Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

For the future of our environment

# Marine Modelling Guidance for Aquaculture Applications

January 2024

# New updates in this version

- Shellfish waters rules
- CAT 1 & 2 Water bodies
- Update to Azamethiphos Decay rate sentence

This guidance provides information on recommended defaults for marine modelling, including particle tracking of solids and bath medicines.

Alternative approaches to carrying out marine modelling should be outlined and agreed in an appropriate “Method Statement” and be fully detailed in any modelling report.

This guidance provides information on the basic modelling and outputs required. Risks identified from these may trigger the need for additional model output.

For more information on the background modelling processes please refer to **Regulatory Modelling Guidance for the Aquaculture Sector.**

# Bath Medicine Modelling

- Model with a realistic treatment regime for bath medicines (e.g. 4 treatments in 24hrs, with 3hr intervals between treatments).

- In the Screening Report the risk to the wider environment is assessed and should the discharges from multiple farms be identified as a risk SEPA may ask for multiple farms be included in the Marine modelling. Generally, farms are assessed on their individual discharges though.

- Include a run-up period for the hydrodynamics. Once stable, particles can be added.

- In these cases, the bathymetry (site depth) and near-bed flowmetry depth in NewDepomod should use the average depth (or the most representative depth) of the seabed underneath the farm rather than the time-averaged deployment depth:

- Calibration: In most cases the model should be calibrated with dye and/ or drogue data. SEPA recommends that dye data are collected in such a way as to allow the comparison of a monitored dye patch with a modelled patch, alongside the calculation of a measure dispersion coefficient. Drogue data are particularly useful in assessing the accuracy of the modelled transport of waste over longer distances, particularly where this influences sensitive features.

- Bath particle parameters should be consistent with those used in calibration runs.

- Length of model runs: The model should be run for each chemical applied for according to the EQSs specified in the section *Environmental Quality Standards for Azamethiphos, Cypermethrin and Deltamethrin* following the final treatment plus an additional 24 hrs to account for concentration peaks. Output is required for the whole time period starting from the beginning of treatment.

- Runs should be undertaken during a period of Spring tides and a period of Neap tides, to

ensure the most conservative area and concentration are captured.

- Decay: For Azamethiphos a decay rate of 5.6 days may be applied to the particles (updated from 8.9 days to 5.6 days as of the October 2020 revision to DEFRA SPC guidance). Cypermethrin and Deltamethrin should be modelled without decay.

- Bath particles in the top 0 - 5m of the water column should be considered in the output, as we would expect material released at the surface mainly to remain at the surface over the EQS timescales. In cases where this doesn't occur, the bath particles will be spread over a larger depth, resulting in lower concentrations, and therefore using the top 5m provides a conservative estimate.

- To assess compliance for Azamethiphos after 3hrs, a single release of the 3hr mass should be modelled. A realistic mass should be used, but a passing mass from the short term BathAuto model can be used as a guide to obtain a likely treatment mass, which can be supported by conditions at the site. A plot showing the area above the 250ng/l will be required. Lines should be added to demonstrate the time 3hrs after the first treatment, and the allowed mixing zone area established using BathAuto. The BathAuto mixing zone ellipse is calculated from the mean surface speed, **Fish Farm Manual - Annex G.**

- To assess the long-term risks from Azamethiphos, a realistic treatment regime should be modelled. A plot showing the area above 40ng/l will be required. Lines should be added to demonstrate the 72hrs after final treatment and the allowed mixing zone area of 0.5km$^2$.

- Compliance for Cypermethrin and Deltamethrin is assessed by modelling the single biggest release that can comply with the mixing zone ellipse calculated in BathAuto after 6hrs.

- To show compliance, a plot with the area above 16ng/l for Cypermethrin and 6ng/l for Deltamethrin will be required. Lines should be added to demonstrate the time 6hrs after the first treatment, and the allowed mixing zone area established using BathAuto. The BathAuto mixing zone ellipse is calculated from the mean surface speed, **Fish Farm Manual - Annex G.**

- Instead of using a Marine Model, compliance for Cypermethrin and Deltamethrin can also be modelled using BathAuto. A passing mass from the short term BathAuto model can also be used as guide to obtain a likely treatment mass for marine modelling if needed.

- Output should include:

    - Spatial plots at each of the EQS times (see *Environmental Quality Standards for Azamethiphos, Cypermethrin and Deltamethrin*) and at various time steps in between to demonstrate extent, concentrations and interactions between plumes of the assessed farm and other modelled farms (if identified as required).
    - Time series of maximum concentrations of Azamethiphos for the entire run period.
    - Time series of areal extent at each of the MAC/ EQS concentration contours:
        - 3hr Azamethiphos EQS: area of Azamethiphos concentration above 250ng/l over time for the entire run period not bigger than the mixing zone ellipse area calculated in BathAuto.
        - 72hr Azamethiphos EQS: area of Azamethiphos concentration above 40 ng/l over time for entire run period not bigger than 0.5km2.
        - 6hr Cypermethrin EQS: area of Cypermethrin concentration from a single release above 16ng/l over time not bigger than the mixing zone ellipse area calculated in BathAuto.
        - 6hr Deltamethrin EQS: concentration of Deltamethrin from a single release above 6ng/l over time not bigger than the mixing zone ellipse area calculated in BathAuto.

    **Note:** the size of the mixing zone ellipse area for Azamethiphos after 3hrs differs from the size of the mixing zone ellipse area for Cypermethrin and Deltamethrin after 6 hrs, as the area is time dependent.

## When testing for compliance please follow the principles and EQS/ MAC values used in the previous Bath Auto modelling spreadsheet:

*Environmental Quality Standards for Azamethiphos:*

- *3 hour EQS: 250 ng/l*
- *72 hour EQS: 40 ng/l*
- *72 hour MAC: 100 ng/l*

*Environmental Quality Standards for Cypermethrin:*

- *6 hour EQS: 16 ng/l (modelled value to be divided by 267afterwards)*

*Environmental Quality Standards for Deltamethrin:*

- *6 hour EQS: 6 ng/l*

**Please note:** Quantities of Cypermethrin, which are demonstrated to be passing the EQS standard described in the *Environmental Quality Standards for Cypermethrin* above will then be reduced by a factor of 267, in order to comply with the Dec 2018 update to the **WAT-SG-53 guidance.**

For additional information on Environmental Quality Standards for bath chemicals please also consult *Models for Assessing the use of Medicines in Bath Treatments*: **Fish Farm Manual - Annex G.**

# Bath Medicine Modelling

## Solids Waste Modelling

Farms should be modelled at peak biomass for the entire period. Peak biomass should be used to calculate solids waste, including waste feed and faeces. Recommended default values are:

- Feed requirement = 7kg feed per tonne biomass per day
- Feed Water Percentage = 9%
- Feed Waste Percentage = 3%
- Feed Absorbed Percentage = 85%
- Feed Carbon Percentage = 49%
- Faeces Carbon Percentage = 30%

## Waste Feed Calculation and Default Parameters

Waste solids (kg) = (1 - feed water content) x feed wastage rate x feed load (kg)
Typical values for the water content of the feed and the feed wastage rate are 0.09 (i.e. 9%) and 0.03 (3%) respectively.

Calculating the discharged carbon specifically requires a small addition:
Waste solids (carbon) (kg) = (1 - feed water content) x feed carbon content x feed wastage rate x feed load (kg) where a typical value for the feed carbon content is 0.49 (49%).

Excreted Solids Calculation and Default Parameters:
Excreted solids (kg) = (1 - feed water content) x (1 - feed wastage rate) x (1 - feed absorbed rate) x feed load (kg) where a typical value for the absorption rate is 0.85.

Calculating the excreted carbon specifically requires a small modification:
Excreted solids (carbon) (kg) = (1 - feed water content) x (1 - feed wastage rate) x (1 - feed absorbed rate) x faeces carbon content x feed load (kg) where the faecal carbon content is typical taken to be 0.3 (i.e. 30%).

- All farms included in SEPA screening modelling should be modelled. Farms identified at screening as having the potential to interact should be included at an appropriate model resolution.
- Include a run-up period for the hydrodynamics. Once stable, particles can be added.
- Solids particle parameters should be consistent with those used in calibration runs. If solids are uncalibrated, default parameters should be used:
    - Decay: 0/s
    - Settling Velocity of feed: 0.095m/s (specified directly)
    - Settling Velocity of faeces: 0.032m/s (specified directly)
    - Horizontal Dispersion: 0.1 $m^2/s$
    - Vertical Dispersion: 0.001 $m^2/s$
    - Erosion Threshold: 0.02 $N/m^2/s$
- The model should be run for 365 days (not including the run-up period).
- Runs should start and finish in summer, as a precaution against impacts of storm events, towards the peak deposition period.
- Output should include:
    - Plot showing the extent and concentration of impact, as an average, taken over the last 90 days of the model run at the 250g/$m^2$ contour. (N.B. This is the approach taken in our default NewDepomod recommendations).
    - Plot of areal extent at the 250g/m2 contour and average concentration, averaged over the last 90 days of the model run *included for each farm identified at screening* (spatial plot).
    - Include table of area of averaged concentration at the 250g/m2 contour, averaged over the last 90 days of the model run for each farm included identified at screening.
    - Output for both the suspended and deposited solids

# Sensitive Features (Including Other Farms)

Sensitive features may also be highlighted during screening as potentially at risk from bath medicines, solids or both. These sensitive features should be addressed in the marine modelling and their risk will be assessed on a case-by-case basis, based on the time series profile.

- Output should include:
    - Plots with features overlaid, showing the extent and concentration of impact, for the various timescales required.
    - Time series of concentrations at the sensitive feature points and for polygons, time series plots of maximum concentrations.
    - Depth profile for each EQS averaged over 90 days for solids and at each EQS for baths, at the sensitive feature point (or polygon centre).

## Shellfish Farms

**Active Shellfish Farms** – Active Shellfish Farms are to be protected from baths and solids, a shellfish farm cannot be impacted by a plume or deposition exceeding the EQSs. As bath plumes are mobile, the time profile showing the maximum concentration for Azamethiphos at the shellfish farm must be below the 250 ng/l at 3hrs and below 40 ng/l at 72 hours. The same applies for Cypermethrin (16 ng/l at 6hrs) and Deltamethrin (6 ng/l at 6hrs). The entire shellfish farm area has to be considered (i.e. a polygon around the farm), not just its central location point. This is because shellfish farms are listed as PMF points, however the actual farm can have ropes of several 100 metres length.

**Shellfish Water Protected Area (SWPA) and Shellfish Harvesting Areas** - The Environmental Quality Standards listed in section *Environmental Quality Standards for Azamethiphos, Cypermethrin and Deltamethrin* apply in these areas.

# Locational Guidelines for Waterbodies – Nutrients & Solids

The following rules apply for CAT 1 and 2 water bodies as listed by the Marine Directorate published under: **Authorisation of marine fish farms in Scottish waters: locational guidelines.** The rules are applicable for the total biomass consented by SEPA under CAR at the time of modelling for each listed waterbody:

Cat 1. Waterbody = must be no net gain of nutrients/solids impacts

Cat 2. Waterbody = must not increase in nutrients/solids to cause it to become a Cat 1 waterbody

# Model Grid Resolution

The chosen model grid resolution should be fine enough to resolve the cages and sensitive feature points (if applicable). The maximum grid resolution around the farms should be 50-55m, but a finer resolution down to 25m (the mean is 36m) has shown to be effective in the past. A fine resolution grid resolution is especially important if the flow outputted from the Marine Model is to be used in NewDepomod in conjunction with variable bathymetry.

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