Medicine Dispersion Modelling
Aird Point (Etive 4), Loch Etive
CAR/L/1018068

Mowi Scotland Limited

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QUALITY ASSURANCE

Mowi Scotland 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 Aird Point (Etive 4) salmon farm will comply with pertinent Environmental Quality Standards (EQS). A realistic treatment regime, with 2 pen treatments per day was simulated. Each pen required 573 g of azamethiphos (the active ingredient in Salmosan, Salmosan Vet and Azure) or 34.4 g of deltamethrin for treatment, resulting in a daily release of 573 g and a total discharge over 2.125 days of 3.43 kg for azamethiphos and separately 0.2064 kg of deltamethrin over 2.125 days. 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 (Table 1) confirmed that the treatment scenario proposed, with a daily release of no more than 573 g of azamethiphos should comfortably comply with the EQS. The peak concentration during the baseline simulation 72 hours after the final treatment was less than 0.1 µg L^{-1}, the maximum allowable concentration, and the area where concentrations exceeded the EQS of 0.04 µg L^{-1} was substantially less than the allowable 0.5 km^2 for both sites. The baseline simulation presented here was designed to be relatively conservative.

The 24-hour mass is substantially larger than the amount predicted by the standard bath model, but the latter is known to be highly conservative, because it does not account for horizontal shearing and dispersion of medicine patches due to spatially-varying current fields, processes which are known to significantly influence dispersion over time scales greater than a few hours.

Table 1. Summary of Results

Site Details	
Site Name:	Aird Point (Etive 4)
Site Location:	Loch Etive
Peak Biomass (T):	1,545.3
Pen Details	
Number of Pens:	6
Pen Circumference (m):	120
Working Depth (m):	15
Pen Group Configuration:	2 x 3
Azamethiphos Consent	
Recommended 3-hour (g):	573
Recommended 24-hour (g):	1146
Deltamethrin Consent	
Recommended 3-hour (g)	34.4

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 sea lice veterinary medicines at the marine salmon farm Aird Point (Etive 4), Loch Etive (Figure 1). 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 October 2024 (SEPA, 2024).

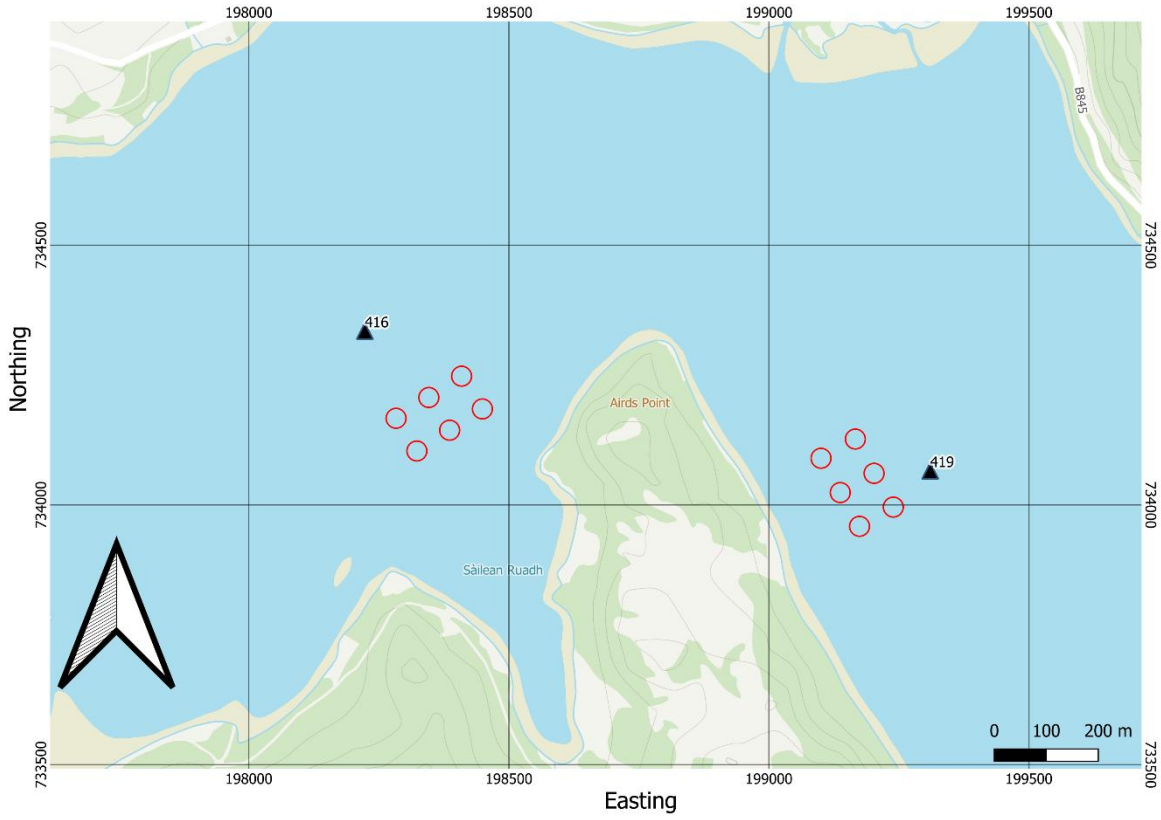

Figure 1. Location of Sailean Ruadh (left) and Aird Point (Etive 4) (right) salmon farms and the location of the ADCP deployments (▲) relative to the existing pen positions (o).

1.1 Site Details

The site is situated in Loch Etive, immediately East of the headland Airds Point (Figure 1). Details of the hydrographic data are provided in Table 2. The receiving water is defined as Loch Etive.

Table 2. Hydrographic Information

Hydrographic Data		
	ID416	**ID419**
Site:	Sailean Ruadh (Etive 6)	Aird Point (Etive 4)
Current Meter Position:	198223E 734335N	199310E 734066N
Depth of Deployment Position (m):	52.18	46.44
Surface Bin Centre Height Above Bed (m):	45.71	40.72
Middle Bin Centre Height Above Bed (m):	34.71	28.72
Bottom Bin Centre Height Above Bed (m):	3.71	3.72
Duration of Record (days):	90.18	48.35
Start of Record:	27/04/2023 15:00	20/06/2023 13:00
End of Record:	26/07/2023 19:20	07/08/2023 08:20
Current Meter Averaging Interval (min):	20	20
Magnetic Correction to Grid North:	-2.26	-2.23

2 MODEL DETAILS

2.1 Model Selection

The modelling approach adopted a coupled hydrodynamic and particle tracking method, whereby water currents in the region, modelled using a calibrated hydrodynamic model, advected particles representing the topical medicine around the model domain. Turbulent eddy diffusion was modelled using a random walk method. Outputs from the modelling were derived to assess the dispersion of the medicine following treatments against statutory EQS. The modelling approach is described in full in the Hydrodynamic Model Description report (Mowi, 2025), and is only summarised here.

The mathematical equations are discretized on an unstructured grid of triangular elements which permits greater resolution of complex coastlines, such as typically found in Scotland. Therefore greater spatial resolution in near-shore areas can be achieved without excessive computational demand.

For the particle tracking component, Mowi Scotland's in-house model UnPTRACK (Gillibrand, 2024) was used. The model used the hydrodynamic flow fields from the FVCOM model simulations. This model has been used previously to simulate sea lice dispersal (Gillibrand & Willis, 2007), the development of a harmful algal bloom (Gillibrand et al., 2016a) and the dispersion of cypermethrin from a fish farm (Willis et al., 2005). The approach for veterinary medicines is the same as for living organisms, except that medicine has no biological behaviour but instead undergoes chemical decay: the numerical particles in the model represent "droplets" of medicine of known mass, which reduces over time at a rate determined by a specified half-life. Particles are released at pen locations at specified times, according to a treatment schedule. The number of particles combined with their initial mass represents the

mass of medicine required to treat a pen. The particles are then subject to advection, from the modelled flow fields, horizontal and vertical diffusion, and chemical decay. Concentrations of medicine can be calculated throughout the simulation and compared with relevant EQS e.g. 72 hours after the final treatment. Here, the dispersion of azamethiphos following treatment scenarios at Aird Point (Etive 4) has been modelled to illustrate the quantities of medicine that disperse safely in the environment.

2.1.1 Model Domain and Boundary Conditions

The unstructured mesh used in the model was adapted from a wider Loch Linnhe model (Figure 2). Model resolution was enhanced in the Loch Etive region particularly around the Mowi Scotland sites at Sailean Ruadh and Aird Point (Etive 4) (Figure 3). The spatial resolution of the model varied from 30 m in some inshore waters to 340 m in wider Loch Linnhe. The model consisted of 33,391 nodes and 59,891 triangular elements. Bathymetry was taken from a wider Loch Linnhe model and local multibeam surveys (Figure 3).

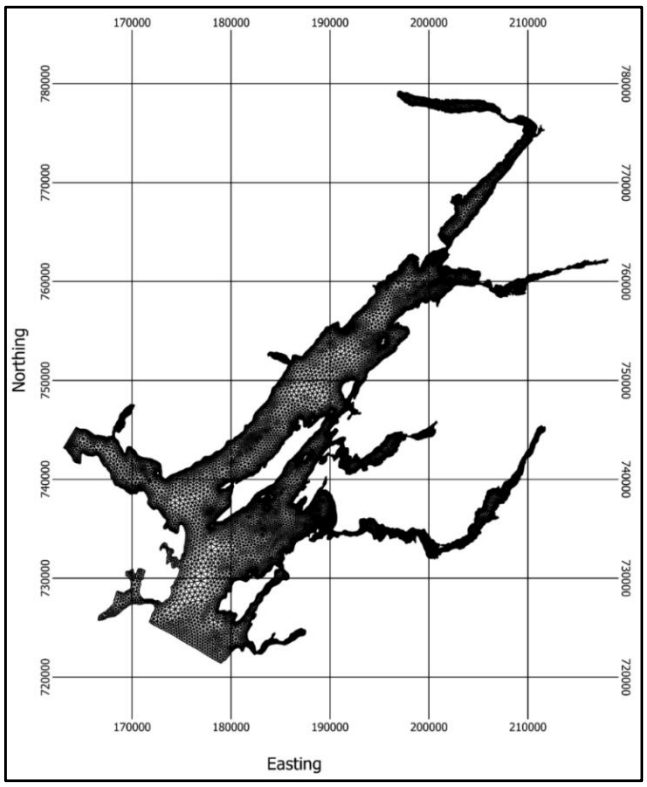

Figure 2. The mesh and domain of the modelling study, adapted from a wider Loch Linnhe model.

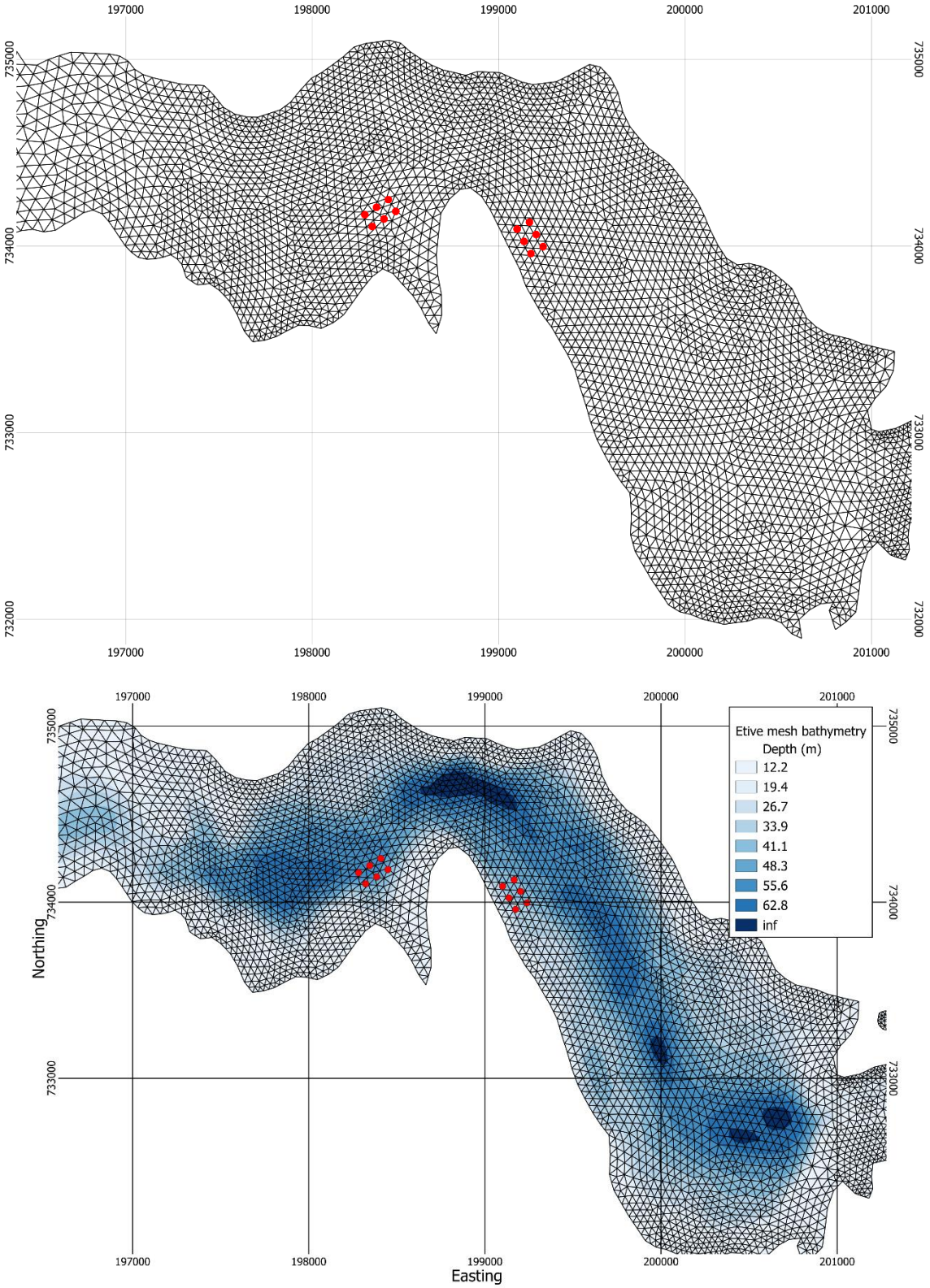

Figure 3. Model mesh (top) and water depths (m, bottom) in the area around the Mowi Scotland sites Sailean Ruadh (left) and Aird Point (Etive 4)(right). The pen locations are indicated (●).

The model is 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 are taken from the Weather Research & Forecasting (WRF) model, developed as part of the WestCOMS modelling suite (Aleynik et al., 2016).

Full details of the calibration and validation of the hydrodynamic model are given in the Hydrodynamic Model at Aird Point (Etive 4) and Sailean Ruadh (Etive 6) sites (Mowi, 2025).

2.2 Medicine Dispersion Modelling

The medicine dispersion modelling, performed using the UnPTRACK model (Gillibrand, 2024), 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. Therefore, no spatial or temporal interpolation of the current fields is required, although current velocities are interpolated to particle locations within UnPTRACK. The treatment scenario assumed 2 pens can be treated per day.

To simulate the worst-case scenario, the dispersion modelling was initially conducted using flow fields over a period of 6.125 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 5 m was chosen as a realistic net depth during application of the medicine for the 120m pens. The initial mass released per pen was calculated from the reduced pen volume and a treatment concentration of 100 µg L^{-1}, with a total mass of 3.44 kg of azamethiphos released during treatment (6 pens). Particles were released from random positions within a pen radius of the centre and within the 0 – 5 m depth range. The simulations used *ca. 572,958* numerical particles in total, each particle representing 6 mg of azamethiphos.

Each simulation ran for a total of 147 hours (6.125 days). This covered the treatment period (51 hours), a dispersion period to the EQS assessment after 72 hours after the final treatment, and an extra 24 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 25 m x 25 m squares using a depth range of 5 m. Using a regular grid for counting makes calculating particle concentrations and presenting the results easier, and also provides consistent accuracy and precision in the calculated concentrations across the grid.

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

(i) The maximum concentration (µg L^{-1}) 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:

(i) Horizontal diffusion coefficient, K_H
(ii) Vertical diffusion coefficient, K_V

The dispersion simulations were performed separately over neap and spring tides during 2023 (ID419) (Figure 4). A further set of simulations were performed over neap tides in January 2023 (ID416) to confirm the adequacy of dispersion during the weakest tides (Figure 5).

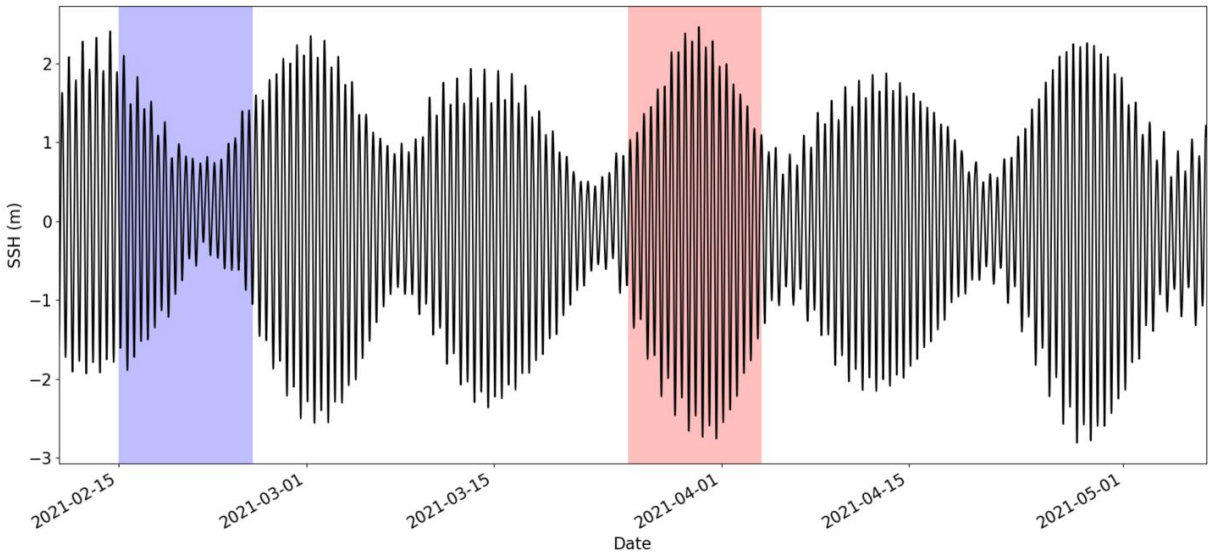

Figure 4. Sea surface height (SSH) at Aird Point (Etive 4) from 20th June 2023 – 7th August 2023 (ID419). Dispersion simulations were performed over periods of neap tides (blue, start day 23rd June 2023) and spring tides (red, start day 3rd July 2023).

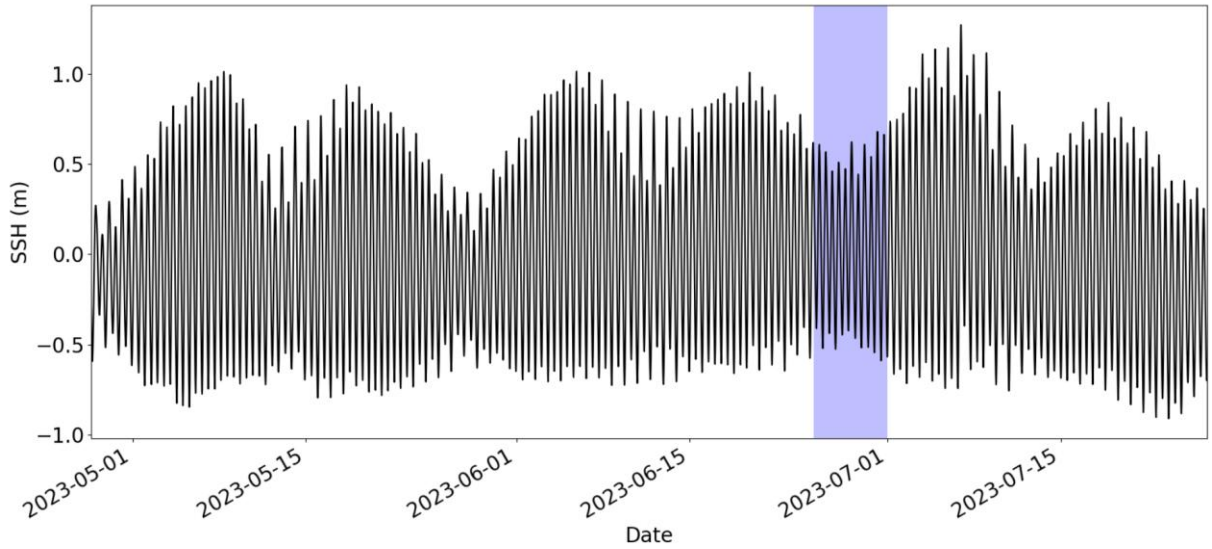

Figure 5. Sea surface height (SSH) at Sailean Ruadh from 27th April 2023 – 26th July 2023 (ID416). Dispersion simulations were performed over periods of neap tides (blue, start day 25th June 2023).

2.3 Medicine 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 4 and Figure 5.

All simulations used the release schedule and quantities outlined in Table 3. In Runs 2 – 7 (Table 4), the release schedule was set back or forward by a number of hours to investigate the effect of tidal state at the time of release on the results. Results for these simulations are still presented in terms of time relative to the first release.

Table 3. Details of the treatment simulated by the dispersion model. The release time is relative to the start of the neap or spring period highlighted in Figure 4 and Figure 5.

Pen	Easting	Northing	Net Depth (m)	Treatment Mass (g)	Release Time (hr)
1	199100	734090	5	573	0
2	199137	734024	5	573	3
3	199174	733959	5	573	24
4	199166	734127	5	573	27
5	199202	734061	5	573	48
6	199239	733996	5	573	51

Table 4. Dispersion model simulation details for the treatment simulations of 6 pens at Aird Point (Etive 4).

Set	Run No.	$T_{1/2}$ (h)	K_H	K_V	Start Time
Neap Tides, Start day = 34 (23rd July 2023, ID419)					
Baseline	1	134.4	0.1	0.001	00:00
2	2	134.4	0.2	0.001	00:00
	3	134.4	0.05	0.001	00:00
3	4	134.4	0.1	0.0025	00:00
	5	134.4	0.1	0.005	00:00
Spring Tides, Start day = 14 (3rd July 2023, ID419)					
5	6	134.4	0.1	0.001	00:00
6	7	134.4	0.2	0.001	00:00
	8	134.4	0.05	0.001	00:00
7	9	134.4	0.1	0.0025	00:00
	10	134.4	0.1	0.005	00:00
Neap Tides, Start day = 60 (25th June 2023, ID416)					
8	11	134.4	0.1	0.001	00:00
9	12	134.4	0.2	0.001	00:00
	13	134.4	0.05	0.001	00:00
10	14	134.4	0.1	0.0025	00:00
	15	134.4	0.1	0.005	00:00

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, 2023b). 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 14.15 cm s^{-1} was used from ID419 (Table 5).

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})	0.1415
Area of 120m pen (km^2)	0.001146
Distance from shore (km)	0.111
Mean water depth (m)	35.25
Treatment Depth (m)	5
Mixing zone ellipse area (km^2)	**0.223917**

For the 3-hour EQS assessment, the baseline runs for neap and spring tides (Runs 1 and 12 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 250 ng L^{-1} determined. Concentrations from these simulations were calculated on a 10 m x 10 m grid (rather than a 25 m x 25 m grid) in order to more accurately calculate the smaller areas of medicine over the initial 3-hour period.

2.5 Deltamethrin 6-Hour EQS

Simulations were also performed to assess compliance of deltamethrin treatments with the 6-hour EQS (SEPA, 2023b). The 6-hour EQS is applied as a mixing zone EQS, whereby the area where concentrations exceed the EQS of 6 ng L^{-1} after 6 hours must be less than the 6-hour mixing zone. The 6-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 14.15 cm s^{-1} was used from ID419 (Table 6).

Table 6. Parameter values used in the calculation of the deltamethrin 6-hour mixing zone ellipse area and the resulting area

Parameter	Value
Mean current speed (ms^{-1})	0.1415
Area of 120m pen (km^2)	0.001146
Distance from shore (km)	0.111
Mean water depth (m)	35.25
Treatment Depth (m)	5
Mixing zone ellipse area (km^2)	**0.633336**

For the 6-hour EQS assessment, the baseline runs for neap and spring tides (Runs 1 and 12 in Table 4) were repeated, but with a treatment mass of 34.4 g of deltamethrin. The medicine half-life was set to zero. Results were output every 20 minutes and the runs were truncated, lasting only until 6 hours after the final treatment. The area of the medicine patch for each individual treatment was then calculated over the 6-hour period following its release, and the area exceeding 6 ng L^{-1} determined. Concentrations from these simulations were calculated on a 10 m x 10 m grid (rather than a 25 m x 25 m grid) in order to more accurately calculate the smaller areas of medicine over the initial 6-hour period.

3 RESULTS

3.1 Dispersion During Neap Tides, July 2023 (ID419)

A standard treatment of 6 x 120 m pens, with a reduced net depth of 5 m and assuming 2 pens could be treated per day at a treatment concentration of 100 µg L^{-1}, resulted in a treatment mass per pen of azamethiphos of 573 g, a daily (24-hour) release of the same mass of 1146 g and a total treatment release of 3.44 kg over 123 hours. The dispersion of the medicine during and following treatment from Run001 (Table 4) is illustrated in Figure 6. After 24 hours, as the second treatment on day 2 was discharged, discrete patches of medicine are evident from the first treatment release from the first day. The maximum concentration at this time is about 100 µg L^{-1}, due to the release of the second treatment. After 72 hours, as the 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^{-1}). Again, the maximum concentration at this time was approximately 100 µg L^{-1}, due to the release of the fourth treatment.

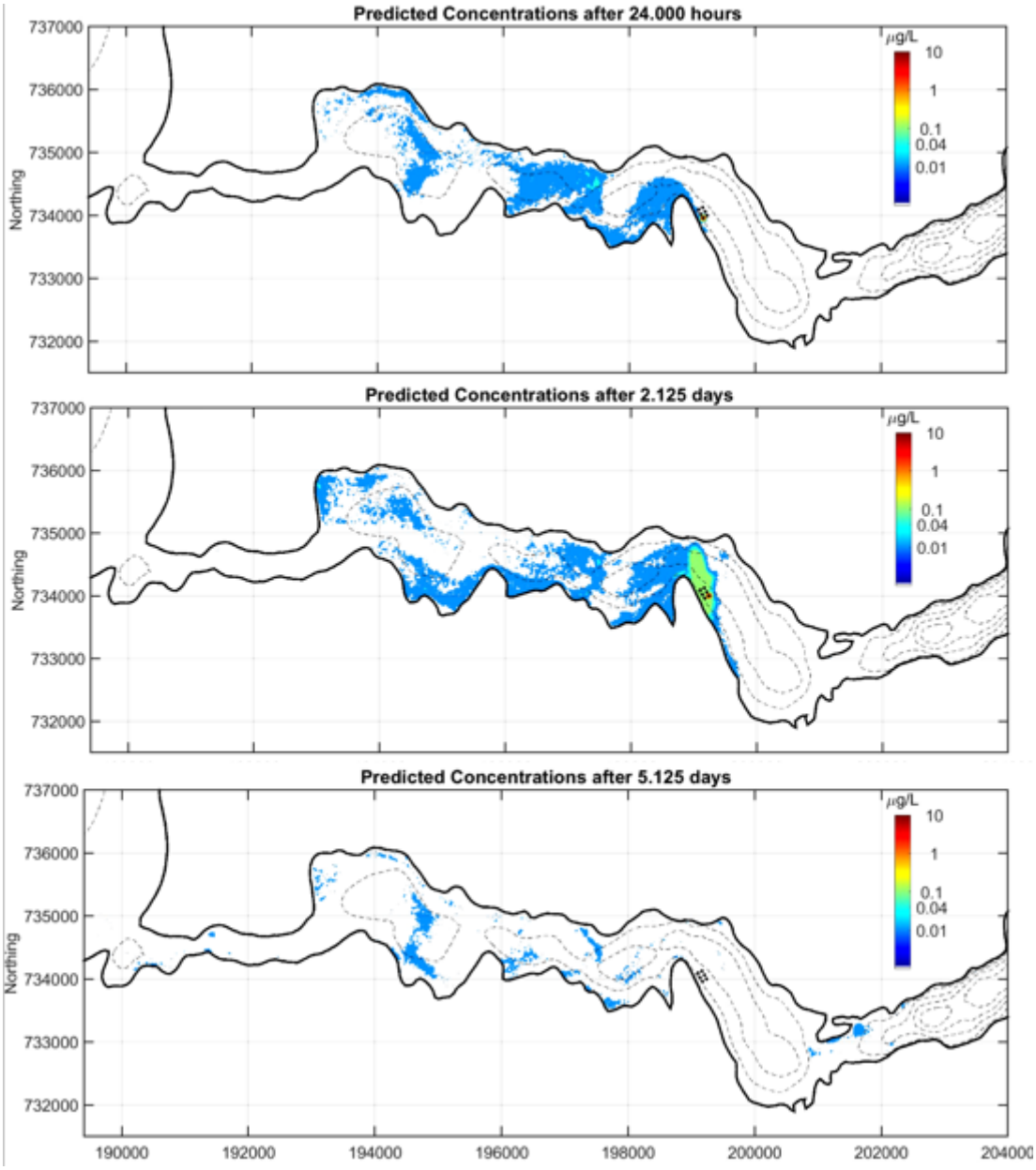

Figure 6. Predicted concentration fields for a dispersion simulation at neap tides after 24 hours (top), 51 hours (middle), 123 hours (bottom).

The treatment schedule completed after 51 hours (2.125 days). At this stage, the medicine released on earlier days had already dispersed West and Eastwards. 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. Following the last treatment at 51 hours, the final treatment patch was rapidly dispersed and concentrations rapidly fell away below the EQS (123 hrs, Figure 6).

The time series of maximum concentration from this simulation is shown in Figure 7. The 8 peaks in concentration of ~100 µg L^{-1} following each treatment event over the first 7 days are

evident. Following the final treatment after 168 hours, the maximum concentration fell steadily away (Figure 7). A default half-life of 134.4 hours (5.6 days) was used. The maximum concentration seventy-two hours after the final treatment (time = 123 hours) was below 0.1 µg L^{-1}, the maximum allowable concentration (MAC).

The area where the EQS of 0.04 µg L^{-1} was exceeded peaked at about 0.4 km^2 following the final treatment, but had fallen below 0.5 km^2 within 48 hours of the final treatment; by 72 hours after the final treatment, the exceeded area was close to zero (Figure 7).

These results indicate that, with a horizontal diffusion coefficient of 0.1 m^2 s^{-1}, and a medicine half-life of 134.4 h, the EQS are comfortably achieved. In the following sections, the sensitivity of the model results to the medicine half-life, diffusion coefficients and tidal state are examined.

3.2 Sensitivity to Diffusion Coefficients

The model results were tested for sensitivity to the horizontal and vertical diffusion coefficients used. The horizontal diffusion coefficient used for the standard runs was K_H = 0.1 m^2 s^{-1}. Simulations were also performed with lower and higher values of K_H, specifically K_H = 0.2 m^2 s^{-1} and K_H = 0.05 m^2 s^{-1} (Table 4). The time series of maximum concentration and area exceeding the EQS are shown in Figure 7. The time series confirm that the MAC was not exceeded after 123 hours (72 hours after the final treatment). The area limit of 0.5 km^2 was also comfortably met in all cases.

Similarly, sensitivity to the vertical diffusion coefficient, K_V, was tested (Figure 8). The model results are not particularly sensitive to the vertical diffusion rate, but increased vertical diffusion, likely in the presence of wind and/or waves, led to slightly smaller areas where the EQS was exceeded.

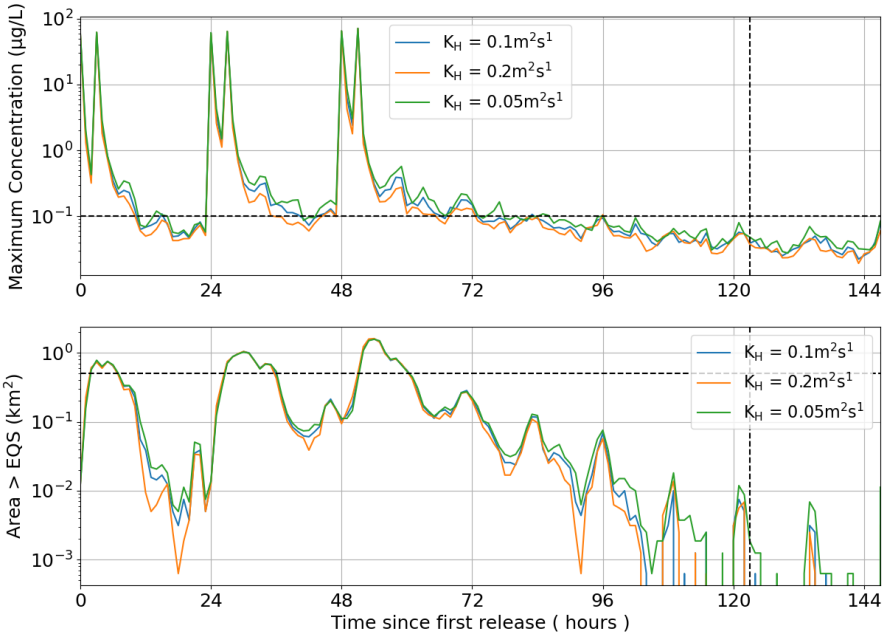

Figure 7. Time series of maximum concentration (top) and area exceeding the EQS (bottom) from the second set of model runs (Table 4). The model was run during neap tide with varying horizontal diffusion coefficient K_H (m^2 s^{-1}). The MAC and area limit 72 hours after the final treatment (Time = 123 h) of 0.1 µg L^{-1} and 0.5 km^2 are indicated by the horizontal dashed lines.

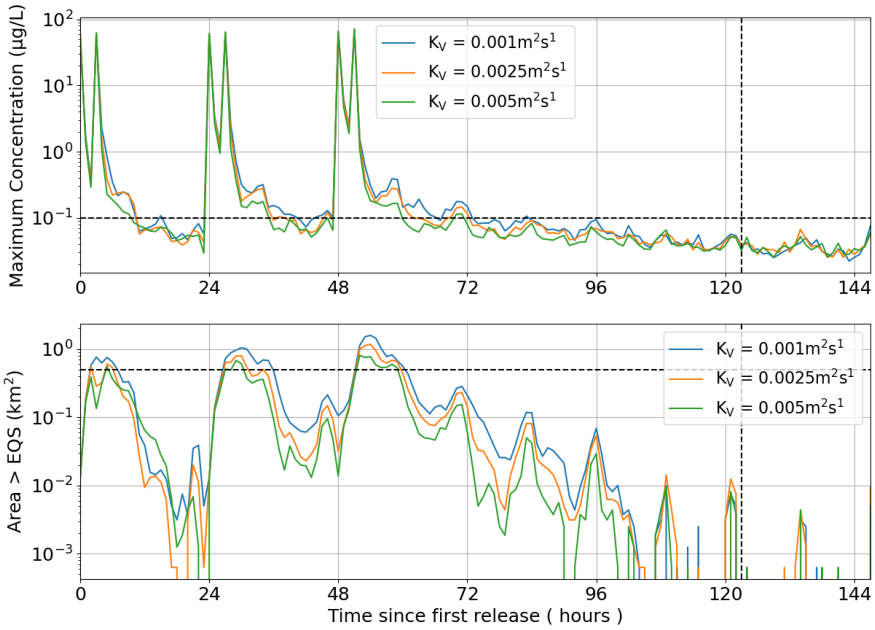

Figure 8. Time series of maximum concentration (top) and area exceeding the EQS (bottom) from the third set of model runs (Table 4). The model was run during neap tides with varying vertical diffusion coefficient K_V (m^2 s^{-1}). The MAC and area limit 72 hours after the final treatment (Time = 123 h) of 0.1 µg L^{-1} and 0.5 km^2 are indicated by the horizontal dashed lines.

3.3 Dispersion during Spring Tides, July 2023 (ID419)

Dispersion simulations were carried out during modelled spring tides in July 2023 (Figure 4), repeating the main set carried out for neap tides (Table 4). The same treatment scenario of 2 treatments per day was simulated, with each treatment using 573 g of azamethiphos. For all medicine half-lives, horizontal and vertical diffusion coefficients simulated both the MAC and area EQS were achieved (Figure 9).

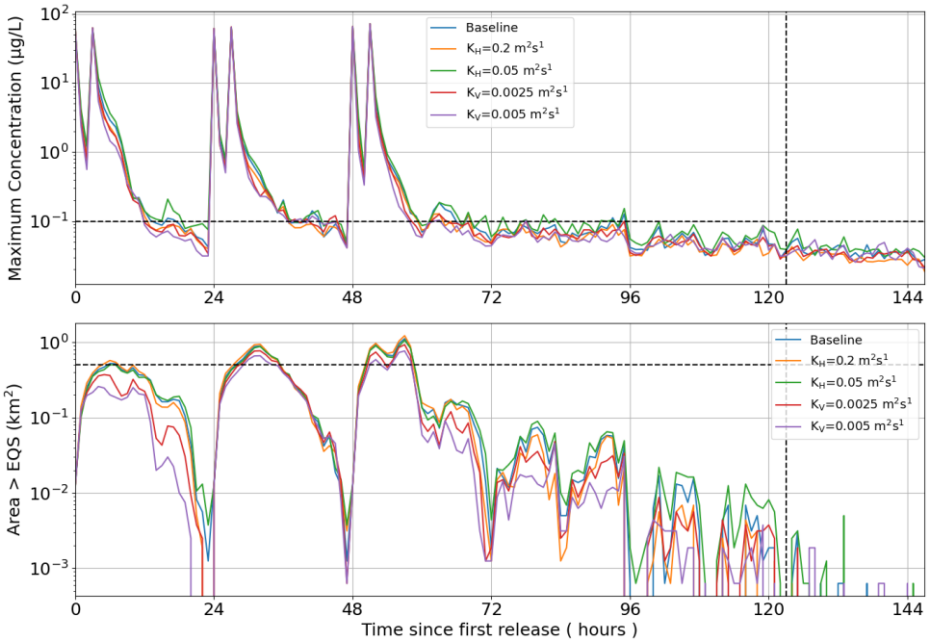

Figure 9. Time series of maximum concentration (top) and the area where concentrations exceeded the EQS (bottom) from the fourth, fifth and sixth set of model runs (Table 4). The model was run at spring tides with varying medicine half-life $T_{1/2}$ (days), horizontal diffusion coefficient K_H ($m^2\ s^{-1}$) and vertical diffusion coefficient K_V ($m^2\ s^{-1}$). The MAC and area limit 72 hours after the final treatment (Time = 123 h) of 0.1 µg L^{-1} and 0.5 km^2 are indicated by the horizontal dashed lines.

3.4 Dispersion During Neap Tides, June 2023 (ID416)

A further set of dispersion simulations during modelled neap tides in June 2023 were carried out (Figure 10), repeating the main set carried out for neap tides in July 2023 (Table 4). The same treatment scenario of 2 treatments per day was simulated, with each treatment using 573 g of azamethiphos. For all medicine half-lives, and horizontal and vertical diffusion coefficients simulated, both the MAC and area EQS were comfortably achieved.

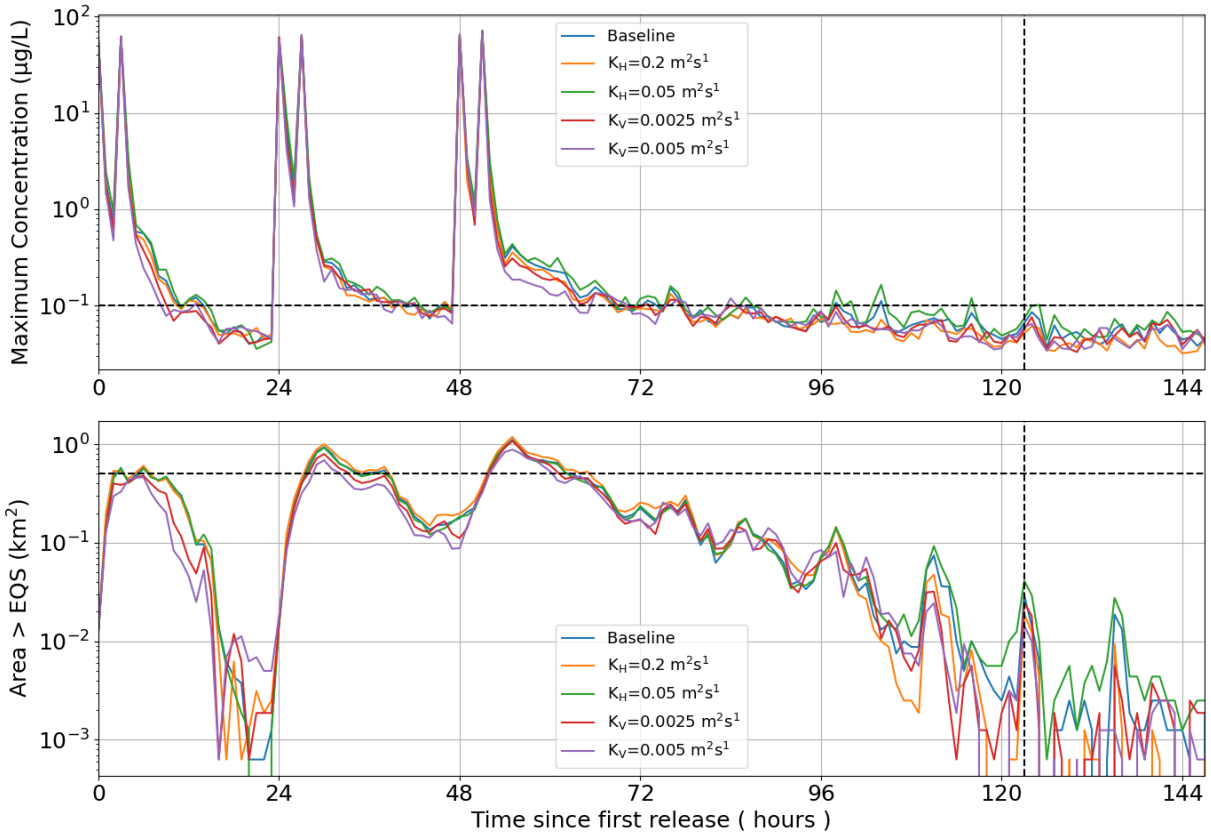

Figure 10. Time series of maximum concentration (top) and the area where concentrations exceeded the EQS (bottom) from the eighth, ninth and tenth set of model runs (Table 4). The model was run at neap tides from June 2023, horizontal diffusion coefficient K_H (m^2 s^{-1}) and vertical diffusion coefficient K_V (m^2 s^{-1}). The MAC and area limit 72 hours after the final treatment (Time = 123 h) of 0.1 µg L^{-1} and 0.5 km^2 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 14.15 cm s^{-1} was used from ID419 (Table 5) which was thought to be a representative value for the surface 0 – 5 m layer at Aird Point (Etive 4). 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 ng L^{-1} is exceeded for each individual pen treatment at neap tide (first release on 23rd July 2023) are shown in *Figure 11*. For each treatment, the area exceeding the EQS was comfortably less than the allowable mixing zone (0.224 km^2) after 3 hours. The peak concentration of 100 µg L^{-1} decreased to less than 10 µg L^{-1} within the 3-hour period.

For spring tide releases (first release on 3rd July 2023), the area where concentrations exceeded the 3-hour EQS also complied with the allowable area (Figure 12). As for the neap tide simulation, the peak concentrations fell by an order of magnitude within the three hours.

This demonstrates that the discharge quantity of 573 g of azamethiphos from a 120 m pen at Aird Point (Etive 4) should not breach the 3-hour EQS.

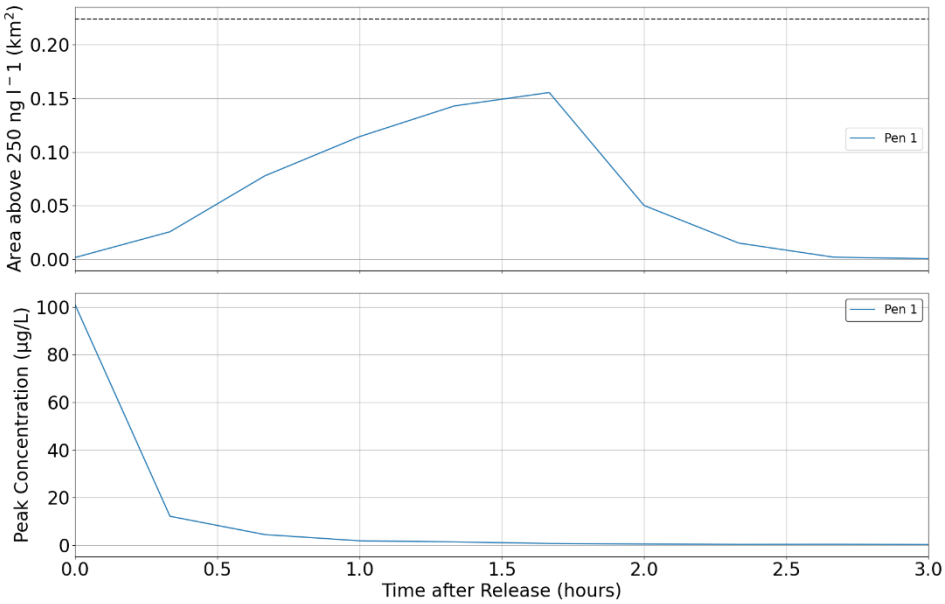

Figure 11. Time series of the area exceeding the 3-hour EQS (top) and the peak concentration (bottom) for a pen treatment during the 3 hours following release at neap tide. The 3-hour mixing zone area is indicated (---).

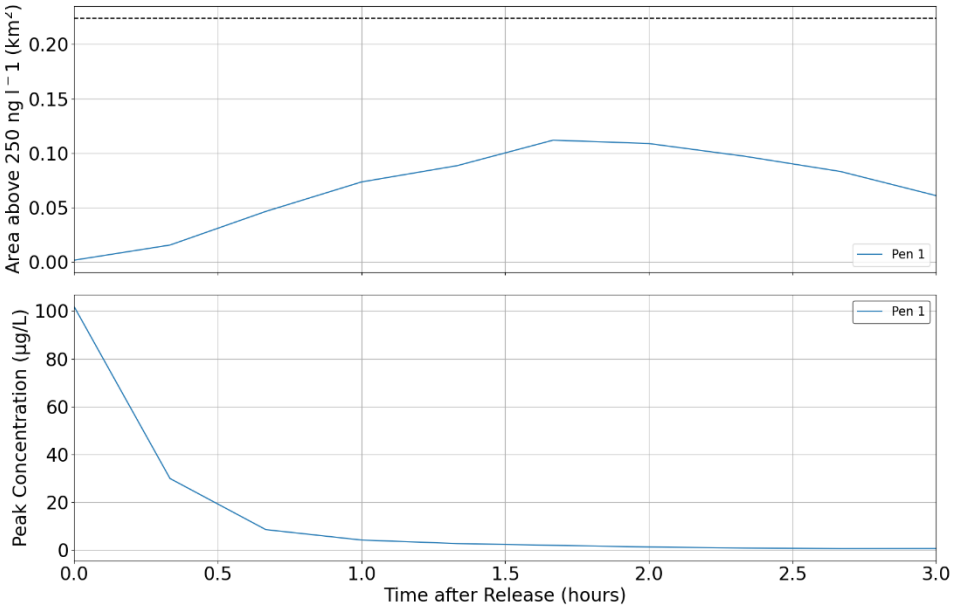

Figure 12. Time series of the area exceeding the 3-hour EQS (top) and the peak concentration (bottom) for a pen treatment during the 3 hours following release at spring tide. The 3-hour mixing zone area indicated (---).

3.6 Deltamethrin 6-Hour EQS

The 6-hour mixing zone for Deltamethrin 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 14.15 cm s^{-1} was used from ID419 (Table 1) which was thought to be a representative value for the surface 0 – 5 m layer at Aird Point (Etive 4). The parameter values used in the calculation of the 6-hour mixing zone ellipse area are shown in Table 6.

The time series of the areas where the 6-hour EQS of 6 ng L^{-1} is exceeded for a pen treatment at neap tide (first release on 23rd July 2023) are shown in Figure 13. For a treatment, the area exceeding the EQS was comfortably less than the allowable mixing zone (0.633 km^2) after 6 hours. The peak concentration of 2 µg L^{-1} decreased to less than 0.1 µg L^{-1} within the 6-hour period.

For spring tide releases (first release on 3rd July 2023), the area where concentrations exceeded the 6-hour EQS also complied with the allowable area (Figure 14). As for the neap tide simulation, the peak concentrations fell by an order of magnitude within three hours.

This demonstrates that the discharge quantity of 34.4 g of deltamethrin from each of the six 120 m pens at Aird Point (Etive 4) should not breach the 6-hour EQS.

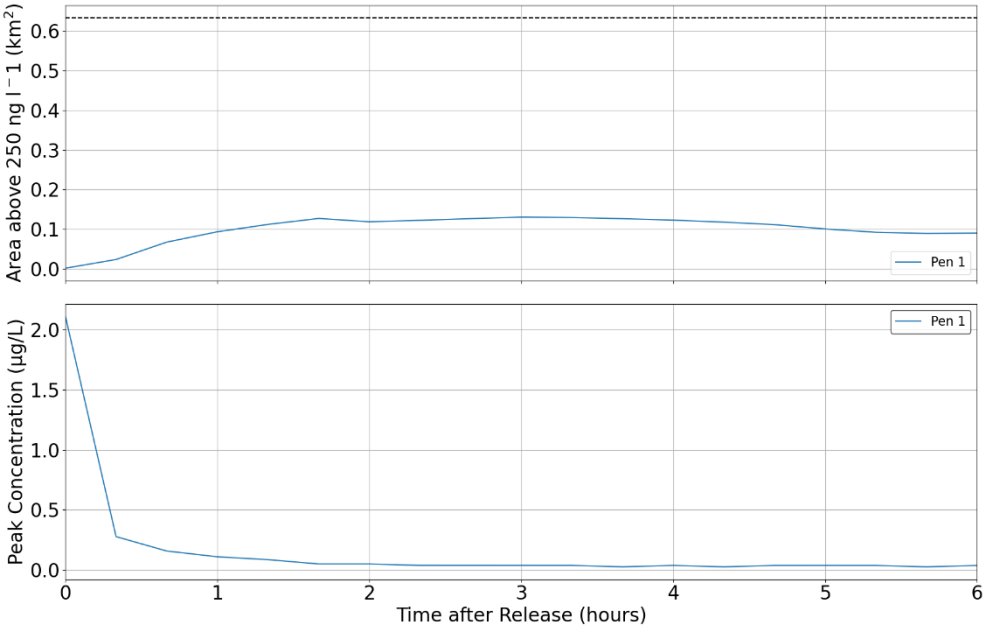

Figure 13. Time series of the area exceeding the 6-hour EQS (top) and the peak concentration (bottom) for a pen treatment during the 6 hours following release at neap tide. The 6-hour mixing zone area is indicated (---).

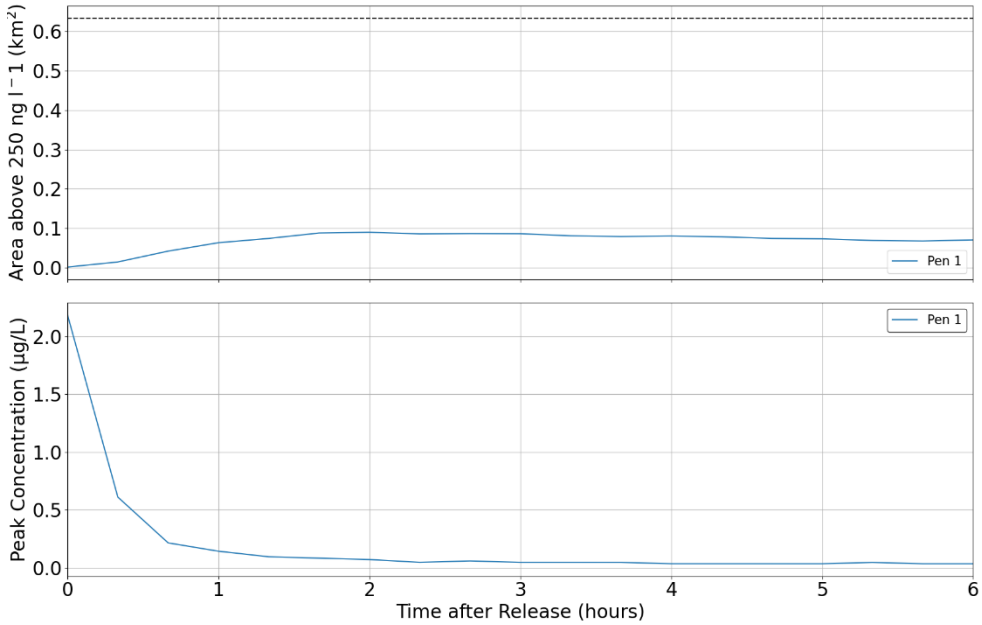

Figure 14. Time series of the area exceeding the 6-hour EQS (top) and the peak concentration (bottom) for a pen treatment during the 6 hours following release at spring tide. The 6-hour mixing zone area indicated (---).

4 SUMMARY AND CONCLUSIONS

A total of 19 dispersion simulations have been performed to assess whether bath treatments at Aird Point (Etive 4) salmon farm will comply with pertinent EQS. A realistic treatment regime, with 2 pen treatments a day was simulated. Each pen required 573 g of azamethiphos for treatment, resulting in a total discharge over 2.125 days of 3.44 kg and separately 0.2064 kg of deltamethrin over 2.125 days. 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 7.

The model results confirmed that the treatment scenario proposed, with a daily release of no more than 1146 g of azamethiphos or 68.8g of deltamethrin, should consistently comply with the relevant EQS. The peak concentration of azamethiphos during the baseline simulation after 123 hours (72 hours after the final treatment) was less than 0.1 µg L^{-1}, the maximum allowable concentration, and the area where concentrations exceeded the EQS of 0.04 µg L^{-1} was substantially less than the allowable 0.5 km^2. For the simulations during spring tides, greater dispersion meant that the MAC and EQS were met very comfortably. Therefore, it is believed that the requested daily quantity of 1146 g of azamethiphos or 68.8 g of deltamethrin and can be safely discharged at Aird Point (Etive 4) without breaching the MAC or EQS.

Table 7. Summary of Results

Site Details	
Site Name:	Aird Point (Etive 4)
Site Location:	Loch Etive
Peak Biomass (T):	1,545.3
Pen Details	
Number of Pens:	6
Pen Circumference (m):	120
Working Depth (m):	15
Pen Group Configuration:	2 x 3
Azamethiphos Consent	
Recommended 3-hour (g):	573
Recommended 24-hour (g):	1146
Deltamethrin Consent	
Recommended 3-hour (g)	34.4

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