Environmental Exposure Following The Use Of Veterinary Medicinal Products As Bath Treatments - An Extended Version Of The MLA Model

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Introduction

Infestations of parasites, for example sea lice, are often treated in marine fish farms using solutions of veterinary medicinal products (VMPs) applied topically *via* bath treatment. At the end of the treatment period, the spent treatment solution is discharged from the fish cages into the surrounding waters, where any unused medicine is dispersed and degraded. Chemical exposure in the water column is commonly assessed – for example as part of an EU Phase II environmental impact assessment – using the MLA (Marine Laboratory Aberdeen) dispersion model provided by the Scottish Environment Protection Agency (Gillibrand and Turrell, 1999; SEPA, 2008). In this poster we present an extended version of the MLA model, recoded in VB.NET for improved compatibility with modern operating systems, which provides additional spatial resolution of the model results. Using this extended model, chemical concentrations can be followed over time at any point in the waterbody, allowing analysis of exposure duration, intervals between exceedence events, peak chemical concentration and total cumulative exceedence at the specified location. This additional functionality provides an opportunity to refine environmental risk assessments for VMPs, and also to attain greater understanding of environmental exposure patterns resulting from their use.

The extended MLA model

The original MLA model (Gillibrand and Turrell, 1999) simulates multiple chemical releases from a fish farm, and their subsequent dispersion and degradation in the surrounding waters. Advection and diffusion are considered in the model, along with the impact of the coastline upon the dispersion of chemical patches.

An updated version of the MLA model has been developed, extending the calculations performed by the original model to include detailed analysis of temporal profiles of chemical concentration at each spatial point in the water body. The capabilities of this extended MLA model are demonstrated below using a test simulation based on azamethiphos use in a Scottish sea loch.

Parameters used in the test simulation

Treatment with azamethiphos was simulated at a fish farm consisting of 16 cages, each 100 m in circumference. Each cage was treated in turn, at a concentration of 100 µg/L, up to a maximum of 3 cages per day. The tidal and residual current values input into the model were derived as the 50th percentile values across 33 UK sites. In accordance with SEPA recommendations (SEPA, 2008), a DT_{50} of 8.9 days was used for azamethiphos, and an environmental quality standard (EQS) of 0.04 µg/L was applied in the model 72 hours after the final treatment, such that each location in the water body exceeding the EQS at this time point could be identified and its exposure profile analysed further by the model.

Example exposure profiles output by the extended MLA model

The central co-ordinates of the chemical patches resulting from each cage treatment were tracked over the duration of the simulation (15 days), and are displayed in Figure 1 (only cages 1-3 are presented for clarity). Four locations within the model grid – A, B, C and D – were selected as being directly in the path of these chemical patches at different times within the simulation. The exposure profiles output by the model at these locations, displayed in Figure 2, indicated fluctuating exposure levels at each location, with concentrations decreasing as the patches moved further downstream from the treatment site.

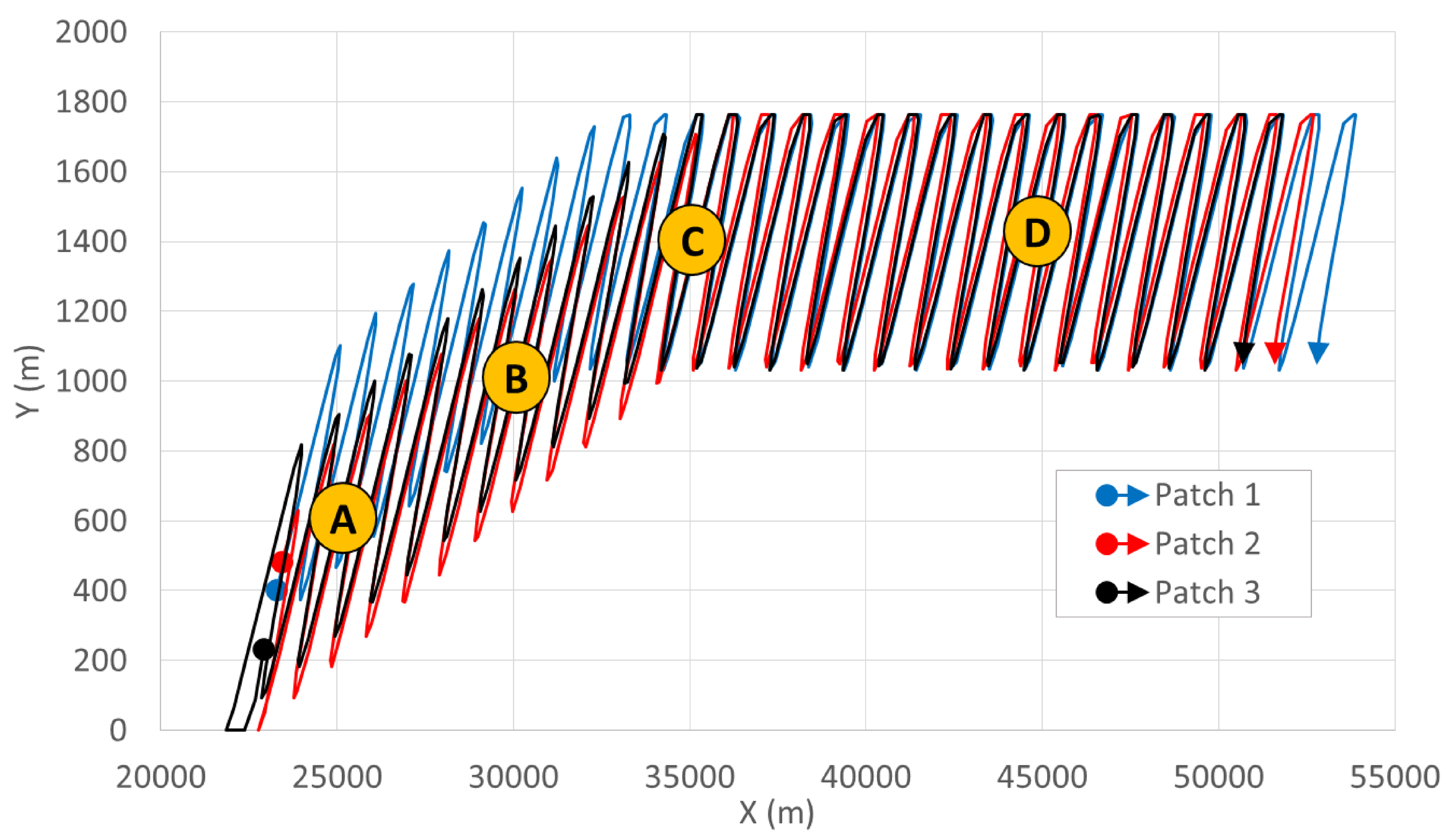

Figure 1 – Central (X,Y) co-ordinates throughout the simulation of the first 3 chemical patches released from the fish farm, as output by the model. Arrowheads indicate the direction of patch travel over time through the water body. (Note: x and y axes are presented to different scales.)

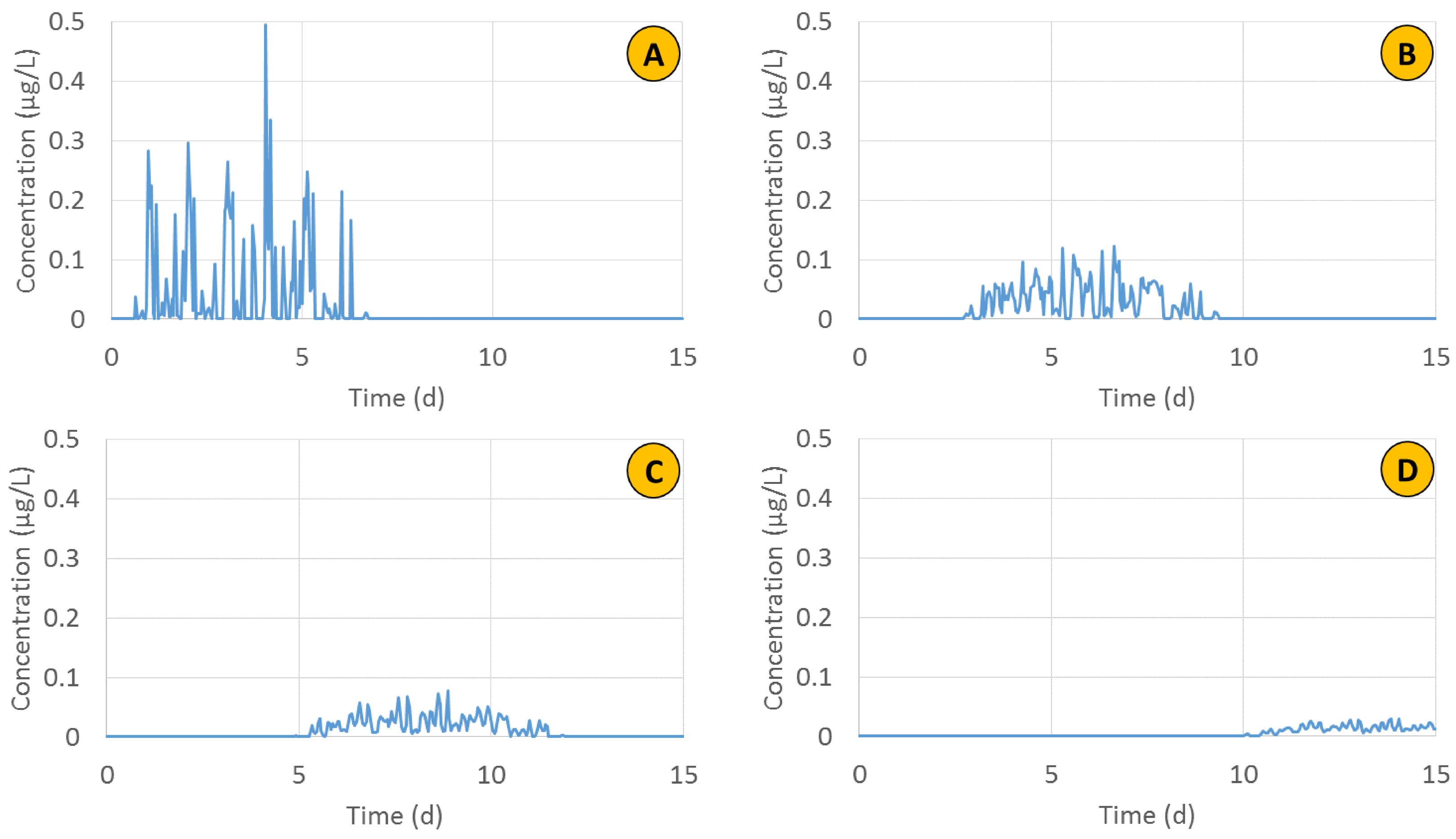

Figure 2 – Exposure concentrations over time output by the model at four grid points (A, B, C and D) within the sea loch.

Detailed analysis by the extended MLA model of grid points failing the EQS

Application of the 0.04 µg/L EQS 72 hours after the final treatment indicated that this concentration was exceeded at 65 points within the model grid, corresponding to a total area of 1.95 km^2. The exposure profiles of these 65 grid points were analysed in further detail by the model across the entire simulation period, examining the duration, interval and peak concentration of every exceedence event (n=672), plus cumulative exposure (in µg.d/L) at levels >EQS for each grid point (n=65). The results are presented as histograms in Figure 3. Exceedence events were typically short and closely-spaced (duration and interval <1d), with a peak concentration only slightly above the EQS. Cumulative exceedence at each point was typically below that of the EQS concentration applied constantly over 72 hours (0.12 µg.d/L).

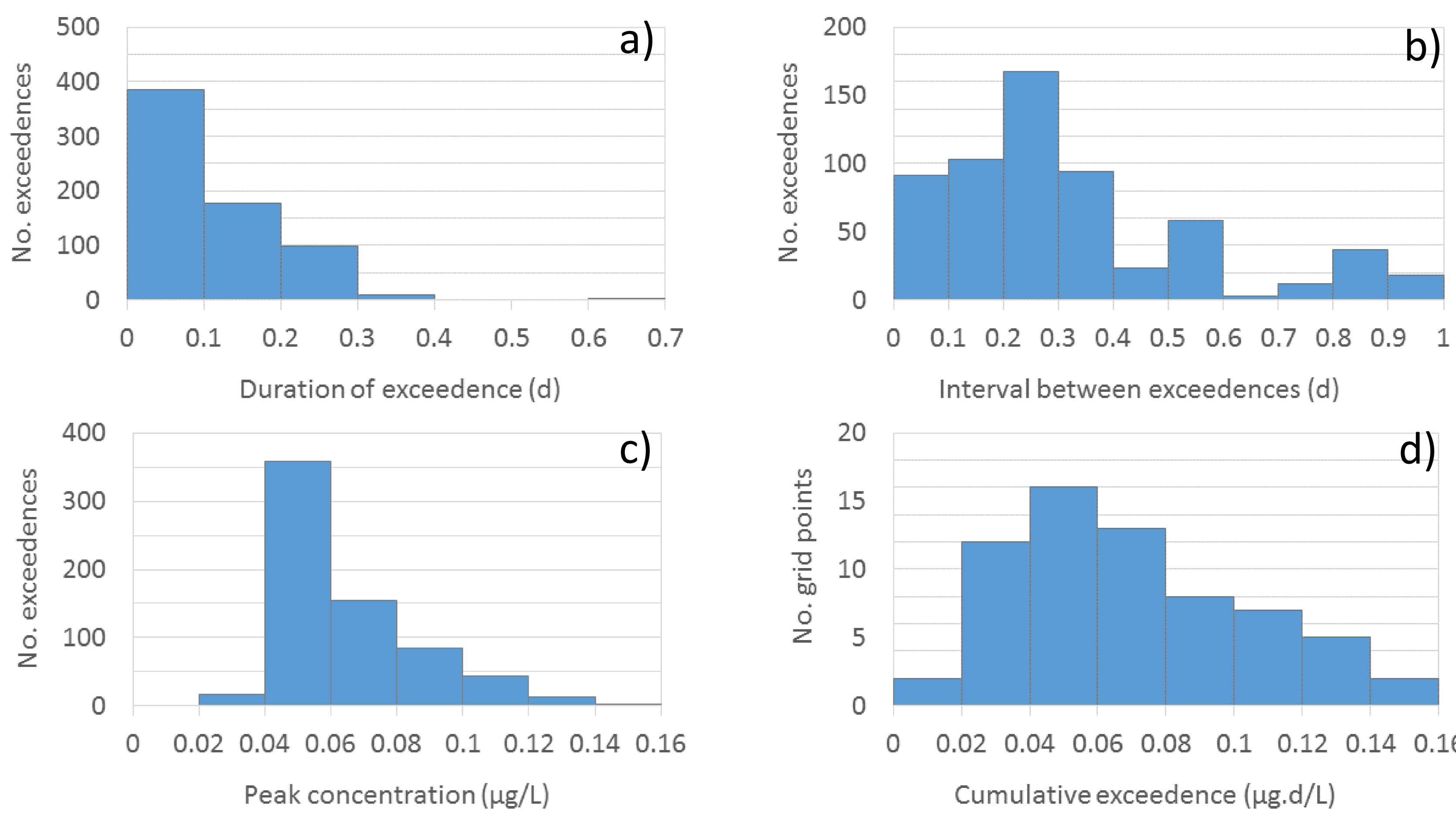

Figure 3 – Histograms indicating: a) duration b) interval and c) peak concentration of exceedence events, plus: d) cumulative exceedence (in µg.d/L) at each grid point.

Conclusions

An extended version of the MLA model has been developed, recoded in VB.NET for improved compatibility with modern operating systems. This extended version provides additional spatial resolution of model results, permitting detailed analysis of exposure patterns at any location in the water body.

References

Gillibrand, P. A. & Turrell, W. R. (1999). A Management Model to Predict the Dispersion of Soluble Pesticides from Marine Fish Farms. Fisheries Research Services, Marine Laboratory, Aberdeen; Report No 2/99.

SEPA (2008). Regulation and monitoring of marine cage fish farming in Scotland - a procedures manual. Annex G: Models for assessing the use of chemicals in bath treatments v2.2. Scottish Environment Protection Agency.