Loch Kemp Storage - EIA Report (Additional Information)

AI Appendix 13.1: Update to Mitigation Measures Proposed for Fish

September 2024

ash design + assessment
Suite 2/3, Queens House
19 St Vincent Place
Glasgow, G1 2DT

Tel: 0141 227 3388
Fax: 0141 227 3399

Email: info@ashglasgow.com
Web:
www.ashdesignassessment.com

Contents

List of Figures

List of Appendices

Update to Mitigation Measures Proposed for Fish

1.1 Introduction

1.1.1 The Appendix provides additional information on the fish deterrent system proposed in Loch Ness at the inlet for the Loch Kemp Storage Scheme, since the submission of the Section 36 Application for the proposed pumped storage hydro (PSH) scheme in November 2023.

1.2 Background

1.2.1 With regards to mitigation for fish, both paragraph 13.9.10 of **Volume 1, Chapter 13: Fish** of the EIA Report and Section 6.2.2 of the **Shadow Habitats Regulation Appraisal Report (HRA)** state:

1.2.2 ‘An *appropriately designed fish deterrent system will be installed which will deter fish from the draw of water from the intake, preventing entrainment / impingement at the screens and reducing predation impacts. Fish deterrent systems work best when multiple fish deterrent types are working in tandem and could include bubble curtains, acoustic fish deterrents (AFD) or intensive flashing light. Bubble curtains alone have been shown to divert salmon smolts with high efficiency under natural conditions.*

1.2.3 The conclusion in the Shadow HRA that the Loch Kemp Storage Scheme, prior to mitigation, is likely to undermine conservation objective 2a for the River Moriston SAC, is based on a precautionary principle, whereby there is no evidence to prove that some Atlantic salmon (*Salmo salar*) smolts exiting the River Moriston, undertaking an indirect migratory route, would not pass the inlet structures of the Loch Kemp Storage Scheme, located in in Loch Ness. The assessment in the Shadow HRA has therefore been undertaken based on the assumption that a proportion of smolts originating from the River Moriston would pass the inlet. However, following the implementation of appropriate mitigation measures, the Shadow HRA concludes that the Conservation Objectives pertaining to the population of salmon would not be compromised, even under the precautionary principle.

1.2.4 Similarly, the conclusion in **Volume 1, Chapter 13: Fish of the EIA Report** is that the inlet structures of Loch Kemp Storage Scheme, prior to mitigation, will have a significant effect on downstream migrating salmon and sea trout smolts is also based on a precautionary principle, whereby there is no evidence to prove that some smolts, undertaking an indirect migratory route through Loch Ness, would not pass the proposed inlet. The assessment in the EIA Report has therefore been undertaken based on the assumption that a proportion of smolts originating from the rivers within the upper Ness catchment would pass the inlet. However, following the implementation of appropriate mitigation measures, the assessment in the EIA Report concludes that there would be a minor (not significant) effect on smolts, even under the precautionary principle.

1.3 Fish Deterrent System

1.3.1 Since the submission of the Section 36 Application for the Loch Kemp Storage Scheme in November 2023, the Applicant has appointed Aztec Management Consultants (Aztec) to provide advice on a suitable deterrent system for Atlantic Salmon smolt. Aztec’s recommendation would be that rather than a bubble curtain and/or AFD system, the most effective method to deter smolt from the inlet would be to install a buoyed barrier net with 12.5 mm mesh spacing installed during the smolt season (March – June). Salmon smolt migrating through Loch Ness will generally have a fork-length[1] range of 10-15 cm and would not be able to pass through a net with 12.5 mm mesh spacing. The barrier net option for the deterrent system for smolt was first proposed to NatureScot in a Memo issued by the Applicant in April 2024 (see **Appendix A**).

1.3.2 An indicative net layout is shown in **Figure 1**. Hydraulic assessment undertaken by the Applicant (see **Appendix B**) demonstrates the PSH scheme would have no discernible influence on flows in Loch Ness out with approximately 27 m from the inlet screens when the facility is in its maximum pumping rate (i.e., the water velocity arising from the flow through the inlet screens would be equal to or less than natural water velocities within Loch Ness at ~27 m distance from the inlet screens, even under very calm conditions). This calculation is based on the area required within Loch Ness to dissipate the maximum flow volume through the half cylinder shaped intakes to the baseline flow velocities observed in water velocity surveys undertaken at the mouth of the River Moriston by Aspect Land & Hydrographic Surveys Ltd (ALHS) in June 2023[2].

1.3.3 Meteorological data for the ALHS monitoring period obtained from Inverness Airport[3] indicate that the wind conditions during the water velocity surveys were light breeze (4-6 knots) of wind direction ranging from 350 – 90 degrees (inverted from prevailing south-westerly winds). The closer Drumnadrochit met station was discounted as a reliable reference point due to its sheltered location within Urquhart Bay, which would provide unrepresentative wind conditions for the open Loch Ness waterbody. The wind conditions observed during the surveys were opposed to the natural flow of Loch Ness from the southwest into Loch Dochfour and the River Ness in northeast, which in turn would reduce the flow velocities observed in the water near the surface. Therefore, it is considered that the ALHS surveys were carried out during conservative conditions, when the natural water flow velocity in Loch Ness would have been low. These results therefore represent a reasonable worst-case scenario to compare the predicted flow velocity from the Loch Kemp Storage inlet structures on Loch Ness during a pumping cycle against natural conditions in the loch.

1.3.4 This zone of 'flow influence' from the Proposed Development during pumping represents ~0.0053% of the total area of Loch Ness. Additionally, this estimation conservatively assumes no vertical mixing effect within Loch Ness, just uniform horizontal mixing. In reality, the likely additional vertical mixing would aid flow dissipation, in turn reducing the distance to which the flow is discernible from the baseline.

1.3.5 Although the hydraulic assessment presented in **Appendix B** suggests that the inlet would have no discernible influence on water velocity in Loch Ness at a distance of ~27 m from the inlet screens, early engagement with a potential net supplier (Pacific Netting Products) suggest that optimal conditions for the net to function would be in water with a velocity of 0.1 m/s or less. Furthermore, researchers from the University of Glasgow (UoG) have advised the Applicant that they are in the process of publishing research on the water velocity level required for salmon to pick up directional cues. Although this research is not yet publicly available, the Applicant understands from preliminary

---

[1] The length of a fish measured from the tip of the jaw or snout with closed mouth to the centre of the fork in the tail (i.e., the middle caudal fin rays)

[2] Water velocity surveys undertaken at the mouth of the River Moriston by Aspect Land & Hydrographic Surveys Ltd (ALHS) on behalf of the Applicant in June 2023 found the average water velocity in this area of Loch Ness to range between 0.03 m/s and 0.12 m/s.

3 June 2023 Metar meteorological reports from Inverness Airport met station (ID: EGPE 03059), data source: https://www.ogimet.com/metars.phtml.en

discussions with the researchers that the study indicates that salmon begin to pick up directional cues at a water velocity of ~0.1 m/s.

1.3.6 The hydraulic assessment undertaken by the Applicant indicates that during a pumping cycle, the water velocity from the water abstraction from Loch Ness would reduce to <0.1 m/s approximately 40 m from the inlet screens. It is therefore proposed that, if the barrier net approach is taken forward as the deterrent system, it should be installed a minimum of 27 m from the inlet screens during the smolt season, although this distance could increase to up to ~40 m to meet net specifications and/or to align with scientific literature available at the time (such as the UoG research paper, if published). Further velocity measurements would also be undertaken in the vicinity of the inlet structures in Loch Ness to identify a suitable position for the barrier net. At a radius of 40 m from the inlet screens, it is anticipated that the barrier net would need to be approximately 300 m in length.

1.3.7 The specific details of the net would be determined at detailed design by the appointed Principal Contractor in liaison with the appointed net manufacturer. However, at this stage it is assumed that the net would be suspended on a boom, which would be designed to accommodate water level fluctuations in Loch Ness. Buoys would be used to keep the net floating in the surface, regardless of the water level. The bottom of the net would be held down by weights to keep it taut. It is proposed the barrier net would extend to a depth of 10 m from the surface of Loch Ness (or to the depth of the loch substrate where the maximum loch depth is <10 m). Although some sections of Loch Ness may be deeper than 10 m, particularly if the net is required to extend out to 40 m from the inlet screens, scientific literature provides evidence that Atlantic Salmon smolt are generally surface orientated, and that smolt seldom reach depths greater than 10 m in freshwater bodies (see **Appendix C**).

1.3.8 Given the absence of a natural flow signal and the vast size of Loch Ness (56.4 km^2), there is a low statistical probability that smolt originating from the River Moriston SAC or elsewhere in the Ness catchment would swim in the proximity of the powerhouse location and enter the zone of 'flow influence' during a pumping cycle. However, the barrier net proposed would provide a suitable deterrent to prevent any smolt that enter this zone from being attracted to the inlets during a pumping cycle, which could lead to a delayed journey for the smolt, resulting in excessive energy expenditure and increased risk of predation. The effectiveness of the barrier net would be monitored through the Fish Monitoring Plan (FMP) (as described in **Volume 1, Chapter 13: Fish** of the EIA Report) and modifications would be made to the deterrent system accordingly, if required.

1.3.9 The barrier net option for the deterrent system for smolt was first proposed to NatureScot in a Memo issued by the Applicant in April 2024 (see **Appendix A**). It should be noted that in this Memo it states that the barrier net should be located 30-40 m from the inlet structure based on the hydraulic assessment. However further analysis undertaken since this memo was issued in April 2024, has demonstrated that whilst during a generation cycle the maximum distance from the intake where flow velocities would have an influence on Loch Ness would be within a ~40 m radius from the inlet screens, during a pumping cycle this distance would be reduced to a ~27 m radius from the inlet screens (see **Appendix B** for further details).

1.4 Potential Impacts on Otter

1.4.1 The Applicant did not receive a formal response from NatureScot to the Memo issued in April 2024 (see **Appendix B**) relating to the barrier net proposal at the intake in Loch Ness. However, during discussions with NatureScot in July 2024, it was noted that the potential impacts of a barrier net on otter (*Lutra lutra*), a qualifying feature of the adjacent Ness Woods SAC, would need to be considered.

1.4.2 Whilst no scientific literature has been identified which specifically assesses the effects of similar barrier nets upon otter, an assessment of possible effects of such a net on otter is detailed in Section 1.3 of **AI Appendix 10.1: Updates to Terrestrial Ecology Assessment in the Loch Kemp Storage EIA Report, and the Shadow Habitats Regulations Appraisal Report** of the Additional Information (AI). This assessment is based on the known ecology of otter, survey data indicating the nature of otters' usage of the site and professional judgement.

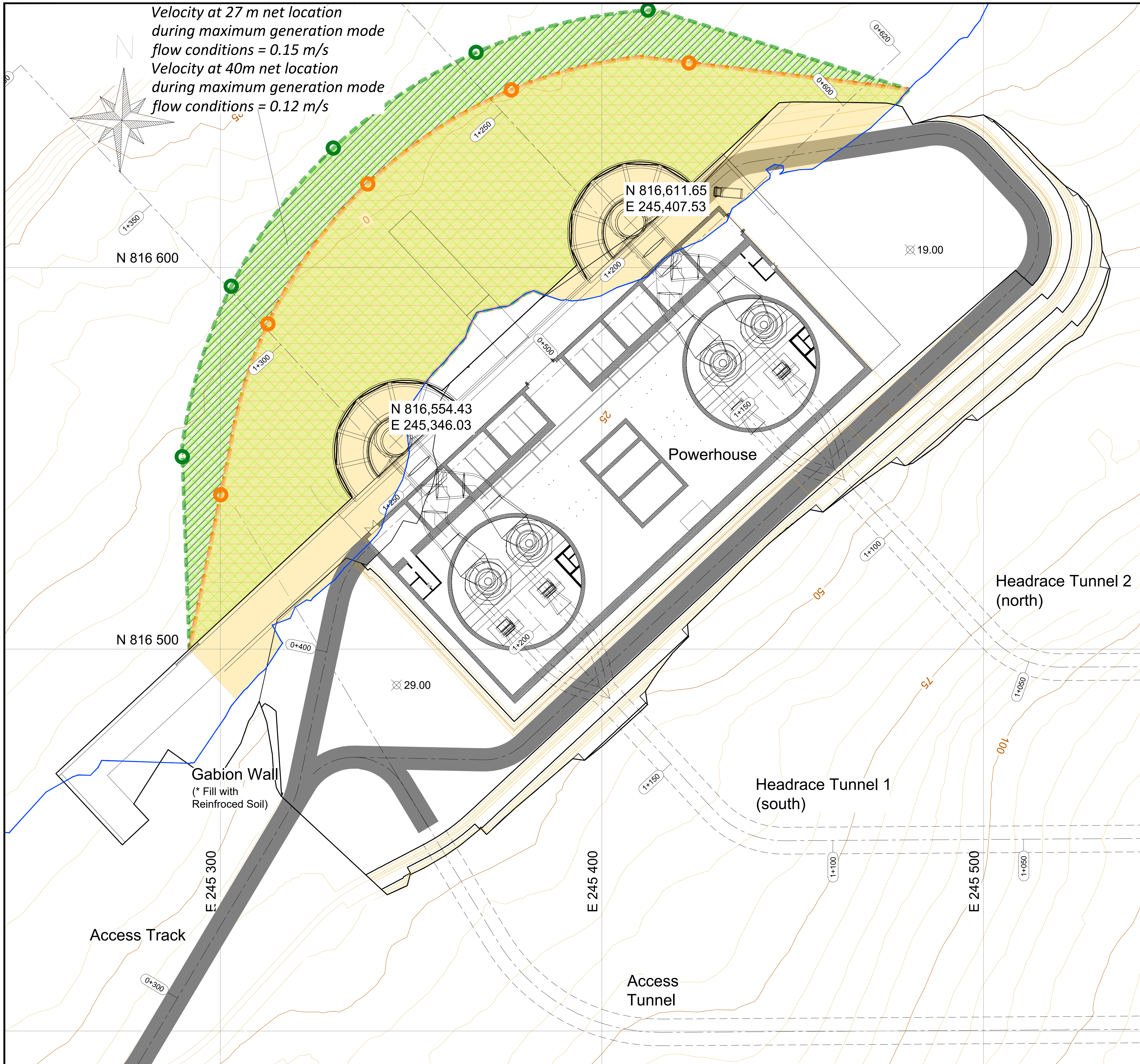
1.5 Conclusion

1.5.1 Based on expert advice from Aztec, it is considered that the installation of a barrier net with 12.5 mm mesh spacing, at least 27 m from the inlet screens of the Loch Kemp Storage PSH Scheme during the smolt season (March – June) would be a suitable deterrent system for Atlantic salmon smolt, to meet the conclusion of the Shadow HRA for the River Moriston SAC. At this stage it is anticipated the net would be approximately 300 m in length and would extend 10 m below the surface of Loch Ness (or to the depth of the loch substrate where the maximum loch depth is < 10 m). It is not anticipated that a barrier net would adversely impact otter, a qualifying feature of the adjacent Ness Woods SAC (see Section 1.3 of **AI Appendix 10.1: Updates to Terrestrial Ecology Assessment in the Loch Kemp Storage EIA Report, and the Shadow Habitats Regulations Appraisal Report** for further details).

1.5.2 This mitigation measure also relates to the conclusions of the **Volume 1, Chapter 13: Fish** of the EIA Report and satisfies the mitigation requirements for salmon smolts at the intake (i.e. salmon smolts emanating from other rivers within the Ness catchment (non-SAC), as well as the River Moriston SAC.

1.5.3 The Applicant remains open to discuss options for fish deterrent system(s) for smolt and other species with NatureScot, the Ness District Salmon Fisheries Board and other key stakeholders. Regardless of the deterrent system that is ultimately taken forward, the impacts of the deterrent system on Atlantic salmon smolt would be monitored through the FMP once the Loch Kemp Pumped Storage Scheme is operational.

Figure 1: General Overview Powerhouse - Indicative Location of Barrier Net



Indicative location of protective net

- ~ 40 m from intake screen
- ~ 27 m from intake screen
- Boom - buoy and anchor (spacing to permit otter transit over net)
- Existing shoreline

PROTECTIVE NET			
DISTANCE FROM INTAKE	LENGTH	AREA TO EXISTING SHORELINE	AREA TO INTAKE
~40m	306.0m	13,155.0m²	7,135.8m²
~27m	284.4m	10,181.7m²	4,256.3m²

0 10 20 30 40 50 m
SCALE A3 1:1'000

Coordinate system:	British National Grid
Projection:	Transverse Mercator
Datum:	OSGB36

REV.	DETAILS OF REVISION	DRAWN	CHKD	APR	DATE
3	modified acc. to client's comments	M.Tso	M.Clegg	T.Clegg	13.09.2024
2	modified acc. to client's comments	M.Tso	M.Clegg	T.Clegg	04.09.2024
1	drawing title/label modified	M.Tso	M.Clegg	T.Clegg	30.07.2024
0	First Issue	M.Tso	M.Clegg	T.Clegg	29.07.2024

FICHTNER

Loch Kemp Storage
A STATERA COMPANY

Pre-FEED

Loch Kemp Pumped Storage

	Name	Date
Designed	S.Komaei	27.07.2023
Checked	T. Clegg	27.07.2023
Modified	D. He	27.07.2023
Status		13.09.2024

General Overview
Powerhouse
Indicative location of protective net

Project No.	Scale in Paper Size A3	Drawing No.	Rev.
FIS0000261	1:1000	LKCV_FIC_PH_ZZ_PV_O_000324	3

13-Sep-24 D:\Fichtner GmbH & Co. KG\FIS P_FIS0000261 OE_Loch Kemp - 02 Repository\900_Technical_Docs\950_Civil_Eng\05_OBP\LKCV_FIC_PH_ZZ M2_O_000048.dwg

Appendix A: Consultation with NatureScot on Fish Deterrent System (April 2024)

Memorandum

Loch Kemp Storage Ltd
4th Floor, 80 Victoria Street
London SW1E 5JL.

Telephone : 07778 027385
Email : atroup@stateraenergy.co.uk

To:	Debbie Green (NatureScot)		
From:	Andrew Troup (Loch Kemp Storage Ltd)		
Subject:	River Moriston SAC – Shadow HRA Response		
File Ref.:	120019-M-M1-1.0.0-NS Response – Fish	**Date:**	15/04/2024

Dear Debbie,

Following on from our discussion on 3rd April 2024, we would like to respond to the concerns raised about smolt exiting the River Moriston Special Area of Conservation (SAC) and being attracted to the inlet of the proposed Loch Kemp Storage Scheme (the Proposed Development). Our understanding is that this concern stems from the findings of the smolt tracking study conducted in Loch Lomond in 2020[1], which concludes that whilst smolt migration routes appear to be indirect, once successful smolts are within approximately 2 km (more specifically 1.75 km +/-0.80 km (mean +/-SD)) of the loch outlet, directional cues become apparent, and a high proportion remained in this region prior to entering the River Leven. This area is referred to in the study as the 'Goldilocks' zone. Other recent tracking studies conducted in Loch Lomond have also identified that smolt migration routes in the loch are indirect (see Honkanen *et al,* 2018[2] & Lilly *et al*, 2022[3]).

The reference to the Loch Lomond smolt tracking study, amongst other similar studies, is included in the Shadow Habitats Regulation Appraisal (HRA) for the Proposed Development to demonstrate that smolt tracking studies in Scotland and further afield have concluded smolt migration routes in large, slow-moving bodies of water, such as lochs / lakes, appear to be indirect. We acknowledge that the Loch Lomond study concludes that the randomness of such smolt migration routes appear to reduce within approximately 2 km of the River Leven (i.e., the 'Goldilocks' zone). However, we do not believe this is to be a directly comparable situation to smolt exiting the River Moriston and being attracted to the Kemp inlet on the opposite side of Loch Ness for the following reasons:

- The mouth of the River Moriston is more than 2 km from the proposed location of the Loch Kemp inlet structure. The inlet would be approximately 2.3 km from the mouth of the River Moriston at its closest point.

[1] Lilly, J., Honkanen, H. M., McCallum, J. M, Newton, M., Bailey., D. M. & Adams, C. E (2021), *Combining acoustic telemetry with a mechanistic model to investigate characteristics unique to successful Atlantic salmon smolt migrants through a standing body of water.* Environmental Biology of Fishes (Volume 105 (12), pp 2045-2063). Available at: https://doi.org/10.1007/s10641-021-01172-x [Last Accessed 11/04/2024].
[2] Honkanen, H. M., Rodger, J. R., Stephen, A., Adams, K., Freeman, J. & Adams, C. E. (2018). *Counterintuitive migration patterns by Atlantic salmon Salmo salar smolts in a large lake.* Journal of Fish Biology (Volume 93, pp 159–162). Available at: https://doi.org/10.1111/jfb.13650 10.1111/jfb.15200 [Last Accessed 11/04/2024].
[3] Lilly, J., Honkanen, H. M., M., Bailey., D. M., Bean, C. W., Forrester, R. & Adams, C. E (2021), *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 (Volume 101(5), pp 1285-1300). Available at: 10.1111/jfb.15200 [Last Accessed 11/04/2024].

- Our hydraulic assessment suggests that the inlet would have no influence on Loch Ness out with 40 m from the inlet. This is based on the area required within Loch Ness to dissipate the maximum flow volume through the half cylinder shaped intakes to the baseline flow velocities observed in water velocity surveys undertaken at the mouth of the River Moriston by Aspect in June 2023. Additionally, this estimation conservatively assumes no vertical mixing effect within Loch Ness, just uniform horizontal mixing. In reality, the likely additional vertical mixing would aid flow dissipation, in turn reducing the distance to which the flow is discernible from the baseline.

- Whilst we do not have velocity data at outflow from Loch Lomond, the River Leven is known to be a very fast-moving river, considered to be the second fastest river in Scotland after the River Spey. It can therefore be assumed that the velocity at the outlet is significantly greater than at the Kemp inlet where the velocity would be 0.3m/s or less (in pumping mode). During the Loch Lomond study period referenced, the SEPA 85001 - Leven at Linnbrane gauging station data shows an average flow volume of 25.1 m^3/s. Based on an average measured depth during the period of 0.75 m and an approximate channel width of 35 m, the average velocity would be about 0.9 m/s. This is approximately 3 times greater than at the Kemp inlet. We do however, note that factors such as the River Leven Barrage could impact the river velocity at Linnbrane, which is between the flow gauging station and the outlet of Loch Lomond.

- In contrast, water velocity surveys undertaken at the mouth of the River Moriston by Aspect Land & Hydrographic Surveys Ltd (ALHS) on behalf of the Applicant in June 2023 found the average water velocity in this area of Loch Ness to range between 0.03 m/s and 0.12 m/s[4].

- The Loch Kemp PSH scheme would only act as a potential artificial outlet when the scheme is in pumping mode (during smolt season), which is predicted to occur typically around 4 hours per day[5].

- The geography of Loch Ness is very different to Loch Lomond. The southern 2 km of Loch Lomond narrows towards the River Leven and acts as a natural funnel towards the outlet, whereas the stretch of Loch Ness has a relatively uniform width.

- There is no evidence that there is a correlation between the decline in salmon catches in the Ness catchment in recent years and the operation of the Foyers PSH, which has been operational since 1974[6]. Although the Foyers inlet is further from the mouth of the River Moriston than the proposed Kemp inlet, smolts still need to travel past the Foyers to reach the River Ness and enter the sea.

The conclusion in the Shadow HRA that the Proposed Development, prior to mitigation, is likely to undermine conservation objective 2a[7] for the River Moriston SAC, is based on a precautionary principle, whereby we are unable to prove that some smolt exiting the River Moriston, undertaking an indirect migratory route, would not pass the Kemp inlet. The assessment in the Shadow HRA has therefore been undertaken based on the assumption that a proportion of smolts originating from the River Moriston would pass the inlet. However, following the implementation of appropriate mitigation measures, the Shadow HRA concludes that the Conservation Objectives pertaining to the population of salmon would not be compromised, even under the precautionary principal.

Whilst to maintain our professional integrity, we have based the assessment of potential adverse effects of the Proposed Development on the qualifying features of the River Moriston SAC in the Shadow HRA on the precautionary principle the reality is there is no evidence or scientific logic to suggest that smolts

---

[4] Aspect Land & Hydrographic Surveys Ltd, (2023), *ADCP / Current Monitoring – Loch Kemp Hydro Scheme Loch Ness*. Two transects were used to record the water velocity near the mouth of the River Moriston (within Loch Ness). Each recorded the mean water velocity at three different depths (3 m, 10 m and 20 m) at three different times of day (09:27, 13:50 and 16:25).

[5] Current trends in other operational PSH schemes indicate an average dispatch time of 4 hours.

[6] Sea Trout Fishing, Scottish Salmon and Sea Trout Catches. Available at: https://www.seatrout-fishing.com/scottish-salmon-sea-trout-catches.htm [Last Accessed: 11/04/2024]

[7] Conservation Objective 2a - for restoring the population of Atlantic salmon, including range of genetic types, as a viable component of the site

exiting the River Moriston would be attracted to the Kemp inlet. Further the proportion of smolt that are likely to migrate more than 2 km across Loch Ness to a point where they are temporarily delayed due to an attraction to the inlet during a pumping cycle is likely to be minimal. Compared to other man-made and natural factors that are impacting salmonids in the Ness Catchment we anticipate this effect would be negligible. For example, the Ness District Salmon Fisheries Board (NDSFB) has advised that recent smolt tracking studies undertaken in the Ness catchment have found that losses of tagged smolts within the canal network ranged from 15-26% over three years of study. This loss could be easily be prevented.

We have always maintained that whilst we consider there would be benefits of a wider smolt tracking study in the Ness catchment, such a study would be of limited value to the EIA Report and Shadow HRA for the Proposed Development, particularly given the timeframes that would be required to obtain meaningful results from such studies. Furthermore, such studies would only provide insight on the specific impacts of PSH on smolt if SSE Renewables (SSER) were willing to cooperate and share pumping cycle information for the existing Foyers PSH scheme. We have tried to engage with SSER on this issue several times over the past few years, but they have not been willing to engage with us on this issue. If circumstances were to change, we would be happy to contribute to a smolt tracking study in Loch Ness in consultation with NatureScot and NDSFB. We also note that such studies have not been a requirement for other existing or recently consented pumped storage hydro schemes in Scotland, including developments in Loch Ness.

Related to this point, NatureScot has also requested that the Applicant provides evidence that the mitigation proposed at the inlet structure in the Shadow HRA would be effective. Section 6.2.2 of the Shadow HRA it states:

'*An appropriately designed fish deterrent system will be installed which will deter fish from the draw of water from the intake, preventing entrainment / impingement at the screens and reducing predation impacts. Fish deterrent systems work best when multiple fish deterrent types are working in tandem*[8] *and could include bubble curtains, acoustic fish deterrents (AFD) or intensive flashing light. Bubble curtains alone have been shown to divert salmon smolts with high efficiency under natural conditions*[9]*.*

Since the submission of the Section 36 Application in November 2023, the Applicant has appointed Aztec Management Consultants (Aztec) to provide advice on a suitable fish deterrent system. Aztec's recommendation would be that rather than a bubble curtain and/or AFD system, the most effective method to deter smolt from the inlet would be to install a barrier net with 12.5 mm mesh spacing during the smolt season (March – June). As our hydraulic assessment suggests that the inlet would have no influence on Loch Ness out with 40 m from the inlet, we would propose to construct this barrier net 30-40 m from the inlet to prevent passing smolt picking up direction cues from the inlet during a pumping cycle. At this distance from the shoreline, we would anticipate that the barrier net required would need to be approximately 200 m long and 5-10 m deep. We have started dialogue with Pacific Netting Products[10] in relation to this barrier net, which we consider would be a suitable fish deterrent system to meet the conclusion of the Shadow HRA, which concludes that following the implementation of appropriate mitigation measures, the Conservation Objectives pertaining to the River Moriston SAC population of salmon would not be compromised.

For the reasons set out in this note, we are firmly of the view that smolt exiting the River Moriston would not be attracted to the inlet for the Proposed Development located over 2 km away, on the opposite side of Loch Ness. Based on the precautionary principal and the findings of recent scientific literature, which

[8] A.W.H.Turnpenny & N. O'Keeffe (2005) Bubble screens in combination with other behavioural stimuli, Screening for Intake and Outfalls: a best practice guide. Available at: Microsoft Word - W6_103 TR _amended _ 1.doc (publishing.service.gov.uk) [Last Accessed: 13/09/2023]

[9] J. Leander a, J. Klaminder a, G. Hellström b, M. Jonsson (2021) Bubble barriers to guide downstream migrating Atlantic salmon (*Salmo salar*): An evaluation using acoustic telemetry

[10] Available at: https://www.pacificnettingproducts.com/ [Last Accessed 12/04/2024]

conclude that smolt migration routes in large, open water bodies appear to be indirect, we cannot rule out that some smolt from the River Moriston may pass within 40 m of the inlet structure during their migration. If smolt do enter this area during a pumping cycle, they may be able to detect directional cues from the inlet structure, which could potentially lead to delayed journeys and thereby experience increased risk of predation and energy exertion. However, we are confident with the conclusion with the Shadow HRA, that with the implementation of an appropriately designed fish deterrent system, the Conservation Objectives pertaining to the River Moriston SAC population of salmon would not be compromised. Based on our advice from Aztec, we anticipate that this deterrent system would comprise the installation of a barrier net with 12.5 mm mesh spacing, approximately 30-40 m from the inlet structure during the smolt season (March – June). However, we would be happy to discuss options for consideration with NatureScot.

We hope this note provides NatureScot with some clarifications relating to the Shadow HRA for the River Moriston SAC. If you have any further questions, please do not hesitate to get in touch.

[redacted]

Andrew Troup
Development Director

Appendix B: Smolt Intake Flow Determination Calculations

FICHTNER
Consulting Engineers Limited

Memorandum

To	Andrew Troup	**Organisation**	Statera Energy Ltd
CC		**Organisation**	
From	Matt Clegg	**Our ref**	3864-0261-0044MJC
Date	09 August 2024	**Pages**	4
Subject	Loch Kemp – PSH intake flow determination calculations		

Dear Andrew,

As discussed, Fichtner understands a request from NatureScot (NS) has been received to provide further information on the calculations made to determine the intake flow velocity impacts from the Loch Kemp PSH scheme. The calculations and commentary provided within this memorandum seek to satisfy this request and Fichtner are happy to discuss any of the contents herein if required.

Objective

The objective of this calculation is to determine the point at which the flow velocity from the PSH intake screens reduces to naturally occurring baseline flow velocities within Loch Ness.

Calculations

Generation flow

The calculations of intake flows are based on inputs derived from the engineering design fix submitted for planning and are listed below in Table 1 and Table 2, with any assumptions noted.

Table 1: Loch Kemp intake generation flow calculation inputs

Parameter	Value	Unit	Notes
Intake screen radius (r)	18.47	m	Width of D-shape intake diffuser (as shown in attached drawing no: LKCV_FIC_PH_BT_OS_O_000305)
Submergence height of intake screen (h)	10.40	m	Based on an intake sill level of +5.0 mAOD and a minimum Loch Ness water level of +15.4 mAOD
Area of intake screen submerged within Loch Ness	603.5	m^2	Surface area of a cylinder (2πrh) divided by 2 for half cylinder D-shaped screen area
Total submerged area of intake screens	1,207	m^2	Doubled for two intake screens
Maximum rated flow of both intakes during generation	455.2	m^3	Maximum possible flow from the scheme, only achieved when required to operate at maximum generation (600 MW) and the Loch Kemp upper reservoir is reduced to just above the minimum inundation level (+177 mAOD). All operating

Parameter	Value	Unit	Notes
			scenarios above this level would result in a reduced flow volume to be dissipated.
Measured baseline flow velocities in Loch Ness (target velocity)	0.12	m/s	Flow velocities measured in two transect surveys at the mouth of the River Moriston during May 2023.
Area required for maximum rated flow dissipation to target velocity	3,793	m^2	Derived from the maximum rated flow of both intakes divided by the target velocity
Distance (radius) from intake centre where target velocity is achieved	58.05	m	Area required for flow dissipation to target velocity divided by (2πh)
Distance from intake screen where target velocity is achieved	39.58	m	Distance from intake centre minus radius of intake screen

From the above parameters, the maximum distance from the intake screen where flow velocities from the intakes would be above that measured during in-situ flow monitoring surveys (0.12 m/s) in Loch Ness would be 39.58 m. It is worth noting that this calculation represents the hydraulic worst case scenario for flow dissipation in Loch Ness based on the following conservative assumptions:

1. Operation has been calculated at the maximum rated conditions which, as noted in Table 1, requires the scheme to be operating at both:
   a. maximum power output (600 MW); and
   b. the lowest gross head available from the upper reservoir water level (+177 mAOD) for power generation.

   The likelihood of these conditions occurring is low and all other operation of the scheme would result in a smaller flow rate to be dissipated and therefore, a shorter flow dissipation distance from the intake screens.
2. Calculations have been made assuming a minimum Loch Ness water level (+15.4 mAOD) which results in a diminished intake submergence height. Any operation at higher Loch Ness water levels would allow dissipation of flow velocities over a taller column of water, thus reducing the horizontal dissipation distance to achieve target baseline flow velocities.
3. It has been assumed that no element of vertical mixing within the flow from the intakes occurs. In reality, some vertical mixing (dependent on flow vectors, water temperatures and chemical parameters) would occur further reducing the horizontal dissipation distance.
4. The target baseline velocities were monitored during a period of still weather and therefore are lower than the majority of conditions in Loch Ness where wind run would elevate flow velocities within the waterbody.

Pumping flow

During pumping operation, the geometry of the waterways remains the same as during generation. In addition, the target baseline velocities are also the same.

Table 2: Loch Kemp intake pumping flow calculation inputs

Parameter	Value	Unit	Notes
Maximum rated flow of both intakes during pumping	359.5	m^3	Maximum possible flow from the scheme, only achieved when required to operate at maximum pumping and the Loch Kemp upper reservoir is reduced to just above the minimum inundation level (+177 mAOD) where pumping efficiency is lowest. All operating scenarios above this level would result in a reduced flow volume to be dissipated.
Area required for maximum rated flow dissipation to target velocity	2,996	m^2	Derived from the maximum rated flow of both intakes divided by the target velocity
Distance (radius) from intake centre where target velocity is achieved	45.85	m	Area required for flow dissipation to target velocity divided by ($2\pi h$)
Distance from intake screen where target velocity is achieved	27.38	m	Distance from intake centre minus radius of intake screen

During pump mode operation, the maximum flow rate at both intakes is significantly lower however, the geometry of the intake screens and waterways do not change from generating conditions. As such, the horizontal dissipation distance to achieve target baseline flow velocities is also significantly lower than during generation mode. Additionally, as the waterway geometry remains the same, the conservative assumptions listed above still apply during pumping mode.

Conclusions

From the above c.40 m maximum distance requirement from the intake screens and a required dissipation area of c.3,800 m^2, this represents a highly localised impact area within the wider Loch Ness waterbody where flow velocities above the baseline could be observed. This decreases during pumping mode to a distance and area requirement of c.27 m and c.3,000 m^2 respectively.

With Loch Ness occupying 56.4 km^2, the dissipation area required for the hydraulic worst case conditions represents 0.00673% of Loch Ness during generation and 0.00531% during pumping.

When incorporating the conservative assumptions listed above, this percentage would decrease further in any other operating conditions.

Given the low predicted impact, even with very conservative assumptions, it was not considered that detailed hydraulic modelling was required.

Yours sincerely

FICHTNER Consulting Engineers Limited

[redacted] [redacted] [redacted]

Matt Clegg
Environmental Consultant

Tom Clegg
Head of Hydropower UK

Stephen Other
Technical Director

Appendix C: Aztec Management Consultants Memo on Swimming Depth of Atlantic Salmon

Appendix C: A Note on Salmon Smolt Swimming Depth

September 2024

AZTEC
MANAGEMENT
CONSULTANTS

Contents

Swimming Depth of Atlantic Salmon Smolt

1.1 Introduction

1.1.1 Loch Kemp Storage Ltd (the Applicant) previously appointed Aztec Management Consultants (Aztec) to provide advice on a suitable fish deterrent system at the inlet structure of the Proposed Loch Kemp Storage Pumped Storage Hydro (PSH) Scheme, to prevent Atlantic salmon (*Salmo salar*) smolt from being attracted to the inlet structure during pumping cycles. Aztec advised that the most effective method to deter smolt from the inlet would be to install a buoyed barrier net with 12.5 mm mesh spacing during the smolt season (March – June). Aztec also advised that the net would need to extend up to 10 m below the surface level of to exclude salmon smolt.

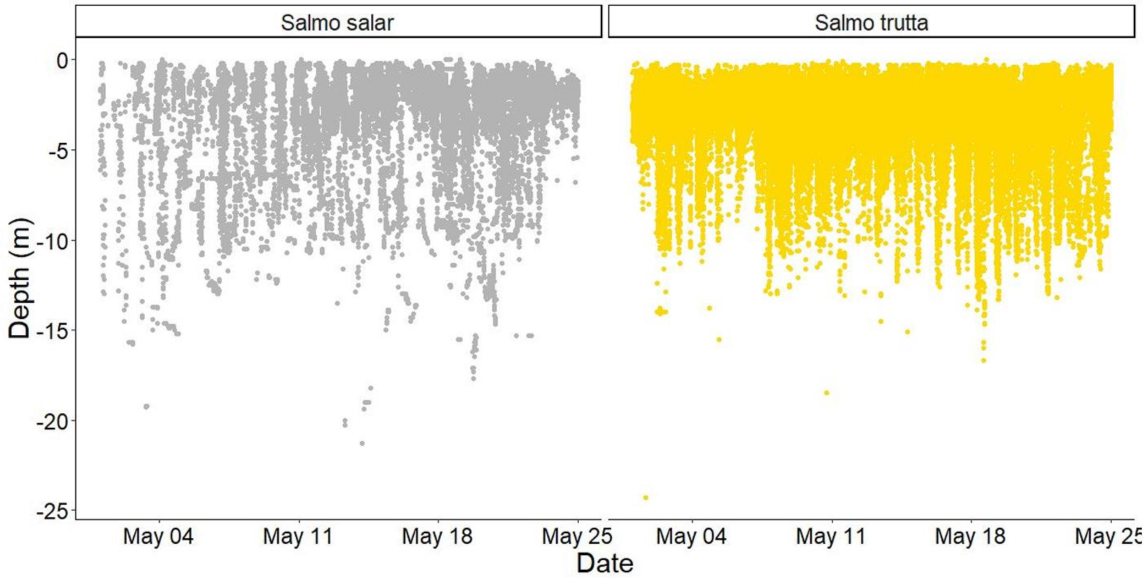
1.1.2 Following the advice provided on the smolt deterrent system previously, the Applicant has requested that Aztec advise on the effectiveness of a net extending to a depth of 10 m below the surface of Loch Ness for excluding salmon smolt, given the loch depth may be deeper than 10 m at some locations around the inlet screens. The purpose of this Memo is therefore to provide additional information on the swimming depths of Atlantic salmon smolt in freshwater lakes, which will provide evidence that a barrier net extending up to 10 m below the surface level of Loch Ness would effectively exclude Atlantic salmon smolt from the area surrounding the inlet structures of the proposed Loch Kemp Storage PSH Scheme.

1.1.3 While the scientific literature is replete with accounts of salmon smolt migrating in rivers and lakes, there is a dearth of information relating to the depths at which they swim in freshwater lakes. However, the scientific literature that is available strongly suggests that salmon smolt are generally surface orientated and tend to occupy the upper layers of waterbodies. In this note, scientific articles are referenced which document the depths occupied by Atlantic salmon smolt in a Norwegian lake, by Atlantic salmon post-smolt in a Norwegian fjord and finally, by Atlantic salmon post-smolt in the open sea (in the context of avian predation).

1.2 Evidence from the Scientific literature

1.2.1 Nash *et al* (2022) studied the water depths at which Atlantic salmon smolt migrated in a Norwegian lake. Nash *et al* (2022) also studied the water depths occupied by piscovorous brown trout (Salmo trutta) during the salmon smolt migration period. Nash *et al* (2022) tracked 20 Atlantic salmon smolts and their most prevalent predator, brown trout (N=21), and recorded their depth use in a basin of Lake Evanger, Norway with acoustic telemetry during May 2020. Both salmon smolts (3.8 ± 3.3 SD m) and trout (2.9 ± 1.7 SD m) were distributed relatively close to the surface of the lake despite depths in the area largely exceeding 30 m. Both species were deeper at midday and smolts tended to be deeper in the water earlier in the migration, overlapping less with trout early in May, but as daily daylight increased and water temperature warmed, vertical distribution of smolts and trout increasingly overlapped. Figure 2 of Nash *et al (*2022) is reproduced as Graph 1 below and illustrates that the vast majority of detections of salmon smolt were at 0-5 m and 5-10 m from the surface. Deeper detections may have been associated with attempts to escape piscovorous predators.

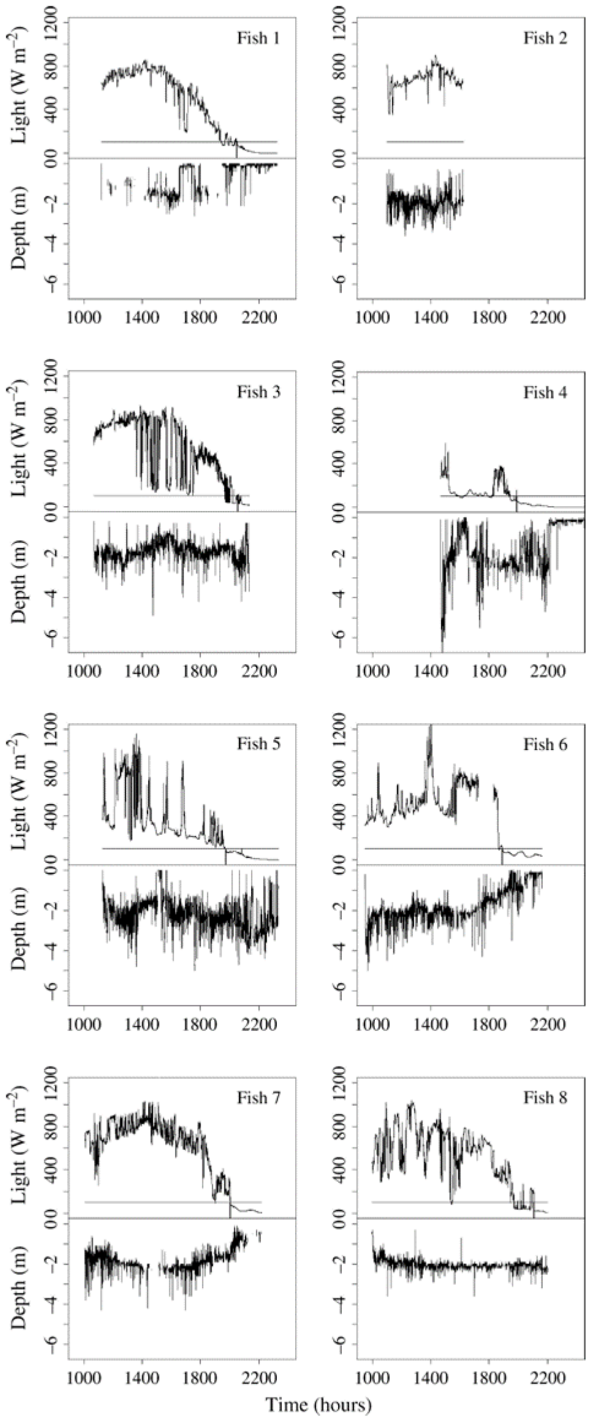
Graph 1: Raw Detections (N=822836) of Atlantic salmon (Salmo salar; grey) and brown trout (Salmo trutta; gold) in the eastern basin of Lake Evenger with individual depth. Taken from Nash *et al* (2022) (Figure 2).



1.2.2 After leaving freshwater, there is further evidence that Atlantic salmon post-smolt maintain their surface orientated behaviour and ecology. Davidsen *et al* (2008) studied the behaviour of eight hatchery-reared Atlantic salmon *Salmo salar* post-smolts, implanted with acoustic depth sensing transmitters and manually tracked for 5–12 h in the Hardangerfjord (Norway). They found that these fish spent most of their time (49–99%) at 1–3 m depth during the day, whereas four of seven fish tracked were found close (<0.5 m) to the surface at night, with a strong negative cross-correlation between general swimming depth and surface light intensity. No cross-correlations were found between light intensity and swimming depth during daytime periods with rapid changes in light intensity, indicating that other factors than light intensity were important in initiating the irregular dives that were recorded down to 6.5 m depth.

1.2.3 Fig.1 from Davidsen *et al* (2008) is reproduced as Graph 2 below, describes the depths occupied by each tagged Atlantic salmon post-smolt over the study period of up to 12h.

Graph 2: Depths occupied by tagged Atlantic salmon (*Salmo salar*) post-smolt over a study period of up to 12h in the Hardangerfjord (Norway)



1.2.4 When Atlantic salmon post-smolt enter the open ocean there is also evidence that they maintain a surface orientation which makes them vulnerable to avian predators. Northern gannets (*Morus bassanus*), the largest seabird species breeding in Canada, plunge-dive into surface waters to capture pelagic prey, including post-smolt Atlantic salmon that frequently swim in surface waters.

1.2.5 Similarly, adult Atlantic salmon returning to natal rivers from distant marine feeding areas are vulnerable to surface orientated commercial fishing gear e.g. drift nets as they approach coastal waters. Typically, these drift-nets fish the top 10 metres of water and because of their indiscriminate nature (capable of catching salmon destined for one to several natal rivers) they have now been outlawed in most countries where rivers support Atlantic salmon populations.

1.3 Summary

1.3.1 In summary, while the fry / parr stage of the salmon life-cycle is spent in shallow fast flowing sections of rivers and streams where the young fish are orientated benthically – using their large pectoral fins against the current to maintain station close to the river bed, once smoltification occurs the fish become surface orientated and this orientation continues throughout their migration through freshwater rivers and lakes and also in estuarine and open sea habitat and even continues throughout their return marine migration as adult salmon before they enter the natal river. The colouration of salmon smolt, post-smolt and adults at sea and on their immediate return as adults to freshwater is generally a white underbelly, silver sides and darker dorsal appearance. These colouration characteristics may make post-smolt more vulnerable from diving avian predators such as gannets but probably assist smolt, post-smolt and adults in minimising predation from below.

1.3.2 Whilst the scientific literature relating to the depths at which salmon smolt swim in freshwater lakes, provides evidence that salmon smolt are generally surface orientated and tend to occupy the upper layers of freshwater bodies. The scientific articles referenced within this note document the depths occupied by Atlantic salmon smolt in a Norwegian lake, which provide evidence that a barrier net extending to a depth of 10 m from the loch surface level, would effectively exclude salmon smolt in Loch Ness from the area surrounding the inlet structures of the proposed Loch Kemp Storage Scheme.

1.4 References

Davidsen JG, N Plantalech Manel-la, F Økland, OH Diserud, EB Thorstad, B. Finstad, R Sivertsgard, RS Mckinley and AH Rikardsen (2008), Changes in swimming depths of Atlantic salmon Salmo salar post-smolts relative to light intensity. Journal of Fish Biology (2008) **73**, pages 1065–1074.

Montevecchi WA, DK Cairns and RA Myers (2002), Predation on marine-phase Atlantic salmon (Salmo salar) by gannets (Morus bassanus) in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. **59**: pages 602–612.

Nash AJ, KW Vollset, EM Hanssen, S Berhe, AG Salvanes, TE Isaksen, BT Barlaup, RJ Lennox (2022)), A tale of two fishes: depth preference of migrating Atlantic salmon smolt and predatory brown trout in a Norwegian lake. Canadian Journal of Fisheries and Aquatic Sciences **79** (12).