May (0.06), increasing in a linear distribution to a maximum in September. It was also concluded that there were insufficient data points to conclude that a normal distribution, and therefore the analysis should focus on median values.

3.9.1.2 The analysis of stock assessment data focused on the first step in the process in which rod catch data is converted to fish numbers based on published correction factors, including flow, to account for variations in angling conditions. The 4 river systems within the Loch Roag/*Loch Ròg* salmon fishery district were included since these were considered the most likely to support fish which would pass through ensonified zone. The highest stock estimate across all river systems occurred in July, with the second highest predominantly falling in August. For all rivers the small number of 3SW fish enter the rivers from January-April. 2SW fish represent the largest proportion between January and May, and 1SW from June-December.

3.9.1.3 For the EIAR assessment a conservative assumption has been made that fish is present in coastal waters (and therefore at risk of effects from percussive piling noise) for 4 weeks prior to the month in which they were recorded in their natal rivers. This is a conservative assumption since most adult salmon are likely to pass through coastal waters days or several weeks before they are recorded in river systems. Based on this approach it would be assumed that approximately 20% of fish are present in coastal waters from beginning of May, peaking at around 40% in June, and declining to around 20% in July, 10% in August and 9% in September and October (**Table 3-2**). A small percentage of fish (around 1%, comprising primarily MSW fish) will enter river systems between January and March.

3.9.1.4 Based on the findings of the stock assessment analysis almost all the adult salmon population may pass through the ensonified zone at least once during their inward migration given that percussive piling operations will take place between April and October (inclusive). This is highly conservative since the stock assessments are based on data collected during the May/June to September angling season, and no empirical data exists for these rivers for the other months of the year. MSW fish, which represent less than 1% of the population by number, but contribute a greater proportion of eggs than other age classes, are unlikely to pass through the ensonified zone since their migrations occur between January and March (**Plate 3-13**). Although this conservative assumption has been adopted, the limitations of the data are highlighted in the chapter (**Chapter 12, Volume 2a**) and additional information regarding salmon returns based on published research was used to inform the assessment of significance.

3.9.1.5 There are significant limitations in the use of the rod catch and stock assessment data which primarily relate to the paucity of the data set, the lack of consistency in the way data is collected through rod returns, and inadequate information on fish returns outside the angling season (Section 3.7). However, it is considered that the precautionary approach outlined allows the seasonality of salmon returns to inform the impact assessment and any subsequent mitigation.

4 SMOLT SWIM SPEED REVIEW

4.1 INTRODUCTION

4.1.1.1 Following consultation with MD-LOT, NatureScot, and MD-SEDD (refer to **Table 2-1**) on UWN and Atlantic salmon it was advised that, for post smolt, the ZOI for underwater noise should be modelled for a moving and stationary receiver. To that end, available literature on Atlantic salmon post smolt swim speeds was reviewed. The purpose of the review was to generate an appropriate swim speed for incorporation into the underwater noise modelling that informed the assessment of underwater noise impacts on Atlantic salmon post-smolts. This review is provided in the subsequent sections.

4.2 LITERATURE REVIEW OF RELEVANT SWIM SPEEDS IN ATLANTIC SALMON POST SMOLTS

4.2.1.1 Post smolt is the name given to Atlantic salmon after smoltification (physiological change in preparation for marine life) and on entry to seawater to begin the marine phase of their lifecycle. Determining accurate swim speeds is essential for acoustic modelling of impact ranges for post smolts exposed to noise from percussive piling and assumed to continue swimming rather than remaining stationary.

4.2.1.2 Studies report swim speeds in terms of the number of body lengths moved per second (commonly total body or fork length (FL)) or as meters per second (m s^{-1}). Arriving at a realistic swim speed for Atlantic salmon post smolts in their early sea migration is complicated by the variation in the units used to report swim speeds, variations in fish size and area specific tides and currents. For example, there are several ways to measure fish length (such as total, standard and FLs) and swimming speed is also related to fish size (Tang and Wardle, 1992). It is acknowledged that in several of the studies included in this analysis, body length and fork length were used interchangeably - which could result in slight inaccuracies in estimates of swim speeds. We found no standard conversion factor to apply between total body and FLs for Atlantic salmon post smolts in the scientific and grey literature and where possible (i.e. where length data is reported) all measurements were converted to m s^{-1} in this summary.

4.2.1.3 A commonly reported metric for early post smolt movement is the time taken for tagged individuals to move from a release point to a detector or between 2 or more detectors. Detectors are commonly set out in an array at increasing distances from a release point; this type of data does not reflect actual swim speeds since the exact route travelled by the fish (and therefore distance) is not known, and neither the effect of noise (percussive piling), currents or tides. In this summary, data of this type is referred to as migration speed and not swim speed, which is reserved for controlled studies specifically investigating the speed at which an individual swims.

4.2.1.4 This difference is highlighted here because the effect of percussive piling on Atlantic salmon swim speeds has not been investigated. Migration speed is relevant in areas or at times not impacted by percussive piling. However, according to the assumptions of the noise model a behavioural response with movement away from the noise source occurs at relevant and sustainable swim speeds. Where commonly reported migration speeds are assumed in areas impacted by percussive piling a reduced or no behavioural response is implicit (i.e. fish swimming is not impacted by percussive piling).

4.2.1.5 The most comprehensive review of post smolt, early marine phase migration speed is found in Thorstad *et al.* (2012). Data has also been compiled in Malcolm *et al.* (2010) and these 2 studies were combined with later studies (Lilly *et al.,* 2022, 2024, Doogan, 2023) reporting migration speeds to provide the range of speeds presented here. Migration speeds were reported between 0.07 m s^{-1} and 0.46 m s^{-1} (Shelton *et al.,* 1997, Holm *et al.,* 2003, Finstad *et al.,* 2005, Lacroix, 2008, Kocik *et al.,* 2009, Lilly *et al.,* 2022, 2024, Doogan, 2023), which includes studies measuring movement over short (3 km) and long (up to 874 km) distances. The lower migration speed estimates likely represent individuals that pause, double back or take a roundabout route between detection points, or potentially the effect of currents. The higher estimates likely represent more direct routes and possibly swimming with a current.

4.2.1.6 In a study where tagged Atlantic salmon post smolts (n = 7) were actively followed after release, and currents accounted for, Økland *et al.* (2006) found that fish swam between 0.33-1.89 body lengths per second (mean 1.17 body lengths per second equating to 0.17 m s^{-1}, or maximum 0.28 m s^{-1} based on the average fish length). This is similar to the migration speed reported by Thorstad *et al.,* 2004 (1.2 body lengths per second, as suggested during consultation with NatureScot (refer to **Table 2-1**). Modelling studies on post smolt migration movements commonly assume a migration speed of 1-1.5 body lengths which equates to ~0.2 m s^{-1} (Booker *et al.,* 2008, Mork *et al.,* 2012) based on typical post smolt body lengths. It is worth repeating that calculations on migratory speeds typically (though not always) represent the amount of time for fish to move between 2 points which includes their swim speed, the effect of currents or tides and without knowing the distance travelled (a straight line trajectory between points is unrealistic for post smolts navigating coastal marine areas) and in unsonified environments (or at least not exposed to percussive piling). This may not represent a realistic estimate of post smolt swim speeds when modelling sound impact ranges when assuming an avoidance strategy.

4.2.1.7 To deduce a relevant and sustained swim speed, assuming an avoidance response, one can turn to literature investigating physiological swimming capabilities. Fish swimming performance is classified into 3 categories; sustained, prolonged, and burst (Beamish 1978). Burst swimming is the fastest attainable speed for fish, but can only be maintained for a short period of time (<20 seconds). Prolonged swim speeds are speeds that can be maintained up to 200 minutes but which leads to fatigue. Sustained swimming speeds can be maintained for over 200 minutes without leading to muscle fatigue. Data on recorded speeds for Atlantic salmon post smolts of a relevant size class (~10-20 cm) in each of these categories is provided below (**Table 4-1**).

Table 4-1 Recorded swim speeds (in body lengths per second BL s^{-1} or meters per second m s^{-1}) of Atlantic salmon smolt or post smolt between ~10-20 cm in length

Swim category	**Recorded speed (Atlantic salmon post smolt)**	**Reference**
Burst (<20 seconds)	10.24 BL $\cdot s^{-1}$ >10 BL $\cdot s^{-1}$ 9.24-15.73 BL $\cdot s^{-1}$ or 1.95 m $\cdot s^{-1}$	Booth (1998) Booth *et al. (*1997) Peak and McKinley (2008)
Prolonged (20 seconds - 200 minutes)	6.70 BL $\cdot s^{-1}$ 2.5-8 BL $\cdot s^{-1}$ 7.7-13.23 BL $\cdot s^{-1}$ or 1.64 m $\cdot s^{-1}$	Booth (1998) Booth *et al.* (1997) Peak and McKinley (2008)
Sustained (over 200 minutes)	4.39 BL $\cdot s^{-1}$ 2.6 BL $\cdot s^{-1}$ 3.6-5.4 BL $\cdot s^{-1}$ or 0.56 m $\cdot s^{-1}$ 5.97-10.16 BL $\cdot s^{-1}$ or 1.26 m $\cdot s^{-1}$	Booth (1998) Booth *et al.* (1997) Tang and Wardle (1992) Peak and McKinley (2008)

4.2.1.8 A sustained swimming speed is likely to be the most appropriate measure of swim speed for fish exposed to noise from percussive piling (which takes place over several hours). In laboratory studies Atlantic salmon smolt and post smolt have been shown to be able to swim between 2.3 (Fängstam, 1993) -10.16 body lengths per second (see **Table 4-1**) with the upper estimates sustained for over 200 minutes. The 4.39 body lengths per second reported by Booth (1998) was judged to be a reasonable (though not lowest) swim speed estimate according to the relevant literature found. This equates to a sustained swimming speed of 0.78 m s^{-1} (based on mean fish lengths from that study). A study using larger Atlantic salmon post smolts (mean 39.2 cm fork length) found that fish were able to maintain swimming at 2.5 body lengths (or ~0.98 m s^{-1}) between 2-72 hours before fatigue (Hvas *et al.*, 2021). A sustained swimming speed of 2.5 body lengths per second was also found for adult Atlantic salmon (Booth, 1998), and post smolts have been shown to have a greater sustained swimming speed relative to their length (Booth, 1998, Tang and Wardle, 1992), which has also been shown for Pacific salmon (Brett and Glass, 1973).

4.2.1.9 A tagging study has been carried out on post smolts from the River Grimersta as part of the application process (ZSL, 2024) (provided in full as part of **Appendix 12.1, Volume 2c**). The amount of time taken for fish to move from the point of release to the outermost point of the estuary (estuary movement) and the time taken between detection at the outer estuary and Array Area (coastal or near shore movement) for the Offshore Project are noted, together with the shortest distance between these points. The results indicate a slower migration speed in the estuary (median 0.09 m s^{-1}, fastest 0.28 m s^{-1}) compared to the coastal area (median 0.18 m s^{-1}, fastest 0.41 m s^{-1}). The fastest migration speeds likely represent a more direct route between points (which closer reflects actual swim speeds), larger post smolts and or swimming with prevailing currents -

but is unlikely to represent actual swimming speed. An indicative conversion, based on FLs of fish measured in the Grimersta study (range 132-178 mm; ZSL, 2024), and sustained swim speeds in Booth (1998) (4.4 body lengths per second) gives a swim speed of ~ 0.58-0.78 m s^{-1}.

4.3 CONCLUSIONS

4.3.1.1 According to the information provided above a summary of, and estimate for, appropriate swim speeds are summarised below.

4.3.1.2 The range of post smolt size (FL) and migration speeds recorded in the tagging study on Grimersta Atlantic salmon post smolts are in line with those reported for Atlantic salmon post smolts in numerous other studies. However, migration speeds are not equivalent to swim speeds since fish rarely move in a straight line (between receptors used to register tagged individuals) in estuary and coastal environments. In addition, the effect of currents and tides on migration speed is not known. After accounting for currents Økland *et al*. (2006) report migration speeds of between ~0.17 and 0.28 m s^{-1} for post smolts of similar size to those leaving Loch Roag/*Loch Ròg*. This, however, does not represent the swim speed at which post smolts would likely swim during percussive piling, where an avoidance strategy is assumed. Data on sustained swimming for smolts suggests a likely swim speed of 4.4 body lengths per second or, based on length data for post smolts from the Grimersta river (ZSL, 2024), ~0.58-0.78 m s^{-1}. The most comprehensive data on the length of individual Atlantic salmon post smolts leaving the Grimersta system have been provided by the Outer Hebrides Fisheries Trust. Mean FL based on 677 individuals measured between 18th April-9th May 2021 was 137.3 (median 137.0 mm) equating to a mean swim speed of 0.604 m s^{-1} (at 4.4 body lengths per second). The effects of local current speeds and directions are not accounted for in this estimate.

4.3.1.3 On the basis of the literature review, a swim speed of 0.604 m s^{-1} for salmon post smolt was determined for percussive piling where an avoidance strategy is assumed. This was not applied to salmon in the adult phase, where the precautionary stationary receptor modelling was used.

4.3.1.4 The assumptions of the noise modelling for a moving receptor highlight an important point when carrying out underwater noise impact assessments on fish where both behaviour and physiology are to be considered. By assuming a swim speed measured on fish not exposed to noise impacts it implies a limited (if any) behavioural response to noise from percussive piling - particularly when there is data showing that maximum sustainable swim speeds are higher. This may indeed be the case for salmon, and studies have shown a lack of behavioural response to noise (Harding *et al.*, 2016, Knudsen *et al.,* 1992). Other responses may include startle (freezing) or diving, and where habituation occurs a change in behavioural response to noise over time is likely. Whilst behavioural reactions to underwater noise are known to vary within a species depending on activity (higher threshold for a reaction when feeding or spawning) and possibly across life histories, some consistency on the assumed level of behavioural impact of underwater noise will have to be adopted. Where a behavioural response is assumed to be reduced or non-existent, physiological impacts (TTS and fitness loss/mortality) will likely form the focus of the assessment. Therefore, 2 conclusions to the salmon post smolt stage assessment are presented, as summarised in **Table 4-2** below.

Table 4-2 Parameters applied to the dual assessment approach for salmon post smolt with physiological thresholds based on Popper *et al*., (2014) for fish with a swim bladder not primarily involved in hearing

Parameter	**No avoidance response**	**Avoidance response**
Physiological impact (Mortality/potential mortality)	Impact range for 210 dB SEL_{cum} re 1 μPa^2s or 207 dB peak with swim speed 1.2 BL $\cdot s^{-1}$ or worst-case stationary receptor	Impact range for 210 dB SEL_{cum} re 1 μPa^2s or 207 dB peak with swim speed 4.4 BL $\cdot s^{-1}$
Physiological impact (Recoverable injury)	Impact range for 203 dB SEL_{cum} re 1 μPa^2s or 207 dB peak with swim speed 1.2 BL $\cdot s^{-1}$ or worst-case stationary receptor	Impact range for 203 dB SEL_{cum} re 1 μPa^2s or 207 dB peak with swim speed 4.4 BL $\cdot s^{-1}$
Physiological impact (TTS)	Impact range for TTS (186 dB SEL_{cum} re 1 μPa^2s) with swim speed 1.2 BL $\cdot s^{-1}$ or worst-case stationary receptor	Impact range for TTS (186 dB SEL_{cum} re 1 μPa^2s) with swim speed 4.4 BL $\cdot s^{-1}$
Behavioural impact	Reduced	Avoidance

5 SUMMARY

5.1.1.1 The assessment of potential impacts from underwater noise on Atlantic salmon has been directly informed by consultation with MD-LOT, NatureScot, and MD-SEDD. These discussions shaped the approach to baseline characterisation, modelling assumptions, and mitigation strategies adopted within the Environmental Impact Assessment and HRA.

5.1.1.2 MD-LOT, NatureScot, and MD-SEDD supported the use of the Temporary Threshold Shift onset contour (186 dB re 1 $\mu Pa^2 \cdot s$ SELcum) as a precautionary threshold for assessing underwater noise impacts. For the post-smolt life stage, the assessment considers 2 behavioural scenarios. The first scenario assumes fish remain stationary during exposure, representing a precautionary worst case. The second scenario assumes fish continue swimming through the sound field at sustained speeds. Swim speeds applied in this second scenario were derived from literature and tagging studies: 1.2 body lengths per second to represent typical migration and 4.4 body lengths per second to represent sustained swimming under avoidance behaviour. Adult salmon were assessed using the precautionary stationary receptor approach only.

5.1.1.3 Mitigation measures were developed in response to consultation feedback. These include temporal restrictions to avoid peak smolt migration periods, spatial sequencing of percussive piling activities to reduce exposure near sensitive areas, and the incorporation of quiet periods within the construction schedule. These mitigation measures are detailed in the percussive piling mitigation strategy in **Appendix 12.3, Volume 2c**. Stakeholders recommended that mitigation should be adaptive, with flexibility to respond to environmental cues such as river spate events.

5.1.1.4 In summary, consultation has resulted in a precautionary and evidence-based approach to the assessment. Key outcomes include the adoption of conservative assumptions regarding fish presence in coastal waters, the application of dual modelling scenarios for underwater noise exposure, and the integration of mitigation measures aligned with stakeholder advice. These measures ensure that the assessment is robust, transparent, and consistent with regulatory expectations.

6 GLOSSARY OF TERMS AND ABBREVIATIONS

6.1.1.1 A list of key terms and acronyms used in this appendix are provided in **Table 6-1** and **Table 6-2**.

Table 6-1 Acronyms and abbreviations

Term	Definition
AEOI	Adverse Effect on Integrity
$BL{\cdot}s^{-1}$	Body Lengths per Second
CF	Correction Factor
CIEEM	Chartered Institute of Ecology and Environmental Management
EIAR	Environmental Impact Assessment Report
FL	Fork Length
HRA	Habitats Regulations Appraisal
IUCN	International Union for Conservation of Nature
MD-LOT	Marine Directorate – Licensing Operations Team
MD-SEDD	Marine Directorate - Science, Evidence, Digital and Data
MHWS	Mean High Water Springs
MSW	Multi Sea-Winter (Atlantic salmon age class)
OCAS	Offshore Cable Area of Search
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
RIAA	Report to Inform Appropriate Assessment
SAC	Special Area of Conservation
SELcum	Sound Exposure Level (Cumulative)
TTS	Temporary Threshold Shift
UWN	Underwater Noise
WTG	Wind Turbine Generator
ZOI	Zone of Influence
1SW	One Sea-Winter (Atlantic salmon age class)

Table 6-2 Glossary

Term	Meaning
Array Area	The offshore area within which the offshore wind turbine generators (WTGs), associated foundations, Offshore Cables, and Offshore Substation Platform (OSP) (if required), will be located. This area encompasses the Turbine Area that will contain all above water surface infrastructure (WTGs/OSP) and an additional area within which further below water infrastructure (foundations and cables) may also be located.
Body lengths per second ($BL{\cdot}s^{-1}$)	A size-independent measure of swim speed expressed as the number of fish body lengths traversed per second.

Term	Meaning
Burst swimming	The fastest category of swimming performance; can be maintained for <20 seconds before fatigue.
Coastal corridor	A nearshore pathway used by migrating fish; extent can span several kilometres offshore and varies by region/conditions.
Correction factor (CF)	A modelled adjustment applied to rod catch to estimate returning fish numbers, accounting for monthly differences in catchability and river flow.
Cumulative Sound Exposure Level (SELcum)	The time-integrated sound energy experienced at a receiver over an event or period, in dB re 1 $\mu Pa^2 \cdot s$.
Diadromous fish	Fish that spend part of their life in both freshwater and sea water and migrate between the two.
Diadromous Fish Study Area	Study area for salmonid species (Atlantic salmon and sea trout), and European eel, and includes all waters located within the northwest anadromous fish region boundary.
Diel	Relating to a 24-hour cycle; diel migration refers to different movement patterns by day vs night.
Egg requirement	The number of eggs needed to sustain a stock in a given area; benchmark used in Scottish stock assessments.
Ensonified area/zone	The area where underwater sound levels exceed a specified threshold (e.g., TTS onset).
Fish counter	Devices (or net/tag methodologies) that count fish passing at specific locations, used to calibrate catch–count relationships for stock assessment.
Fishery District (Atlantic salmon)	Administrative area used for fishery management and reporting; stock assessment areas are nested within or aligned with these.
Fork length (FL)	Standard fish length measurement from snout to the fork in the tail; often used to convert $BL \cdot s^{-1}$ to $m \cdot s^{-1}$.
Hammer energy	The energy delivered per blow during percussive piling; affects sound output and piling duration.
Kelt	Salmon that have spawned in the previous autumn and subsequently return to the marine environment.
Mean High Water Springs (MHWS)	The average height of spring high tides.
Migratory window	The period when specific life stages are most likely to migrate through an area.
Migration speed	An observed movement rate between detection points (in $m \cdot s^{-1}$) that includes routing complexity and current effects; not equal to true swim speed.
Moving receptor	A noise modelling assumption treating fish as moving at a specified swim speed across the sound field during exposure.
Offshore Project Boundary	The 'red line boundary' encompassing the Offshore Project.
Offshore Cable Corridor Area of Search (OCAS)	The area within which the offshore cable infrastructure between the Array Area and Landfall up to Mean High Water Springs (MHWS) will be located.

Term	Meaning
Percussive piling	A method of installing piles and pile casings into the seabed using an impact hammer. This form of percussive piling can be solely used if ground conditions are suitable. If pile depth cannot be achieved through percussive piling alone, a pile-drill-pile technique can be used to reach desired depths. The percussive piling technique can be used for the installation of the Wind Turbine Generators (WTGs) and the Offshore Substation Platform (OSP) (if required) located within the Percussive Piling Area.
Percussive Piling Area	The area within the Turbine Area where both percussive piling, and drill and grout or vibratory piling construction methods can be used for the installation of the wind turbine generators (WTGs) and the Offshore Substation Platform (OSP) (if required) fixed foundations.
Percussive Piling Exclusion Area	An area in the southwest of the Turbine Area where there will be no percussive piling. Other methods including drill and grout methods can be used in this area.
Post-smolt	Juvenile salmonids migrating towards the sea after they have entered the marine environment. Referred to as post-smolts until the end of the first winter in the sea.
Quiet periods	Scheduled breaks in percussive piling (hours/days) to reduce cumulative exposure and facilitate migration.
Reference rivers	Scottish rivers with counters or equivalent datasets used to calibrate the catch–count relationship in stock assessments.
Smolt	Juvenile salmonids migrating towards the sea during the freshwater portion of their journey.
Smoltification	The physiological transition enabling freshwater fish (e.g., salmon parr) to tolerate seawater; precedes marine migration.
Spate	A sudden rise in river flow after rainfall.
Stationary receptor	A noise modelling assumption treating fish as stationary during exposure, a precautionary "worst case" for noise impact.
Stock assessment	A multi-step process converting catches to returning fish, spawning females, and egg numbers to assess stock status against egg requirement.
Stock assessment area	Spatial unit used in Scottish salmon stock assessments to evaluate returns and conservation status.
Swim speed	The actual speed at which fish swim ($m \cdot s^{-1}$); distinct from migration speed and may increase during avoidance behaviour.
Temporary Threshold Shift (TTS)	Reversible and temporary hearing loss.
Turbine Area	A reduced area within the Array Area where above water surface infrastructure would be located i.e. wind turbine generators (WTG) or Offshore Substation Platform (OSP) (if required). This area has been developed and refined through stakeholder consultation and environmental assessment.
Zone of Influence (ZOI)	The spatial area within which project activities may cause ecological effects to receptors.

7 REFERENCES

Beamish, F.W.H. 1978. Swimming capacity. In: Fish Physiology VII, Locomotion. Hoar and D.J. Randall eds. Academic Press, London. pp. 151-178.

Booker D. J. Wells N. C. Smith I. P., Modelling the trajectories of migrating Atlantic salmon (Salmo salar), Canadian Journal of Fisheries and Aquatic Sciences, 2008, vol. 65 (pg. 352-361)10.1139/f07-173

Booth, R.K., E.B. Bombardier, RS. McKinley, D.A. Scruton, and R.F. Goosney. 1997. Swimming Performance of Post Spawning Adult (Kelts) and Juvenile (Smolts) Atlantic Salmon, Sa/ma safar. Can. Manuscr. Rep. Fish. Aquat. Sci. No. 2406: V + 18 p

Booth, R. K. (1998). Swimming performance of anadromous Atlantic salmon, Salmo salar L., during their spawning migration in the Exploits River, Newfoundland, Canada. Waterloo, Ontario, Canada: University of Waterloo.

Brett, J. R. and N.R. Glass. 1973. Metabolic rates and critical swimming speeds of sockeye salmon (Oncorhynchus nerka) in relation to size and temperature. Journal of the Fisheries Research Board of Canada. 30:379-387.

Doogan, A., Cotter, D., Bond, N., Ó'Maoiléidigh, N., & Brophy, D. (2023). Partitioning survival during early marine migration of wild and hatchery-reared Atlantic salmon (Salmo salar L.) smolts using acoustic telemetry. Animal Biotelemetry, 11(1), 39.

Finstad, B. Økland, F. Thorstad, E.B. Bjørn, P.A. McKinley, R.S. (2005) Migration of hatchery-reared Atlantic salmon and wild anadromous brown trout post-smolts in a Norwegian fjord system. Journal of Fish Biology 66 (1) 86-96.

Fängstam, H. (1993). Individual downstream swimming speed during the natural smolting period among young Baltic salmon (Salmo salar). Canadian Journal of Zoology 71, 1782–1786.

Harding, H., Bruintjes, R., Radford, A. N., & Simpson, S. D. (2016). Measurement of Hearing in the Atlantic salmon (Salmo salar) using Audito-ry Evoked Potentials, and effects of Pile Driving Playback on salmon Behaviour and Physiology. Marine Scotland Science.

Holm, M., Holst, J. C., Hansen, L. P., Jacobsen, J. A., O'Maoileidigh, N. & Moore, A. (2003). Migration and distribution of Atlantic salmon post-smolts in the North Sea and North-East Atlantic. In Salmon at the Edge (Mills, D., ed.), pp. 7–23. Oxford: Blackwell Science.

Hubley, P.B., Amiro, P.G., Gibson, A.J.F., Lacroix, G.L., and Redden, A.M., 2008. Survival and behaviour of migrating Atlantic salmon (Salmo salar L.) kelts in river, estuarine, and coastal habitat. ICES Journal of Marine Science, 65(9): pp. 1626-1634.

Hvas, M., Folkedal, O., & Oppedal, F. (2021). What is the limit of sustained swimming in Atlantic salmon post smolts?. *Aquaculture Environment Interactions*, *13*, 189-198.

Knudsen, F. R., Enger, P. S., & Sand, O. (1992). Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, Salmo salar L. Journal of Fish Biology, 40(4), 523-534.

Kocik, J. F., Hawkes, J. P., Sheehan, T. F., Music, P. A. & Beland, K. F. (2009). Assessing estuarine and coastal migration and survival of wild Atlantic salmon smolts from the Narraguagus River, Maine using ultrasonic telemetry. American Fisheries Society Symposium 69, 293–310.

Lacroix, G. L. (2008). Influence of origin on migration and survival of Atlantic salmon (Salmo salar) in the Bay of Fundy, Canada. Canadian Journal of Fisheries and Aquatic Sciences 65, 2063–2079.

Lilly, J., Honkanen, H. H., Rodger, J. R., Del Villar, D., Boylan, P., Green, A., ... & Adams, C. E. (2024). Migration patterns and navigation cues of Atlantic salmon post-smolts migrating from 12 rivers through the coastal zones around the Irish Sea. Journal of Fish Biology, 104(1), 265-283.

Lilly, J., Honkanen, H. M., Bailey, D. M., Bean, C. W., Forrester, R., Rodger, J. R., & Adams, C. E. (2022). Investigating the behaviour of Atlantic salmon (Salmo salar L.) post-smolts during their early marine migration through the Clyde Marine region. Journal of Fish Biology, 101(5), 1285-1300.

Malcolm, I. A., Godfrey, J., & Youngson, A. F. (2010). Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: Implications for the development of marine renewables. Marine Scotland Science.

Marine Scotland, 2024. Rod fishery statistics: salmon 2011 to 2023, sea trout 2017-2023 - reported catch by Stock Assessment Area (Dataset). Available at: Rod fishery statistics: salmon 2011 to 2023, sea trout 2017-2023 - reported catch by Stock Assessment Area | Marine Scotland Data Publications. [Accessed January 2026].

Marine Scotland, 2023. Salmon fishing: proposed river gradings for 2025 season – Outer Hebrides (Dataset). Available at: https://scotland.shinyapps.io/sg-salmon-conservation-detailed/[Accessed January 2026].

Marine Scotland, 2018. Estimating Abundance of Adult Salmon. Available at: Estimating Abundance of Adult Salmon[Accessed January 2026].

Mork, K. A., Gilbey, J., Hansen, L. P., Jensen, A. J., Jacobsen, J. A., Holm, M., ... & Wennevik, V. (2012). Modelling the migration of post-smolt Atlantic salmon (Salmo salar) in the Northeast Atlantic. ICES Journal of Marine Science, 69(9), 1616-1624.

Matthew Newton, James Barry, Angus Lothian, Robert Main, Hannele Honkanen, Simon Mckelvey, Paul Thompson, Ian Davies, Nick Brockie, Alastair Stephen, Rory O'Hara Murray, Ross Gardiner, Louise Campbell, Paul Stainer, Colin Adams. (2021). Counterintuitive active directional swimming behaviour by Atlantic salmon during seaward migration in the coastal zone, *ICES Journal of Marine Science*, Volume 78, Issue 5, August 2021, Pages 1730–1743, https://doi.org/10.1093/icesjms/fsab024 [Accessed January 2026].

Økland, F., Thorstad, E. B., Finstad, B., Sivertsgård, R., Plantalech, N., Jepsen, N., & McKinley, R. S. (2006). Swimming speeds and orientation of wild Atlantic salmon post-smolts during the first stage of the marine migration. *Fisheries Management and Ecology*, *13*(4), 271-274.

Peake, S., & McKinley, R. S. (1998). A re-evaluation of swimming performance in juvenile salmonids relative to downstream migra-tion. Canadian Journal of Fisheries and Aquatic Sciences, 55(3), 682-687.

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S., Carlson, T. J., ... & Tavolga, W. N. (2014). Sound exposure guidelines. In ASA S3/SC1. 4 TR-2014 sound exposure guidelines for fishes and sea turtles: A technical report prepared by ANSI-accredited standards committee S3/SC1 and registered with ANSI (pp. 33-51). Cham: Springer International Publishing.

Shelton, R. G. J., Turrell, W. R., Macdonald, A., McLaren, I. S. & Nicoll, N. T. (1997). Records of post-smolt Atlantic salmon, Salmo salar L., in the Faroe–Shetland Channel in June 1996. Fisheries Research 31, 159–162.

Strøm, J.F., Thorstad, E.B., Chate G, Sigrunn H. Sørbye, Righton D., Audun H. Rikardsen, Carr J. (2017) Ocean migration of pop-up satellite archival tagged Atlantic salmon from the Miramichi River in Canada. *ICES Journal of Marine Science*, Volume 74, Issue 5, May-June 2017, Pages 1356–1370, https://doi.org/10.1093/icesjms/fsw220 [Accessed January 2026].

Tang, J. and C.S. Wardle. 1992. Power output of two sizes of Atlantic salmon (Salmo salar) at their maximum sustained swimming speeds. Journal of Experimental Biology. 66:33-46.

Thorstad, E., Kland, F., Finstad, B., Sivertsgrd, R., Bjorn, P., & McKinleyd, R. (2004). Migration speeds and orientation of Atlantic salmon and sea trout post-smolts in a Norwegian fjord system. Environmental Biology of Fishes, 71(3), 305-31

Thorstad, E. B., Whoriskey, F., Uglem, I., Moore, A., Rikardsen, A. H., & Finstad, B. (2012). A critical life stage of the Atlantic salmon Salmo salar: Behaviour and survival during the smolt and initial post-smolt migration. Journal of fish biology, 81(2), 500-542.

ANNEX 12.2.1: SLIDE DECK: UNDERWATER NOISE ASSESSMENT ON ATLANTIC SALMON (25/07/2025)

Spiorad na Mara

Underwater Noise Assessment on Atlantic Salmon

Presentation of our approach

Welcome!

1. **Introductions**

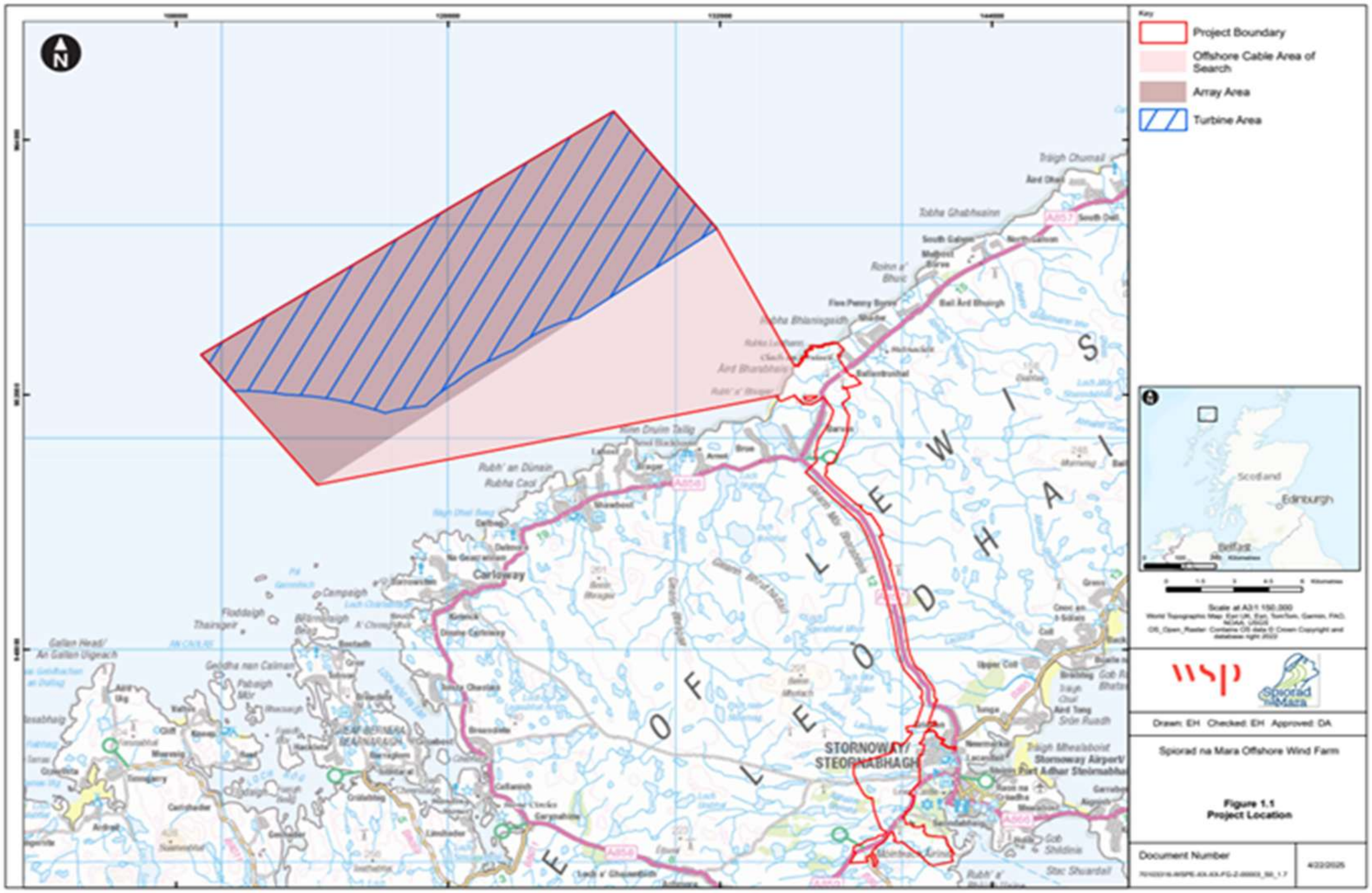
Agenda

Purpose of this engagement

To support engagement with NatureScot and MD-SEDD regarding the assessment of Underwater Noise (UWN) impacts on Atlantic salmon and to seek the advice and confirmation from NatureScot and MD-SEDD on the following matters:

- Salmon ecology/ migration and baseline data collection / assumptions
- Approach to Environmental Impact assessment
- Approach to Habitats Regulations Appraisal (HRA)/Report to Inform Appropriate Assessment (RIAA) including discussion on connectivity between Special Areas of Conservation (SAC)s that feature Salmon

Project overview



- Project owned by Northland Power (75%) and ESB (25%)
- Located approximately 5-13km off west coast of the Isle of Lewis
- Up to 60 fixed bottom turbines
- Foundations will be of either 3-4 leg jacket or hybrid gravity based / jacket
- Piling Method: Percussive hammer with upto 4 pin piles per turbine (for piled foundations)
- Array cables connecting to offshore Sub-station with export cable to onshore TJB or onshore substation directly.

Atlantic salmon baseline conditions

General Lifecycle and Migratory Behaviour

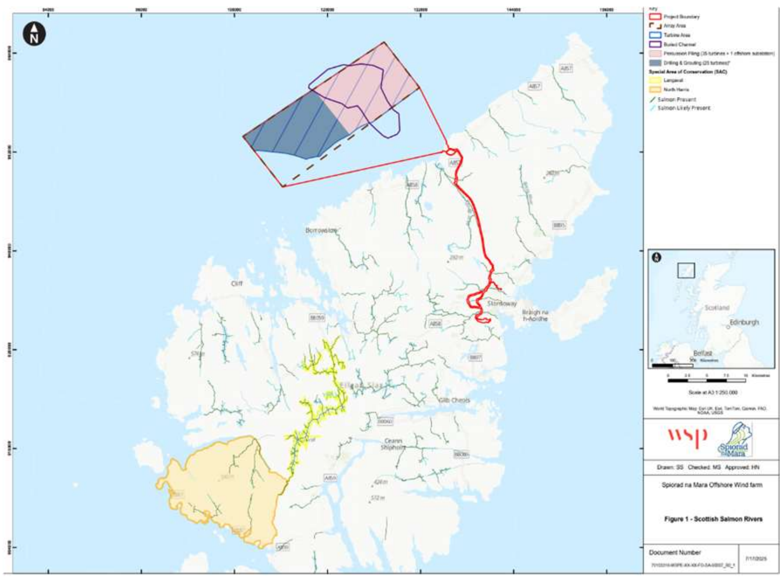
- Atlantic salmon exhibit complex life cycles with distinct marine and freshwater phases
- Salmonoid rivers draining to the west of the Isle of Lewis have been identified as this represents the most likely stocks to pass through the Offshore Project Boundary. Key loch systems / rivers identified in Technical Note and on figure.
- Pathway movement: Nearshore zone as key migration corridor

Baseline population

- Key Receptors: Atlantic salmon populations from designated SACs and nearby rivers.
- Proximity to SACs: ~19.7 km from Langavat SAC (Qualifying feature Atlantic salmon), ~31 km from North Harris SAC (Qualifying features Atlantic salmon and FWPM)

Data References

- **ZSL acoustic tagging** and **Atlantic Salmon Trust tracking studies** provide evidence of smolt migratory routes and timing.
- These datasets support assumptions on **diel activity patterns** (smolt movement during darkness) relevant to impact assessment
- **Rod catch data** from Scottish rivers used to infer seasonal presence and adult migration intensity.
- **Rodger et al. (2024)** tracking study shows post-smolts from rivers in western Scotland, Northern Ireland, and Ireland follow northerly migration routes, often passing through the **North Channel** and west of the Hebrides



➡ **Request 1:** Confirmation that these assumptions are appropriate for EIAR and RIAA.

➡ **Request 2:** Are there any assumption with regards to coastal movement corridors for Atlantic Salmon.

Approach to underwater noise modelling

Modelling Framework

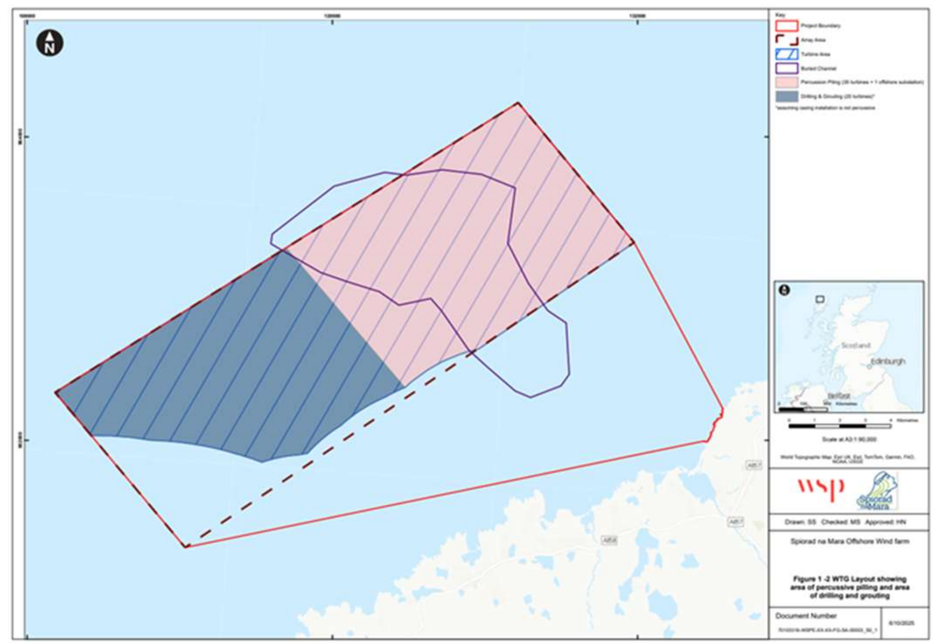
- Based on maximum design scenario from the Project Design Envelope
- Percussive piling, in the northeast portion of the site, only considered (drill & grout excluded due to negligible UWN impact)

Modelling Parameters

- **Maximum design scenario**: 35 turbines and 1 offshore substation using percussive piling
- **Piling method**: Hydraulic hammer with 4 pin piles per turbine and 16 for the substation
- **Variable maximum blow energy:** reducing toward the south
- **Propagation model**: Range-dependent, accounting for bathymetry, sediment, and water column

Temporal Scope

- Assessment based on **daily exposure**, not cumulative effects over the full construction period



Proposed UWN thresholds

Threshold Application

Use of Temporary Threshold Shift (TTS) onset contour as a precautionary threshold

186 dB re 1 μPa^2s SEL_{cum} TTS is applied (Popper et al., 2014), also as proxy for behaviour. PTS will also be included.

Assumes stationary fish at the point of exposure – recognised as a highly conservative assumption

Alternative Behavioural Assumptions

Consideration of swimming fish behaviour as a more realistic exposure scenario

Request 3: Views on suitability of this threshold and any alternative perspectives.

Request 4: Are the current assumptions appropriate for EIAR/HRA?

Request 5: Would NatureScot support a more realistic scenario (e.g. stationary vs. swimming fish) to better reflect migratory behaviour?

Request 6: Do Stakeholders agree with incorporating this into the modelling approach?

EIA: Impact assessment approach

Impact significance is determined by combining:

Magnitude: spatial extent, duration, reversibility, and timing of the effect.

Sensitivity: species' tolerance, adaptability, and recoverability, including auditory sensitivity.

Magnitude reflects ecological consequence (e.g. disruption to migration, recovery time), not just the extent of the noise at that level.

Assessment Matrix: Sensitivity and magnitude are combined to determine significance of effect (per CIEEM 2018 guidance).

Clarification: Spatial and temporal considerations can influence both magnitude and sensitivity assessments.

Request 7: Confirm alignment of this interpretation with NatureScot and MD-SEDD.

EIA: Temporal considerations

Temporal analysis will draw on our baseline understanding of Atlantic salmon movement patterns, we are looking to seek agreement with NatureScot and MD-SEDD on the relevant seasonal migration periods for Atlantic salmon:

- Smolt: April – April-May (2-week window)[1]
- Adults: May–August (peak June–July)
- Kelts: October–May

Request 8: Confirmation on the above key migration windows is sought from NatureScot and MD-SEDD.

In addition to seasonal timing, the diel (daily) activity patterns of emigrating smolts show increased movement during periods of darkness. Confirmation of the relevant diel migration windows is important to support the accuracy of the impact assessment.

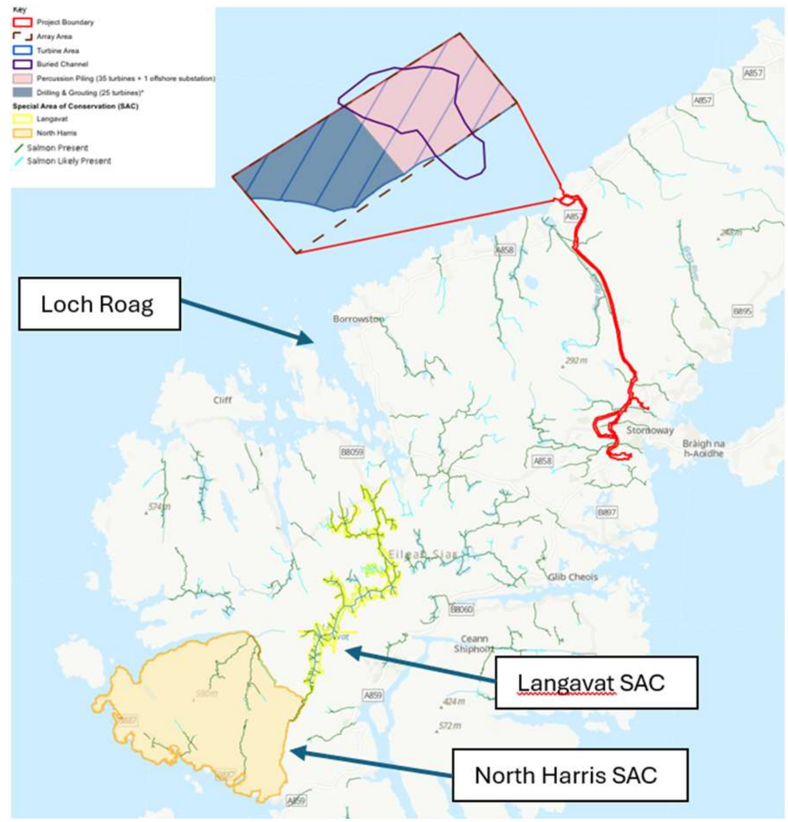
Request 9: Confirmation on the above key diel activity patterns is sought from NatureScot and MD-SEDD.

[1]50% of population migrating over two-week period: Graeme Diack, George Brown, & Colin Bull. **(2021).** *Atlantic salmon smolt migration timing for 9 rivers across UK, Ireland and France*. Knowledge Network for Biocomplexity. urn:uuid:e3939e37-bc7c-488b-b64d-43c0494a3593.

EIA: Spatial considerations

Assessment of Atlantic salmon will consider spatial extent of potential disturbance. There are two key spatial aspects that will be assessed:

- The broader migratory corridor used by Atlantic salmon as they pass along the west coast of Isle of Lewis.
- Localised access points at the entrances to estuaries and natal rivers, which are critical for the final stages of the migration route.



Request 10: Confirmation on the expected key migratory pathway for Atlantic salmon returning to natal rivers is sought from NatureScot and MD-SEDD.

EIA: Exposure considerations

No direct density estimates available for Atlantic salmon across all salmon rivers. There are stock estimated for Langavet SAC (2023 rod catch data) and North Harris SAC (2017 raw rod catch data).

Due to lack of available density data, two options could be used as a proxy:

Option 1: Spatial Assessment

- Divides fish stock by area
- Assumes even distribution (not realistic as doesn't account for migratory behaviour)
- Not preferred

Option 2: Temporal Assessment

- Uses average migrating fish per day
- Reflects seasonal/daily movement
- <u>Preferred method</u>

Request 11: The assessment applies a precautionary threshold as a basis for determining potential significance. We consider this to be a scientifically justified and proportionate approach in the context of the available evidence. However, we would welcome any feedback or alternative perspectives that NatureScot and MD-SEDD may wish to offer on this approach, particularly regarding the suitability of Option 2 as the preferred method for estimating exposure in the absence of robust spatial density data.

HRA: Protected sites

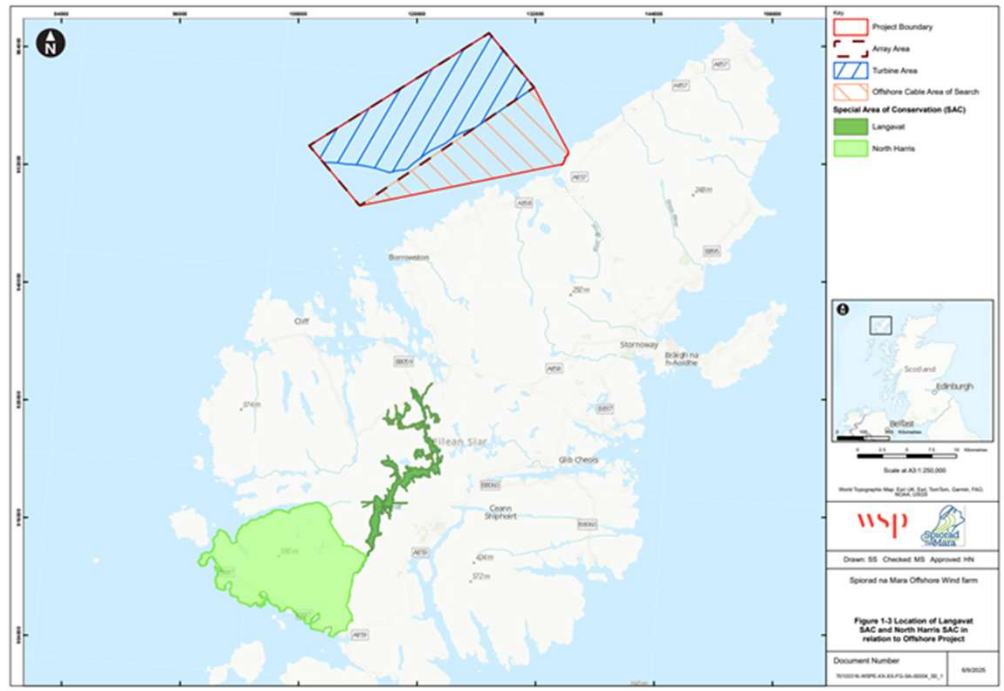
Regional Populations

- Atlantic salmon populations are present in rivers near the project area, including those connected to **Langavat SAC** and **North Harris SAC**
- These SACs are designated for their importance to migratory salmon and are considered key ecological receptors

Designated Sites and Connectivity

- Clarification sought on whether **North Harris SAC** and **Langavat SAC** are **hydrologically connected**
- Discrepancy in NatureScot’s Scoping Opinion vs. mapped boundaries.
- Potential for salmon to enter/exit via **Loch Roag** is under consideration
- These factors influence assumptions on migratory pathways and exposure zones for underwater noise modelling

Request 12: Advice on whether salmon from North Harris SAC could enter/exit via Loch Roag.



HRA: Conservation objectives

The RIAA will need to make the assessment for the conservation objectives for the SACs.

Langavat SAC:

1. To ensure that the qualifying feature of the Langavat SAC is in favourable condition and makes an appropriate contribution to achieving favourable conservation status.

2. To ensure that the integrity of the Langavat SAC is restored by meeting objectives 2a, 2b and 2c for the qualifying feature

   a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site

   b. Restore the distribution of Atlantic salmon throughout the site

   c. Maintain the habitats supporting Atlantic salmon within the site and availability of food

North Harris SAC:

1. Population of the species, including range of genetic types for Atlantic salmon, as a viable component of the site

2. Distribution of the species within site

3. Distribution and extent of habitats supporting the species

4. Structure, function and supporting processes of habitats supporting the species

5. No significant disturbance of the species

6. Distribution and viability of FWPM host species

7. Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species

HRA: Approach

Key Elements of the HRA Approach:

Assessment Basis:
Draws on outputs from the EIAR, including underwater noise modelling, baseline data, and impact assessment.

Focus SACs:

Langavat SAC (Atlantic salmon)

North Harris SAC (Atlantic salmon and FWPM)

Assessment Criteria:

Spatial extent of UWN relative to migratory pathways and estuarine access points

Temporal overlap with key migration windows (e.g. smolt out-migration, adult return)

Use of TTS onset threshold (186 dB SELcum) as a precautionary benchmark

Assessment Outcome:

Evaluate potential for adverse effect on site integrity (AEOI)

Consideration of mitigation (e.g. -12 dB source reduction) and avoidance opportunities

Potential further mitigation measures?

Specific mitigation measures to reduce UWN are yet to be finalised, however the Project is committed to achieve a -12dB in noise levels using noise abatement techniques and will use the drill and grout approach in approximately 50% of the site.

Follow further assessment work and design development, additional mitigation may be required to reduce the potential impact. Should this be required, the Project will consider mitigation that are feasible to deliver from an engineering perspective and could consider mitigation that encompasses:

- Scheduling of piling activities based on daylight cycle
- Scheduling for rate of piling activities per day / month / year
- Spatial based construction sequencing of turbine installation
- Speed and duration of piling activities

Request 13: What is your opinion on the existing measures incorporated into the Project?

Request 14: What is your opinion on potential further measures (if required) and are there any further mitigation measures that the Project could consider?

Summary of key requests

Atlantic salmon baseline conditions

1. Confirmation that these assumptions are appropriate for EIAR and RIAA.
2. Are there any assumption with regards to coastal movement corridors for Atlantic Salmon

Proposed UWN Thresholds

3. Views on suitability of this threshold and any alternative perspectives.
4. Are the current assumptions appropriate for EIAR/HRA?
5. Would NatureScot support a more realistic scenario (e.g. stationary vs. swimming fish) to better reflect migratory behaviour?
6. Do Stakeholders agree with incorporating this into the modelling approach?

Impact Assessment Approach

7. Confirm alignment of this interpretation with NatureScot and MD-SEDD.

Temporal Considerations

8. Confirmation on the above key migration windows is sought from NatureScot and MD-SEDD.
9. Confirmation on the above key diel activity patterns is sought from NatureScot and MD-SEDD.

Spatial Considerations

10. Confirmation on the expected key migratory pathway for Atlantic salmon returning to natal rivers is sought from NatureScot and MD-SEDD.

Exposure Considerations

11. The assessment applies a precautionary threshold as a basis for determining potential significance. We consider this to be a scientifically justified and proportionate approach in the context of the available evidence. However, we would welcome any feedback or alternative perspectives that NatureScot and MD-SEDD may wish to offer on this approach, particularly regarding the suitability of Option 2 as the preferred method for estimating exposure in the absence of robust spatial density data.

HRA protected sites

12. Advice on whether salmon from North Harris SAC could enter/exit

Potential further mitigation measures?

13. What is your opinion on the existing measures incorporated into the Project?
14. What is your opinion on potential further measures (if required) and are there any further mitigation measures that the Project could consider?


Thank You
www.spioradnamara.co.uk

ANNEX 12.2.2: UNDERWATER NOISE SALMON IMPACT ASSESSMENT MEETING (10/10/2025)

Underwater Noise Assessment on Atlantic Salmon

Update of assessment progress

Agenda

1. Introductions
2. Purpose of this engagement
3. Project updates and progress since last meeting
4. Salmon migratory patterns
5. Adult salmon baseline (rod/stock analysis)
6. Underwater modelling parameters
7. Post smolt swim speed
8. EIA: salmon UWN impact assessment
9. HRA: assessment progress

Purpose of this engagement

To provide an updated on the assessment of Underwater Noise impacts on Atlantic salmon undertaken following the previous meeting and feedback provided. This engagement will provide updates on:

- EIA adult Atlantic salmon baseline information from rod catch and stock assessment analysis
- Underwater noise modelling parameters used and outputs
- EIA outputs for impacts on salmon and measures to be used to minimise effects

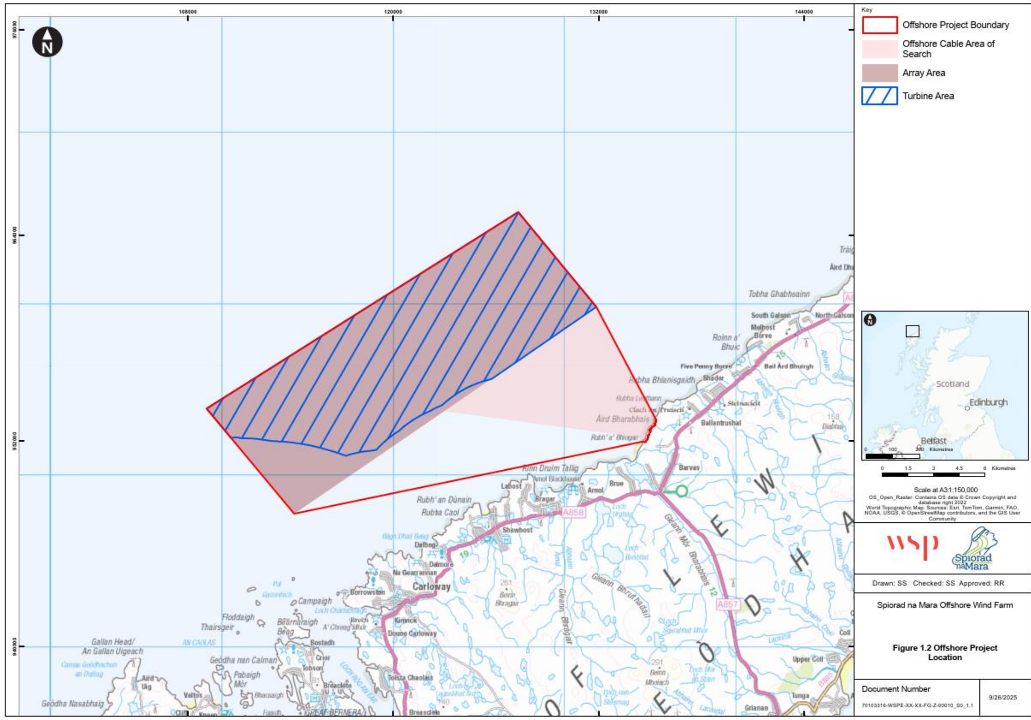
Project updates and progress since last meeting

Project updates:

- Refinement of Offshore Cable Area of Search following fisheries stakeholder feedback and assessment work.
- Split of offshore and onshore applications following further onshore Grid Substation location optioneering being required.

UWN and Fish assessment progress:

- Reviewed and incorporated stakeholder feedback into assessment received following last meeting.
- Updated and shared Swim Speed Technical Note to provide further clarity on movement speeds to be used in the assessment.
- Reviewed rod catch / stock analysis and incorporated information into assessment baseline.
- Further refined mitigation measures to be used by the Project to reduce potential effects to achieve an acceptable outcome.
- Completed Fish Ecology underwater noise impact assessment for Atlantic salmon.
- Begun work on the fish ecology assessment for the RIAA.



Salmon Migration Patterns

Inward Migration (Fish entering rivers from the sea to spawn)		
Fish Type	**Timing**	**Notes**
Adult MSW	Jan–Apr	Older salmon returning in late winter to early spring
Grilse (1SW)	May–Late Autumn	Younger salmon, 1 winter at sea
2SW Females	May (Peak in June)	Slightly older females

Outward Migration (Fish leaving rivers to return to the sea)		
Fish Type	**Timing**	**Notes**
Kelts	Oct-May	Post-spawning salmon leaving rivers. May stay in rivers or estuaries before migrating.

SW stands for 'Sea Winter', indicating the number of winters a salmon has spent at sea before returning to freshwater to spawn. 1SW (Grilse) = 1 winter, 2SW = 2 winters, 3SW = 3 winters. MSW (Multi Sea Winter) refers to salmon that have spent more than one winter at sea. Kelts are post-spawning salmon that survive spawning and return to the sea.

Adult salmon baseline (rod/stock analysis)

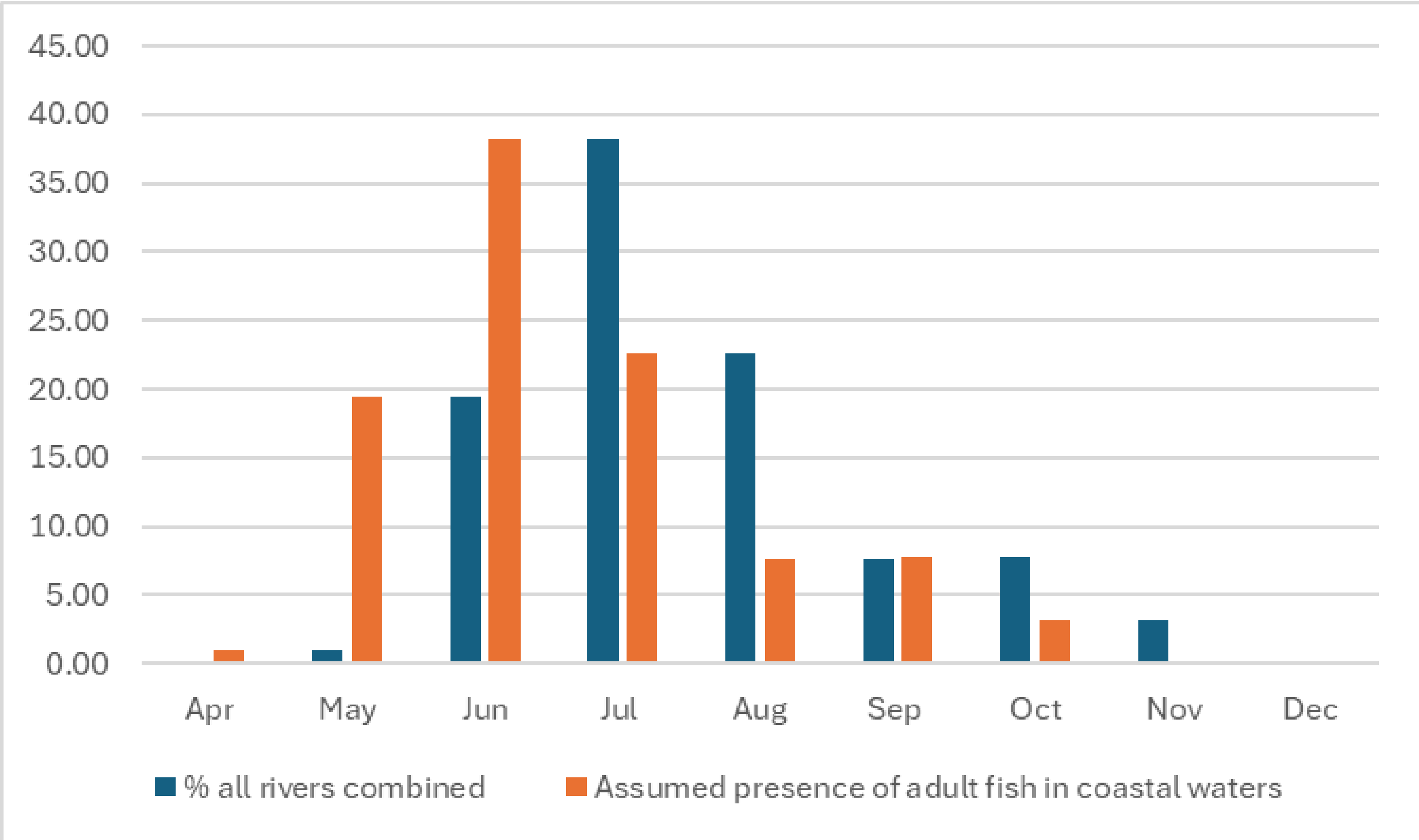
Actions from July meeting

- Document the rationale and assumptions behind the chosen exposure methodology.
- Clearly state the limitations of rod catch data and the implications for confidence levels.
- Explore the use of multi-year aggregated data and consult the Freshwater Lab on extrapolation techniques.
- Consider framing exposure in terms of population proportions rather than absolute numbers.
- Identify what additional data would improve future assessments and propose monitoring or validation measures where possible.

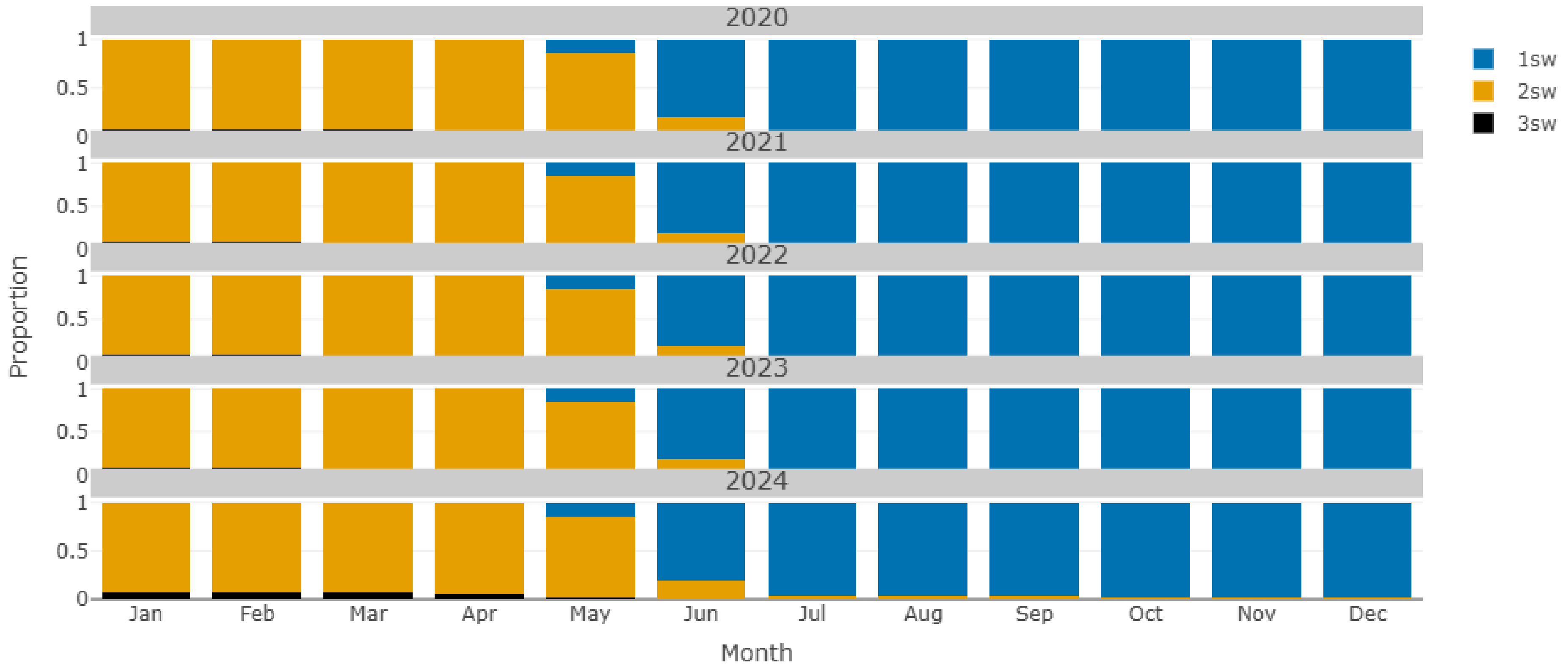
Atlantic salmon population estimates

- An analysis of raw rod catch and stock assessment data was undertaken to support an estimate of the proportion of the adult Atlantic salmon population within the project study area
- Thirteen years of raw rod catch data (2011 to 2023) and five years of stock assessment data (2020 to 2024) were accessed via the Marine Scotland website.
- The analysis of stock assessment data focused on converting rod catch data to fish numbers based on published correction factors, including flow and month, to account for variations in angling conditions.
- The five river systems within the Loch Roag salmon fishery district were included since these were considered the most likely to support fish which would pass through project area.
- The highest estimate of returning fish across all river systems occurred in July, with the second highest predominantly falling in August.
- For all rivers the small number of 3SW fish enter the rivers from January to April.
- 2SW fish represent the largest proportion between January and May, and 1SW from June to December.

Proportion of adult salmon assumed to be in coastal waters by month based on stock assessment data



Proportion of age class spawners by month

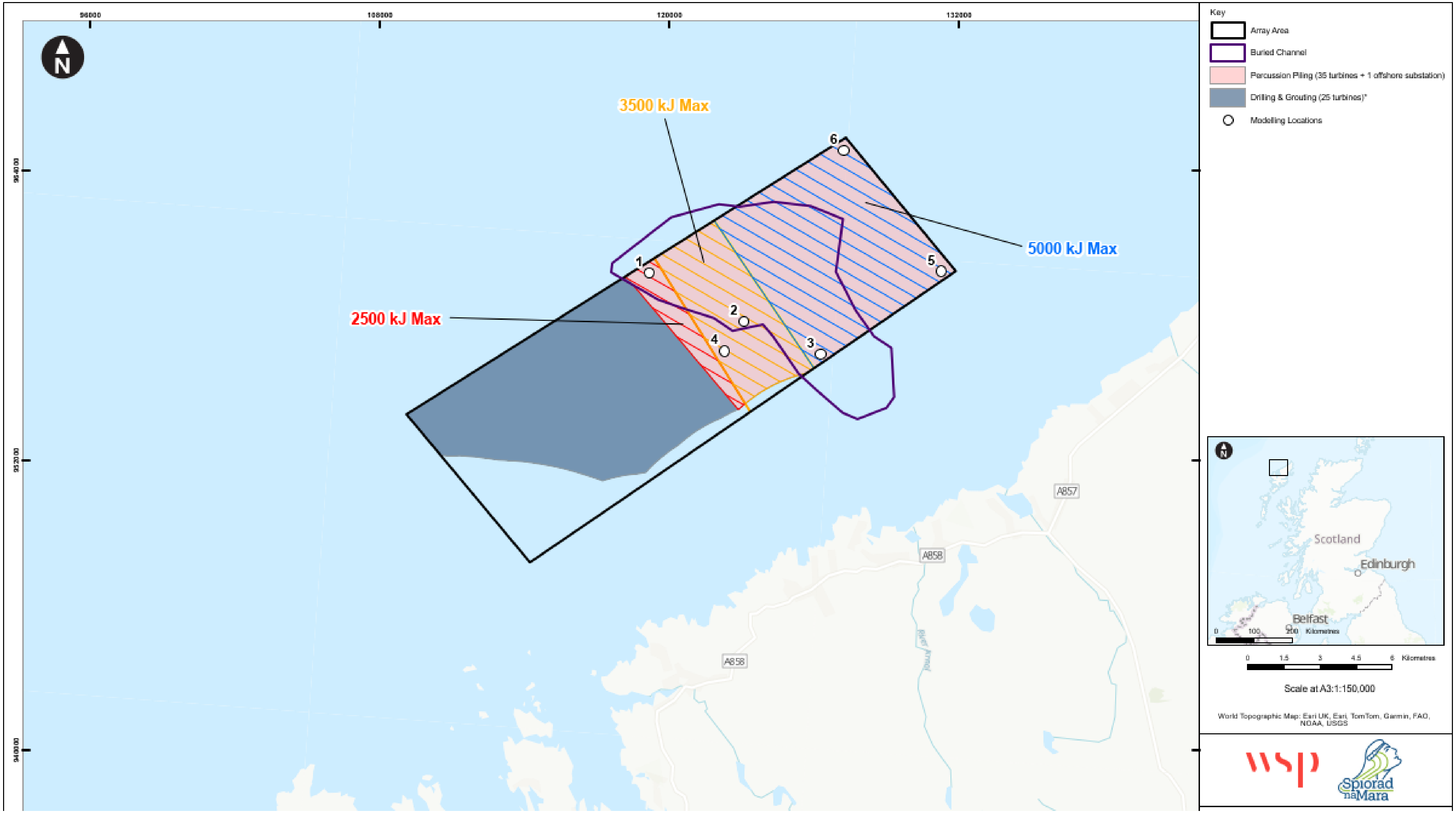


EIA assumptions

- Assume all age classes of returning adults are present in coastal waters (and therefore at risk of effects from piling noise) for **4 weeks prior to the month in which they were recorded in their natal rivers**.
- Given that piling operations will take place between April and October (inclusive) **almost all the population (99.82%) may pass through the ensonified zone at least once during their inward migration, with the outward migrating kelts potentially passing through twice or more in consecutive years.** This will be limited due to kelts outward migration period (October to May).
- MSW fish, which represent less than 1% of the population by number, but contribute a significant proportion of eggs, are **unlikely to pass through the ensonified zone** since their migrations occur between January and March.

Limitations

- Limited data points in the rod catch, and therefore stock assessment data for most river systems
- Rod catch returns could have been misreported.
- Fishing effort is not standardised across river systems or accounted for in stock assessment models.
- In Langavat the fishing season only starts in June and ends in October. In the stock assessments that means no fish are modelled as returning in January-May or November-December. This is also an unrealistic assumption, which should lead to an underestimate of returning adults.
- Efforts/Catch success could also have been hindered by weather conditions and hydrology which are known to influence Atlantic salmon runs and only partly accounted for using correction factors in stock assessment.
- The characteristics of the 9 reference rivers used as proxies in the model and weighting of co-variables may not accurately reflect Hebridean river systems.
- There is limited evidence for the period in which fish are migrating through coastal waters prior to entering their natal rivers. The estimate of one month is likely to be over precautionary.



96000
108000
120000
132000
964000
952000
940000
N
3500 kJ Max
5000 kJ Max
2500 kJ Max
1
2
3
4
5
6
A857
A858
A858
Key
Array Area
Buried Channel
Percussion Piling (35 turbines + 1 offshore substation)
Drilling & Grouting (25 turbines)*
Modelling Locations
Scotland
Edinburgh
Belfast
0 100 200 Kilometres
0 1.5 3 4.5 6 Kilometres
Scale at A3:1:150,000
World Topographic Map: Esri UK, Esri, TomTom, Garmin, FAO, NOAA, USGS
Spiorad na Mara

Underwater noise modelling parameters

Temporal Scope

- Assessment based on daily exposure, not cumulative effects over the full construction period
- Piling to take place between April – October over a 2-year period

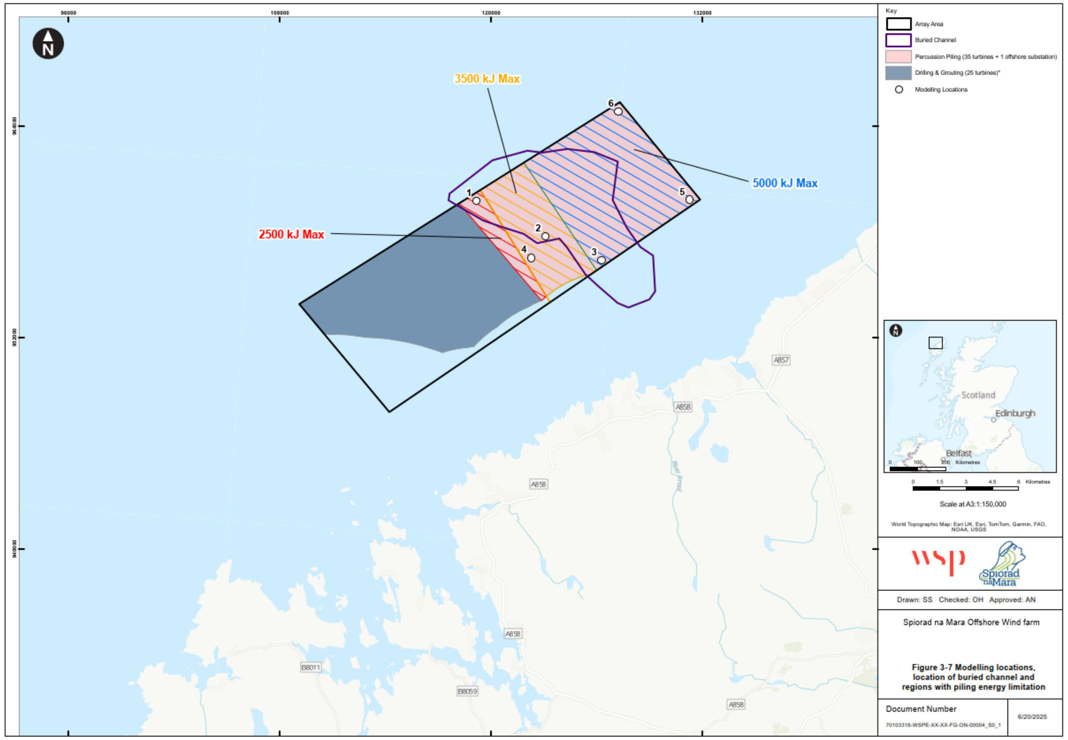
Threshold Application

- Use of TTS onset contour (Popper *et al.*, 2014) as a precautionary threshold for Atlantic salmon disturbance

Dual approach

Consideration of swimming fish behaviour as a more realistic exposure scenario:

- Smolts assessed using swimming / fleeing scenario parameters
- Adults assessed using stationary parameters



Post smolt swim speed

Post smolt modelled as a moving receptor (transient use of coastal areas)

- Realistic swim speed related to likely behavioural response to impulse noise
  - Movement away from the noise source (standard in UWN modelling)
  - Relatively undisturbed by pile driving (lack of or reduced behavioural response; Knudsen et al. 1992, Harding et al. 2016)

Modelling parameters

- Movement away from the noise source = experienced as unpleasant resulting in elevated, but sustainable swim speeds
  - Based on controlled experiments, maximum sustained swimming speeds for smolt / post smolt 10-20 cm recorded between **2.6- 10.16 BL s^{-1}** (Booth et al. 1997, Tang & Wardle 1992, Peak & McKinley 2008)
  - **4.4 BL s^{-1}** used for modelling (Booth 1998)

- Where no or reduced behavioural response is assumed, swimming speeds for post smolts not exposed to pile driving are used
  - From studies actively following fish and accounting for effect of currents etc.
  - **1.2 BL s^{-1}** used for modelling (Newton, pers com; Thorstad et al. 2004)

- Based on mean length of smolt leaving Grimersta (*n* = 677) swim speeds assumed to be **0.604** and **0.165 m s^{-1}**

Assessment method - Sensitivity

3 factors incorporated into sensitivity scale:

- **Tolerance** (ability of a feature to absorb stress or disturbance without changing character).
- **Recoverability** (temporal scale and extent to which a feature will recover following an effect).

	Tolerance			
Recovery	**None**	**Low**	**Medium**	**High**
Very low	High	High	Medium	Low
Low	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
High	Medium	Medium	Low	Negligible

- **Value** (nature conservation status). 4-point scale from High (International/National); Medium (Regional); Low (Local); Negligible

Sensitivity – Atlantic salmon and underwater noise

High tolerance

- Relatively low auditory sensitivity
- Group 2 - Fish with a swim bladder that does not aid in hearing; Limited to detecting particle motion; Narrow hearing bandwidth. Popper et al (2014)

Low recoverability

- Depleted stocks – minor effects on survival could be important at population level

High value - qualifying feature for several Special Areas of Conservation (SAC) in the near vicinity (the Langavat and North Harris SACs).

Overall sensitivity – Medium

Embedded mitigation measures

Embedded mitigation measures, are those measures which are integrated into the design process of the project and are considered as part of the Project within the topic assessments.

Embedded mitigation measures include:

- No percussive piling zone
- -12dB noise abatement at source
- Piling programme restrictions: April to October over a 2-year window
- Variable maximum blow energy reducing toward the south

Impact magnitude

Definition: Level of change based on duration, timing, scale, size and frequency to determine the magnitude of the impact to each receptor.

4-point scale:

Magnitude of Impact	Definition
Negligible	Changes to baseline conditions within the range of natural variability.
Low	Partial loss and/or recoverable alteration to the extent, composition or character of a habitat/community, or population of a species, with recovery expected within less than 5 years.
Medium	Partial loss and/or recoverable alteration in extent, composition or character of a habitat/community, or population of a species, with recovery expected within 5-10 years.
High	Changes to natural conditions that alters the extent, composition or character of a habitat/community, or population of a species beyond the ability of the receptor to recover within a period of 10 years.

Impact magnitude – Underwater noise

5 categories of effect based on Popper et al (2014) criteria:

- Mortality and potential mortal injury
- Recoverable injury
- Temporary Threshold Shift (TTS)
- Masking
- Behavioural changes

Quantified criteria for evaluating noise impacts in salmon:

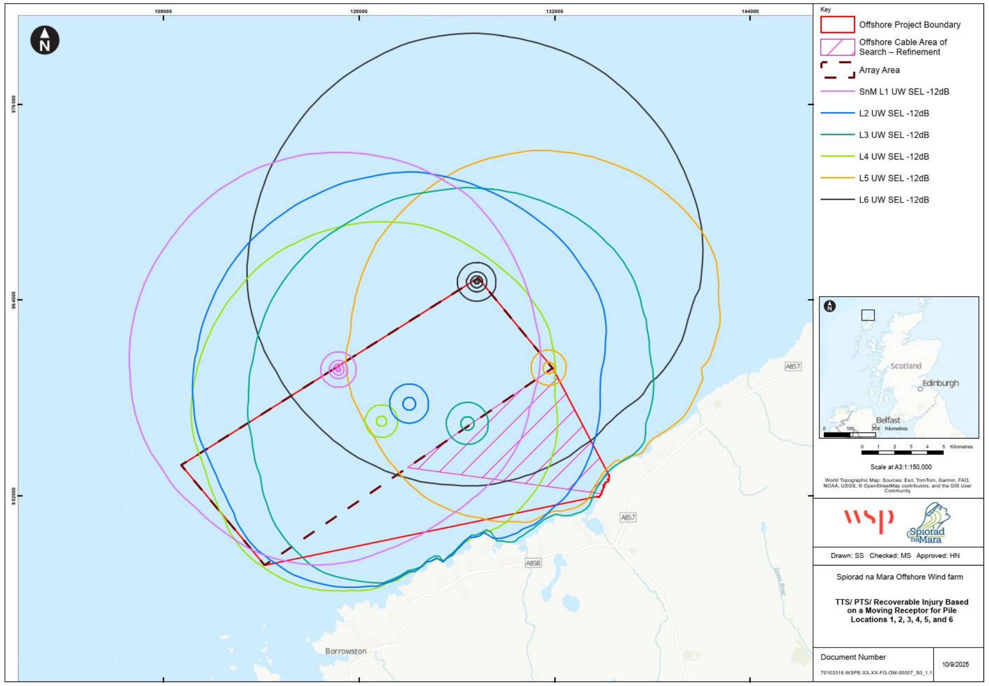
- Mortality	210_{SELcum} dB re 1 $\mu Pa^2 s$
- Recoverable injury	203_{SELcum} dB re 1 $\mu Pa^2 s$
- TTS	$>186_{SELcum}$ dB re 1 $\mu Pa^2 s$

Impact magnitude - Impact ranges

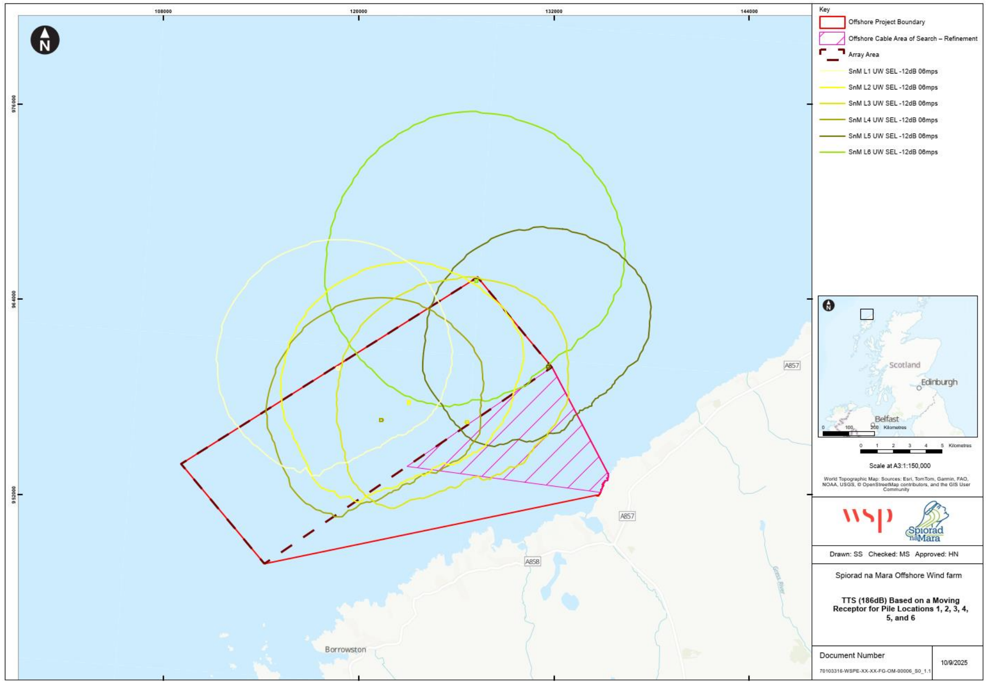
Impact ranges for TTS at example location (Location 1; 2,500kJ) using SELcum metric

	Stationary receptor	Moving receptor (0.6 m·s⁻¹)
Relevant receptor	Adult salmon	Atlantic salmon smolts
Maximum range (km)	15	7.9
Minimum range (km)	11	5.4
Mean range (km)	13	7

Adult



Smolt



Significance of effect

Species	Sensitivity	Impact magnitude	Embedded mitigation	Significance
Mortality and potential mortal injury			• No percussive piling zone • -12dB noise abatement • Piling programme restrictions • Variable hammer energy	
Salmon (adults)	Medium	Low		Minor (Not significant)
Salmon (smolt)	Medium	Low		Minor (Not significant)
Recoverable injury				
Salmon (adults)	Medium	Low		Minor (Not significant)
Salmon (smolt)	Medium	Low		Minor (Not significant)
TTS				
Salmon (adults)	Medium	Medium		**Moderate (Potentially significant)**
Salmon (smolt)	Medium	Medium		**Moderate (Potentially significant)**
Masking				
Salmon (adults)	Medium	Low		Minor (Not significant)
Salmon (smolt)	Medium	Low		Minor (Not significant)
Behavioural changes				
Salmon (adults)	Medium	Low		Minor (Not significant)
Salmon (smolt)	Medium	Low		Minor (Not significant)

Significant of effect matrix

		Sensitivity of Receptor/Receiving Environment to Change/Effect			
		Negligible	**Low**	**Medium**	**High**
Magnitude of Change/ Effect	**Negligible**	Negligible (Not Significant)	Negligible (Not Significant)	Negligible (Not Significant)	Negligible (Not Significant)
	Low	Negligible (Not Significant)	Negligible (Not Significant)	Minor (Not Significant)	Minor (Not Significant)
	Medium	Negligible (Not Significant)	Minor (Not Significant)	**Moderate** (Potentially Significant)	**Moderate** (Potentially Significant)
	High	Negligible (Not Significant)	Minor (Not Significant)	**Moderate** (Potentially Significant)	**Major** (Significant)

Assessment Matrix: Sensitivity and magnitude are combined to determine significance of effect (CIEEM 2018 guidance).

Secondary mitigation measures

Mitigation is proposed to enable sufficient spatial and temporal access to the migratory window

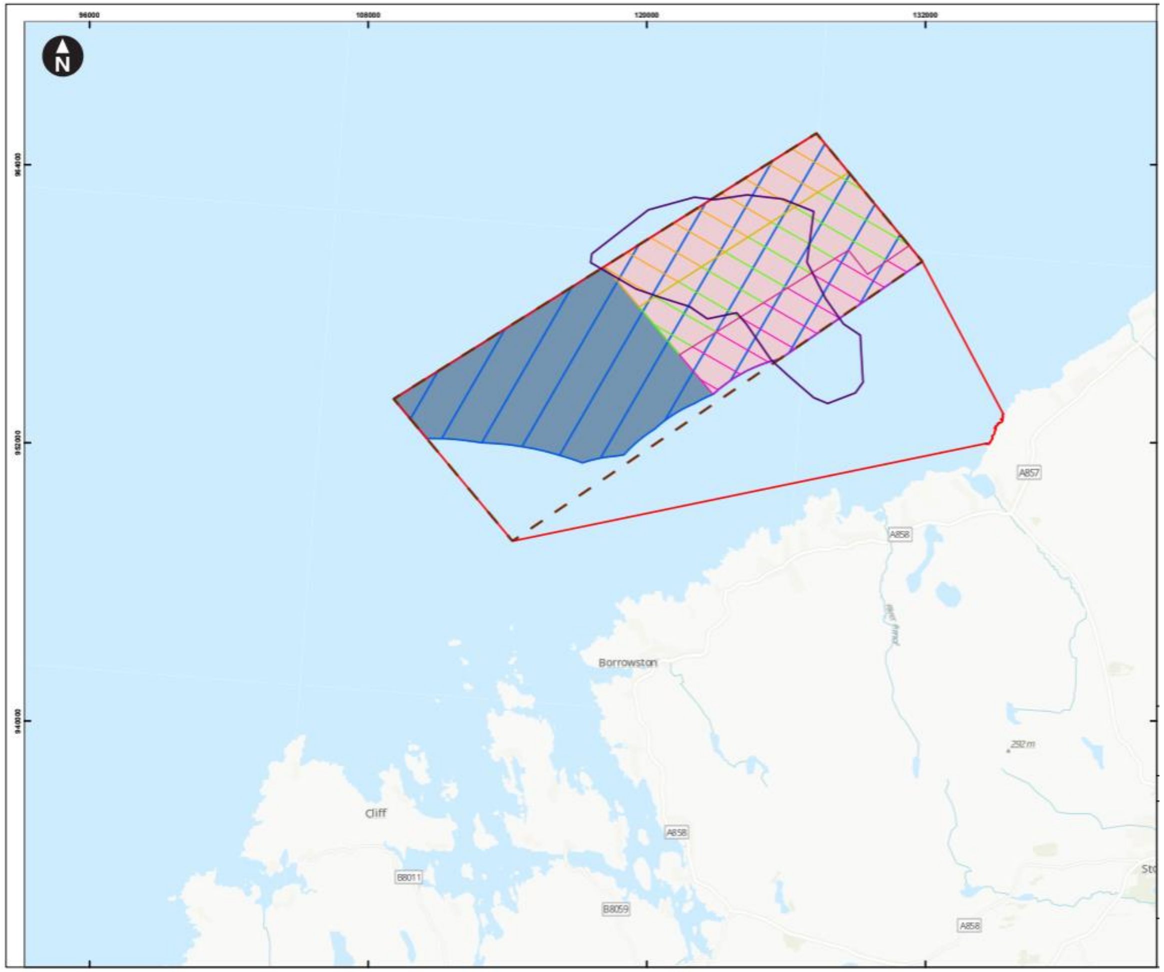
Spatial mitigation

- The coastal corridor maintained in key sensitive migratory periods by managing pile locations

Temporal mitigation

- Managing pile timings to allow respite period

Proposed sequence of foundation installation due to UWN impact on Atlantic Salmon migration



Orange Zone

Piling can occur April - October

Consideration of continuous quiet period during June and July.

Green Zone

Piling can occur April - October

Consideration of continuous quiet period during April and May.

Purple Zone

Piling can only be undertaken in September and October.

Consideration of continuous quiet period during September and October.

Grey Zone

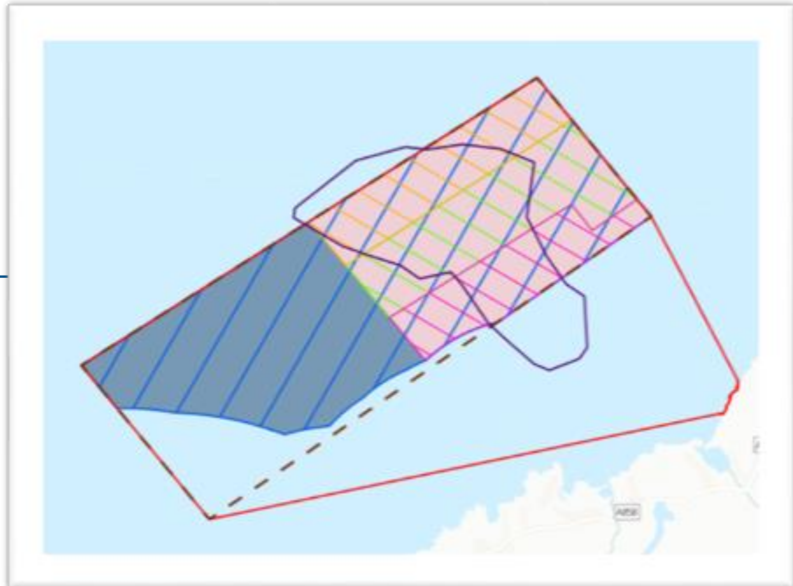
No percussive piling

Proposed sequence of foundation installation due to UWN impact on Atlantic Salmon migration

Piling Permissions Calendar by Zone

Species Migration	April	May	June	July	August	September	October
Kelt Migration (seawards)							
Smolt Migration (seawards)							
Atlantic Salmon Migration			Peak period	Peak period			
Construction activity							
Orange Zone Piling							
Green Zone Piling							
Purple Zone Piling							

- Piling Permitted
- Piling Not Permitted
- Piling Permitted – with quiet period in piling operations
- Migration periods



Orange Zone: Piling is allowed in **April to October** - with quiet periods in **June** and **July**.

Green Zone: Piling is allowed in **April to October** - with quiet periods in **April** and **May**.

Purple Zone: Piling is only permitted in **September** and **October** - quiet periods for all operations.

Proposed sequence of foundation installation due to UWN impact on Atlantic Salmon migration

Spatial Area	Mitigation	Receptor	Justification
Orange Zone	Piling operations between April and October can occur with targeted quite periods in June and July.	Atlantic Salmon (returning adults) - qualifying features of Langavat SAC and North Harris SAC and resident populations from other salmon rivers along the coast. Peak migration of returning adults (returning adult salmon)	To allow passage of returning Adults.
Green Zone	Piling operations between April and October can occur with targeted quite periods in April and May.	Atlantic Salmon (returning adults) - qualifying features of Langavat SAC and North Harris SAC and resident populations from other salmon rivers along the coast. Spring migration of kelts may occur (adult salmon leaving the estuary)	To avoid smolt emigration and returning adults.
Purple Zone	Piling operations between April and August cannot occur. Piling operations between September and October.	Atlantic Salmon (Smolt emigration and returning adults) - qualifying features of Langavat SAC and North Harris SAC and resident populations from other salmon rivers along the coast.	To avoid smolt emigration and returning adults.

References: Bjerck et al., 2021; Lothian et al., 2018; Haraldstad et al., 2016; Lefèvre et al., 2012

Residual Effect

Receptor	Sensitivity	Magnitude	Embedded mitigation	Significance of effect	Further mitigation	Residual significance
TTS						
Atlantic salmon (adult)	Medium	Medium	• No percussive piling zone • -12dB noise abatement • Piling programme restrictions • Variable hammer energy	Moderate (**Potentially significant**)	• Zonal piling sequencing for maintenance of seasonal coastal corridors • Provision of respite	Minor (**not significance**)
Atlantic salmon (smolt)	Medium	Medium		Moderate (**Potentially significant**)		Minor (**not significance**)

HRA: assessment progress

Regional Populations

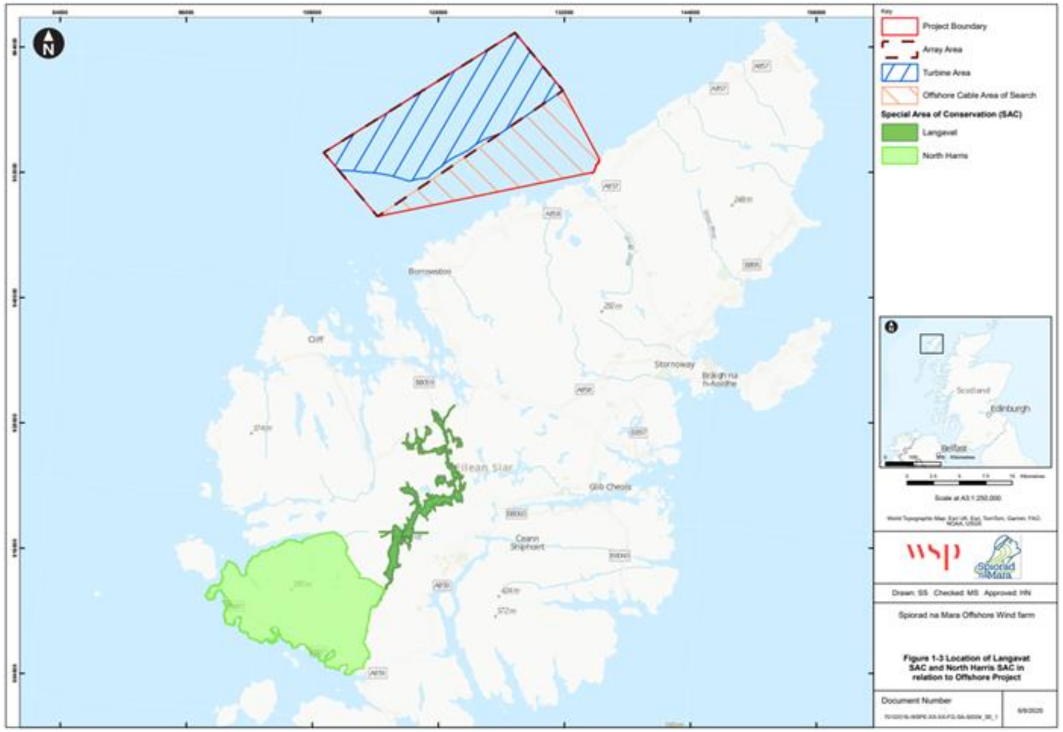
- Atlantic salmon populations are present in rivers near the project area, including those connected to **Langavat SAC** and **North Harris SAC**
- These SACs are designated for their importance to migratory salmon and are considered key ecological receptors
- (FWPM also a qualifying feature (North Harris) and impacts on migratory brown trout are considered (host))

Designated Sites and Connectivity

- No biological freshwater connectivity between SACs (separate populations)

Approach

- EIA assessment approach applied to specific conservation objectives
- Fewer salmon populations allows for higher resolution of key migratory periods – where data is available
- Assessments of AEOI according to maintaining (North Harris SAC) or recovering (Langavat SAC) qualifying features




Thank You
www.spioradnamara.co.uk

ANNEX 12.2.3: MEDIAN NUMBERS OF FISH IN RIVERS IN THE LOCH ROAG SALMON FISHERY DISTRICT AREA BASED ON STOCK ASSESSMENT

River Bravas	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
2020		0	387	831	464	324	331	132		2469
2021			21	301	252	60	62	25		721
2022			258	296	223	76	77	30		960
2023			0	81	75	67	68	27		318
2024			78	357	299	89	91	36		950
Total										5418
Monthly median by year			**78**	**301**	**252**	**76**	**77**	**30**		**814**
Percentage proportion of median			**9.58231**	**36.97789**	**30.95823**	**9.336609**	**9.459459**	**3.685504**		
River Carloway										
2020	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Sum**
2021			No data							
2022				17	35	11	11	5		
2023				8	8	7	7	3		
2024				8	16	8	8	4		
River Blackwater	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Sum**
2020		65	528	675	108	163	166	67		1772
2021			21	93	48	32	33	13		240
2022			138	409	256	182	180	74		1239
2023	11		0	147	49	22	22	9		260
2024			105	315	408	77	77	31		1013
Total										4524
Monthly median by year	**11**	**65**	**105**	**315**	**108**	**77**	**77**	**31**		**789**
Percentrage proportion of median	**1.39417**	**8.238276**	**13.30798**	**39.92395**	**13.68821**	**9.759189**	**9.759189**	**3.929024**		
Langavat SAC	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Sum**
2020		41	1093	1444	856	301	301	123		4159
2021		0	952	1981	848	321	319	131		4552
2022		104	2088	1757	916	290	283	117		5555
2023		0	442	506	205	133	136	54		1476
2024		0	399	1376	627	420	424	171		3417
Total										19159
Monthly median by year		**0**	**952**	**1444**	**848**	**301**	**301**	**123**		**3969**
Percentage proportion of median		**0**	**23.98589**	**36.38196**	**21.36558**	**7.583774**	**7.583774**	**3.099017**		

Loch Morsgail	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
2020			No data							
2021						4	4	2		
2022			No data							
2023			No data							
2024				75	99	21	21	8		

Mhor a' Ghlinne Ruaidh and Geisiada										
2020			No data							
2021			No data							
2022			No data							
2023			No data							
2024					5					

Forsa River	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
2020			89	513	125	29	29	12		797
2021			21	278	167	0	0	0		466
2022			82	336	139	57	60	24		698
2023				47	34	0	0	0		81
2024				255	132	16	16	6		425
			192	1429	597	102	105	42		2467
Total										4934
Monthly median by year			**82**	**278**	**132**	**16**	**16**	**6**		530
Percentage proportion of median			**15.4717**	**52.45283**	**24.90566**	**3.018868**	**3.018868**	**1.132075**		

Caslabhat and Tamanabhaigh	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
2020			11	62	108	11	11	5		208
2021			0	47	48	4	4	0		103
2022			9	130	68	16	16	6		245
2023			0	16	42	0	0	0		58
2024			0	26	68	13	13	5		125
Total										739
Monthly median by year			**0**	**47**	**68**	**11**	**11**	**5**		**142**
Percentage proportion of median			**0**	**33.09859**	**47.88732**	**7.746479**	**7.746479**	**3.521127**		