



SHUNA, LOCH LINNHE

NEWDEPOMOD REPORT

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EXECUTIVE SUMMARY

Modelling has been carried out by Scottish Sea farms Ltd (SSF) for the proposed relocation and reconfiguration of the marine cage fish farm Shuna (CAR/L/1009032).

It is proposed that the existing group of 10 x 80 m circumference cages in a 50 m grid be moved 550 m northwest to the northern end of Shuna Island, Loch Linnhe and have the existing

configuration replaced 8 x 120 m circumference cages in a 2x6 75 m grid. New transects and sample stations, in line with current SEPA regulation, have been identified.

A maximum consented biomass of **1870.4 tonnes** with a stocking density of **17.0 kg/m³** is applied for for this configuration. Chemical treatment modelling has also been carried out and this, along with new sampling transects, are presented below.

The infeed medicine Slice is not included in this application at this time, although this may be revisited in the future once there is calibration data for this site and the UK-TAG inquiry into the appropriate EQS has been finalised.

Table 1: Consent limits for Biomass and treatment chemicals at Shuna.

Treatment	Recommended consent mass
Biomass	A maximum consent biomass of 1870.4 t and stocking density 17.0 kg/m³ is recommended for this site.
Salmosan (Azamethiphos)	The total quantity of Azamethiphos to be discharged should not exceed 329.1 g in a 3-hour period or 458.4 g in a 24-hour period. This can be used to treat one cage in 3 hours or two cages in 24 hours at a maximum treatment depth of 2.0 m.
Alphamax (Deltamethrin)	The total quantity of chemical to be discharged in a 3h period should not exceed 22.3 g . The equivalent treatment volume is 11150 m³ . Which can be used to treat, for example, 1 cage at a depth of up to 6.0 m every 3 hrs or 2 cages at a depth of 4.2 m every 3 hours.

1. Introduction

1.1 Site Details

The proposed new site location is situated against a short length of straight coast at the north end of Shuna, Loch Linnhe. The site is sheltered from prevailing SW winds with the greatest exposure to the wind from northerly directions, and in particular the NE.

This location is deeper and has a greater mean current speed when compared with the existing site location 550 m away of the east coast of the island (mid-point 56 35.577N 05 22.824W)

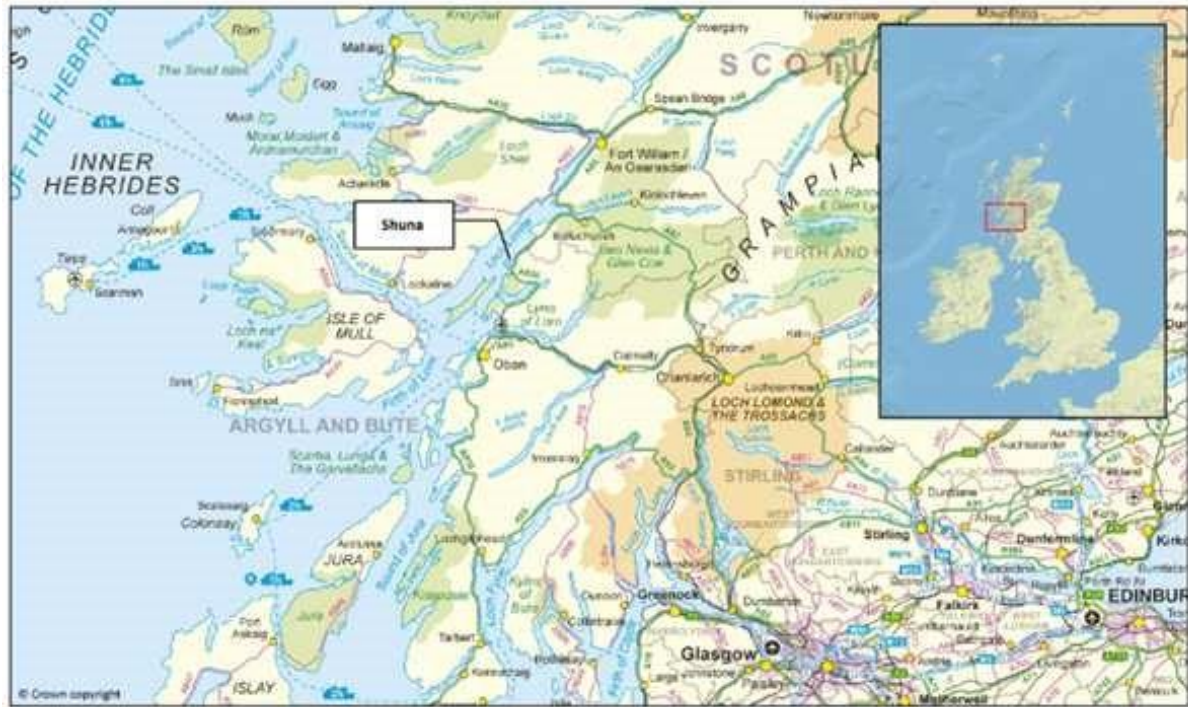


Figure 1: Location of the proposed site relocation for MCFF Shuna, Loch Linnhe

2. Model Input Details

2.1 Hydrographic Data

Three separate Acoustic Doppler Current Profiler (ADCP) surveys were carried out at this location in order to collect the 90 days of current speed and direction data required for this site. The details of these surveys are reported in *Shuna(2015) Hydrographic Report* (Report No. H0716-1) and *Shuna, Loch Linnhe Modelling Data Collection Report* (Report No. H0121-1). Data was collected in 2015, 2018 and 2020 appropriate subsets were selected from each of these periods and matched for tidal level and phase where possible and connected together into one 90 day period (Report No, H01211) the data has been corrected to °G. The summary statistics for this 90 days is shown in table 2 below.

Table 2: Statistics for the 90-day composite current meter dataset at Shuna.

	Near-bed	Pen-bottom	Sub-surface
Mean velocity (m s ⁻¹)	0.060	0.068	0.083
Min velocity (m s ⁻¹)	0.000	0.000	0.001
Max velocity (m s ⁻¹)	0.239	0.312	0.349
Ranked percentage 0.095 m s ⁻¹	82 %	61 %	64%
Major axis (°G)	105	270	270
Amplitude anisotropy	2.88	2.86	2.70
Residual velocity (m s ⁻¹)	0.004	0.011	0.030
Residual direction (°G)	115.4	216.2	238.2
Parallel Residual (m s ⁻¹)	0.004	0.007	0.025
Normal Residual (m s ⁻¹)	0.001	-0.009	-0.016
Parallel tidal amplitude (m s ⁻¹)	0.094	0.114	0.127
Normal tidal amplitude (m s ⁻¹)	0.033	0.040	0.047

2.2 NewDepomod Modelling

SSF have used the precautionary Standard Default Approach as outlined in *Regulatory Modelling Guidance for the Aquaculture Sector* (July 2019 – Version 1.1) (SEPA 2019). Model parameters were set as defined in Appendix A of the same document.

A single point 90 day current meter dataset located at (192374, 750188) was used in combination with a uniform bathymetry at a depth of (30.2 m). The model domain is a 2 km x 2 km regular grid made up of 25 m grid cells with bounding coordinates

Domain.spatial.maxX=193320

Domain.spatial.maxY=751310

Domain.spatial.minX=191320

Domain.spatial.minY=749310

2.3 Run Details

The user interface was used to set up an 8 x 120 m circumference cage configuration with a 12 m sidewall and a SD of 17 kg m⁻³ (equivalent 1870.4 tonnes) details in table 3 below

Table 3: Cage setup for model run Shuna21-One.

	CageGroup1	CageGroup2
Origin X (m)	192555.0	192180.0
Origin Y (m)	750186.0	750205.0
X spacing (m)	75.00	75.00
Y spacing (m)	150.00	75.00
Bearing	273.00	273.00
Cages X	2	2
Cages Y	3	1
Type	Circles	Circles
Diameter (m)	38.20	38.20
Net Depth (m)	12.00	12.00
Circumference (m)	120.01	120.01

The vertical dispersion coefficient for the resuspension phase ($\sigma_{z,r}$) is set using

$$\sigma_{z,r} = 0.0003 u^{0.762}$$

where u is mean flow speed at the bed (m s⁻¹)

The 90 day mean flow speed at this site (u) is 0.060123 ms⁻¹ which gives an $\sigma_{z,r}$ of 0.0025556123 m² s⁻¹.

Single runs were carried out with 10 particles for 365 days. The model was set to produce output every 3 hours for the last 90 days of the model run. These surfaces were then used to create an aggregated footprint averaged over the last 90 days of the model run.

2.4 Bath Medicines

Bath medicines are medicines used to treat sea-lice topically, either within an enclosed tarpaulin or with the wells of a wellboat. Maximum consent limits for Azamethiphos and Deltamethrin were calculated using the SEPA tool BathAuto. The input details for this tool are shown below:

Table 4: BathAuto inputs for Shuna.

Loch Data	
Loch/Strait/Open water :	Open Water
Loch area (km ²) :	
Loch length (km) :	
Distance to head (km) :	
Distance to shore (km) :	0.27
Width of Strait (km) :	
Average water depth (m) :	26.30
Flushing time (days) :	
Cage Data	
# of cages :	8
Cage shape :	Round
Diameter/Width (m) :	38.2
Working depth (m) :	12
Stocking density (kg/m ³) :	17
Treatment	
No. of cages possible to treat in 3 hours :	1.00
Initial Treatment Depth (m) :	2
Treatment Depth Reduction Increment (m) :	0.1
Hydrographic data analysis	
Mean current speed (m/s) :	0.083
Residual Parallel Component U (m/s) :	0.025
Residual Normal Component V (m/s) :	0.016
Tidal Amplitude Parallel Component U (m/s) :	0.127
Tidal Amplitude Normal Component V (m/s) :	0.047

3. Modelling Results

3.1 Biomass Results

3.1.1 Full Modelled Flow

A passing run was achieved for a consent biomass of 1870.4 tonnes and a stocking density of 17 kg m⁻³. The following statistics were derived using the SEPA MATLAB scripts and are based on the 90day averaged solids footprint (Fig. 2).

Available mixing zone area (cage composite area) - 174291 m²

Predicted mixing zone - 149704 m²

Average intensity within predicted mixing zone - 1719.3 g m⁻² yr⁻¹

The predicted mixing zone for this configuration is 85.9 % of the available mixing zone area.

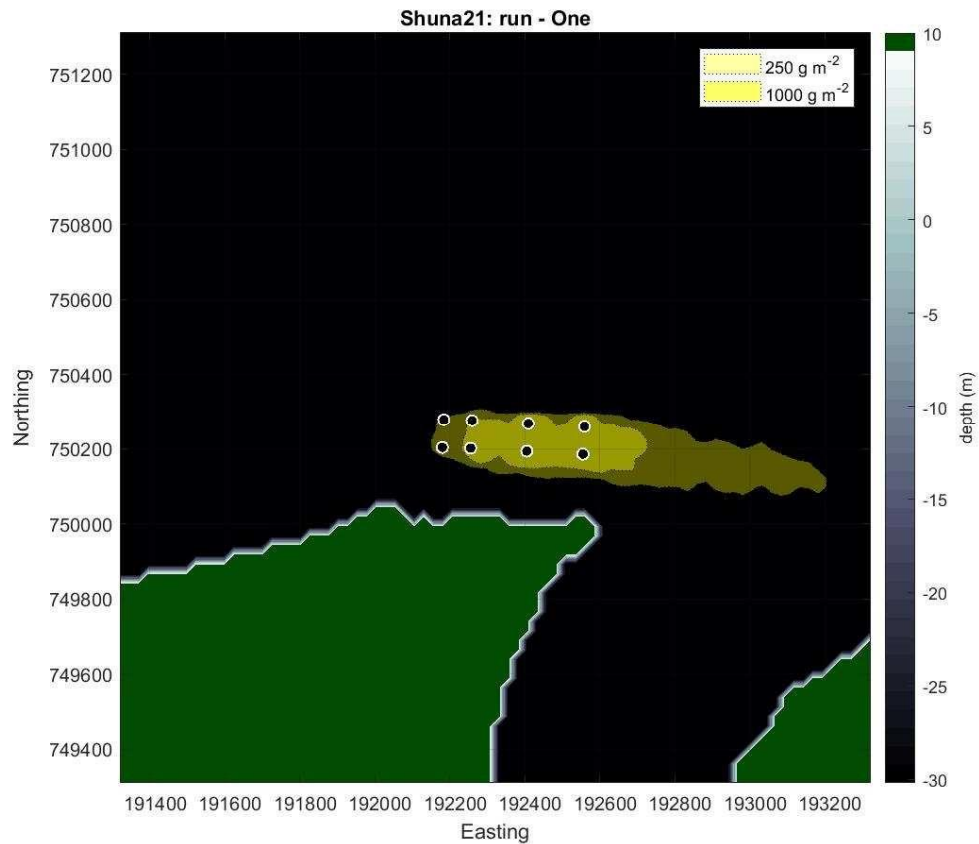


Figure 2: Averaged output from the last 90 day of model run Shuna21-One

3.1.2 Transect and Sampling Stations

In line with the new Environmental Monitoring Protocol four sampling transects have been positioned at orthogonal angles (Fig. 3). Seven sampling stations have been placed along each transect at regular intervals. Stations are detailed in table 4 below.

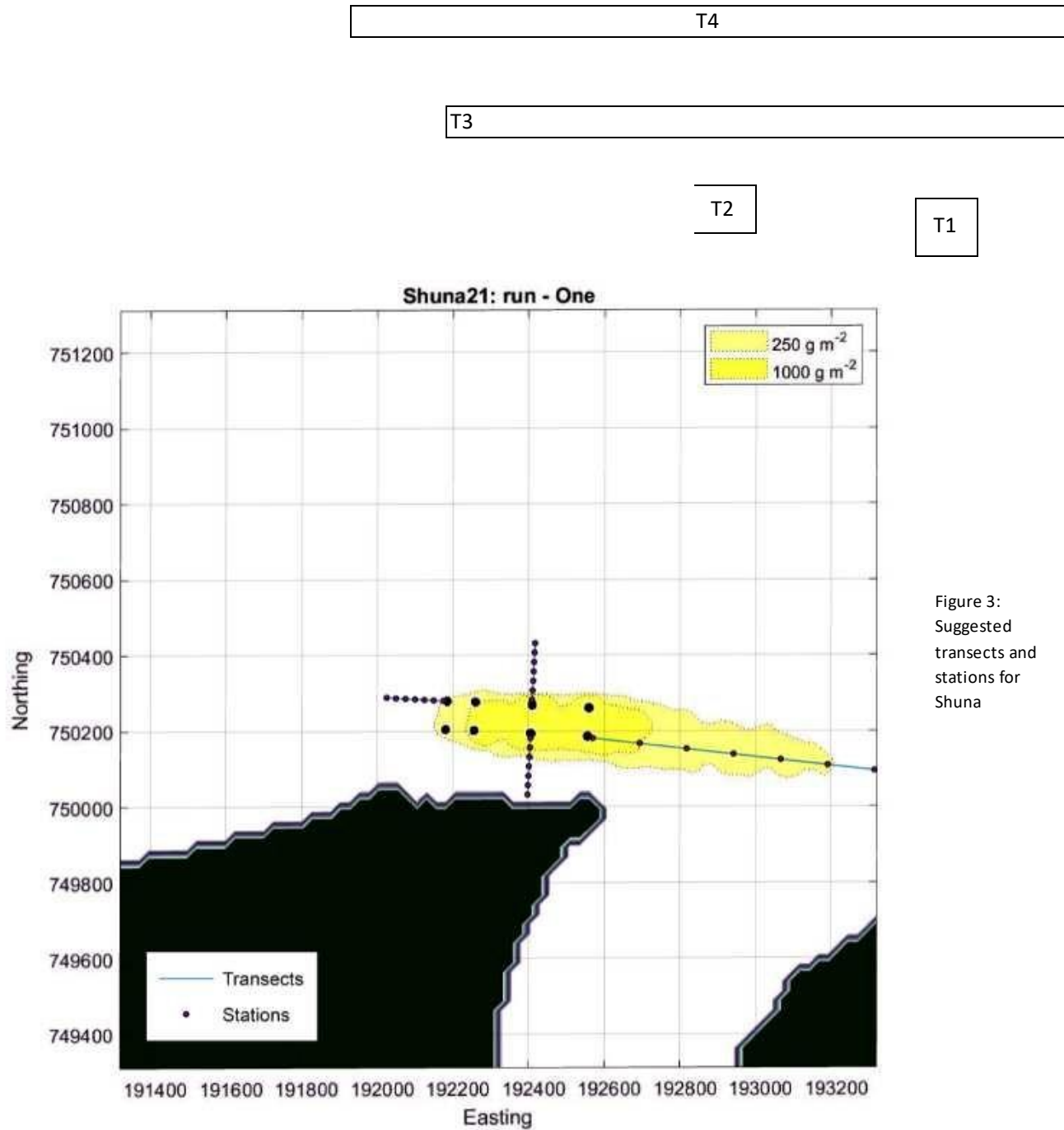


Figure 3:
Suggested
transects and
stations for
Shuna

Table 5: Transect and station details.

Transect	Bearing	Distance	Latitude	Longitude	Easting	Northing
1	96.5	0m	56°35.850'	-5°22.828'	192571	750182

1	96.5	125m	56°35.850'	-5°22.706'	192696	750176
1	96.5	250m	56°35.850'	-5°22.584'	192821	750169
1	96.5	375m	56°35.849'	-5°22.462'	192945	750163
1	96.5	500m	56°35.849'	-5°22.340'	193070	750156
1	93.4	625m	56°35.849'	-5°22.218'	193195	750149
1	96.5	750m	56°35.849'	-5°22.095'	193320	750143
2	183.3	0m	56°35.898'	-5°22.988'	192412	750279
2	183.3	25m	56°35.912'	-5°22.988'	192413	750304
2	183.3	50m	56°35.925'	-5°22.988'	192415	750329
2	183.3	75m	56°35.939'	-5°22.987'	192416	750354
2	183.3	100m	56°35.952'	-5°22.987'	192417	750379
2	183.3	125m	56°35.965'	-5°22.987'	192419	750404
2	183.3	150m	56°35.979'	-5°22.987'	192420	750429
3	272.6	0m	56°35.890'	-5°23.217'	192177	750276
3	272.6	25m	56°35.890'	-5°23.241'	192152	750278
3	272.6	50m	56°35.890'	-5°23.266'	192127	750279
3	272.6	75m	56°35.890'	-5°23.290'	192102	750280
3	272.6	100m	56°35.890'	-5°23.314'	192077	750282
3	272.6	125m	56°35.890'	-5°23.339'	192052	750283
3	272.6	150m	56°35.890'	-5°23.363'	192027	750284
4	3.2	0m	56°35.844'	-5°22.987'	192407	750178
4	3.2	25m	56°35.763'	-5°22.988'	192400	750028
4	3.2	50m	56°35.776'	-5°22.988'	192401	750053
4	3.2	75m	56°35.817'	-5°22.987'	192405	750128
4	3.2	100m	56°35.830'	-5°22.987'	192406	750153
4	3.2	125m	56°35.790'	-5°22.988'	192402	750078
4	3.2	150m	56°35.803'	-5°22.988'	192403	750103

3.2 Bath Treatments (Azamethiphos, Deltamethrin)

Azamethiphos

Recommended consent mass (3h) – 329.1 g
 Recommended consent mass (24h) – 458.4 g
 Treatment Depth – 2.0 m (16.7 % of the full cage volume)
 No. of cages per treatment – 1.4 in 3hrs, 2.0 in 24hrs

The TS plot for Azamethiphos is shown in figure 6 below:

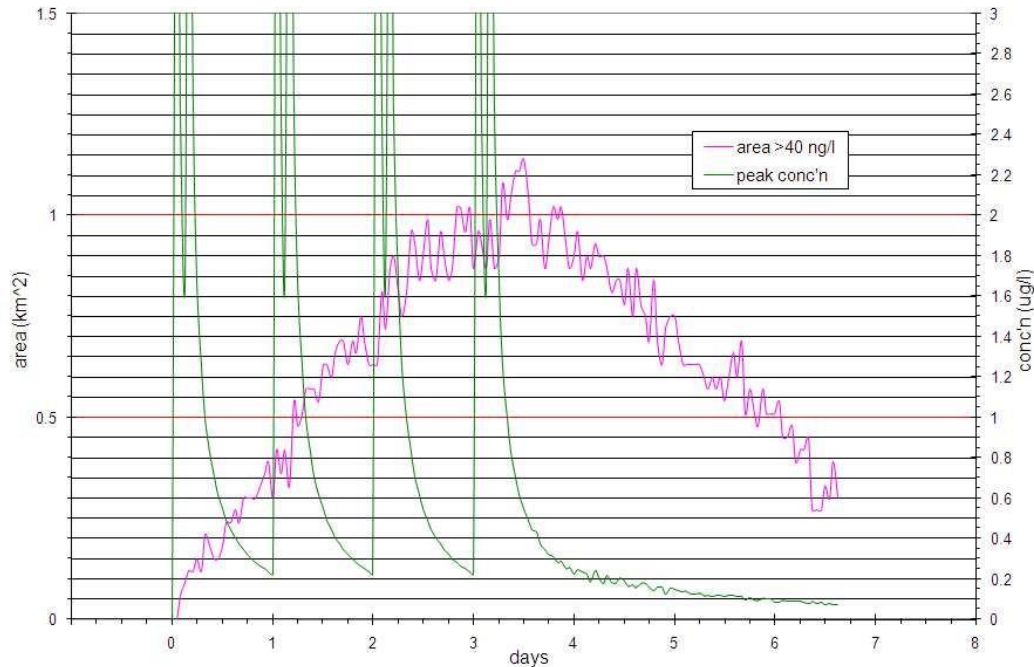


Figure 4: Azamethiphos TS plot

Deltametrin

Recommended consent mass (3h) – 22.3 g

Treatment Depth – up to 9.7 m

Treatment Volume - 11150 m³

4. Results and Conclusions

The footprint of deposition produced by the model is consistent with that expected at a moderately flushed site.

763,213,248 g of solids were released during the model run, 324,824,530 g remain within the model domain at the end of the run. This means that 42.6 % of the mass released is retained within the model indicating that a proportion of the solids released during the model run are exported from the model grid.

At the proposed new Shuna site the near bed residual current (0.004 ms^{-1} at 115.4°) flows east south east towards the Sound of Shuna. Given that CM deployments at the existing Shuna site (mid-point $56 \ 35.577\text{N } 05 \ 22.824\text{W}$) located in the Sound of Shuna indicate that currents tend to flow along a north-south axis rather than east - west it is likely that any material transported from the grid will be dispersed within the Sound of Shuna and the wider Loch Linnhe area. Particles are less likely to resuspend up slope, it is expected that any exported material will be influenced by the shallowing bathymetry to the east of the site where the contours curve northward to follow the shoreline of Loch Linnhe.

The area around Shuna is characterised by a relatively uniform bathymetry with a simple hydrography which would imply that the short term and MLA bath treatment models adequately simulate the behaviour of bath treatment chemicals released at this site.

The recommended consent limit for this is a maximum biomass of 1870.4 tonnes at a stocking density of 17 kg/m³. There are sufficient medicinal options to treat the whole site within a timely manner. Appropriate sampling transects and stations have been established to reflect this change (Fig. 3)

The recommended chemical consent limits for this site are:

Azamethiphos – a 3 hour recommended consent limit of **329.1 g** and a 24 hour recommended consent limit of **458.4 g**. This quantity is sufficient to treat one whole cage in three hours and two whole cages in 24 hours. In order to treat the whole site four treatments of two cages over four days would be required.

Deltamethrin – 3 hour recommended consent limit of **22.3 g**, this is sufficient to treat a volume of **11150 m³**. This is sufficient to treat the whole site within one day using four treatments of 2 cages every 3 hours.

REFERENCES

Scottish Environment Protection Agency (SEPA) (2019) “Regulatory Modelling Guidance for the Aquaculture Sector” Version 1.1. Available at <https://www.sepa.org.uk/media/450279/regulatory-modelling-guidance-for-the-aquaculturesector.pdf> (Accessed on 01/12/20)