



Bath Medicine Dispersion Modelling

Cairidh, Caol Mor

CAR/L/1010432

Mowi Scotland Limited
August 2025

Mowi Scotland	OFFICE	PHONE	FAX
	Mowi, Farms Office, Glen Nevis Business Park PH33 6RX Fort William		-
	POSTAL	MAIL	
	Mowi, Farms Office, Glen Nevis Business Park PH33 6RX Fort William	environment@mowi.com	
		WEB	
		http://mowiscotland.co.uk	

CONTENTS

	Page
EXECUTIVE SUMMARY	5
1 INTRODUCTION	6
1.2 Site Details	6
2 MODEL DETAILS	7
2.1 Model Domain and Boundary Conditions	7
2.2 Medicine Dispersion Modelling	9
2.3 Azamethiphos Dispersion Simulations	11
2.4 Azamethiphos 3-hour EQS	11
2.5 Deltamethrin 6-hour EQS	12
2.6 Interactions with Special Features	12
3 RESULTS	14
3.1 Azamethiphos Dispersion During Neap Tides, May 2024 (ID437)	14
3.2 Sensitivity to Horizontal Diffusion Coefficient	15
3.3 Azamethiphos Dispersion during Spring Tides, April 2024 (ID437)	16
3.4 Azamethiphos Dispersion During Neap Tides, July 2024 and August 2018 (ID439 & ID230)	17
3.5 Azamethiphos 3-Hour EQS	18
3.6 Deltamethrin 6-hour EQS	19
3.7 Interactions with Special Features	19
4 SUMMARY AND CONCLUSIONS	23
5 REFERENCES	24

List of Figures

Figure 1. Location of the salmon farms at Cairidh (south), and neighbouring site Maol Ban (north), on Skye, including the locations of the ADCP deployments (▲) relative to the pen (o) positions.....	6
Figure 2. The mesh and domain of the modelling study, adapted from the ECLH sub-model.	7
Figure 3. The unstructured mesh around the Cairidh and neighbouring Maol Ban sites in the modified model grid, with the pen locations indicated (O) and the ADCP deployments (▲).....	8
Figure 4. Model water depths (m) around the Cairidh and neighbouring Maol Ban salmon farms from the modified model. The pen locations indicated (●) and the ADCP deployments (▲).....	8
Figure 5. Sea surface height (SSH) at Cairidh from 28 th March –13 th June 2024 (ID437). Dispersion simulations were performed over neap tides (red, start day 12 th May 2024) and spring tides (purple, start day 4 th April 2024).....	10
Figure 6. Sea surface height (SSH) at neighbouring site Maol Ban from 13 th June to 15 th August 2024 (ID439). Dispersion simulations were performed over neap tides (yellow, start day 26 th July 2024)	10
Figure 7. Sea surface height (SSH) at neighbouring site Maol Ban from 5 th July to 20 th September 2018 (ID230). Dispersion simulations were performed over neap tides (green, start day 1 st August 2018)	10
Figure 8. Identified special features near the Cairidh and neighbouring Maol Ban salmon farms.....	13
Figure 9. Predicted concentration fields for a dispersion simulation at neap tides after 48 hours (top left), 96 hours (top right), 120 hours (bottom left) and 192 hours (bottom right).....	14
Figure 10. Time series of maximum concentration (top) and area exceeding the EQS (bottom) from run 1 and run 2 (Table 4). The model was run during neap tide with varying horizontal diffusion coefficient K_H ($m^2 s^{-1}$). The MAC and area limit 72 hours after the final treatment (Time = 192 h) of 0.1 $\mu g/L$ and 0.5 km^2 are indicated by the horizontal dashed lines.....	16
Figure 11. Time series of maximum concentration (top) and the area where concentrations exceeded the EQS (bottom) from runs 3 & 4 (Table 4). The model was run at spring tides with varying horizontal diffusion coefficient K_H ($m^2 s^{-2}$). The MAC and area limit 72	

hours after the final treatment (Time = 192 h) of 0.1 $\mu\text{g/L}$ and 0.5 km^2 are indicated by the horizontal dashed lines.	17
Figure 12. Time series of maximum concentration (top) and the area where concentrations exceeded the EQS (bottom) from runs 5 & 6 (Table 4). The model was run at neap tides from July 2024 and August 2018. The MAC and area limit 72 hours after the final treatment (Time = 192 h) of 0.1 g/L and 0.5 km^2 are indicated by the horizontal dashed lines.	18
Figure 13. Time series of the area exceeding the 3-hour EQS for the third (middle) pen treatment during the 3 hours following release at neap and spring tide. The 3-hour mixing zone area is indicated (---).	19
Figure 14. Peak concentrations at all special feature locations over neap (top) and spring (bottom) tides	20
Figure 15. Predicted concentration fields for a baseline neap (top) and spring (bottom) tide dispersion simulation at 3 (left) and 72 (right) hours after the final treatment at Cairidh. Specified special features are shown, Flame Shell beds (red), Mearl bed (blue) and Seagrass bed (magenta).	21
Figure 16. Concentration depth profiles for the fifteen special features at 3 and 72 hours after final treatment over neap tides (top) and spring tides (bottom).	22

List of Tables

<i>Table 1. Summary of Results</i>	<i>5</i>
<i>Table 2. Hydrographic Information</i>	<i>6</i>
<i>Table 3. Details of the treatment release simulated by the dispersion model. The release time is relative to the start of the neap or spring period highlighted in Figure 5.</i>	<i>11</i>
<i>Table 4. Dispersion model simulation details for the treatment of the 6 pens at Cairidh.....</i>	<i>11</i>
<i>Table 5. Parameter values used in the calculation of the 3-hour mixing zone ellipse area and the resulting area.....</i>	<i>12</i>
<i>Table 6. Details of identified special features.....</i>	<i>13</i>
<i>Table 7. Locations of each of the identified special features (excluding Native Oysters).....</i>	<i>13</i>
<i>Table 8. Summary of Results</i>	<i>23</i>

QUALITY ASSURANCE

Mowi Scotland Ltd. maintains a Quality Manual which defines the Quality and Environmental Policy of Mowi Scotland Farming Limited and includes an overview of its processes and acts as a signpost to key elements of its Quality Management System according to the requirements of BS EN ISO 9001, BS EN ISO 14001, GLOBALG.A.P. and British Retail Consortium Global Standard Food. Note the BRC standard is relevant to Blar Mhor processing plant only.

EXECUTIVE SUMMARY

Dispersion model simulations have been performed to assess whether bath treatments at Cairidh salmon farm will comply with pertinent environmental quality standards. A realistic treatment regime, with one treatment per day, was simulated. Each treatment utilised 700 g of azamethiphos (the active ingredient in Salmosan, Salmosan Vet and Azure), resulting in a daily release of 700 g (Table 1) and a total discharge over 5 days of 4.2 kg. Simulations were performed separately for modelled neap and spring tides, and the sensitivity of the results to key model parameters was tested.

The model results confirmed that the treatment scenario proposed, with a daily release of no more than 700 g of azamethiphos will comply with the EQS. The peak concentration during the baseline simulation 72 hours after the final treatment was less than 0.1 µg/L, the maximum allowable concentration, and the area where concentrations exceeded the EQS of 0.04 µg/L was substantially less than the allowable 0.5 km². The baseline simulation presented here was designed to be relatively conservative.

Simulations using the BathAuto spreadsheet for Deltamethrin resulted in a consentable quantity of 16 g.

Table 1. Summary of Results

Site details	
Site Name:	Cairidh
Site Location:	Caol Mor
Peak Biomass (T):	1,800
Pen details	
Number of Pens:	6
Pen Circumference (m):	160
Pen Depth (m):	12
Pen Group Configuration:	2 x 3
Azamethiphos consent to be applied for	
Recommended 3-hour (kg):	0.700
Recommended 24-hour (kg):	0.700
Deltamethrin consent to be applied for	
Recommended 6-hour (kg)	0.016

1 INTRODUCTION

This report has been prepared by Mowi Scotland Ltd. to meet the requirements of the Scottish Environment Protection Agency (SEPA) for an application to increase the current consent of topical sealice veterinary medicines at the marine salmon farm Cairidh, Isle of Skye (Figure 1). The current Azamethiphos consent for Cairidh is 177.4 g (3 hours) and 325.6 g (24 hours). The report presents results from coupled hydrodynamic and particle tracking modelling to describe the dispersion of bath treatments to determine EQS-compliant quantities for the current site biomass and equipment. The modelling procedure follows as far as possible guidance presented by SEPA in December 2023 (SEPA, 2023).

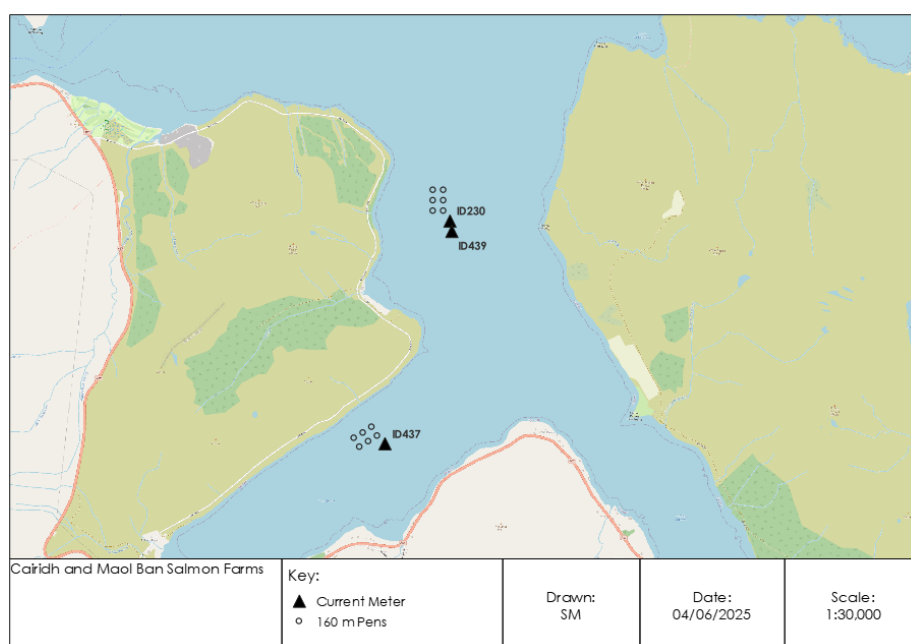


Figure 1. Location of the salmon farms at Cairidh (south), and neighbouring site Maol Ban (north), on Skye, including the locations of the ADCP deployments (▲) relative to the pen (○) positions.

1.2 Site Details

The site is situated in the Caol Mor area of the Isle of Skye (Figure 1). Details of the hydrographic data are provided in Table 2. The receiving water is defined as Loch Ainort.

Table 2. Hydrographic Information

Hydrographic Data	ID437	ID439	ID230
Site:	Cairidh	Maol Ban	Maol Ban
Current Meter Position:	156270, 828862	156911, 830898	156893, 830997
Depth of Deployment Position (m):	39	52.7	56.27
Duration of Record (days):	68	63	76
Start of Record:	28/03/2024	13/06/2024	05/07/2018
End of Record:	04/06/2024	15/08/2024	20/09/2018
Current Meter Averaging Interval (min):	5	5	20
Magnetic Correction to Grid North:	0.84318	0.87664	-0.20299

2 MODEL DETAILS

2.1 Model Domain and Boundary Conditions

The unstructured mesh used in the model was adapted from the East Coast of Lewis and Harris (ECLH) sub-model mesh of the Scottish Shelf Model (SSM; Marine Scotland, 2016) (Figure 2). Model resolution was enhanced in the Caol Mor region particularly around the Mowi sites at Cairidh and Maol Ban (Figure 3). The spatial resolution of the model varied from 20 m in some inshore waters and round the farm pens to 5 km along the open boundary. The model consisted of 50,649 nodes and 95,354 triangular elements. Model bathymetry (Figure 4) was also taken from the ECLH sub-model (SSM, MS 2016).

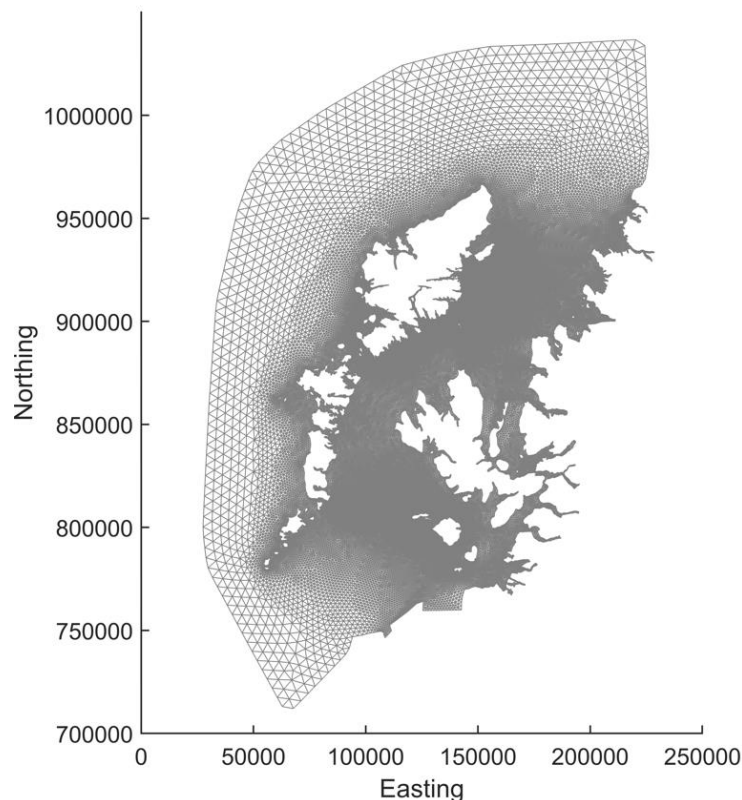


Figure 2. The mesh and domain of the modelling study, adapted from the ECLH sub-model.

The model was forced at the outer boundaries by 8 tidal constituents (M_2 , S_2 , N_2 , K_2 , O_1 , K_1 , P_1 , Q_1) which were derived from tidal analysis (Pawlowicz et al., 2002) of the sea surface elevations at the closest nodes from the Scottish Shelf Model climatology (Marine Scotland, 2016). Spatially- and temporally-varying wind speed and direction data were taken from the ERA5 global reanalysis dataset (ECMWF, 2021) for the required simulation periods. Details of the hydrodynamic modelling that underpins the dispersion model are given in Mowi (2025).

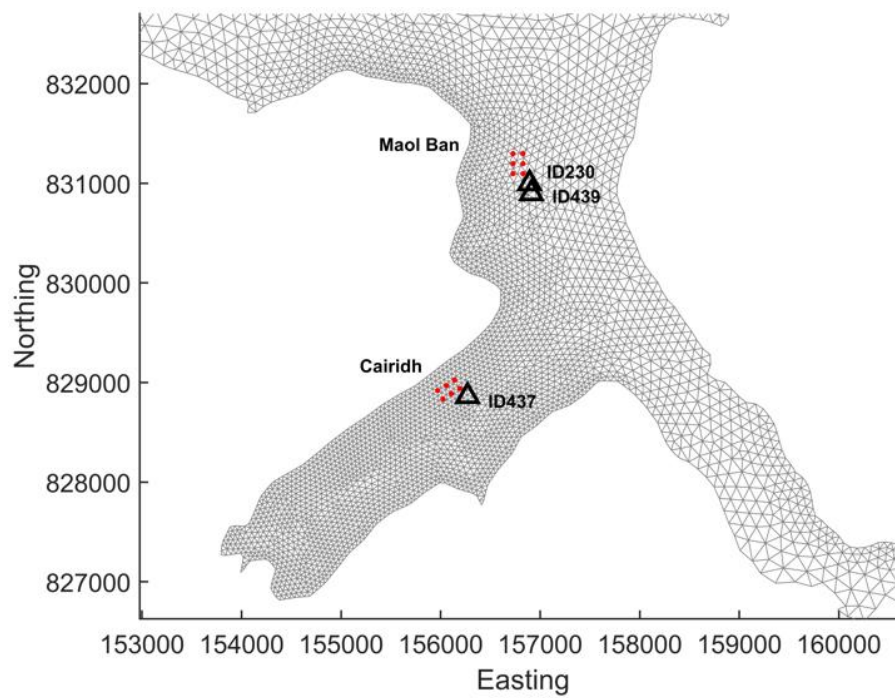


Figure 3. The unstructured mesh around the Cairidh and neighbouring Maol Ban sites in the modified model grid, with the pen locations indicated (●) and the ADCP deployments (▲).

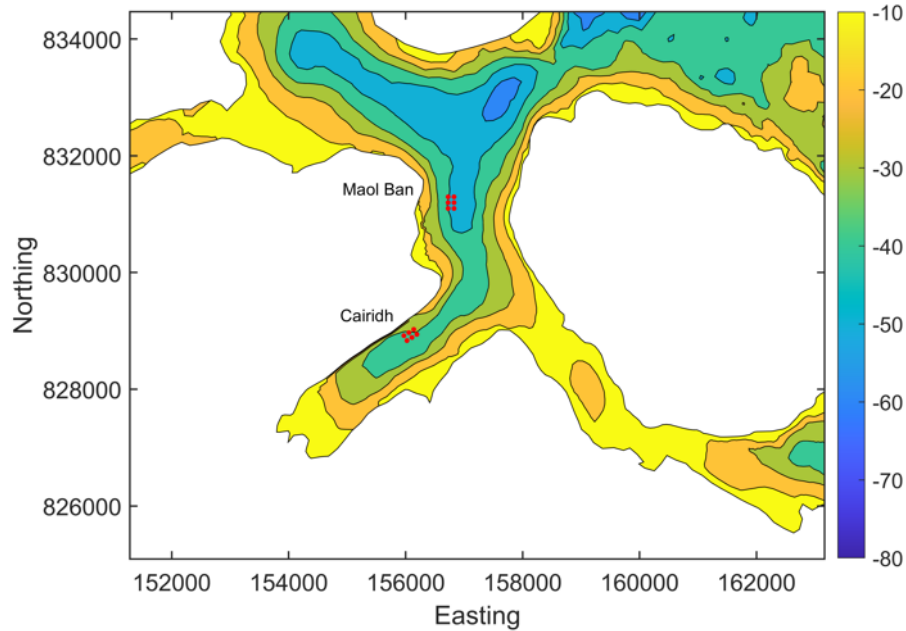


Figure 4. Model water depths (m) around the Cairidh and neighbouring Maol Ban salmon farms from the modified model. The pen locations indicated (●) and the ADCP deployments (▲).

2.2 Medicine Dispersion Modelling

The medicine dispersion modelling, performed using the UnPTRACK model (Gillibrand, 2022), simulates the dispersion of patches of medicine discharged from pens following treatment using tarpaulins. The UnPTRACK model uses the same unstructured mesh as the hydrodynamic model, and reads the flow fields directly from the hydrodynamic model output files. The hourly current velocities are interpolated in time and space from the hydrodynamic mesh to particle locations at the particle model time step (typically $dt = 600$ s) within UnPTRACK.

To simulate the worst-case scenario, the dispersion modelling was initially conducted using flow fields over a period of 9 days, centred on a small neap tidal range taken from the hydrodynamic model simulations. This is assumed to be the least dispersive set of ambient conditions, when medicine dispersion is least likely to meet the required EQS. Later simulations tested dispersion during spring tides.

A treatment depth of 3.7 m was chosen as a realistic net depth during application of the medicine for the 160 m pens. The initial mass released per pen was calculated from the reduced pen volume and a total mass of 5.39 kg of azamethiphos released during treatment (6 pens). Numerical particles were released from random positions within a pen radius of the centre and within the 0 – 3.7 m depth range. The simulations used 420,000 numerical particles in total, each particle representing 10 mg of azamethiphos.

Each simulation ran for a total of 217 hours (9.1 days). This covered the treatment period (120 hours), a dispersion period to the EQS assessment 72 hours after the final treatment, and an extra 25 hours to check for chance concentration peaks. At every hour of the simulation, particle locations and properties (including the decaying mass) were stored and subsequently concentrations calculated. Concentrations were calculated on a grid of 50m x 50m squares using a depth range of 0 – 5 m. Using a regular grid for calculating concentrations means that a known, constant, accuracy and precision of the calculated values applies across the grid.

From the calculated concentration fields, time series of two metrics were constructed for the whole simulation:

- (i) The maximum concentration ($\mu\text{g/L}$) anywhere on the regular grid; and
- (ii) The area (km^2) where the EQS was exceeded.

These results were used to assess whether the EQS or MAC was breached after the allotted period (72 hours after the final treatment).

Sensitivity analyses were conducted to assess the effects of the horizontal diffusion coefficient using the value produced from the dye study conducted at the site. The dispersion simulations were also performed separately over three neap tides to confirm the dispersion during the weakest tides, and a spring tide (Figure 5, Figure 6 and Figure 7).

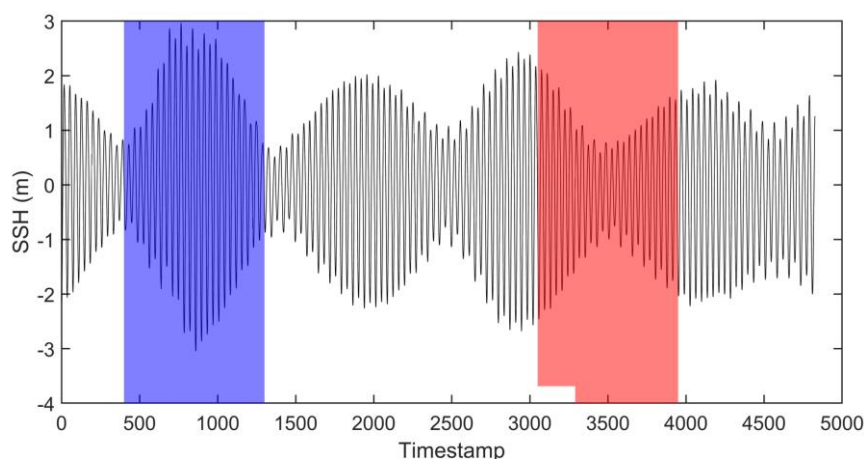


Figure 5. Sea surface height (SSH) at Cairidh from 28th March –13th June 2024 (ID437). Dispersion simulations were performed over neap tides (red, start day 12th May 2024) and spring tides (purple, start day 4th April 2024)

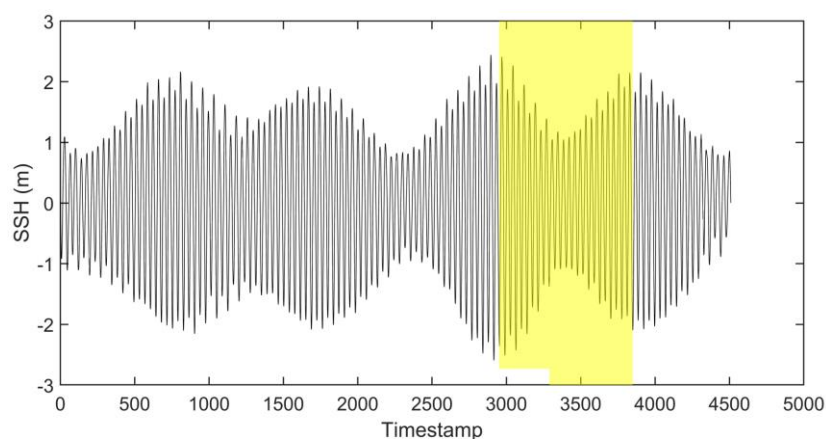


Figure 6. Sea surface height (SSH) at neighbouring site Maol Ban from 13th June to 15th August 2024 (ID439). Dispersion simulations were performed over neap tides (yellow, start day 26th July 2024)

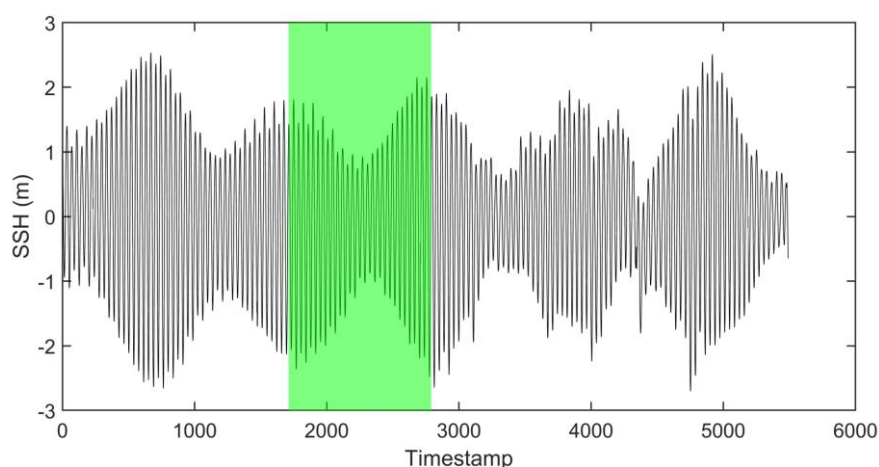


Figure 7. Sea surface height (SSH) at neighbouring site Maol Ban from 5th July to 20th September 2018 (ID230). Dispersion simulations were performed over neap tides (green, start day 1st August 2018)

2.3 Azamethiphos Dispersion Simulations

The pen locations and details of the medicine source are listed in Table 3. The time of release is relative to the start of the neap or spring period highlighted in Figure 5, Figure 6 and Figure 7. All simulations used the release schedule and quantities outlined in Table 3.

Table 3. Details of the treatment release simulated by the dispersion model. The release time is relative to the start of the neap or spring period highlighted in Figure 5.

Pen	Easting	Northing	Net Depth (m)	Treatment Mass (kg)	Release Time (hours)
1	156139	829025	3.7	0.700	0
2	156192	828940	3.7	0.700	24
3	156107	828887	3.7	0.700	48
4	156023	828833	3.7	0.700	72
5	155969	828919	3.7	0.700	96
6	156055	828969	3.7	0.700	120

Table 4. Dispersion model simulation details for the treatment of the 6 pens at Cairidh.

	Run No.	T 1/2 (h)	Kh	Kv
Neap Tides, Start day = 45 (12th May 2024, Cairidh ID437)				
Baseline	1	134.4	0.1	0.001
Sensitivity	2	134.4	0.084	0.001
Spring Tides, Start day = 7 (4th April 2024, Cairidh ID437)				
Baseline	3	134.4	0.1	0.001
Sensitivity	4	134.4	0.084	0.001
Neap Tides, Start day = 43 (26th July 2024, Maol Ban ID439)				
Baseline	5	134.4	0.1	0.001
Neap Tides, Start day = 26 (1st August 2018, Maol Ban ID230)				
Baseline	6	134.4	0.1	0.001

2.4 Azamethiphos 3-hour EQS

In addition to the main simulations described above to assess compliance with the 72-hour EQS, simulations were also performed to assess compliance with the 3-hour EQS (SEPA, 2023). The 3-hour EQS is applied as a mixing zone EQS, whereby the area where concentrations exceed the EQS of 250 ng L⁻¹ after 3 hours must be less than the 3-hour mixing zone. The 3-hour mixing zone is primarily a function of mean near-surface current speed at the site, and has traditionally been calculated by the BathAuto Excel spreadsheet. For calculation of the mixing zone, a mean surface current speed of 6.0 cm s⁻¹ was used from ID437 surfaced referenced data (Table 5).

For the 3-hour EQS assessment, the baseline runs for neap and spring tides (Runs 1 and 3 in Table 4) were repeated, but with results output every 20 minutes and the runs were truncated, lasting only until 3 hours after the final treatment. The area of the medicine patch for each individual treatment was then calculated over the 3-hour period following its release, and the area exceeding 0.25 µg L⁻¹ determined. Concentrations from these simulations were

calculated on a 10m x 10m grid (rather than a 50m x 50m grid) in order to more accurately calculate the smaller areas of medicine over the initial 3-hour period.

Table 5. Parameter values used in the calculation of the 3-hour mixing zone ellipse area and the resulting area

Parameter	Value
Mean current speed (ms^{-1})	0.060
Area of 160 m pen (km^2)	0.00203718
Distance from shore (km)	0.29
Mean water depth (m)	38
Treatment Depth (m)	5
AZA 3-hour Mixing zone ellipse area (km^2)	0.093982

2.5 Deltamethrin 6-hour EQS

Deltamethrin dispersion was modelled using the BathAuto Excel spreadsheet. The same current data from Cairidh, ID437, was used as input to the spreadsheet, and the same treatment depth of 3.7 m. The completed spreadsheet is included with the application files.

2.6 Interactions with Special Features

Four types of near-by PMF features of interest have been identified (SEPA, 2025) which are thought to be at potential risk from medicine influence and hence must be considered when modelling the treatment releases from Cairidh. Table 6 and Table 7 show details of the features of interest, and the locations are indicated in Figure 8. Due to the sensitivity of the Native Oyster beds, the locations of these will not be disclosed.

Predicted concentrations of Azamethiphos at the PMF locations during the simulation periods were extracted from the model results. These calculations were made using a 5 m thick layer immediately above the seabed, since all types of the special features are benthic habitats.

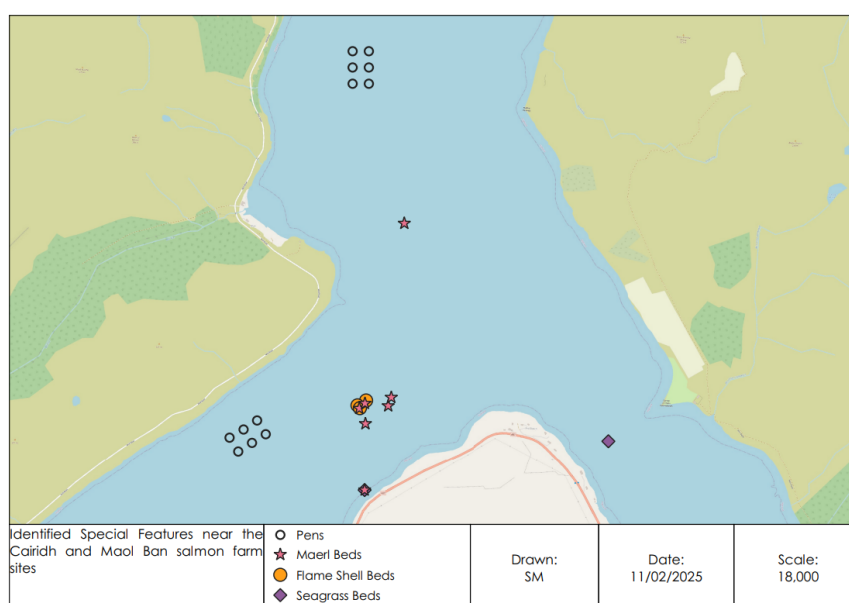


Figure 8. Identified special features near the Cairidh and neighbouring Maol Ban salmon farms.

Table 6. Details of identified special features

Feature Name	Feature Type	Reason for Identification
Maerl Beds	PMF	At risk from bath influence
Flame Shell Beds	PMF	At risk from bath influence
Seagrass Beds	PMF	At risk from bath influence
Native Oysters	PMF	At risk from bath influence

Table 7. Locations of each of the identified special features (excluding Native Oysters).

Name	Easting	Northing
Flameshell Bed 1	156810	829148
Flameshell Bed 2	156757	829118
Flameshell Bed 3	156772	829101
Maerl 1	156801	828597
Maerl 2	156806	829005
Maerl 3	156946	829115
Maerl 4	157045	830238
Maerl 5	156965	829167
Maerl 6	156768	829099
Maerl 7	156803	829130
Seagrass 1	158301	828897
Seagrass 2	156801	828597

3 RESULTS

3.1 Azamethiphos Dispersion During Neap Tides, May 2024 (ID437)

A standard treatment of six 160 m pens, with a reduced net depth of 3.7 m and assuming 1 pen can be treated per day resulted in a treatment mass per pen of azamethiphos of 700 g and a total treatment release of 4.2 kg over 120 hours. The dispersion of the medicine during and following treatment from Run001 (Table 4) is illustrated in Figure 9. After 48 hours, as the third treatment is discharged, discrete patches of medicine are evident from the first two treatment releases from the first and second day. After 96 hours, as the fifth treatment is discharged, discrete patches of medicine from the previous treatment releases are still evident, but the patches of medicine have rapidly dispersed and are already down to concentrations of the same order as the EQS (0.04 µg/L). There is another peak in concentration at this time due to the release of the fifth treatment.

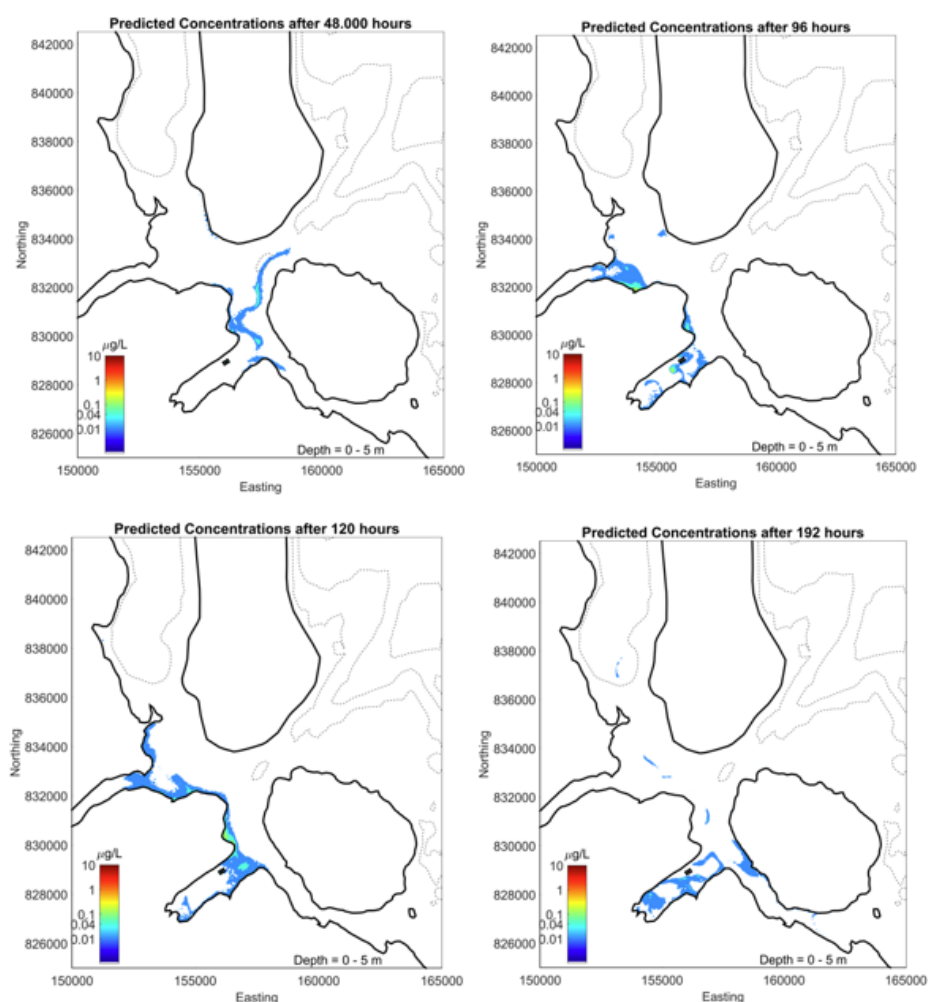


Figure 9. Predicted concentration fields for a dispersion simulation at neap tides after 48 hours (top left), 96 hours (top right), 120 hours (bottom left) and 192 hours (bottom right).

The treatment schedule completed after 120 hours (5 days). At this stage, the medicine released on earlier days has already dispersed north. It is noticeable that dispersion of the medicine does not happen in a gradual “diffusive” manner, but is largely driven by eddies and

horizontal shear in the spatially-varying velocity field, which stretches and distorts the medicine patches and enhances dispersion. 72 hours after the final treatment (192 hours elapsed), the treatment patches were dispersed and concentrations had rapidly fallen away below the EQS. Remnants of medicine are seen but at concentrations below the MAC.

The time series of maximum concentration from this simulation is shown in Figure 10 (blue). The 6 peaks in concentration following each treatment event over the first 5 days are evident. Following the final treatment after 120 hours, the maximum concentration fell steadily away (Figure 10). A default half-life of 134.4 hours (5.5 days) was used. The maximum concentration 72 hours after the final treatment (time = 192 hours) was well below 0.1 µg/L, the maximum allowable concentration (MAC).

The area where the EQS of 0.04 µg/L was exceeded peaked at about 1 km² following the final treatment, but had fallen well below the 0.5 km² threshold immediately after; by 72 hours after the final treatment, the exceeded area was close to zero (Figure 9 and Figure 10).

These results indicate that, with a horizontal diffusion coefficient of 0.1 m² s⁻¹, and a medicine half-life of 134.4 hours, the environmental quality standards are achieved.

3.2 Sensitivity to Horizontal Diffusion Coefficient

The model results were tested for sensitivity to the horizontal diffusion coefficient. The horizontal diffusion coefficient used for the baseline runs was $K_H = 0.1 \text{ m}^2 \text{ s}^{-1}$. Simulations were also performed with $K_H = 0.084 \text{ m}^2 \text{ s}^{-1}$, the value derived from the Dye/Droque study undertaken at the site. The time series of maximum concentration and area exceeding the EQS are shown in Figure 10 (red). The MAC and EQS were both comfortably met 72 hours after the final treatment.

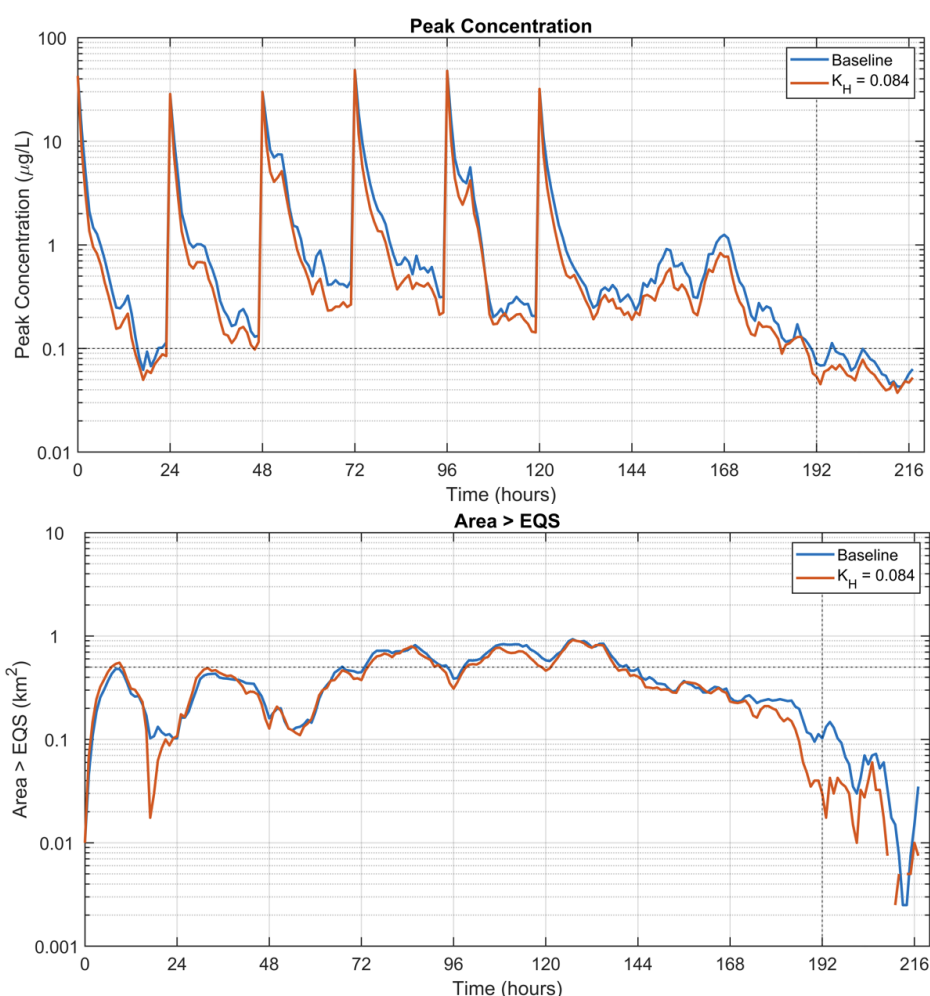


Figure 10. Time series of maximum concentration (top) and area exceeding the EQS (bottom) from run 1 and run 2 (Table 4). The model was run during neap tide with varying horizontal diffusion coefficient K_H ($m^2 s^{-1}$). The MAC and area limit 72 hours after the final treatment (Time = 192 h) of 0.1 $\mu g/L$ and 0.5 km^2 are indicated by the horizontal dashed lines.

3.3 Azamethiphos Dispersion during Spring Tides, April 2024 (ID437)

Dispersion simulations were carried out during modelled spring tides in April 2024 (Figure 5), repeating the main set carried out for neap tides (Table 4). The same treatment scenario of 1 treatment per day was simulated, with each treatment using 700 g of Azamethiphos. For both, the MAC and area EQS were comfortably achieved (Figure 11).

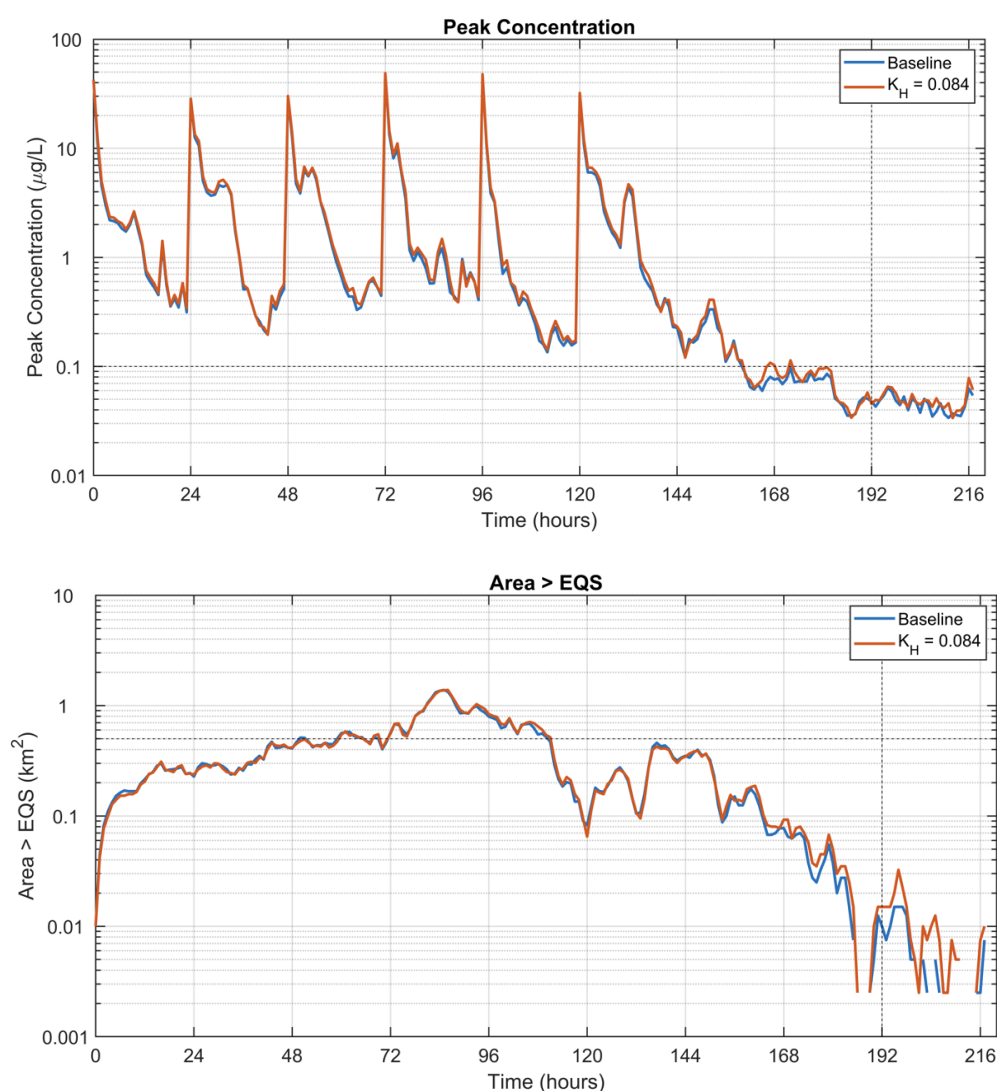


Figure 11. Time series of maximum concentration (top) and the area where concentrations exceeded the EQS (bottom) from runs 3 & 4 (Table 4). The model was run at spring tides with varying horizontal diffusion coefficient K_H ($\text{m}^2 \text{s}^{-2}$). The MAC and area limit 72 hours after the final treatment (Time = 192 h) of 0.1 $\mu\text{g/L}$ and 0.5 km^2 are indicated by the horizontal dashed lines.

3.4 Azamethiphos Dispersion During Neap Tides, July 2024 and August 2018 (ID439 & ID230)

A further set of dispersion simulations during modelled neap tides in July 2024 and August 2018 were carried out (Figure 6 and Figure 7), repeating the baseline carried out for neap tides in May 2024 (Table 4). The results of these are shown in Figure 12. The same treatment scenario of 1 treatment per day was simulated, with each treatment using 700 g of Azamethiphos. There is a minor increase in concentration 72 hours after the final treatment (blue) which is thought to be an artefact of the model and quickly decreases again below the EQS criteria.

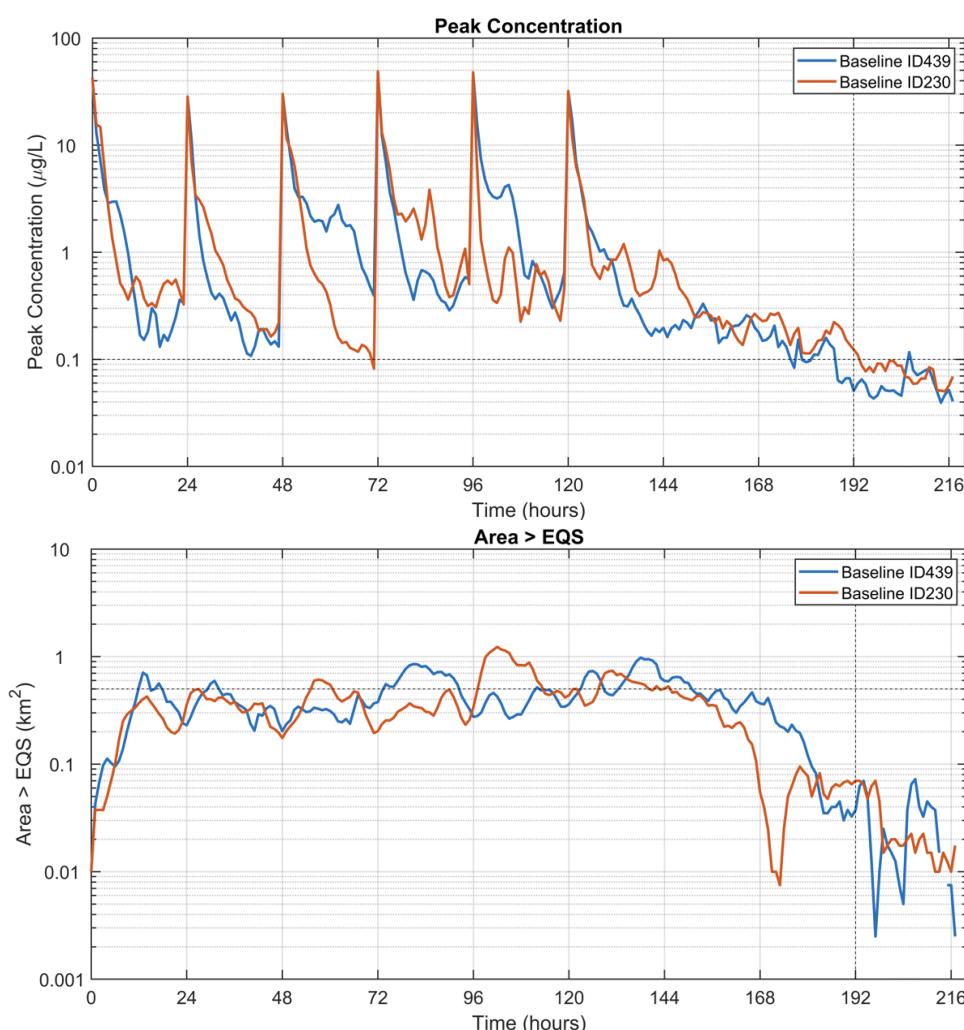


Figure 12. Time series of maximum concentration (top) and the area where concentrations exceeded the EQS (bottom) from runs 5 & 6 (Table 4). The model was run at neap tides from July 2024 and August 2018. The MAC and area limit 72 hours after the final treatment (Time = 192 h) of 0.1 g/L and 0.5 km² are indicated by the horizontal dashed lines.

3.5 Azamethiphos 3-Hour EQS

The 3-hour mixing zone is primarily a function of mean near-surface current speed at the site, and has traditionally been calculated by the BathAuto Excel spreadsheet. For calculation of the mixing zone, a mean surface current speed of 6 cm s⁻¹ was used from ID437 (Table 1) which was thought to be a representative value for the surface 0 – 5 m layer at Cairidh. The parameter values used in the calculation of the 3-hour mixing zone ellipse area are shown in Table 5.

The time series of the areas where the 3-hour EQS of 250 µg/L is exceeded for a single selected treatment at neap tide (first release on 12th May 2024) are shown in Figure 13. The single treatment selected was the 3rd release which is closest to the centre of the neap tide and hence is discharged during what is thought to be the least dispersive conditions. The area exceeding the EQS was less than the allowable mixing zone (0.093982 km²) after 3 hours.

For spring tide releases (first release on 4th April 2024), the area where concentrations exceeded the 3-hour EQS also complied with the allowable area (Figure 13). This demonstrates that the discharge quantity of 700 g of Azamethiphos from each of the six 160 m pens at Cairidh should not breach the 3-hour Environmental Quality Standard.

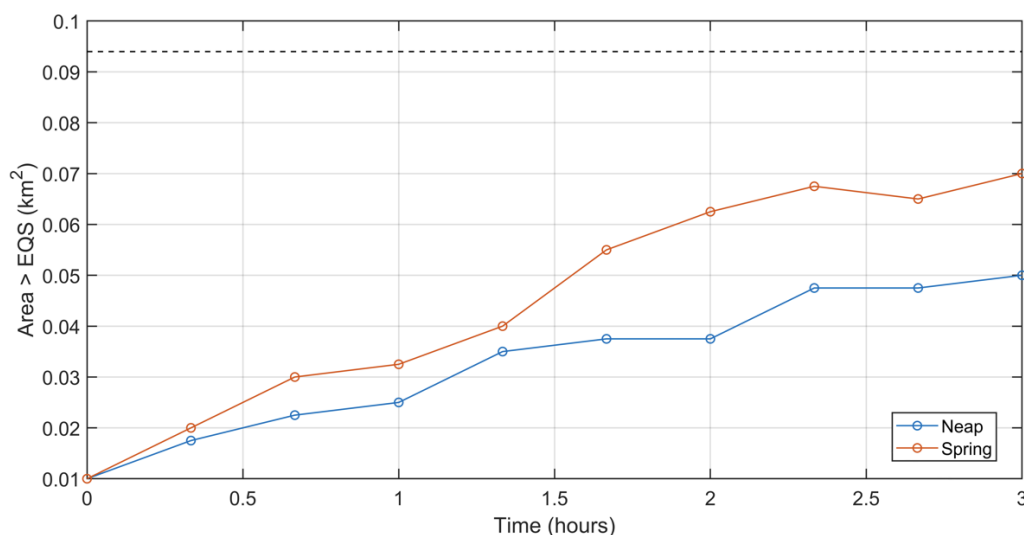


Figure 13. Time series of the area exceeding the 3-hour EQS for the third (middle) pen treatment during the 3 hours following release at neap and spring tide. The 3-hour mixing zone area is indicated (---).

3.6 Deltamethrin 6-hour EQS

The conservative BathAuto excel spreadsheet, using input data from the ID437 deployment at Cairidh (surface referenced), was utilised to calculate a maximum consentable quantity of Deltamethrin. The results gave a permitted Deltamethrin mass of 16 g, which allows for 1 pen to be treated every 6 hours.

3.7 Interactions with Special Features

Figure 14 shows the hourly peak concentrations at each of the identified special feature locations (SEPA, 2024) for a 5 m thick layer above the seabed. The concentrations are minimal throughout at both neap and spring tide. At 141 hours, at least one of each of the Maerl, Seagrass and Oyster locations has a concentration spike that exceeds the 3-hour EQS level. This does, however, rapidly decrease in the hours following down to levels well below both EQS. All spring tide time series stay at consistent low concentration levels throughout.

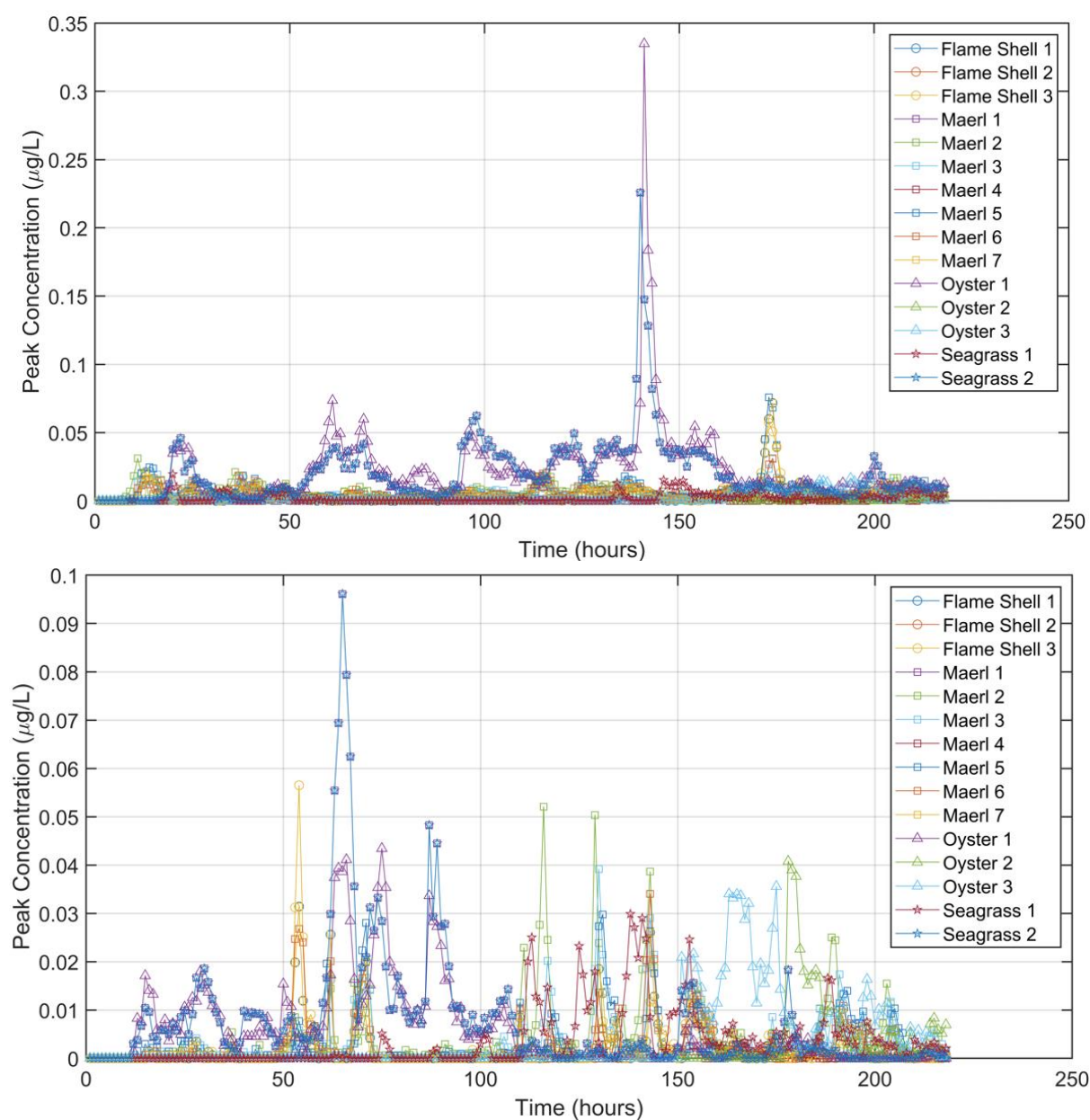


Figure 14. Peak concentrations at all special feature locations over neap (top) and spring (bottom) tides

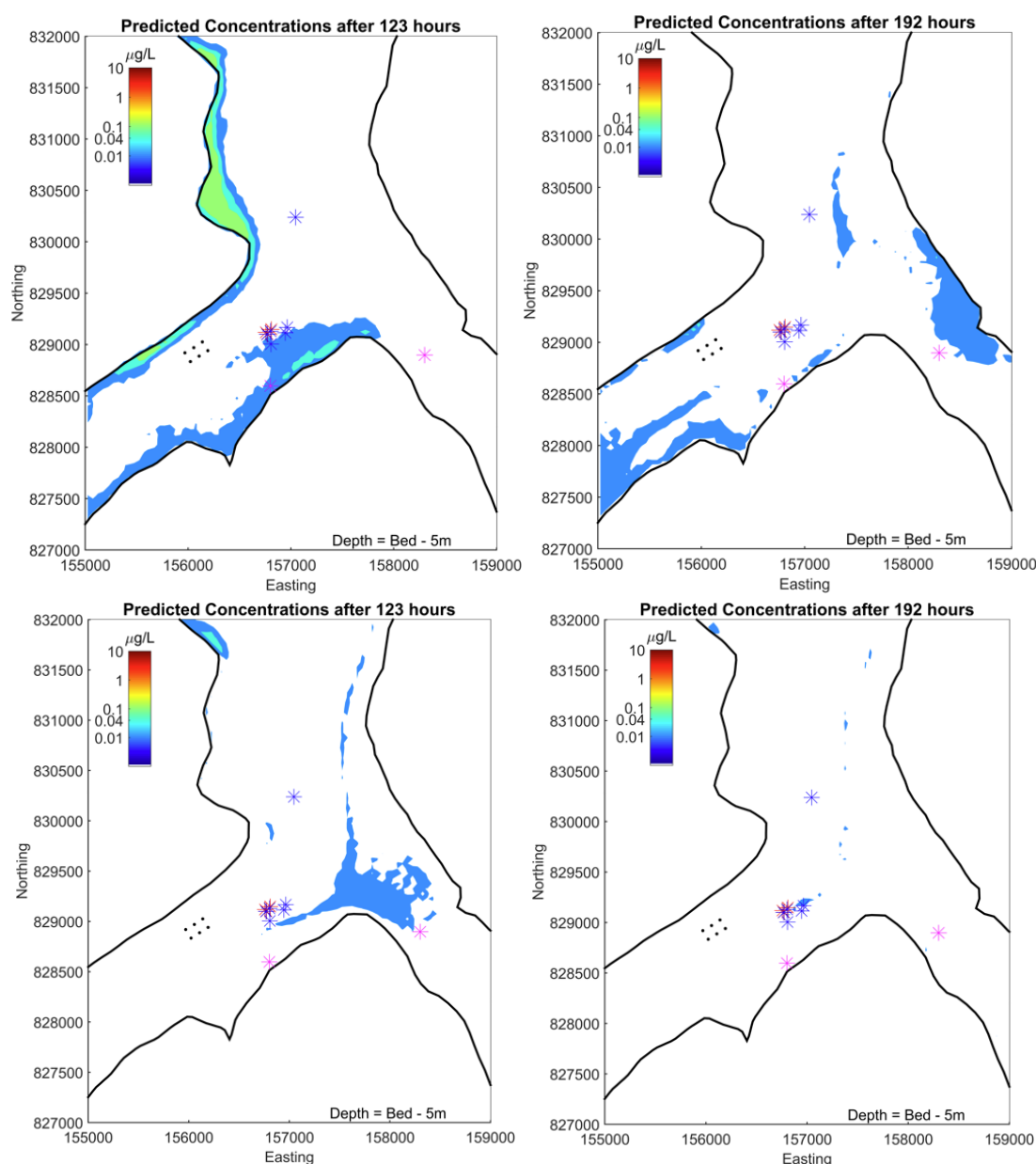


Figure 15. Predicted concentration fields for a baseline neap (top) and spring (bottom) tide dispersion simulation at 3 (left) and 72 (right) hours after the final treatment at Cairidh. Specified special features are shown, Flame Shell beds (red), Mearl bed (blue) and Seagrass bed (magenta).

Figure 15 shows the concentrations around the site and specified special features for the 5 meter layer above the seabed. Concentrations 3 hours after the final treatment are up to 0.1 ug/L but these higher concentration locations are well away from any of the special features. 72 hours after the final treatment, concentrations are a degree of magnitude below the 72-hour MAC within the whole study domain. Due to their sensitivity, the positions of the Native Oyster beds have been omitted from the plots but concentrations have been checked and do not exceed either the 3-hour or 72-hour EQS at their locations.

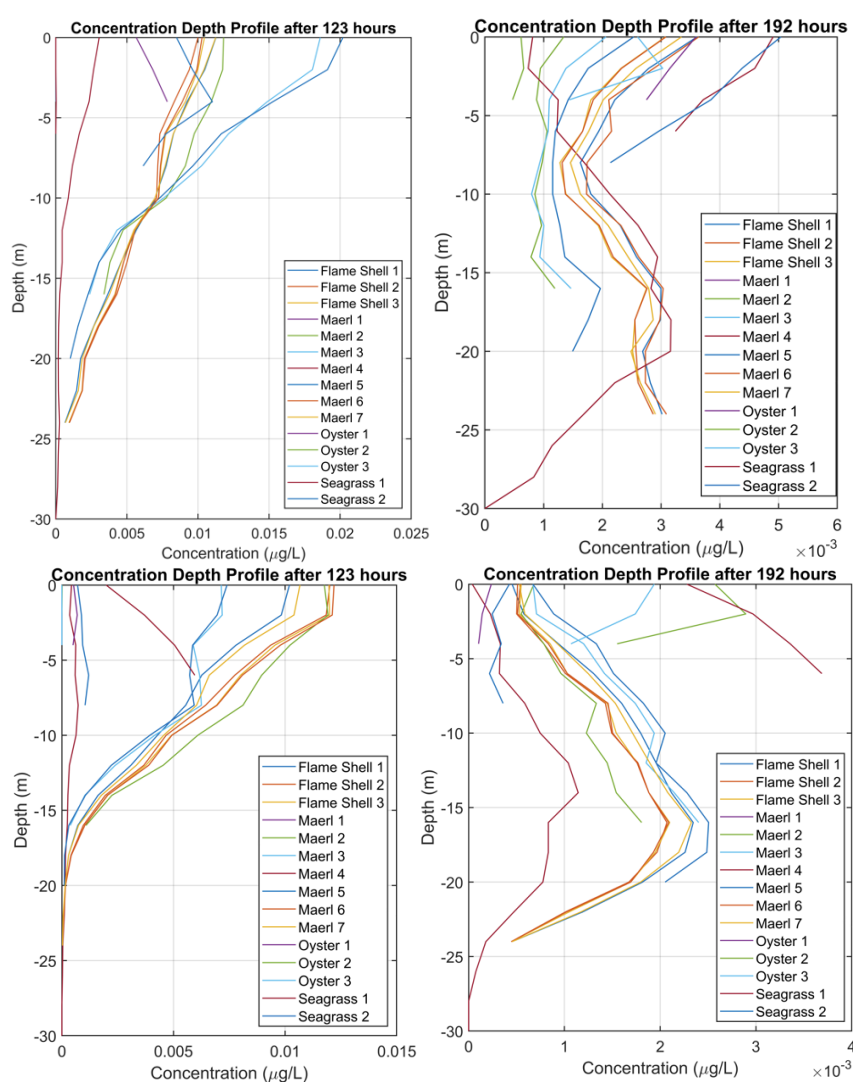


Figure 16. Concentration depth profiles for the fifteen special features at 3 and 72 hours after final treatment over neap tides (top) and spring tides (bottom).

Figure 16 shows concentration depth profiles, calculated using a 250 m radius area around each of the specified special features, at 3 and 72 hours after the final treatment release at both spring and neap tides. Concentrations at all special features are well below both the 3-hour and 72-hour EQS (MACs of 0.25 and 0.1 $\mu\text{g/L}$) throughout the water column. The higher concentrations are seen nearer the surface and decrease towards the seabed, where the special features are located. This is followed by a significant decline in concentration, shown in the 192 hours depth profile. It is clear that the concentrations decrease at depth, highlighting that all of the benthic habitats are less exposed to the medicine releases. These results indicate that the medicine releases from Cairidh fish farm will not have a detrimental effect on the nearby special features and that medicine levels are well below environmental quality standards.

4 SUMMARY AND CONCLUSIONS

A total of 6 dispersion simulations have been performed to assess whether bath treatments at Cairidh salmon farm will comply with pertinent environmental quality standards. A treatment quantity of 700 g of Azamethiphos per release was used.

A realistic treatment regime, with 1 treatment a day was simulated. Each treatment required 700 g of Azamethiphos, resulting in a total discharge over 6 days of 4.2 kg. Simulations were performed separately for modelled neap and spring tides, and the sensitivity of the results to key model parameters was tested. Results are summarised in Table 8.

The model results confirmed that the treatment scenario proposed, with a daily release of no more than 700 g, should consistently comply with the EQS. The peak concentration during the baseline simulation after 192 hours (72 hours after the final treatment) was less than 0.1 µg/L, the maximum allowable concentration, and the area where concentrations exceeded the EQS of 0.04 µg/L was substantially less than the allowable 0.5 km². In all simulations performed, including sensitivity testing, the EQS and MAC criteria were met. Further simulations over a second and third neap tide demonstrated that the modelled treatment regime consistently complied with the relevant EQS and MAC. For the simulation during spring tides, greater dispersion meant that the MAC and EQS were met very comfortably. Peak concentrations near the seabed at the identified special features (SEPA, 2023) were found to be consistently less than both the 3-hour and 72-hour MAC over the full treatment simulation. Therefore, it is believed that the requested daily quantity of 700 g of Azamethiphos can be safely discharged at Cairidh without breaching the MAC or EQS.

Simulations using the BathAuto spreadsheet for Deltamethrin resulted in a consentable quantity of 16 g.

Table 8. Summary of Results

Site details	
Site Name:	Cairidh
Site Location:	Caol Mor
Peak Biomass (T):	1,800
Pen details	
Number of Pens:	6
Pen Circumference (m):	160
Pen Depth (m):	12
Pen Group Configuration:	2 x 3
Azamethiphos consent to be applied for	
Recommended 3-hour (kg):	0.700
Recommended 24-hour (kg):	0.700
Deltamethrin consent to be applied for	
Recommended 6-hour (kg)	0.016

5 REFERENCES

European Centre for Medium-Range Weather Forecasts (ECMWF) 2021, ERA5 Dataset <https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5>

Gillibrand, P.A., 2022. UnPTRACK User Guide. Mowi Scotland Ltd., June 2022, 33pp.

Mowi, 2025. Hydrodynamic Model Description: Caol Mor, Skye. Mowi Scotland Ltd, April 2025.

Marine Scotland, 2016. The Scottish Shelf Model. Marine Scotland. <http://marine.gov.scot/themes/scottish-shelf-model>

Pawlowicz, R.; Beardsley, B.; Lentz, S., 2002. Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE. Computers & Geosciences, 28, 929-937.

SEPA, 2023. Interim Marine Modelling Guidance for Aquaculture Applications. Scottish Environment Protection Agency, Air & Marine Modelling Unit, December 2023, 11 pp.

SEPA, 2025, Aquaculture Modelling Screening & Risk Identification Report: Cairidh (CAIR1), February 2025