Appendix A – Final EIS Guidelines (Section 4.3 and Section 4.3.2)

4.3 Baseline Studies

Baseline studies shall provide a description of existing conditions in biophysical and socio-economic environments that could be affected by the Project, both in the immediate vicinity and beyond. This shall include the components of the existing environment and environmental processes, their interrelations and interactions, as well as their variability over time scales appropriate to the effects analysis. The level of detail shall be sufficient to:

- identify and assess any adverse environmental effects that may be caused by the Project;
- identify and characterize the beneficial effects of the Project; and
- provide the data necessary to enable effective follow-up.

The boundaries of the study area shall be defined for each baseline study and the rational for the boundaries shall be provided. Methodology for each baseline study shall be proposed by the proponent, in consultation with resource agencies, as appropriate, and shall be summarized in the EIS.

Where appropriate and possible to do so, the EIS shall present a time series of data and sufficient information to establish the averages, trends, and extremes of the data that are necessary for the evaluation of potential environmental effects. For key environmental and social components, the Proponent should consider how far back in time and how far into the future the study should be conducted. Rationale for the temporal boundaries chosen should be provided.

Baseline Studies shall be prepared for at least the following components:

- Wild Atlantic Salmon
- Sea Farm Sites
- Fish and Fish Habitat

4.3.1 Wild Atlantic Salmon

The baseline study shall provide a detailed description of the status of wild Atlantic salmon in the vicinity of Project components (the hatchery and Bay Management Areas for sea farms). The baseline study shall consider the most recent information from COSEWIC and DFO regarding the at-risk status and stock assessment of wild Atlantic salmon.

The baseline study shall include, but not be limited to, a discussion of the following features:

a) a characterization of the current distribution, abundance, genetic population structure, morphology, health and fitness, and migratory patterns of wild Atlantic salmon along the south coast of the island and within the vicinity of all Project components;
b) proximity of the sea cages to scheduled and non-scheduled salmon rivers
c) a literature review of the effects of disease and parasites that are prevalent in Newfoundland and affect Atlantic salmon on farms and in the wild, including a review of the transmission of those diseases and parasites;
d) water-quality data at the sea cage sites including water temperature, salinity and dissolved oxygen;

e) genetic and ecological interactions of farmed salmon escapees on wild Atlantic salmon along the south coast of the island;
f) description of the strain of Atlantic salmon to be produced and a breakdown of the ancestries that make up the broodstock;
g) oceanographic and meteorological data at the sea cage sites including water currents, wind and wave action, flood and tidal zones, ice dynamics, and storm patterns;
h) conformity of sea cage design, construction and installation and mooring to meet or exceed standards in the Code of Containment and ability to withstand oceanographic and meteorological conditions identified in g);
i) discuss existing river monitoring and model the potential for farmed salmon escapees in other salmon rivers identified in b).

4.3.2 Sea Farm Sites (Bay Management Areas)

The baseline study shall provide a detailed description of the physical and biological data required to assess the suitability of each farm site for finfish aquaculture.

The baseline study shall include, but not be limited to, a discussion of the following information obtained prior to the introduction of additional fish to the site:

a) within each BMA used by the Project, a site map that shows the exact location of sea farm sites and details of sea cage layouts;
b) benthic surveys which include substrate type, and characterization of flora and fauna;
c) water quality data including water temperature, salinity and dissolved oxygen;
d) oceanographic and meteorological data including bathymetry, water currents, wind and wave action, flood and tidal zones, ice dynamics, and storm patterns;
e) exposure zone modelling for the use of approved fish health treatment products including pesticides, therapeutants, and disinfectants; and

For sites that are undergoing or have completed a production cycle, a discussion of the following information shall be included:

f) identification of past or present fallow periods;
g) benthic monitoring, management of BOD matter and performance; and
h) a discussion of historical information of farm performance that is publicly reported and is also applicable to the expansion, such as fish mortality, deposits of drug or pesticides, disease, escapes, and sea lice.

Appendix B – Exposure Zone Modelling

Azamethiphos Exposure Zone Modelling - Newfoundland and Labrador, Canada

TUFLOW FV - Tracer Modelling

Customer	Mowi Canada East
Project	31333
Deliverable	RPT03
Version	RevD
Date	10 January 2025

Document Control

Document Identification

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Version Date	10 January 20255
Customer	Mowi Canada East
Classification	PUBLIC

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Amendment Record

The Amendment Record below records the history and issue status of this document.

Version	Version Date	Distribution	Record
A	29 October 2024	MCE	Report – First Draft
B	18 November 2024	MCE	Report – Second Draft
C	16 December 2024	MCE	Report – Third Draft
D	10 January 2025	MCE	Report – Fourth Draft

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Executive Summary

This report presents the methodology and results of a simulation study on the dispersion of Azamethiphos, a fish health treatment product, across 53 farm sites operate by Mowi Canada East (MCE), located along the south coast of Newfoundland, Canada. The study focuses on the dispersion dynamics within each Bay Management Area (BMA) and quantifies the exposure zones. Additionally, it examines dispersion patterns near marine protected areas to assess potential impacts. The primary goal of the report is to provide insights into Azamethiphos exposure zones, supporting the Environmental Impact Statement (EIS).

A hydrodynamic model was calibrated at the Broad Cove site within BMA5 and validated at the Little Burdock site within BMA2. The model showed reasonable agreement with observed water levels and current velocities and directions. After validation, the model was used to simulate bath treatments across all BMAs.

Two distinct simulation periods were selected, representing neap and spring tides.

An extreme treatment schedule was selected for the purpose of the modelling to demonstrate a worse-case scenario. In the simulated bath treatment, 2.5 kg of Salmosan® was applied per pen, delivering 1,245 g of Azamethiphos per pen, with releases occurring daily. For farms with 10 pens, such as in the Bays West area, a total of 12.45 kg of Azamethiphos was discharged over a five-day period. In farms with seven pens, such as in the Bays East area, 8.715 kg of Azamethiphos was discharged over 3.5 days.

Azamethiphos treatment was modelled as a tracer and released over a five-minute period across the top four meters of the water column, simulating bath volume discharge. A TUFLOW FV-Tracer model was employed to predict concentration levels using an extreme treatment scenario. BMAs 1 to 5 exhibited relatively larger dispersion footprints compared to BMAs 8 to 15, primarily due to poor flushing characteristics. The highest modelled concentration, 2,200 ng/L, was recorded in BMA2+2B, and lowest, 17 ng/L, in BMA11. Modelled concentrations for farms in Bays West consistently remained below 110 ng/L.

Simulated Azamethiphos concentrations were analysed during and after dosing periods across marine sensitive areas. The highest concentration, 0.05 ng/L, was simulated at Sandbanks Provincial Park near BMA15, while all other sites modelled concentrations below 0.01 ng/L.

The study provides critical insights into the spatial extent, location, and duration of Azamethiphos exposure, serving as a preliminary 'fit for purpose' assessment of dispersion in the region. This work informs the development of optimized treatment plans that prioritize the health of farmed and wild fish, as well as environmental protection.

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Acronyms and Parameter Conventions

Acronyms	
AAR	Aquaculture Activities Regulations
ADCP	Acoustic Doppler Current Profiler
ALRV	Acute Fish Aquatic Life Reference Values
BMA	Bay Management Area
CPAWS	Canadian Parks and Wilderness Society
DEM	Digital Elevation Model
DFO	Canadian Department of Fisheries and Oceans
ECC	Environment and Climate Change
EIS	Environmental Impact Statement
EQS	Environmental Quality Standards
FARM	Framework for Aquaculture Risk Management
GOTM	The General Ocean Turbulence Model
NHSI	Northern Harvest Smolt Inc
MAC	Maximum Allowable Concentration
MAE	Mean Absolute Error
MCE	Mowi Canada East
MPA	Marine Protected Area
MSL	Mean Sea Level
OECMs	Other Effective Area-Based Conservation Measures
PEZ	Potential Exposure Zones
PTM	Particle Tracking Module
SEPA	Scottish Environment Protection Agency
PD	Percentage Difference
WSC	Water Survey of Canada
WQM	Water Quality Model

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1 Introduction

Northern Harvest Smolt Ltd. (NHSL) is proposing to expand the Indian Head Hatchery in Stephenville, Newfoundland and Labrador, Canada, to provide an additional 2.2 million salmon smolt to stock currently licensed sea cages. The expansion is intended to both increase production capacity and improve smolt quality.

On October 25, 2023, the Minister of Environment and Climate Change (ECC) informed NHSL that an environmental impact statement (EIS) is required for the proposed Indian Head Hatchery Expansion Project.

As a part of the EIS requirement, NHSL was seeking services to model the exposure zone for fish health treatment products (such as pesticides, therapeutants, and disinfectants) at their sea farms on the south coast of Newfoundland, Canada (Figure 1.1).

According to the EIS guidelines document (MCE, 2024):

- Baseline studies must be conducted to describe existing conditions and assess potential adverse and beneficial environmental effects; and
- The study area boundaries and methodology must be defined, and the EIS must present data and information on averages, trends, and extremes.

BMT has been commissioned by Mowi Canada East (MCE) to develop a numerical hydrodynamic and tracer model to support the EIS, specifically dispersion modelling for fish health treatment products. This report presents the results of a hydrodynamic modelling study to simulate the dispersion of the Azamethiphos bath treatment under spring and neap tide scenarios. The modelling study estimated an exposure profile for each Bay Management Area (BMA). This profile included a temporal sequence and spatial extent of Azamethiphos concentrations within the immediate vicinity of the BMA. The assessment of Azamethiphos dispersion is based on Potential Exposure Zones (PEZ) modelling guidelines provided by the Canadian Department of Fisheries and Oceans (DFO) (Page et al., 2023a) as set out in the previously submitted method statement (BMT, 2024).

1.1 Regulatory Guidance

Azamethiphos is the treatment therapeutant of this study, which is an organo-thiophosphate insecticide. It is a veterinary drug used to control parasites, specifically sea lice. When released into water, it stays in the water until it breaks down into non-toxic derivatives, for which a decay half-life of 5.6 days has been determined (SEPA, 2023). In trials completed using tarpaulin enclosures (also known as a skirt) around sea cages to create an enclosed bath treatment environment, it was found that concentrations of dye and pesticides were reduced by a factor of 10 after 30 minutes, by a factor of 100 after 1 hour, and by a factor of 1000 after 3 hours (Page et al., 2015). These findings emphasise the time-sensitive nature of harmful effects, necessitating an approach that considers both time-dependent toxicity data and the dispersion rates identified in Canadian modelling studies (e.g., Page et al., 2014; 2015). Health Canada's Pest Management Regulatory Agency (PMRA) has identified an Acute Fish Aquatic Life Reference Values (ALRV), which provides a guideline value for possible impacts to the aquatic environment resulting from short-term exposure to high concentrations of Azamethiphos (20 µg/L). However, there is no Chronic ALVR available for Azamethiphos, due to insufficient toxicological studies being completed on low-level long-term exposure of aquatic organisms. This implies that additional trials, particularly with concentrations between 0 and 1 µg/L, may be required (Hamoutene et al., 2023).

This study modelled concentrations that highlight dispersion characteristics and concentration values over time. There are examples of EQS applications in aquaculture, one of which can be seen in the Scottish Environment Protection Agency's (SEPA) regulatory framework, which governs the use of drugs and pesticides. In the absence of any Canadian standards or regulatory guidance on the matter, the SEPA regulatory frame was used to shape the scenarios of modelling.

According to SEPA regulatory framework, to provide environmental protection from acute exposure, two standards are used: one is applied three hours after any discharge, and the other is applied 72 hours after the final discharge in any treatment period. This model used SEPA EQS as a benchmark to compare the proposed treatment scenarios. The frequency and duration of treatments can be quite variable, and is dependent on seasonal and regional, environmental and production scale factors. The proposed treatment scenarios were based on extreme frequency and duration of treatments within a BMA. To assess the three-hour EQS, a single pen release simulation was performed and the size of the area where the concentration exceeds 250 ng/L was compared against the allowable mixing zone as calculated using BathAuto (SEPA, 2008, 2019). Similarly, after 72 hours, the area exceeding 40 ng L should not exceed 0.5 km2, and the maximum concentration in the domain should not exceed 100 ng/L (maximum allowable concentration—MAC) (SEPA 2008, 2019). These were chosen for illustrative purposes and to evaluate the dispersion of the treatment.

1.2 Study Site and Climate

MCE is currently managing 53 aquaculture farm sites distributed across 13 designated BMAs along the southern coast of Newfoundland (Figure 1.1). BMA1 to 9 were categorised as Bays East, while BMA10 to 15 were categorised as Bays West. No farms operated within BMA6 and BMA9. All farms are situated within bays, with each bay accommodating up to four farms. Several of these bays receive freshwater inflows from upstream catchments.

The South Coast and Avalon Peninsula of Newfoundland exhibit pronounced seasonal changes (HNAL, 2014), during summer, the southern coastal areas experience average temperatures between 10°C and 13°C, influenced by cold oceanic air masses (HNAL 2014, Environment and Climate Change Canada 2024). In winter, minimum nighttime temperatures can drop to -10°C (Environment and Climate Change Canada, 2024). Rainfall distribution is also seasonally variable, with December being the wettest month and June the driest, according to data from the St. John's weather station. Average rainfall in June is 78 mm, while December records 138 mm, reflecting a pattern of drier summers and wetter winters (Environment and Climate Change Canada, 2024). Surface wind speeds at an average of 20–30 km/hr around the coasts, with 50–80 km/hr typically sustained during low-pressure systems (HNAL, 2014).

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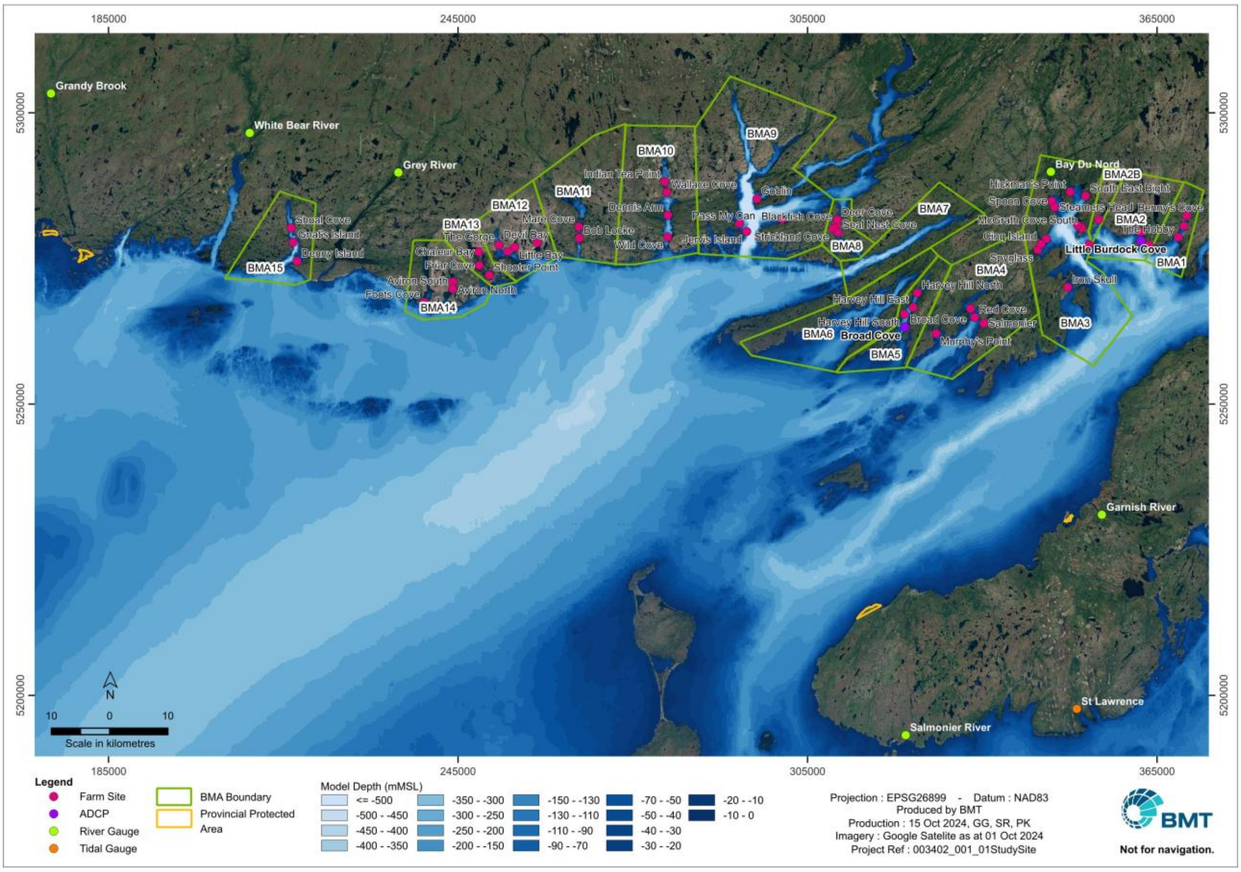

Figure 1.1 Locations of Existing Fish Farm Sites Operated by MCE Near the South Coast of Newfoundland

In Figure 1.1 the map shows ADCP locations, river gauge stations, tidal gauge stations, and nearby provincial protected areas.

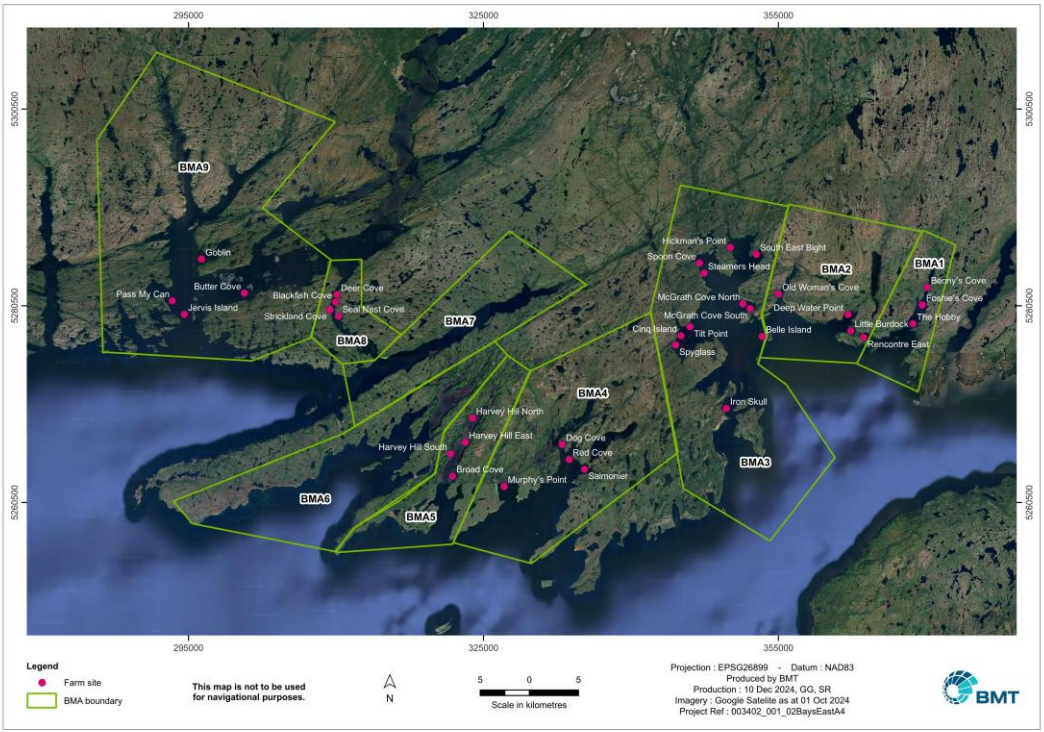

Figure 1.2 Map of Bays East, Including Delineated Embayments and Farms

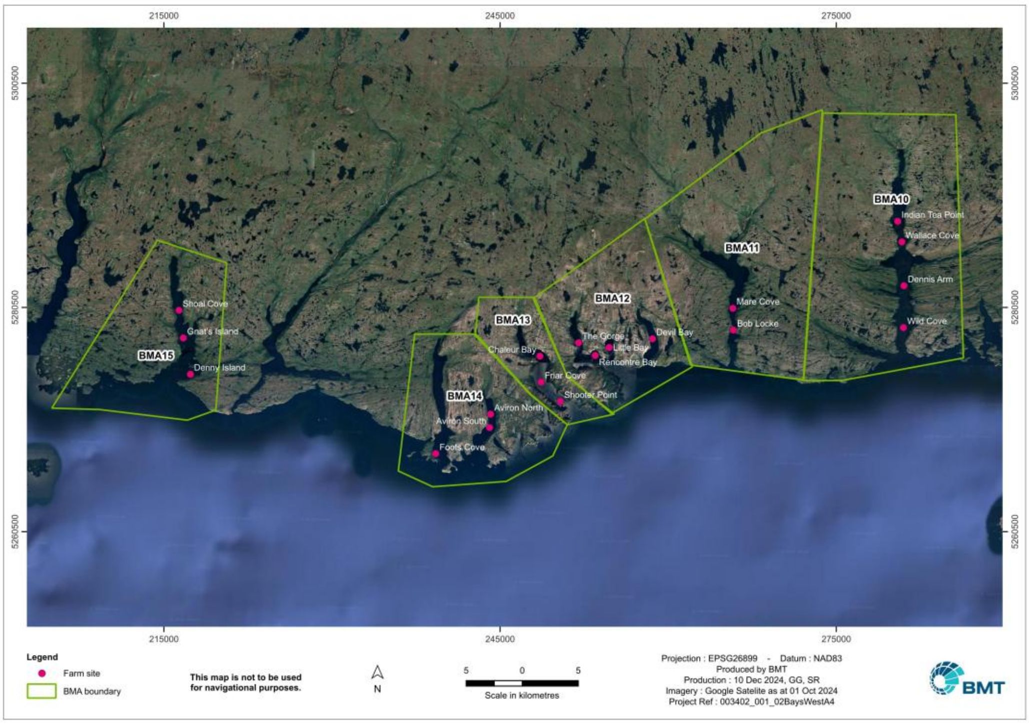

Figure 1.3 Map of Bays West, Including Delineated Embayments and Farms

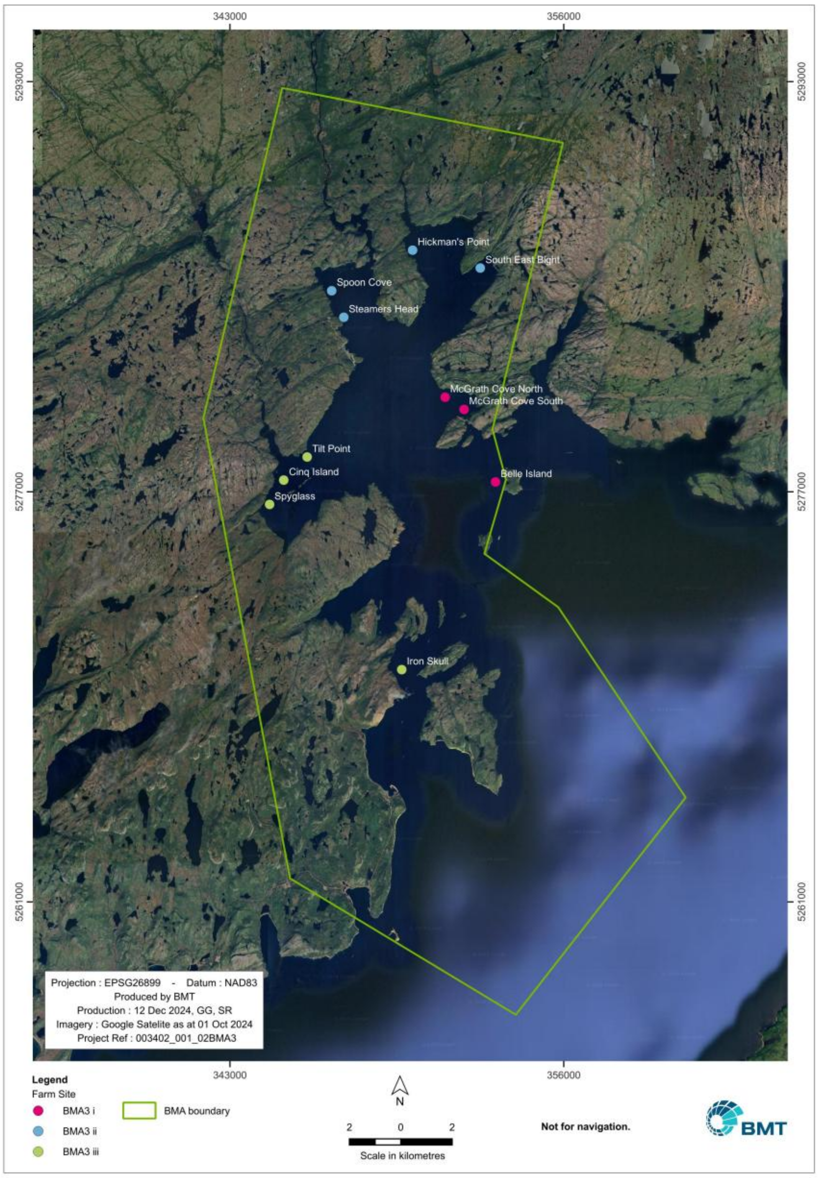

Figure 1.4 BMA 3 Highlighting Farms Belonging to BMA3i, BMA3ii, and BMA3iii

The separation of Bays East and Bays West is shown in Figure 1.2, Figure 1.3, including the delineated embayments of each. Figure 1.4 shows the separation of farms within BMA 3 used in the modelling.

1.3 Approach

The process of estimating the exposure zone profile follows a two-part approach:

1. **Hydrodynamic Modelling**: The selected hydrodynamic model was first calibrated and validated for specific areas; and

2. **Dispersion Modelling**: Following this, the temporal and spatial dispersion footprint of Azamethiphos was determined using particle tracking and/or tracer simulations.

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Calibration and validation tailored to the specific conditions of each site are crucial to ensure confidence in the model outputs (Page et al., 2023b). Over time, modelling strategies and considerations have been identified, acknowledged, and adopted (Page et al., 2023b). For instance, SEPA has introduced more stringent requirements regarding the selection, calibration, and validation of models used for regulating and siting fish farms in Scotland (SEPA, 2019).

The results were presented using the following key approach:

- **Maximum Allowable Concentration Plot**: This plot provides the time series of the maximum concentration of Azamethiphos observed during the simulation period; and

Additionally, tables in this report present the maximum area within each BMA where bath treatment concentration exceeds 100 ng/L, as well as the maximum MAC for each BMA.The maximum area exceedance values provide insight into the near-field dispersion of the chemical, while the MAC plot offers a perspective on its far-field dispersion.

2 Hydrodynamic Modelling

2.1 Model

BMT has employed a numerical hydrodynamic and tracer dispersion approach to simulate the fate and transport of Azamethiphos bath treatment at the 53 finfish sites using a 3D hydrodynamic model, TUFLOW FV.

2.2 TUFLOW FV Hydrodynamic Model

TUFLOW FV (https://www.tuflow.com) is a 3D flexible-mesh (finite volume) hydrodynamic model developed and distributed by BMT. It can be used for modelling a diverse array of inland and coastal water bodies and it is able to call the water quality model (WQM) library directly via a custom interface. The model accounts for variations in water level, the horizontal salinity distribution and vertical density stratification in response to inflows and surface thermodynamics. The finite volume numerical scheme solves the conservative integral form of the Non-Linear Shallow Water Equations in addition to the advection and transport of scalar constituents such as salinity, temperature, inert tracers and the state variables from the coupled biogeochemical model. The equations are solved in 3D with baroclinic coupling with both salinity and temperature using the UNESCO equation of state. Surface momentum exchange and heat dynamics are solved internally within the model from available meteorological boundary condition data.

2.3 Model Domain and Mesh

The model domain covers an overall area of 3,200,000 hectares, with an open boundary of approximately 390 km extending along the southern section (Figure 2.1). The model mesh has been refined as required for this study, with reduced resolution offshore and increased resolution around pen sites. A horizontal resolution of no greater than approximately 30 m was maintained in areas around pen sites selected for calibration and validation (Figure 2.2).

2.4 Model Bathymetry

The digital elevation model (DEM) used to set model bathymetry comprised multiple sources to ensure suitable resolution for current speeds around the area of interest (Figure 2.1 and Figure 2.2). The final bathymetry comprised the following:

- Bathymetry survey data covering the Broad Cove in BMA5 and Little Burdock Cove in BMA2 farm sites, provided by MCE for the farm area;
- 10 m and 100 m non-navigational bathymetric data provided by the Canadian Hydrographic Service;
- The DEM developed by Natural Resources Canada consolidates bathymetric data from various government agencies into a model of 10 m grid spacing;
- Bathymetric data provided by the Canadian Parks and Wilderness Society (CPAWS) covering the Newfoundland and Labrador region;
- NAVIONICS chart data; and
- Manual digitisation of bathymetry and other features based on satellite imagery as needed.

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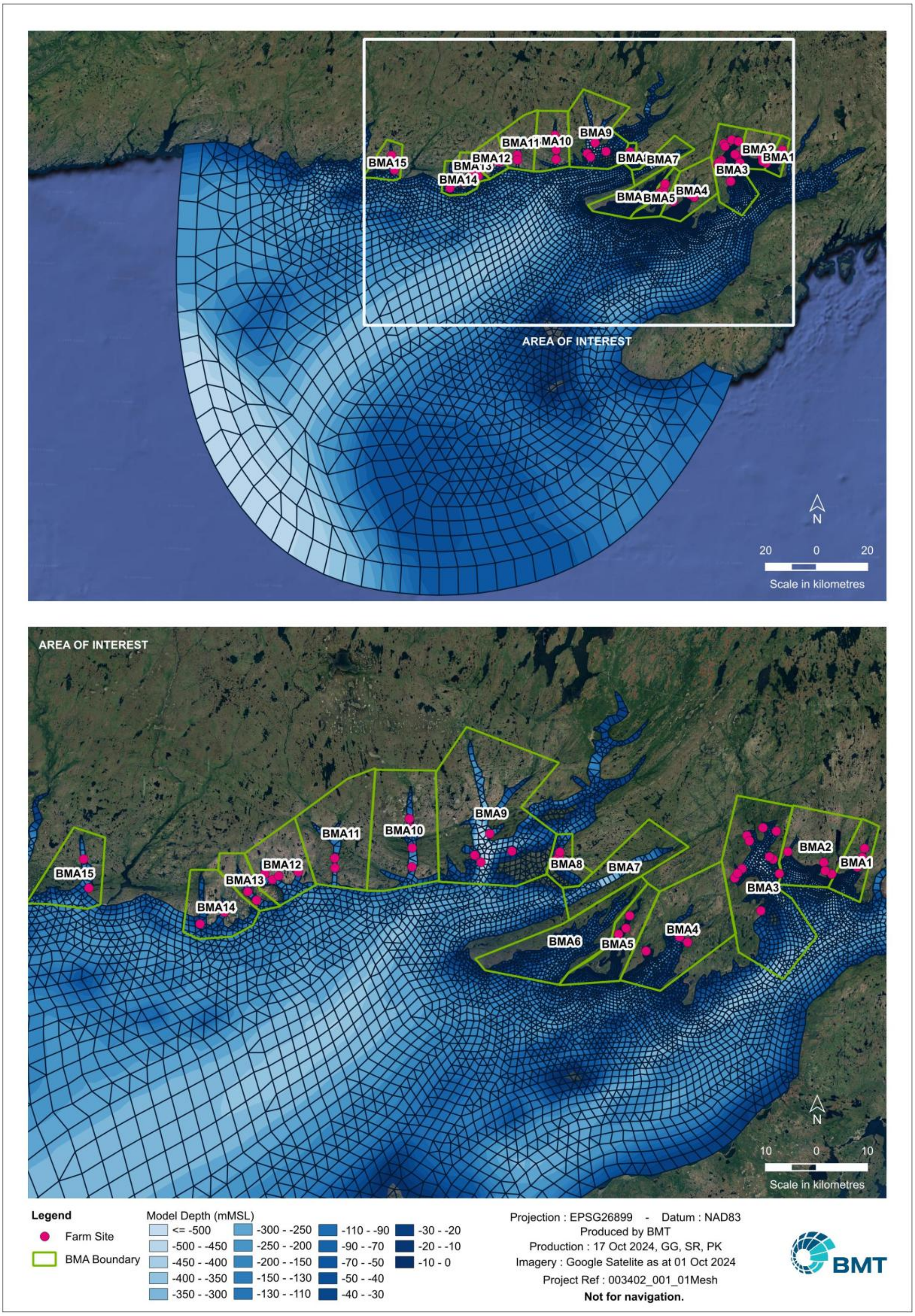

Figure 2.1 The Model Domain, Mesh and Bathymetry

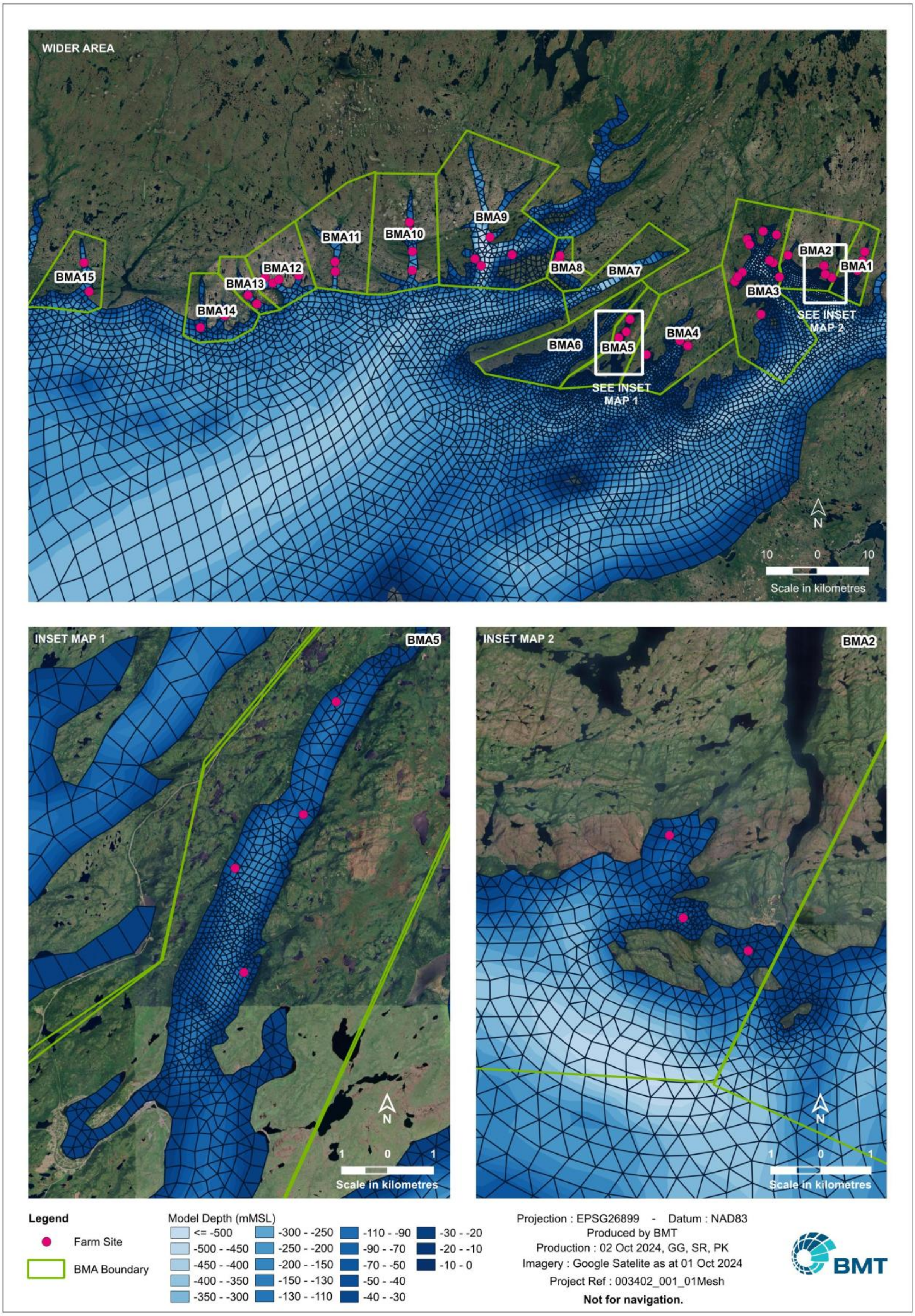

Figure 2.2 Model Mesh Areas for BMA5 (Bottom-Left) and BMA2 (Bottom-Right) as Inset Maps

2.5 Boundary Conditions

The following meteorological and open tidal boundary conditions have been used for the larger regional model:

- The tidal boundary conditions are provided by the FES 2014 global tide model;
- The model was provided with regional current forcing (residual water level, current magnitude and direction), temperature and salinity profiles at the open boundary. These were derived from the ocean general circulation model, HYCOM (http://hycom.org/) and varied both in space (longitude, latitude, and elevation) and time. To capture the sub-daily regional processes, three-hourly HYCOM model datasets were prescribed at the ocean boundary;
- Atmospheric heat fluxes and water column heat dynamics were simulated internally within TUFLOW FV. Boundary condition data including wind, air temperature, long- and short-wave radiation, precipitation and relative humidity were derived from meteorological data from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 climate model (https://www.ecmwf.int/);
- The General Ocean Turbulence Model (GOTM) was coupled with the 3D TUFLOW FV hydrodynamic model in order to simulate the vertical mixing processes in the presence of density stratification (http://www.gotm.net/); and
- Gauged freshwater inputs for the six hydrometric stations (Figure 2.3) connected to the model domain, operated by Water Survey of Canada (WSC) (GOC, 2024).

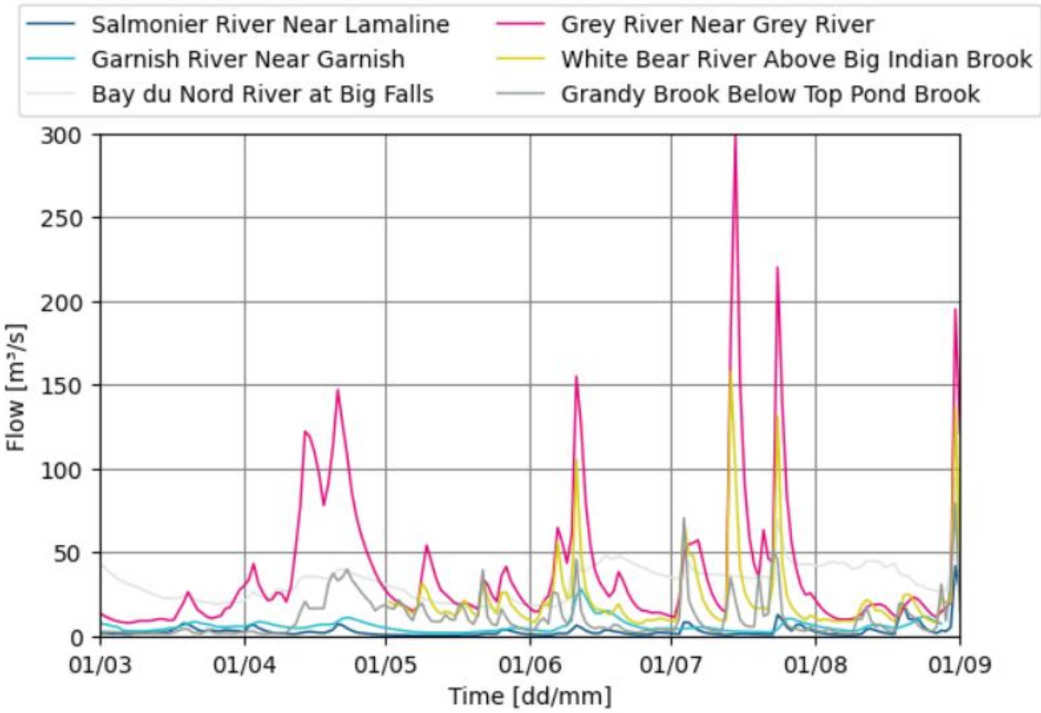

Figure 2.3 Available River Flow Data for Model Periods

2.6 Hydrodynamic Model Calibration

The hydrodynamic model was calibrated against data from an Acoustic Doppler Current Profiler (ADCP) located close to the finfish aquaculture site of interest, Broad Cove in BMA5. The calibration site (Figure 2.2—bottom left) was selected based on data availability, accuracy, and operational preferences of MCE. The calibration process involved the comparison of water levels, velocity direction, velocity magnitude, and the *x* and *y* components of the flow to the observed data, as well as adjusting model parameters and bathymetry to achieve a desired level of model fit.

MCE provided pressure sensor and ADCP data of ocean currents spanning 104 days, collected at the sea farm site Broad Cove in Northeast Arm near Harbour Breton on the Newfoundland South Coast. The pressure sensor data was processed by BMT to derive water levels. The ADCP data had been processed by ASL Environmental Sciences Inc (2023a) prior to BMT receiving it. The calibration period from 21/04/2023 14:45 to 03/08/2023 14:07 aligns with the deployment period. The calibration has been conducted at the three depths throughout the water column provided within the dataset:

- 5 m below Mean Sea Level (MSL);
- 9.11 m below MSL; and
- 15.11 m below MSL.

Further details on the ADCP deployment methodology, instrument specification and data processing can be found in the data report for the Broad Cove site (ASL Environmental Sciences Inc, 2023a).

Comparisons of model against observed data are shown in Figure 2.4 to Figure 2.13. Each calibration plot contains four sub-plots, representing different periods within the total time span. Together, all four sub-plots provide a continuous dataset with more detailed, zoomed-in representations for clearer analysis. On the plots, statistics for R, BIAS (model bias), MAE (mean absolute error), and PD (percentage difference) are included for comparison.

In the absence of model performance criteria within the Canadian regulatory context, the hydrodynamic model performance for this exercise was evaluated using SEPA guidelines (SEPA, 2019) as closely as possible. However, limited availability of detailed bathymetric and boundary forcing data, coupled with computation demands for the calibration process made it challenging to meet SEPA standards.

2.6.1 Water Level

- The R value is high (i.e., ≥0.98), signifying a strong correlation between the model predicted water level and the observed data;
- The tidal range predicted by the model is consistent with the observed data and predicts the variations in tidal range between spring and neap tides;
- The timing of the high and low water matches well between the ADCP and modelled data;
- The MAE value for water levels is 0.09 m, which is within the SEPA guidelines of +/- 0.1 m (SEPA, 2019); and
- This model has a water level calibration suitable for the use of modelling the dispersion of bath treatment.

2.6.2 Velocity Magnitude

- While the R value of 0.25 (for 5 m below MSL) and 0.01 (for 9.11 m below MSL) was indicative of a weak correlation between the ADCP and model data, the main patterns of peaks and troughs were captured by the model;
- There were negative bias of 0.39 m/s (for 5 m below MSL) and 3.3 m/s (for 9.11 m below MSL) for water velocities indicating underestimation of velocities;
- MAE of 4.48 cm/s is well within the SEPA guidelines of 10 cm/s (SEPA, 2019) for the surface water column, where the bath treatment is released;
- Underprediction of the current speeds in the area of interest was consistent with a conservative approach commonly adopted in bath treatment models, leading to reduced rate of dispersion and dilution impact;
- A possible cause of some difference is due to the ADCP having a standard deviation slightly over 0.5 cm/s at all depths; and
- From the full calibration period timeseries, the model represented the difference in velocity magnitude between the neap and spring tidal cycles, with magnitudes varying in a similar range to the ADCP data.

2.6.3 Flow Velocity Components

- While R values for comparison of observed and predicted *x* and *y* components of the flow indicated a weak correlation between the ADCP and model data, the predominant flow direction was captured by the model;
- The BIAS and MAE were below SEPA guidelines of 10 cm/s (SEPA, 2019) for all depths; and
- The phasing of the velocity shows a misalignment which might be the cause of some of the low correlation shown in the statistics.

Meeting several SEPA standards for model performance suggests that, overall, the calibration results indicate the hydrodynamic model is suitable for simulating bath treatment dispersion at the project site. The slight underprediction of current magnitudes led to a more conservative approach in the dispersion modelling.

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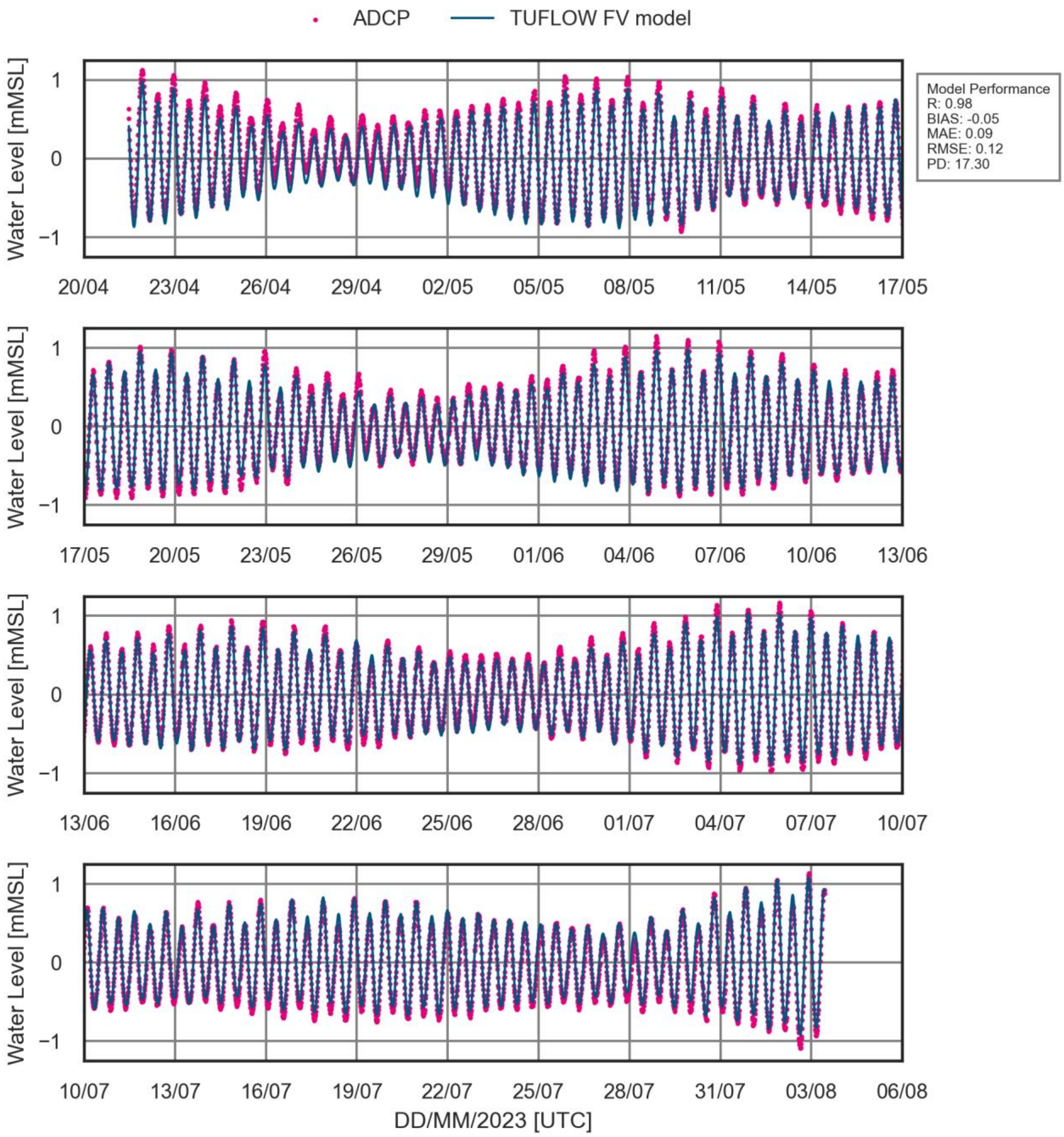

Figure 2.4 Model Comparison to Broad Cove ADCP Water Level Data

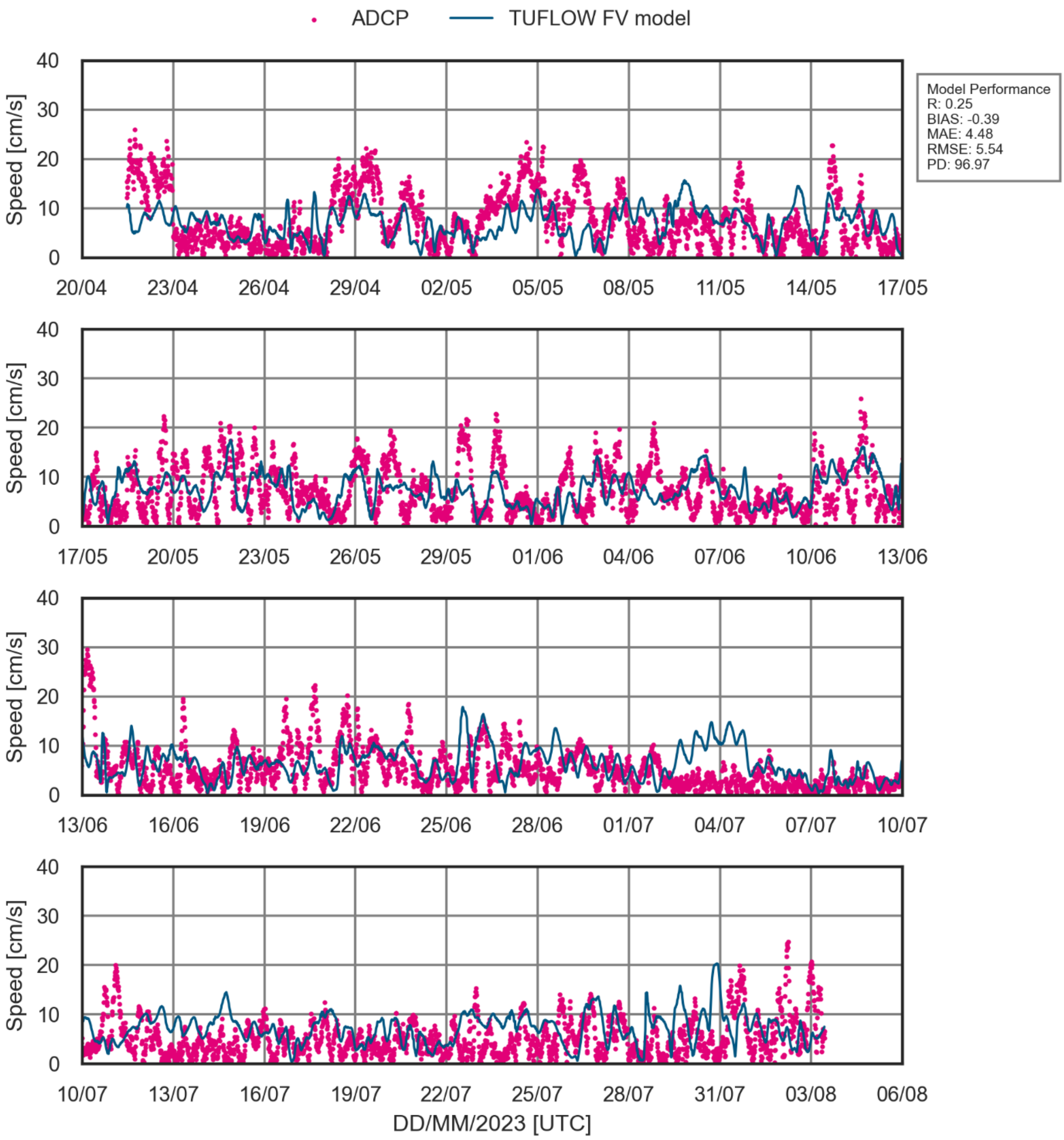

Figure 2.5 Model Comparison to Broad Cove ADCP Current Speed Data at 5 m Below MSL

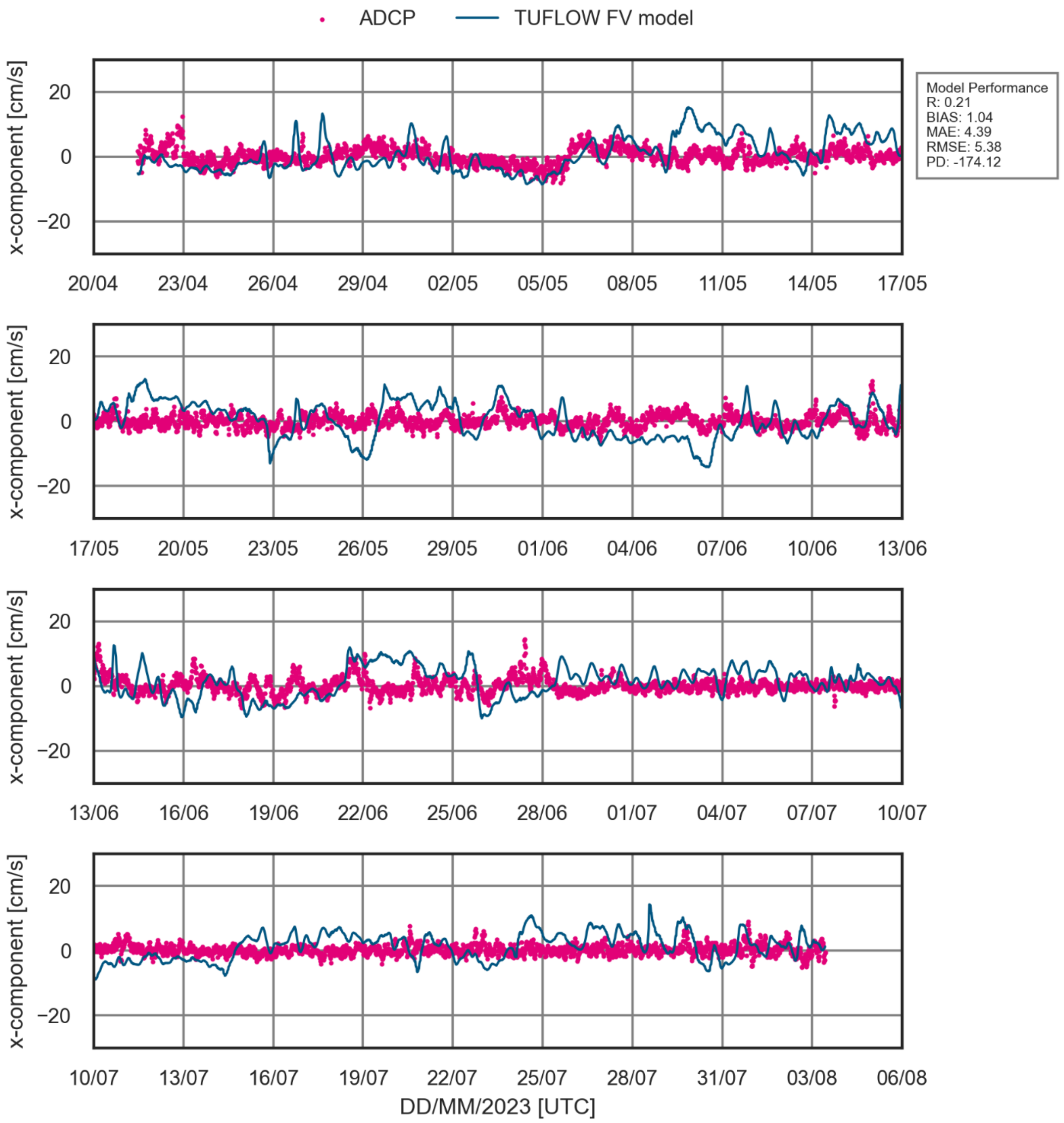

Figure 2.6 Model Comparison to Broad Cove ADCP Current Speed X-Component Data at 5 m Below MSL

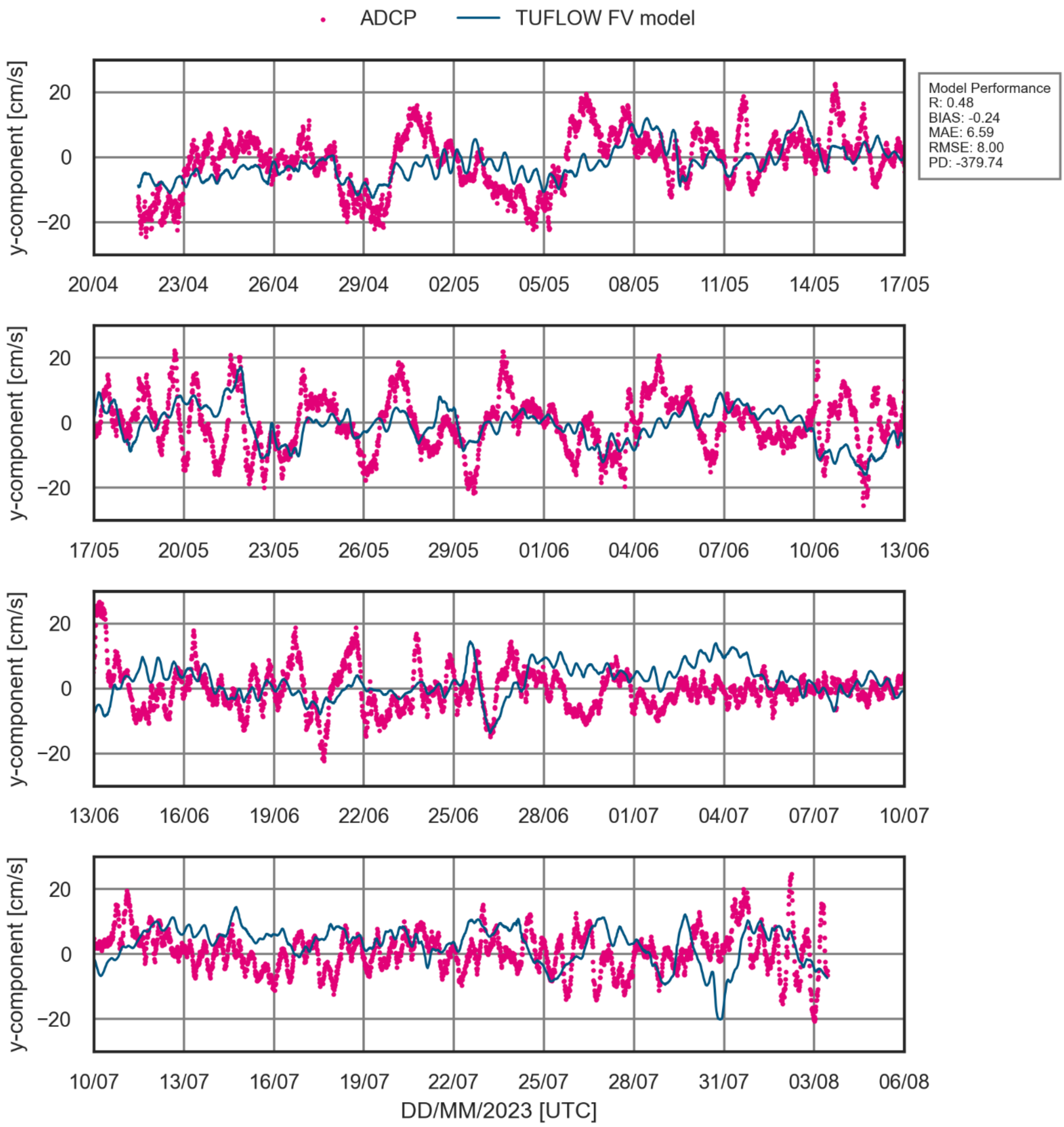

Figure 2.7 Model Comparison to Broad Cove ADCP Current Speed Y-Component Data at 5 m Below MSL

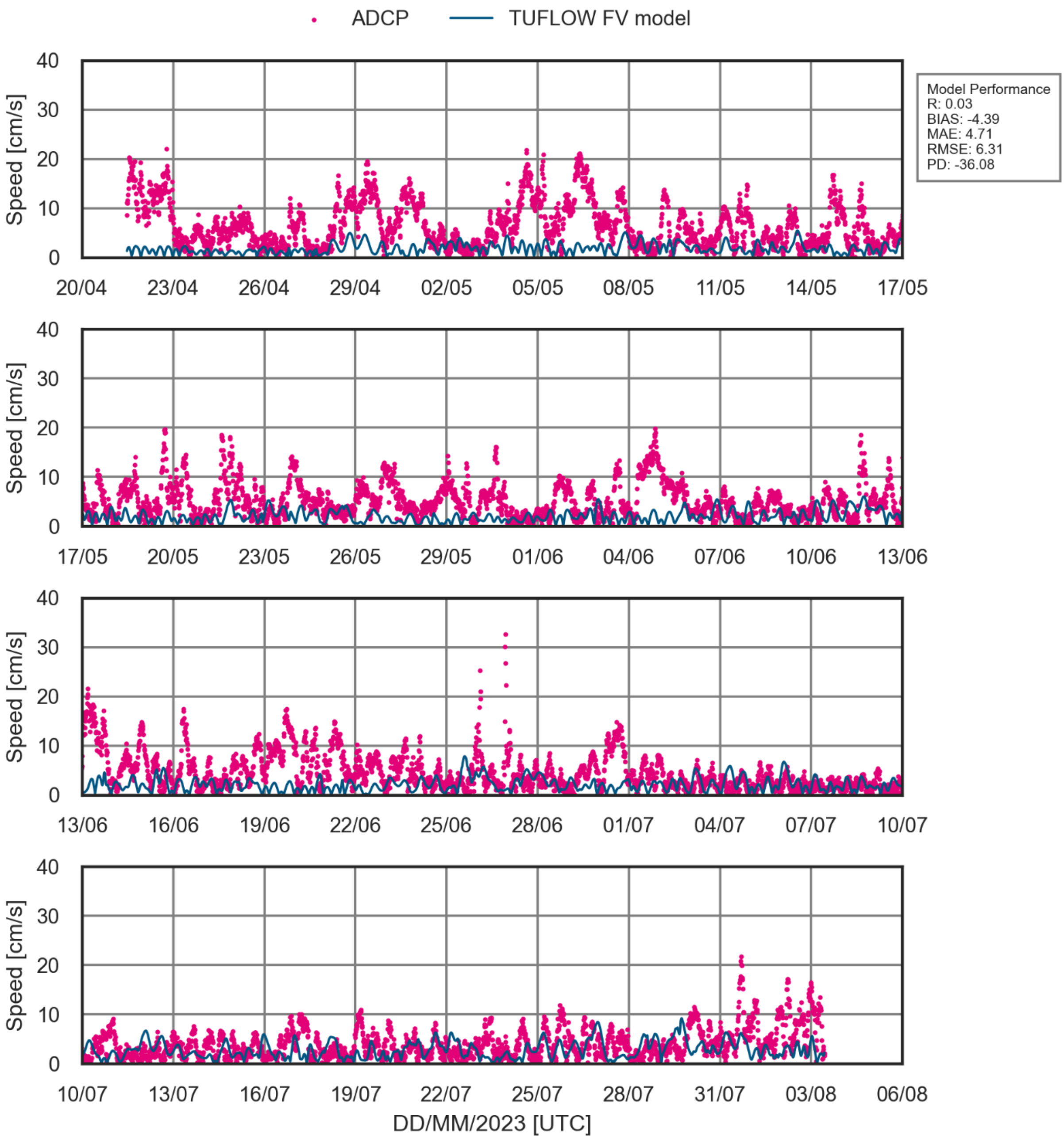

Figure 2.8 Model Comparison to Broad Cove ADCP Current Speed Data at 9.11 m Below MSL

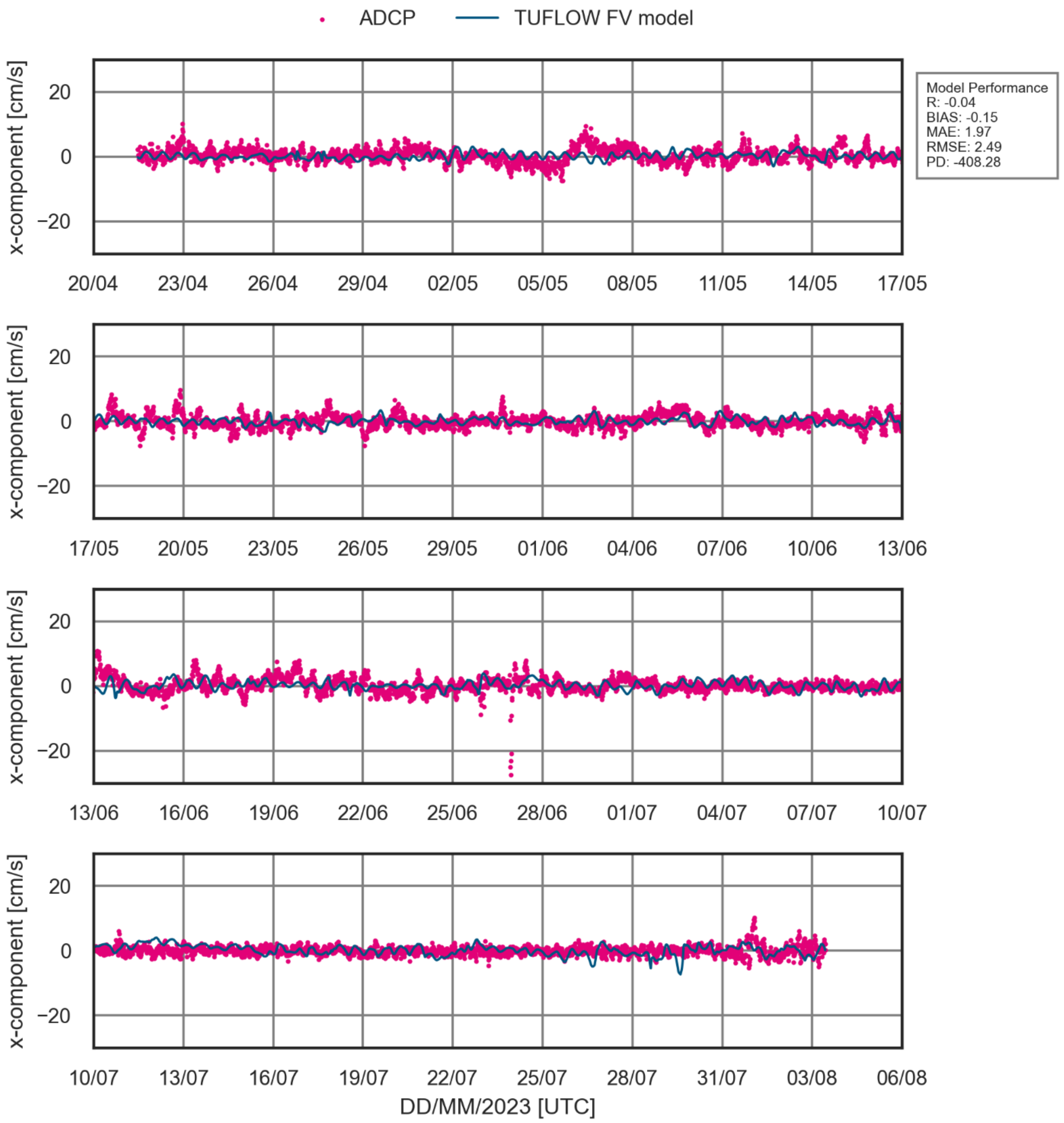

Figure 2.9 Model Comparison to Broad Cove ADCP Current Speed X-Component Data at 9.11 m Below MSL

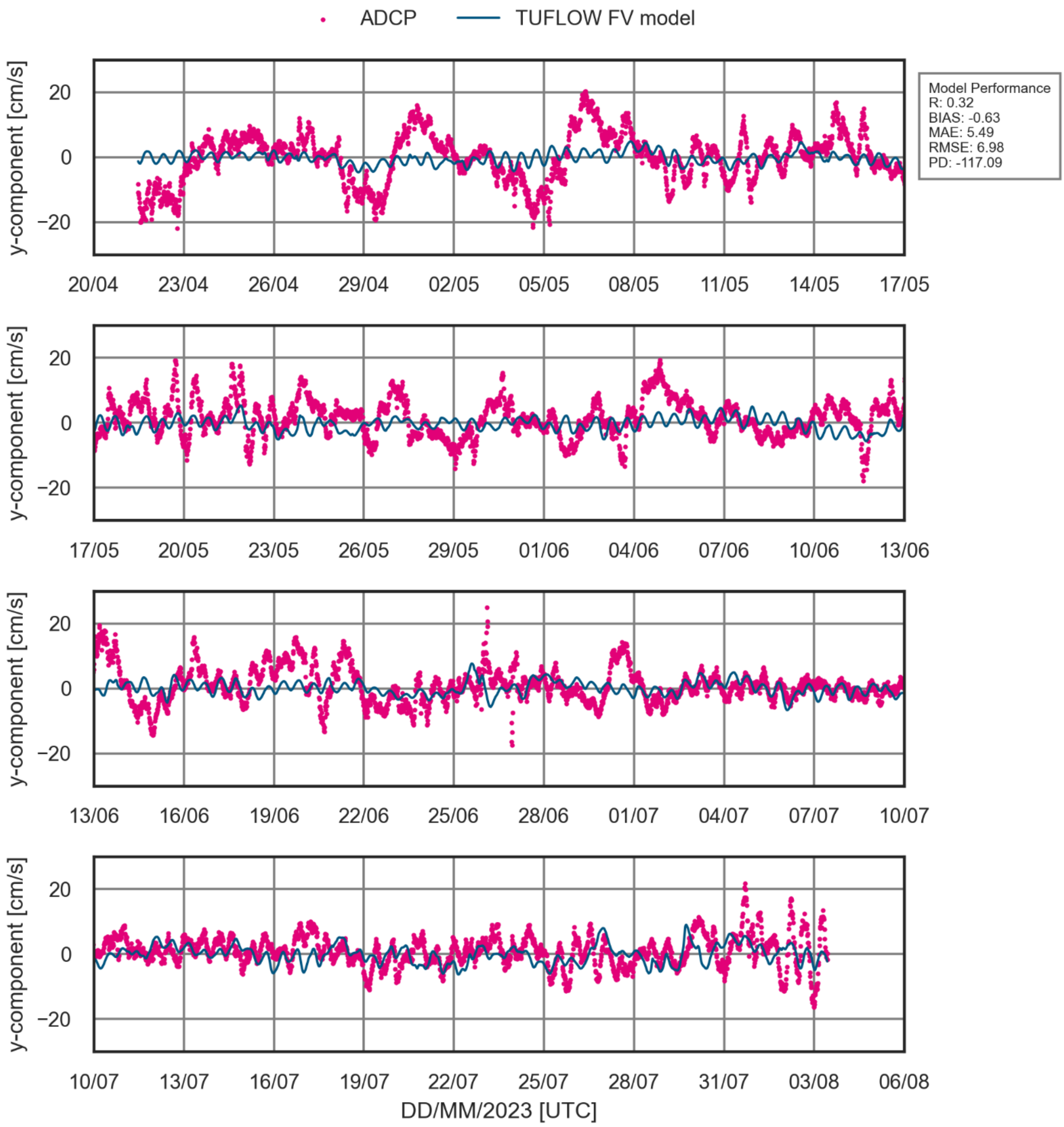

Figure 2.10 Model Comparison to Broad Cove ADCP Current Speed Y-Component Data at 9.11 m Below MSL

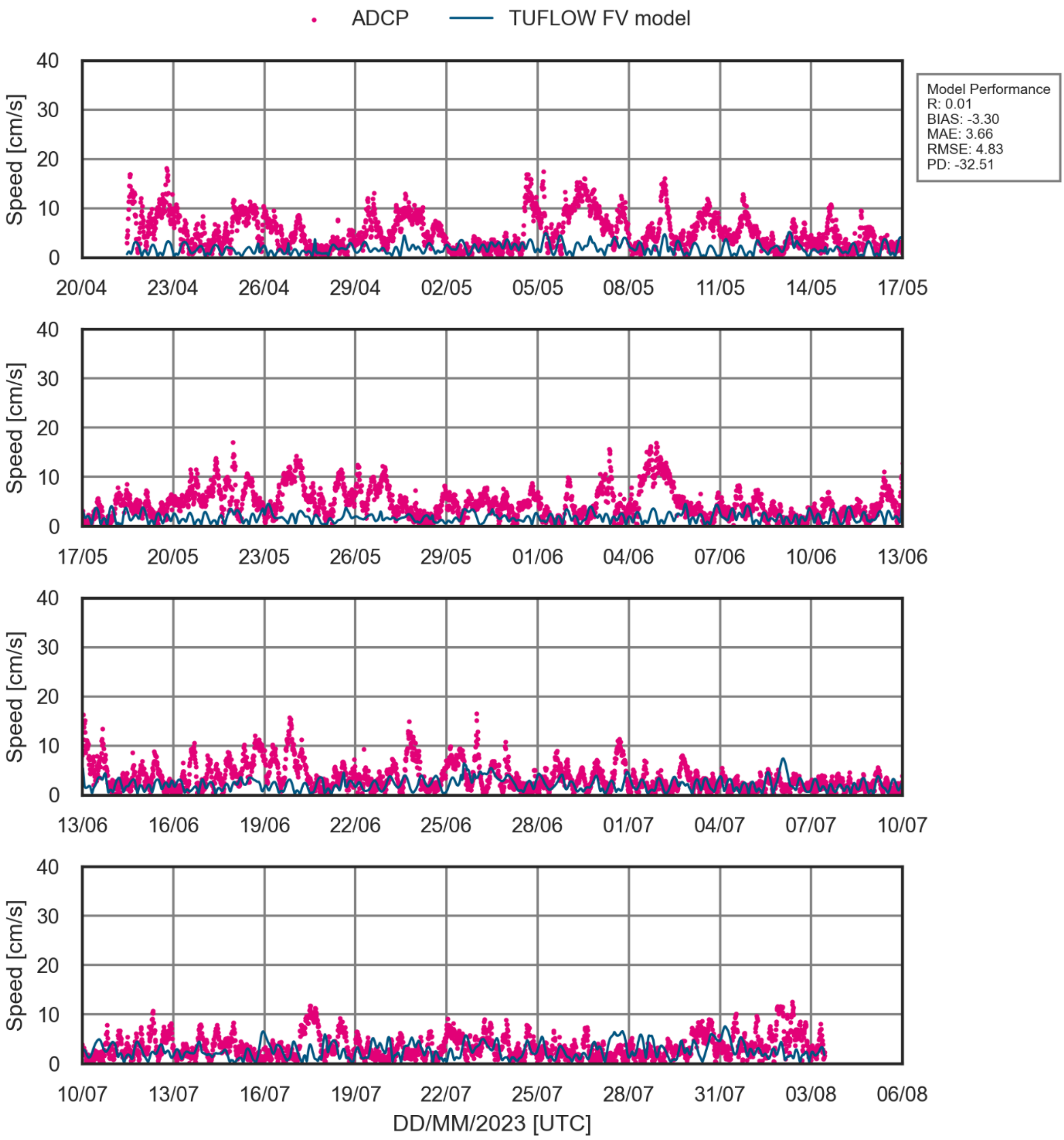

Figure 2.11 Model Comparison to Broad Cove ADCP Current Speed Data at 15.11 m Below MSL

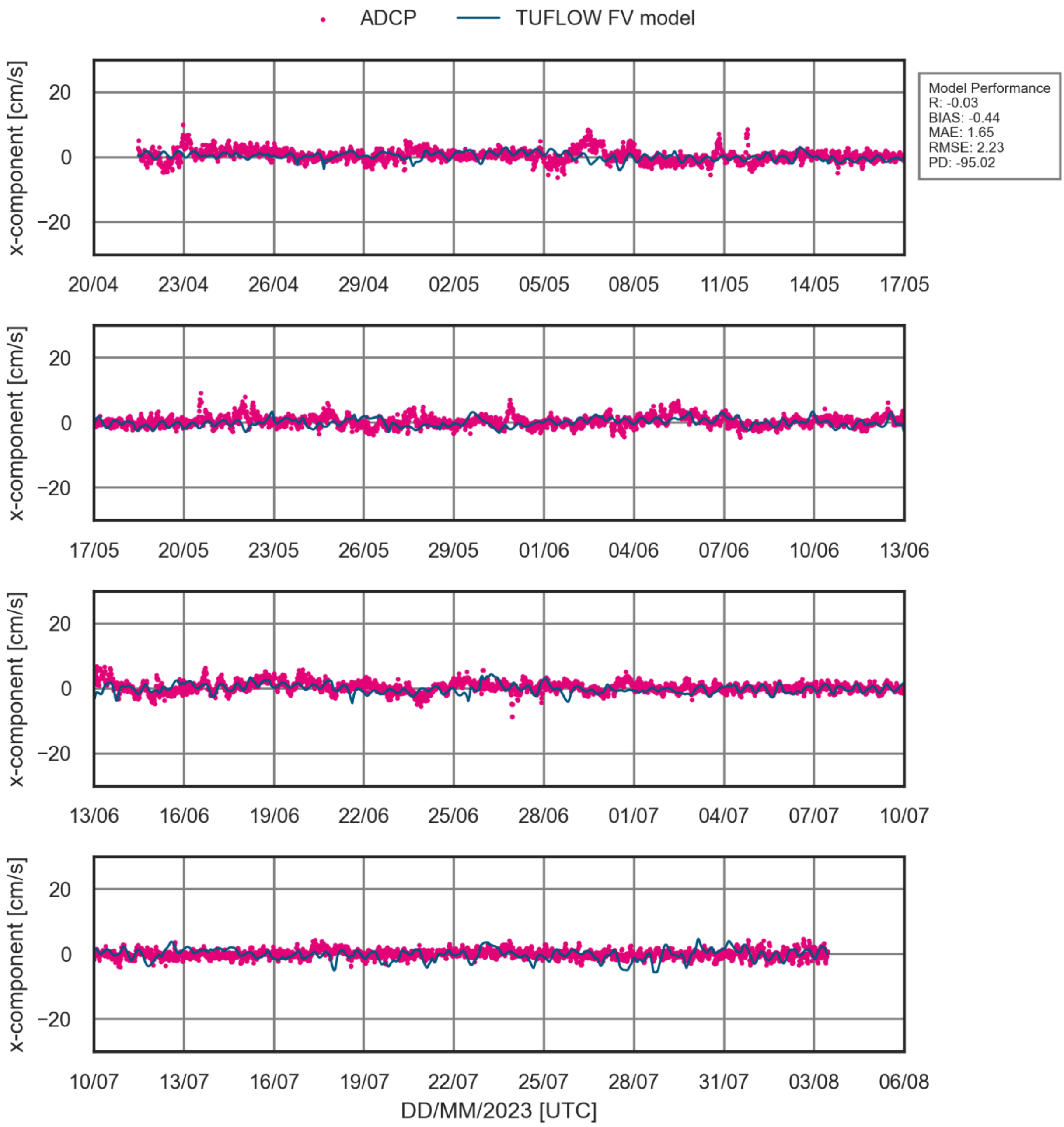

Figure 2.12 Model Comparison to Broad Cove ADCP Current Speed X-Component Data at 15.11 m Below MSL

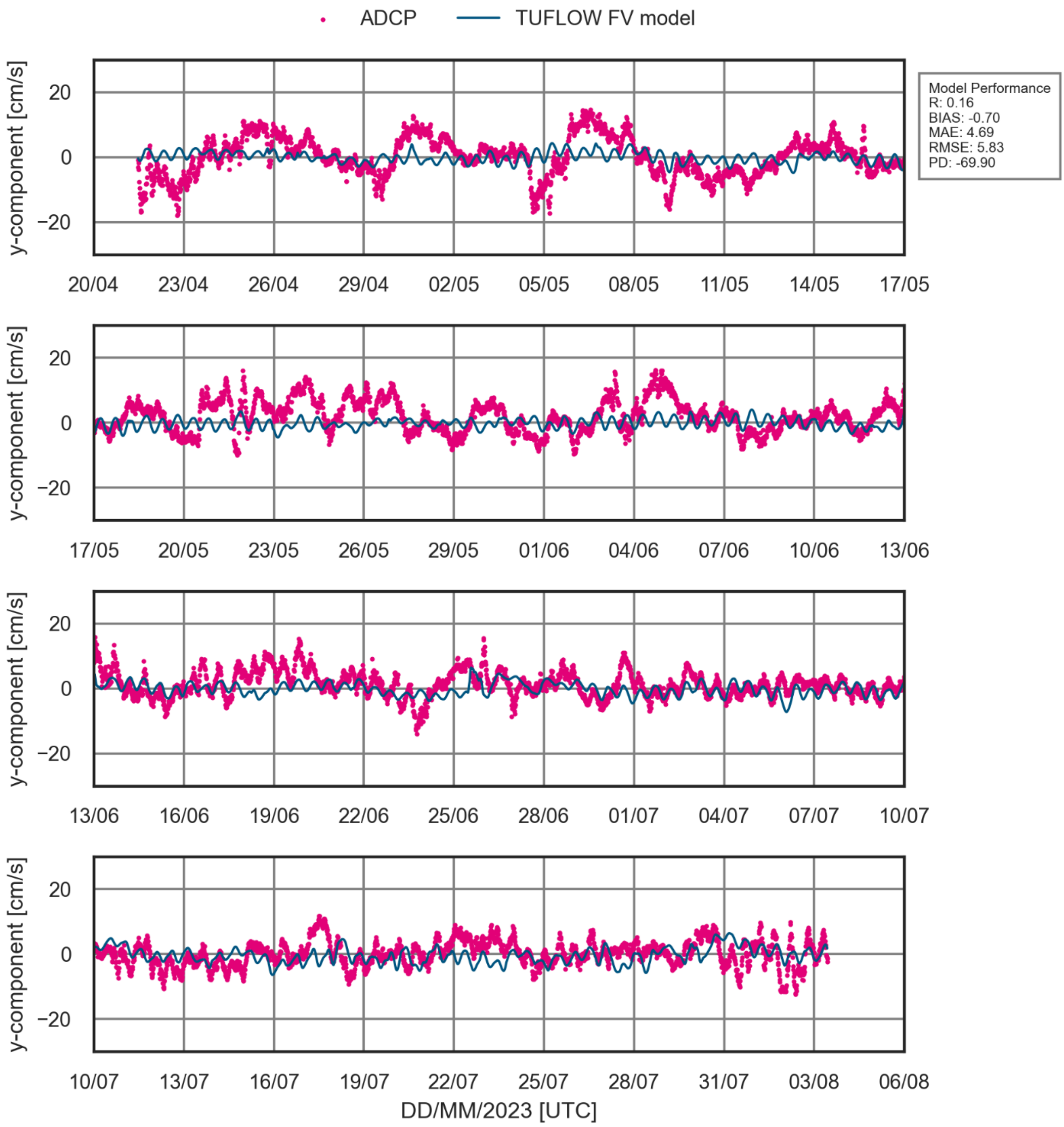

Figure 2.13 Model Comparison to Broad Cove ADCP Current Speed Y-Component Data at 15.11 m Below MSL

2.7 Hydrodynamic Model Validation

The hydrodynamic model was validated against data from an ADCP located close to the finfish sea farm site of interest, Little Burdock Cove in BMA2. The validation site (Figure 2.2—bottom right) was selected due to its data availability, accuracy, and computational efficiency, which pertain to the same year as the calibration period. The validation process involved the comparison of water levels, velocity direction, velocity magnitude, and the *x* and *y* components of the flow to the observed data, as well as adjusting model parameters and bathymetry to achieve a desired level of model fit.

MCE provided pressure sensor ADCP data of ocean currents spanning 104 days, collected at the finfish sea farm site Little Burdock Cove in Belle Bay on the Newfoundland South Coast. The pressure sensor data was processed by BMT to derive water levels. The ADCP data had been processed by ASL Environmental Sciences Inc (2023b) prior to BMT receiving it. The validation period from 22/04/2023 12:15 to 04/08/2023 11:45 aligns with the deployment period. The validation has been conducted at the three depths throughout the water column provided within the dataset:

- 5 m below MSL;
- 10.73 m below MSL; and
- 14.73 m below MSL.

Further details on the ADCP deployment methodology, instrument specification and data processing can be found in the data report for the Little Burdock Cove site (ASL Environmental Sciences Inc, 2023b).

Comparisons of model against observed data are shown in Figure 2.14 to Figure 2.23. Each validation plot contains four sub-plots, representing different periods within the total time span. Together, all four sub-plots provide a continuous dataset with more detailed, zoomed-in representations for clearer analysis. On the plots, statistics for R, BIAS (model bias), MAE (mean absolute error), and PD (percentage difference) are included for comparison.

2.7.1 Water Level

- The R value is high (i.e., ≥0.98), signifying a strong correlation between the model predicted water level and the observed data;
- MAE of 0.08 m and PD of -6.08 % were well within SEPA guidelines (SEPA, 2019);
- The tidal range predicted by the model is consistent with the observed data and predicts the variations in tidal range between spring and neap tides;
- The timing of the high and low water matches well between the ADCP and modelled data; and
- This model has a water level calibration suitable for the use of modelling the dispersion of bath treatment.

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2.7.2 Velocity Magnitude

- There is a bias of 2.85 m/s for water velocities at a depth of 5 m below MSL, indicating that the model is overpredicting velocity at this depth. Conversely, negative biases ranging from 0.5 to 0.8 m/s were observed at other depths, suggesting that the model is slightly underpredicting velocities at these levels;
- Underprediction of the current speeds in the area of interest is consistent with a conservative approach leading to reduced rate of dispersion and dilution impact;
- MAE values at all depths were well within the SEPA guidelines of 10 cm/s (SEPA, 2019); and
- A possible cause of some difference is due to the ADCP having a standard deviation slightly over 0.5 cm/s at all depths.

2.7.3 Flow Velocity Components

- While low R values from the comparison of observed and predicted *x* and *y* components of the flow indicate a poor correlation between the model and the observed data, the predominant flow direction was captured by the model; and
- The BIAS and MAE were below SEPA guidelines of 10 cm/s (SEPA, 2019) for all depths.
- Overall, the validation was satisfactory, meeting several SEPA performance standards. The slight underprediction of current speeds resulted in a more conservative approach to dispersion modelling.

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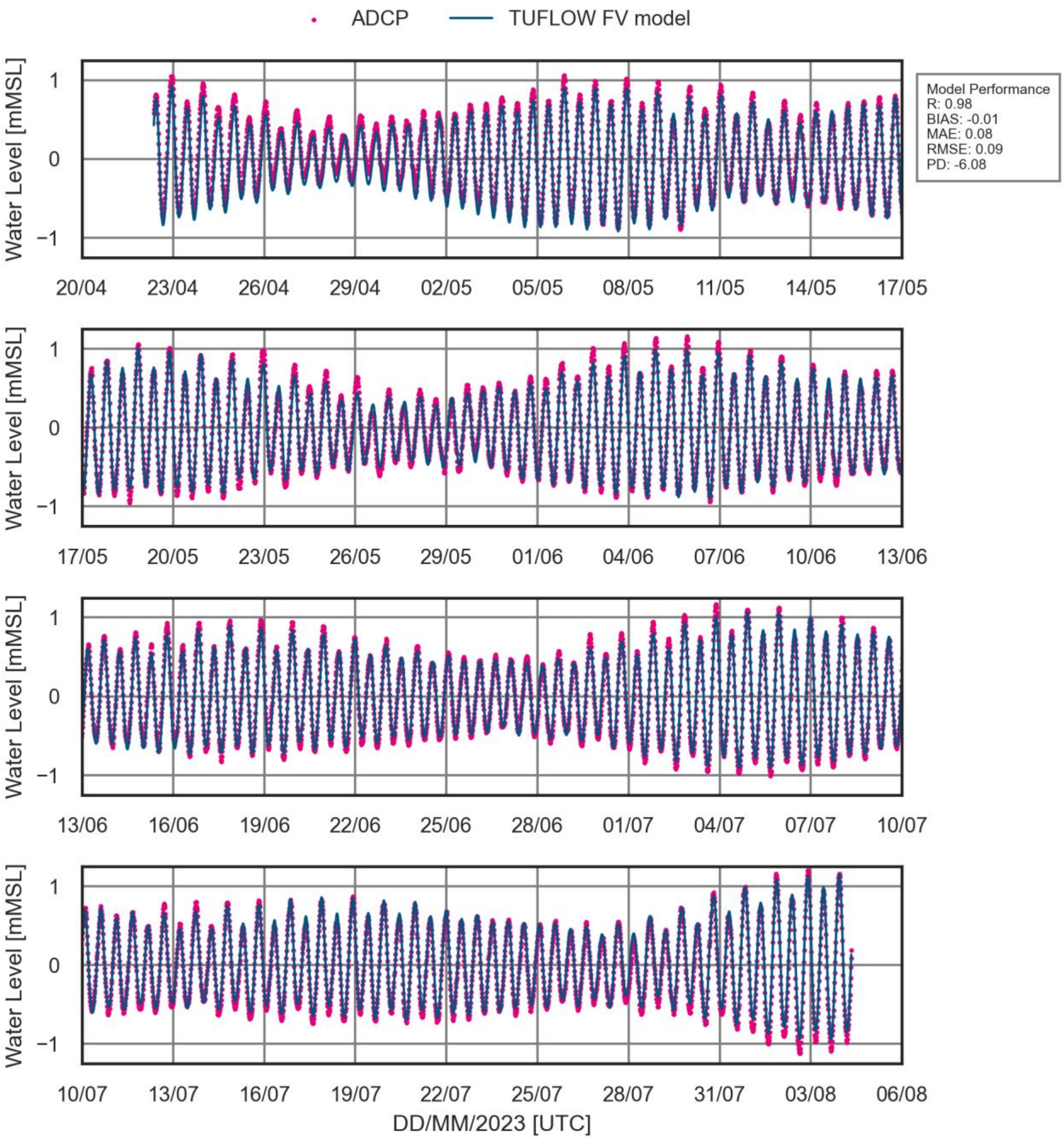

Figure 2.14 Model Comparison to Little Burdock Cove ADCP Water Level Data

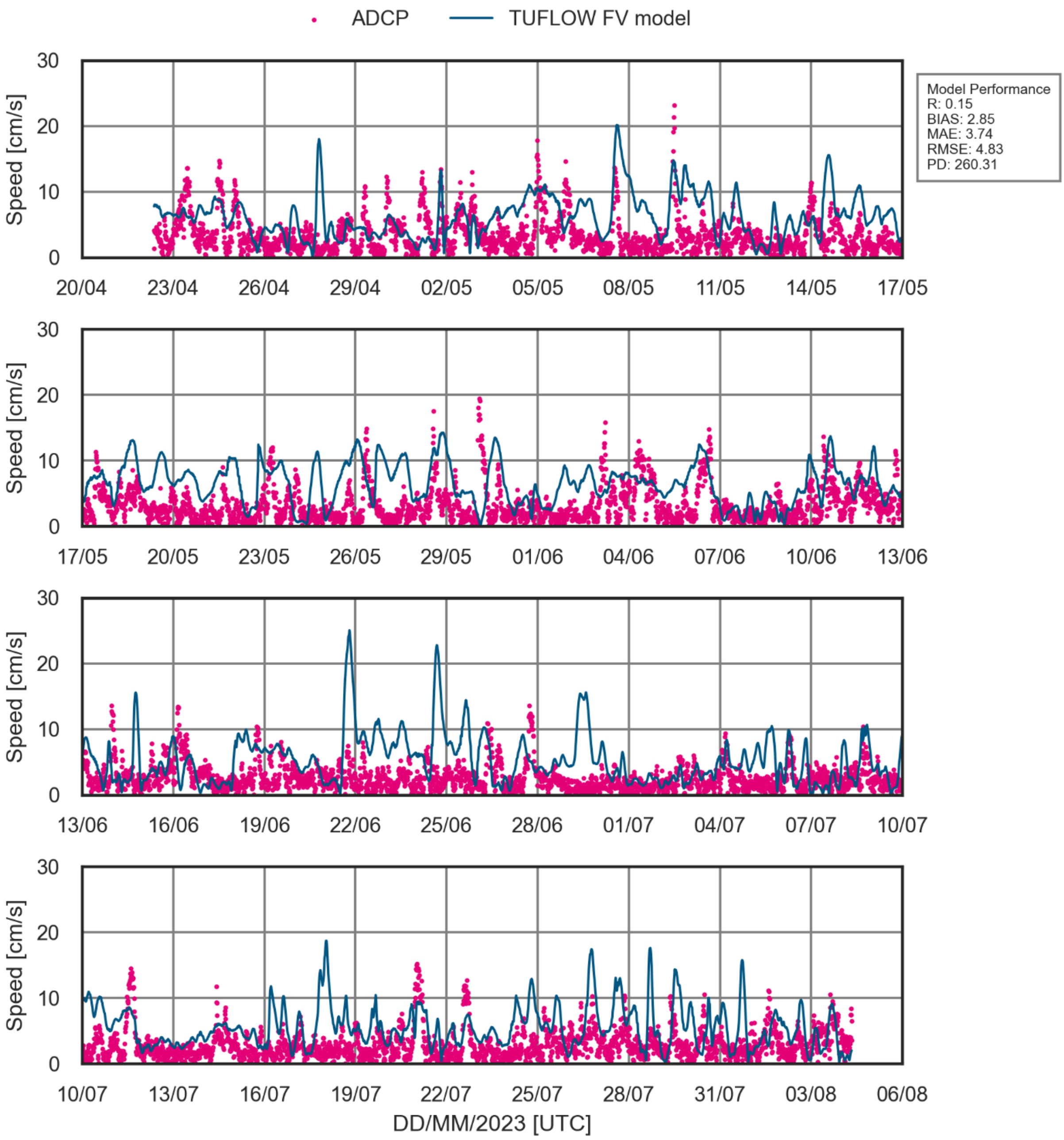

Figure 2.15 Model Comparison to Little Burdock Cove ADCP Current Speed Data at 5 m Below MSL

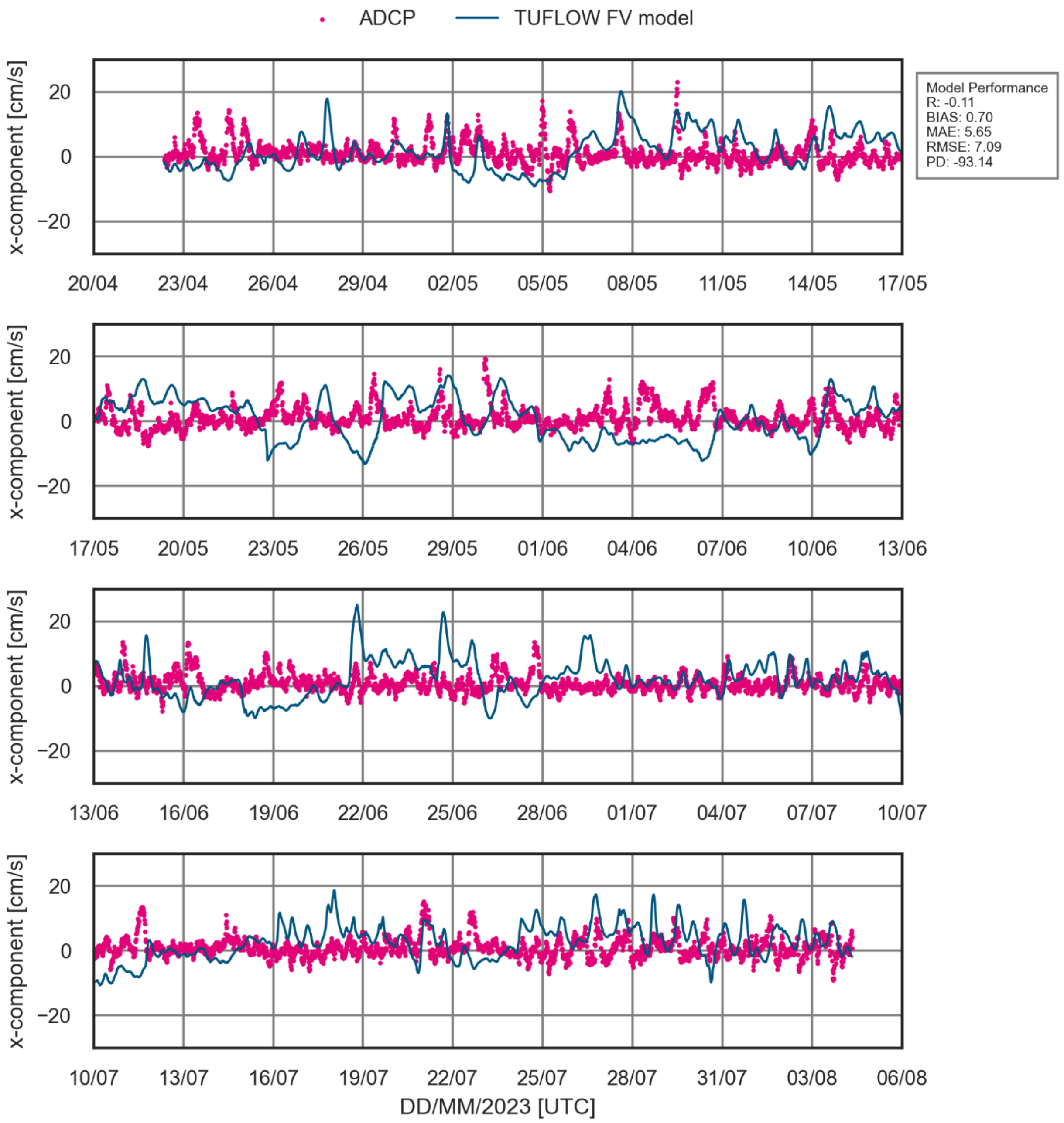

Figure 2.16 Model Comparison to Little Burdock Cove ADCP Current Speed X-Component Data at 5 m Below MSL

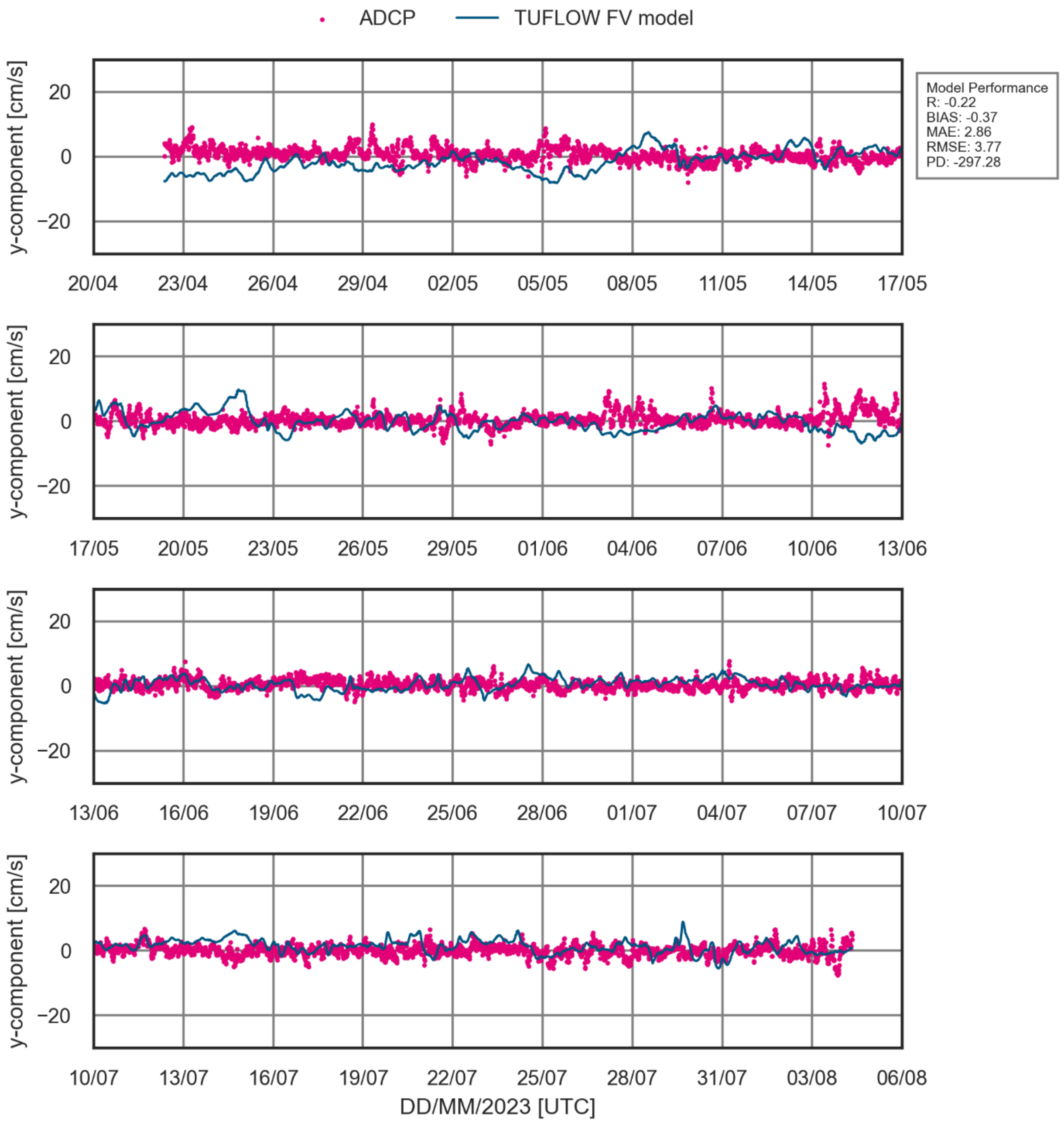

Figure 2.17 Model Comparison to Little Burdock Cove ADCP Current Speed Y-Component Data at 5 m Below MSL

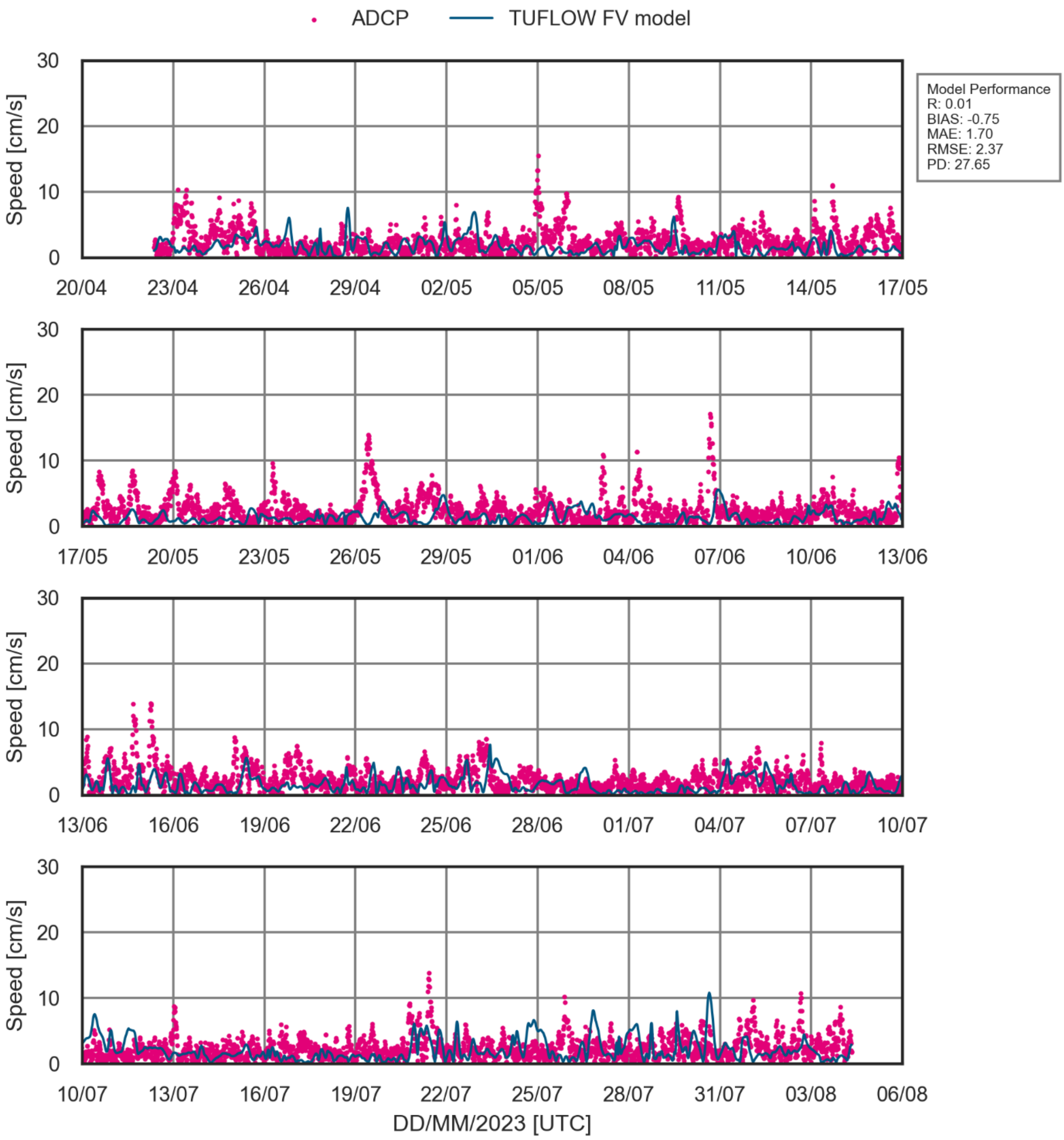

Figure 2.18 Model Comparison to Little Burdock Cove ADCP Current Speed Data at 10.73 m Below MSL

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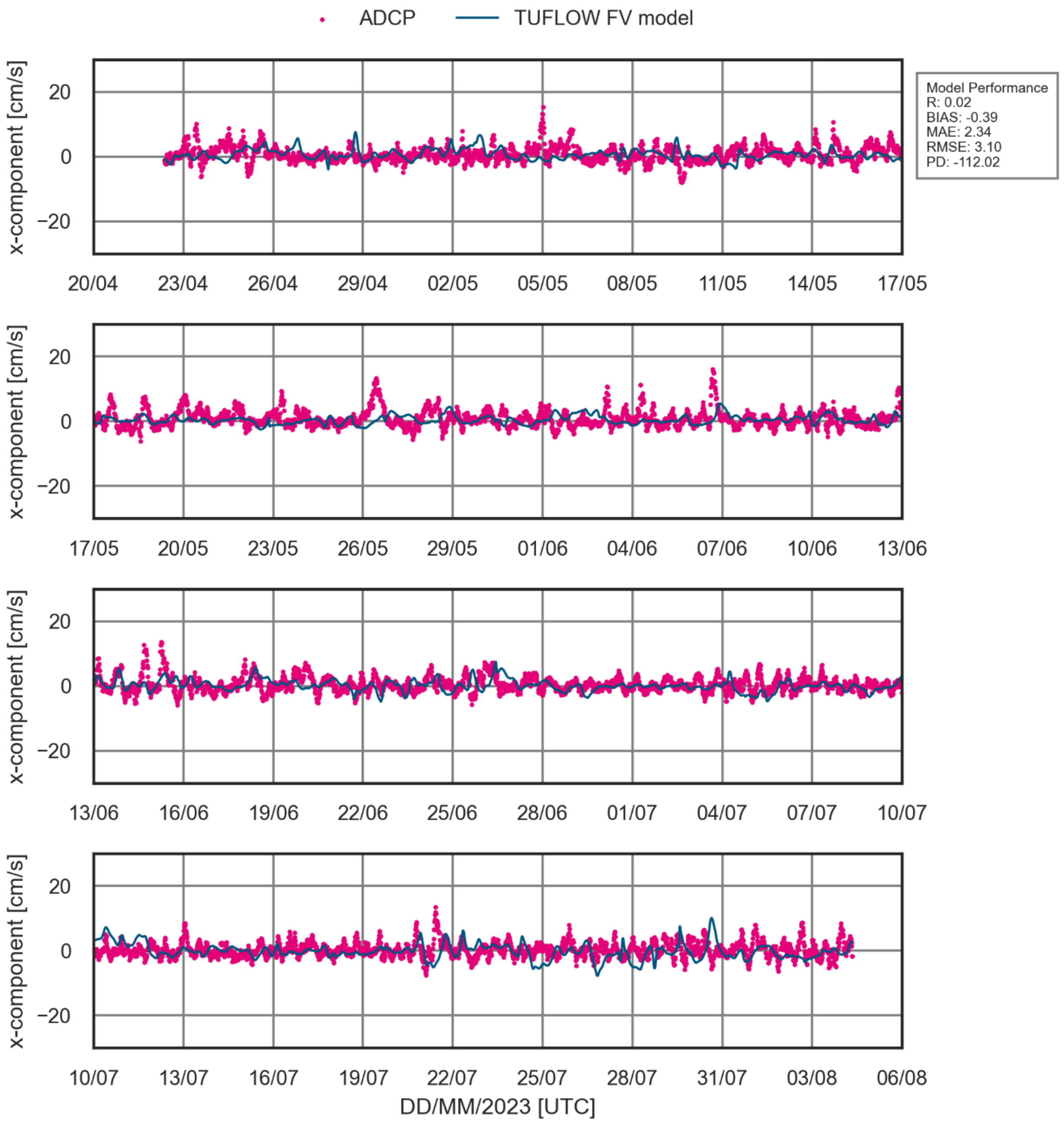

Figure 2.19 Model Comparison to Little Burdock Cove ADCP Current Speed X-Component Data at 10.73 m Below MSL

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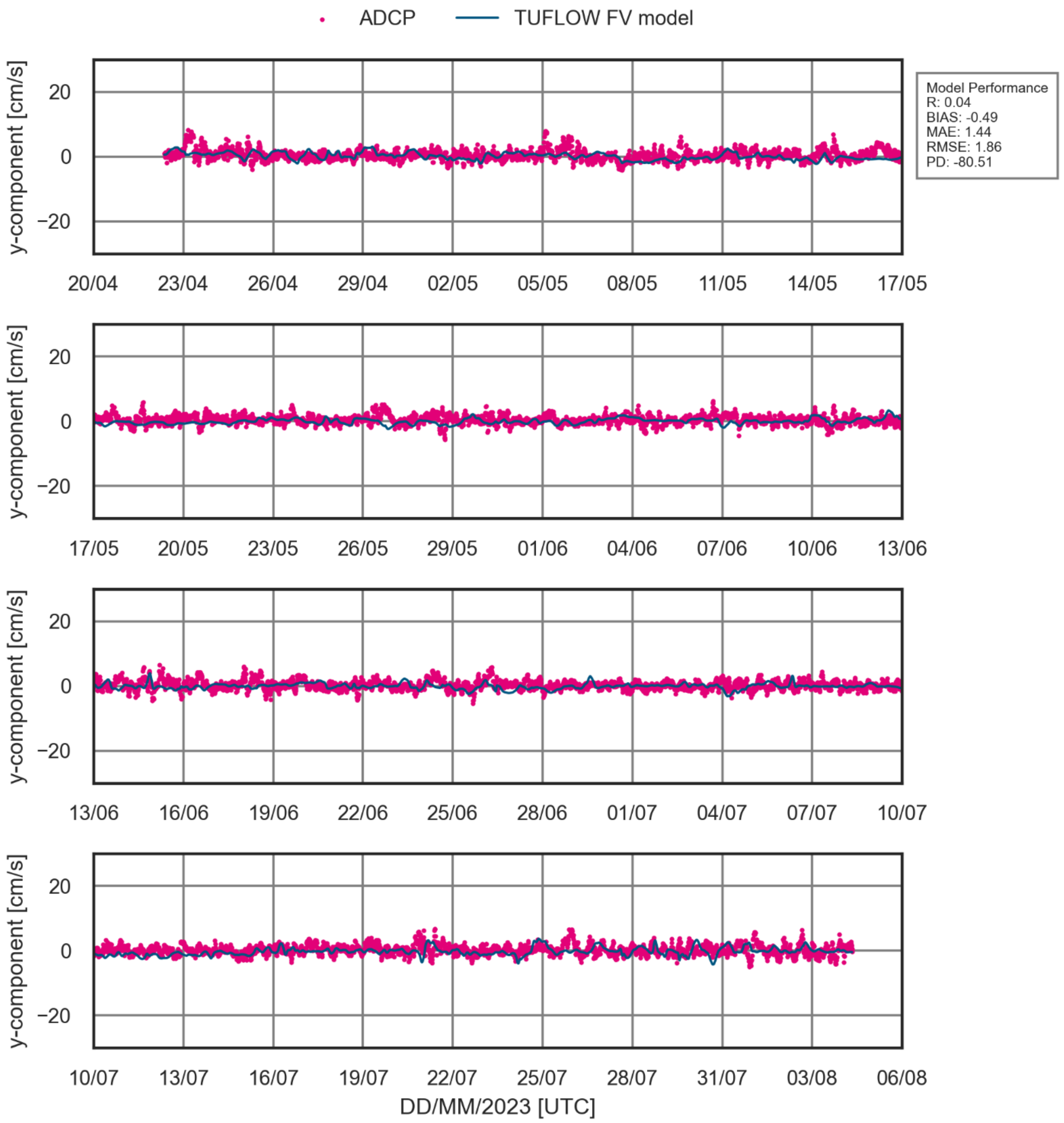

Figure 2.20 Model Comparison to Little Burdock Cove ADCP Current Speed Y-Component Data at 10.73 m Below MSL

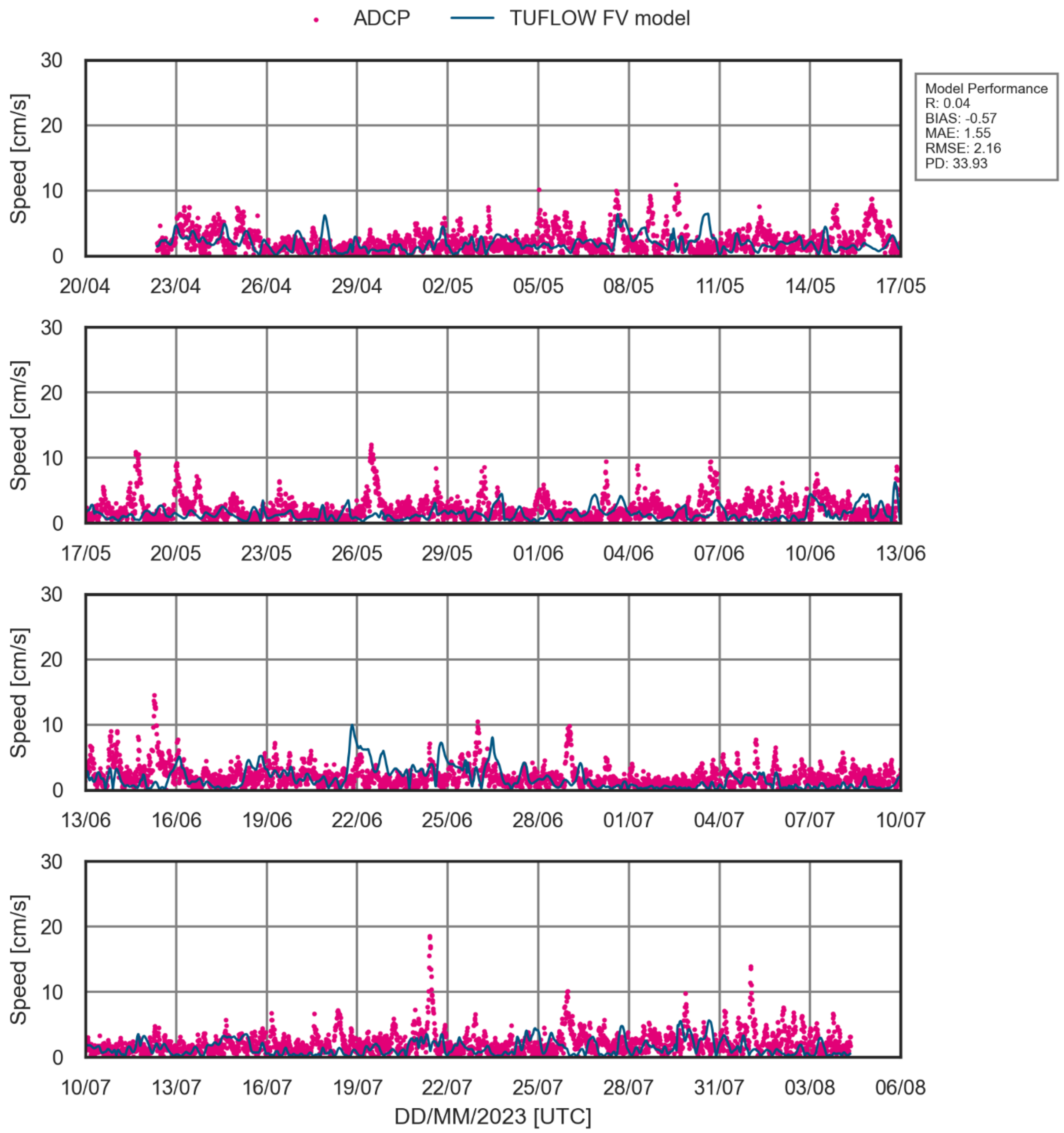

Figure 2.21 Model Comparison to Little Burdock Cove ADCP Current Speed Data at 14.73 m Below MSL

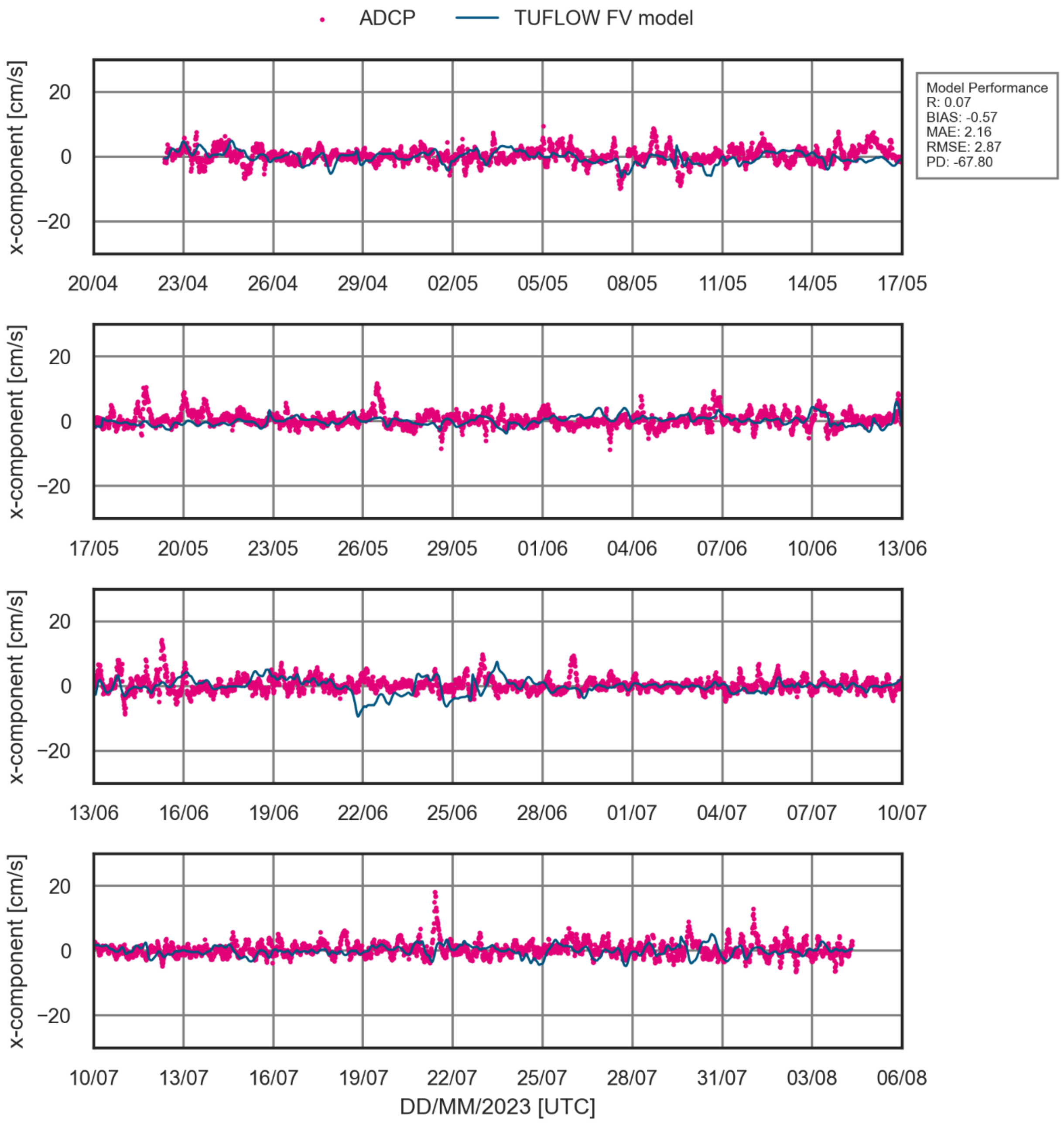

Figure 2.22 Model Comparison to Little Burdock Cove ADCP Current Speed X-Component Data at 14.73 m Below MSL

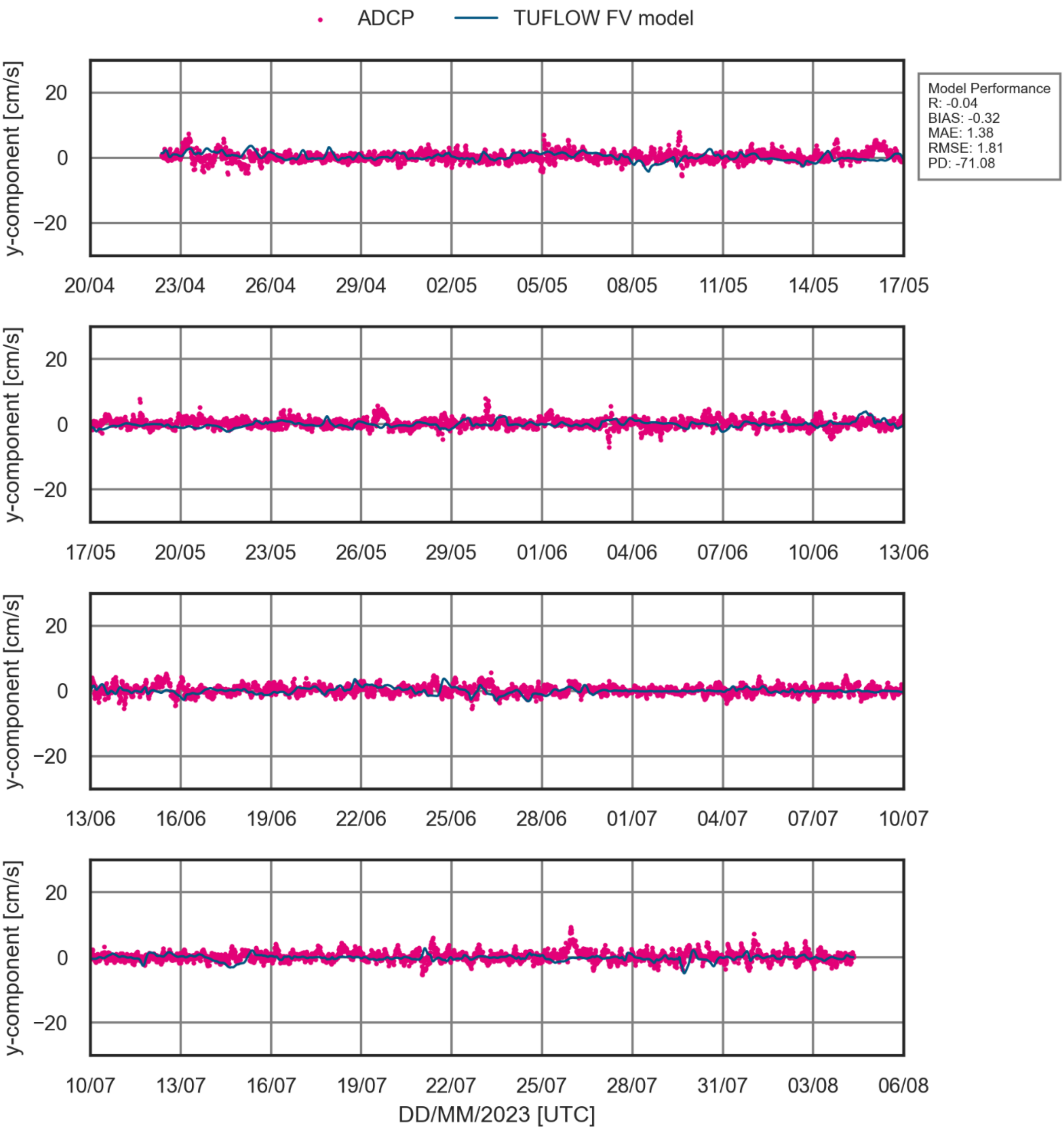

Figure 2.23 Model Comparison to Little Burdock Cove ADCP Current Speed Y-Component Data at 14.73 m Below MSL

3 Dispersion Modelling

3.1 Model

The impact of fish health treatment footprints was represented as plumes of dissolved constituents with increased dilution from the point of treatment release. The dispersion of Azamethiphos following treatment has been simulated using the calibrated TUFLOW FV hydrodynamic model, as described in Section 2.6. The exposure zone of Azamethiphos was investigated through both inert tracer studies and particle tracking module, allowing for a comprehensive exploration of its dispersion dynamics.

3.1.1 Advection / Dispersion of Inert Tracers

Inert tracers were used to simulate the advection and dispersion of Azamethiphos within the area of interest and further afield towards any sensitive receptors. Using inert tracers is viewed as an efficient and accurate way to simulate the dispersion of Azamethiphos in a bath treatment system and assess compliance against the regulatory guidelines (BMT, 2023a, 2023b).

3.1.2 Particle Tracking Module

Another numerical approach involves utilising a particle tracking model to analyse and assess the dispersion characteristics of Azamethiphos in the environment. The TUFLOW Particle Tracking Module (PTM) enables the 2D or 3D simulation of discrete Lagrangian particles as they are transported by a flow field and/or other forcing terms (e.g., wind drift). Particle behaviours such as settling, buoyancy, decay, sedimentation, and resuspension can all be simulated. This tracking of discrete particles can be used to output particle age and fate, which are often useful metrics for environmental applications that are not easily modelled using the Eulerian scheme. The PTM is invoked through the HD Engine, which controls the overall simulation, supplies the forcing fields to the PTM and handles certain PTM outputs. Additional details about the TUFLOW FV-PTM model can be found in the user manual (TUFLOW, 2020b).

3.2 Marine Sensitive Area

Concentration levels of Azamethiphos were predicted for the following sensitive areas: Big Barasway Wildlife Reserve, Sandbanks Provincial Park, Frenchman's Cove Provincial Park, and Fortune Head Ecological Reserve. Figure 3.1 depicts the location of the marine and coastal Provincial Protected Zones located near aquaculture sites along the southern coast of Newfoundland.

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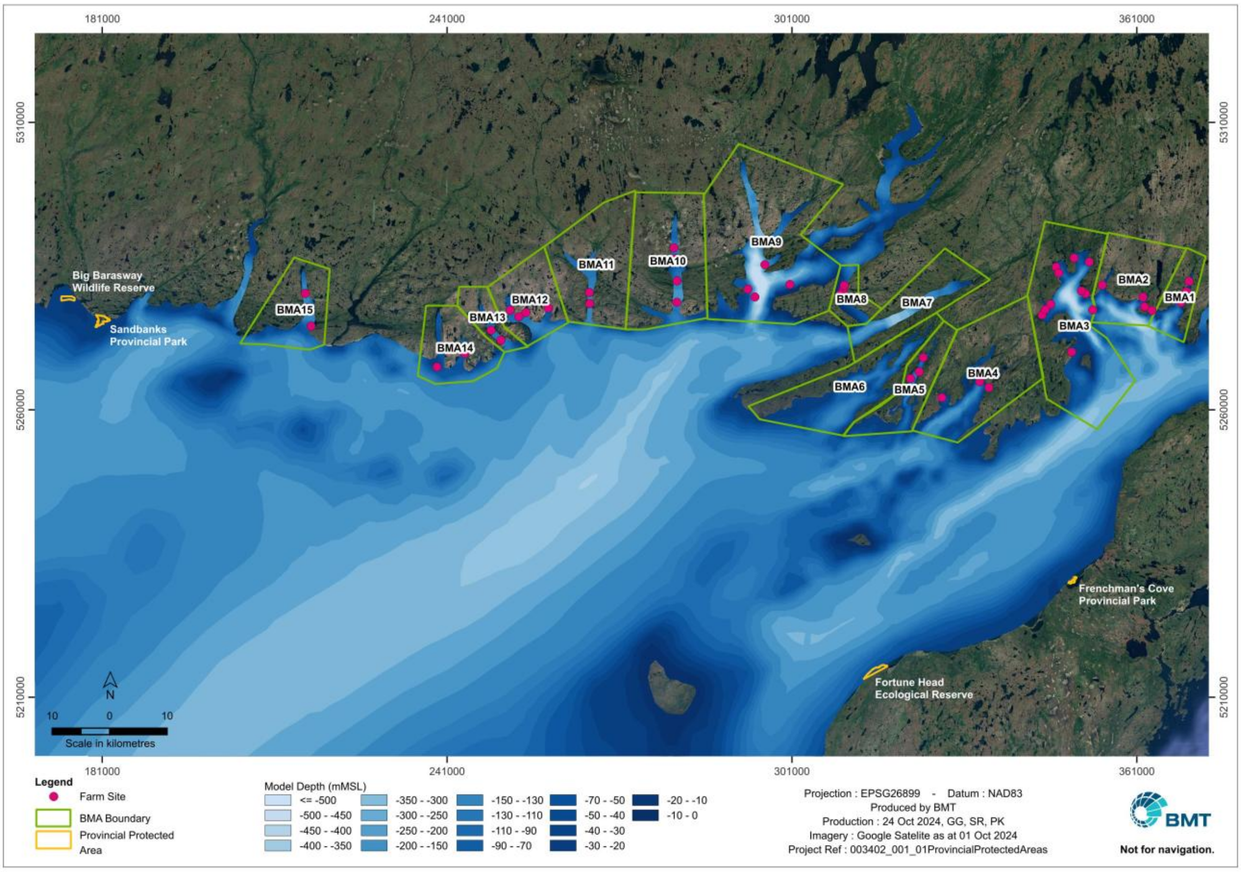

Figure 3.1 Provincial Protected Zones Near BMAs Along the Southern Coast of Newfoundland

3.3 Simulation Time Periods

To simulate worst-case conditions, dispersion modelling was initially performed using TUFLOW FV-generated flow fields over a 34-day period, focusing on neap tidal ranges from the calibrated hydrodynamic simulations. This scenario was selected as it represents the least dispersive ambient conditions, under which Azamethiphos dispersion would be least likely to meet the required EQS (refer to Section 1.1). Additionally, during spring tides, simulations were conducted over a 30-day period, which provided more dispersive conditions with greater water volume exchange, allowing for a better understanding of the dispersion footprint.

The simulation periods varied depending on the number of farms within each BMA and the number of pens per farm. For BMAs containing four farms, each with ten pens, the maximum simulation period was extended to 20 days to complete the treatment cycle, followed by a 14-day monitoring period, resulting in 34 days. This allowed for the detection of any potential concentration peaks. It has been established that the bath treatment medicines used, such as Azamethiphos, are either rapidly degraded or bind to particles in the water, rendering them biologically unavailable (SSFL, 2011). Consequently, short-term simulations have been considered sufficient to assess any potential environmental impact (SSFL, 2011).

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Two dispersion simulations were carried out for two distinct periods representative of neap and spring tide conditions at the time of last treatment. These periods were extracted from the model calibration period in 2023:

- Neap tide model period (Figure 3.2):
  - The dispersion model was initiated on 10/06/2023 00:00 and ended 14/07/2023 00:00. The last treatment was administered on 29/06/2023 04:00:00, corresponding to the smallest maxima of the neap tidal cycle, where the final treatment was released at highwater.
- Spring tide model period (Figure 3.3):
  - The dispersion model was initiated on 28/04/2023 00:00 and ended 01/06/2023 00:00. The last treatment was administered on 17/05/2023 19:00:00, corresponding to the highest maxima of the spring tidal cycle, where the final treatment was released at highwater.

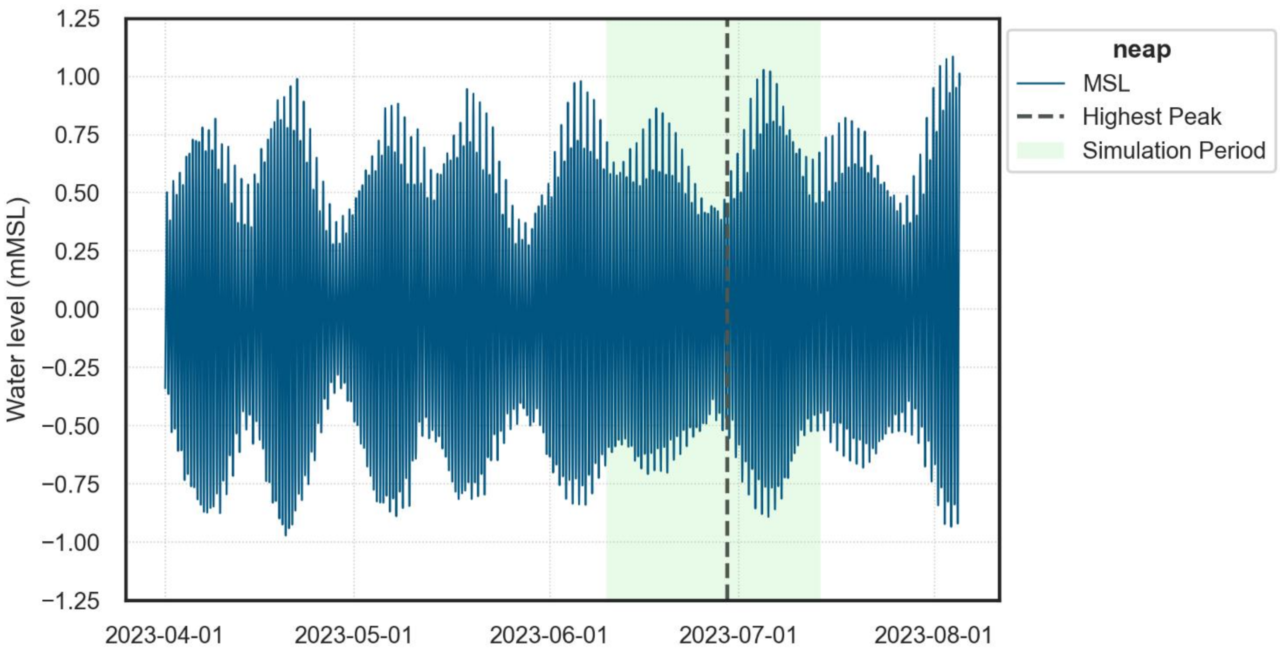

Figure 3.2 Neap Simulation Period: The Smallest Neap Maxima Was on 29/06/2023 19:00:00

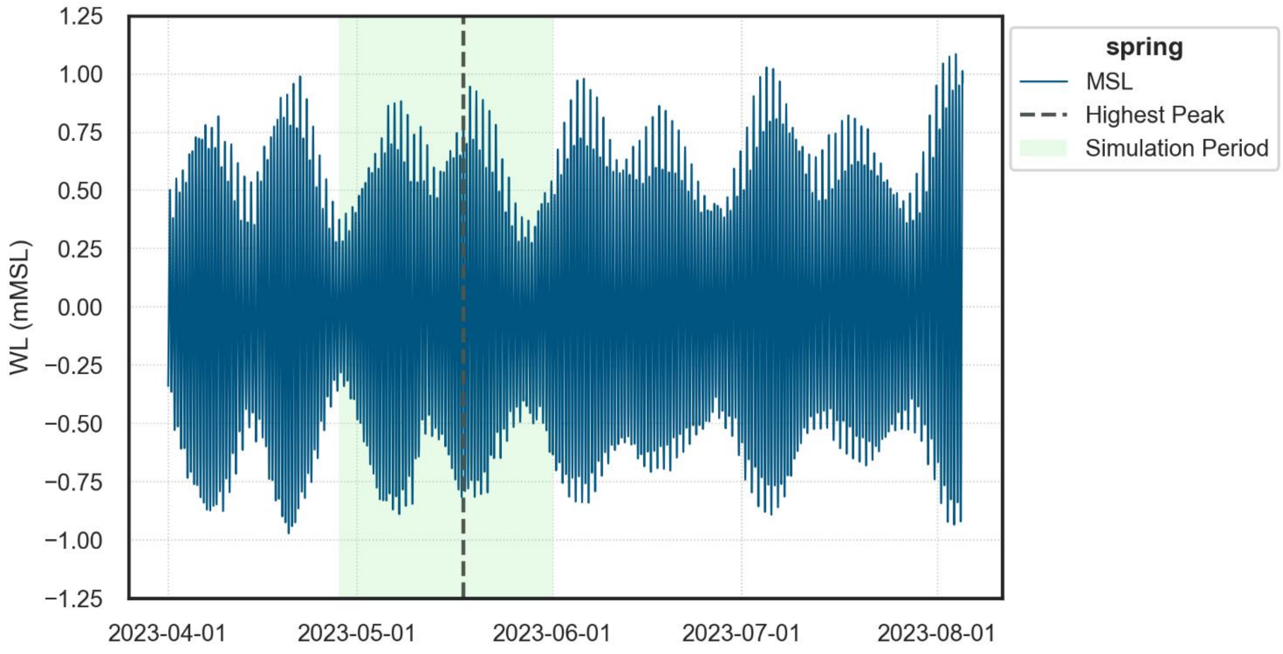

Figure 3.3 Spring Simulation Period: The Highest Spring Maxima Was on 29/06/2023 19:00:00

3.4 Bath Treatment

3.4.1 Azamethiphos Dosage

Azamethiphos is an organophosphate insecticide and the active ingredient in formulations used in Canada and other regions (Hamoutene et al., 2023). The Salmosan® formulation, a wettable powder, contains 49.8% Azamethiphos (Benchmark Animal Health Limited, 2024). In the simulated bath treatment, 2.5 kg of Salmosan® was applied per pen, delivering 1,245 g of Azamethiphos to each pen. Two pens were treated per day (pers.com, MCE) to represent a realistic treatment regime.

- For farms with 10 pens (e.g., Bays West area):
    - A total of 12.45 kg of Azamethiphos was discharged over a five-day treatment period.
- For farms with seven pens (e.g., Bays East area):
    - A total of 8.715 kg of Azamethiphos was discharged over a 3.5-day treatment period.

3.4.2 Treatment Schedule

For numerical modelling purposes, the farm location was used as the pen location, so discharges were released from the same location. For example, a farm with 10 pens had 10 discharges from the same location over a five-day period.

The treatment schedule was designed with consideration to the time needed for setting up each treatment, moving between pens, and the duration of the treatment so there was a three-hour interval between the two daily treatments. The Azamethiphos treatment was modelled as a tracer and particle and released over a period of five minutes spread over the surface four meters of the water column to represent the release of the treatment when the bath volume is released.

Table 3.1 to Table 3.15 present the simulated release times and order for all BMAs during both neap and spring tide scenarios. Each treatment schedule table includes detailed information such as dispersion scenario (neap or spring tide), farm name, pen number, treatment day, date, time, and hours since the final treatment. For example, BMA1 includes three farms: Benny's Cove, Foshie's Cove, and The Hobby, each with seven pens per farm. In each BMA, treatment began on the northernmost farm. Therefore, in BMA1, all seven pens at the Benny's Cove farm were treated first, followed by all seven pens at Foshie's Cove, and finally, all seven pens at The Hobby. The final discharge was determined as the release from the last pen of the southernmost farm, which in this case was Pen 7 of The Hobby. BMA1 to BMA9 include seven pens per farm while BMA10 to BMA15 include 10 pens per farm (pers.com, MCE).

BMA2 and BMA2B were consolidated into a single BMA for modelling purposes. BMA2 comprised two farms, and BMA2B had one farm, resulting in the integration of all three farms into one BMA for streamlined analysis. Conversely, BMA3, which originally contained 11 farms, was subdivided into three distinct BMAs, shown in Figure 1.4 (BMA3i, BMA3ii, and BMA3iii). This subdivision was implemented to enhance computational efficiency and provide more realistic modelling outcomes, as handling discharges from 11 farms in sequence was neither practical nor feasible within the model framework and the real case.

Azamethiphos discharge was included as a point source boundary condition with specifications of location coordinates of pens, discharge rate, temperature, salinity, and bath treatment schedule with concentrations or mass of the Azamethiphos as determined by MCE.

Table 3.1 BMA1—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Benny's Cove	1	1	7-May-23	19:0000	-240
		2	2	8-May-23	16:00:00	-219
		3	2	8-May-23	19:0000	-216
		4	3	9-May-23	16:00:00	-195
		5	3	9-May-23	19:0000	-192
		6	4	10-May-23	16:00:00	-171
		7	4	10-May-22	19:0000	-168
	Foshie's Cove	1	5	11-May-23	16:00:00	-147
		2	5	11-May-23	19:00:00	-144
		3	6	12-May-23	16:00:00	-123
		4	6	12-May-23	19:00:00	-120
		5	7	13-May-23	16:00:00	-99
		6	7	13-May-23	19:00:00	-96
		7	8	14-May-23	16:00:00	-75
		1	8	14-May-23	19:00:00	-72

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	The Hobby	2	9	15-May-23	16:00:00	-51
		3	9	15-May-23	19:00:00	-48
		4	10	16-May-23	16:00:00	-27
		5	10	16-May-23	19:00:00	-24
		6	11	17-May-23	16:00:00	-3
		7	11	17-May-23	19:00:00	0
Neap	Benny's Cove	1	1	19-Jun-23	04:00:00	-240
		2	2	20-Jun-23	01:00:00	-219
		3	2	20-Jun-23	04:00:00	-216
		4	3	21-Jun-23	01:00:00	-195
		5	3	21-Jun-23	04:00:00	-192
		6	4	22-Jun-23	01:00:00	-171
		7	4	22-Jun-23	04:00:00	-168
	Foshie's Cove	1	5	23-Jun-23	01:00:00	-147
		2	5	23-Jun-23	04:00:00	-144
		3	6	24-Jun-23	01:00:00	-123
		4	6	24-Jun-23	04:00:00	-120
		5	7	25-Jun-23	01:00:00	-99
		6	7	25-Jun-23	04:00:00	-96
		7	8	26-Jun-23	01:00:00	-75
	The Hobby	1	8	26-Jun-23	04:00:00	-72
		2	9	27-Jun-23	01:00:00	-51
		3	9	27-Jun-23	04:00:00	-48
		4	10	28-Jun-23	01:00:00	-27
		5	10	28-Jun-23	04:00:00	-24
		6	11	29-Jun-23	01:00:00	-3
		7	11	29-Jun-23	04:00:00	0

Table 3.2 BMA2 +2B—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring		1	1	4-May-23	16:00:00	-315
		2	1	4-May-23	19:00:00	-312

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Old Woman's Cove	3	2	5-May-23	16:00:00	-291
		4	2	5-May-23	19:00:00	-288
		5	3	6-May-23	16:00:00	-267
		6	3	6-May-23	19:00:00	-264
		7	4	7-May-23	16:00:00	-243
	Deep Water Point	1	4	7-May-23	19:00:00	-240
		2	5	8-May-23	16:00:00	-219
		3	5	8-May-23	19:00:00	-216
		4	6	9-May-23	16:00:00	-195
		5	6	9-May-23	19:00:00	-192
		6	7	10-May-23	16:00:00	-171
		7	7	10-May-23	19:00:00	-168
	Little Burdock	1	8	11-May-23	16:00:00	-147
		2	8	11-May-23	19:00:00	-144
		3	9	12-May-23	16:00:00	-123
		4	9	12-May-23	19:00:00	-120
		5	10	13-May-23	16:00:00	-99
		6	10	13-May-23	19:00:00	-96
		7	11	14-May-23	16:00:00	-75
	Rencontre East	1	11	14-May-23	19:00:00	-72
		2	12	15-May-23	16:00:00	-51
		3	12	15-May-23	19:00:00	-48
		4	13	16-May-23	16:00:00	-27
		5	13	16-May-23	19:00:00	-24
		6	14	17-May-23	16:00:00	-3
		7	14	17-May-23	19:00:00	0
Neap	Old Woman's Cove	1	1	16-Jun-23	01:00:00	-315
		2	1	16-Jun-23	04:00:00	-312
		3	2	17-Jun-23	01:00:00	-291
		4	2	17-Jun-23	04:00:00	-288
		5	3	18-Jun-23	01:00:00	-267
		6	3	18-Jun-23	04:00:00	-264
		7	4	19-Jun-23	01:00:00	-243

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Deep Water Point	1	4	19-Jun-23	04:00:00	-240
		2	5	20-Jun-23	01:00:00	-219
		3	5	20-Jun-23	04:00:00	-216
		4	6	21-Jun-23	01:00:00	-195
		5	6	21-Jun-23	04:00:00	-192
		6	7	22-Jun-23	01:00:00	-171
		7	7	22-Jun-23	04:00:00	-168
	Little Burdock	1	8	23-Jun-23	01:00:00	-147
		2	8	23-Jun-23	04:00:00	-144
		3	9	24-Jun-23	01:00:00	-123
		4	9	24-Jun-23	04:00:00	-120
		5	10	25-Jun-23	01:00:00	-99
		6	10	25-Jun-23	04:00:00	-96
		7	11	26-Jun-23	01:00:00	-75
	Rencontre East	1	11	26-Jun-23	04:00:00	-72
		2	12	27-Jun-23	01:00:00	-51
		3	12	27-Jun-23	04:00:00	-48
		4	13	28-Jun-23	01:00:00	-27
		5	13	28-Jun-23	04:00:00	-24
		6	14	29-Jun-23	01:00:00	-3
		7	14	29-Jun-23	04:00:00	0

Table 3.3 BMA3i—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	McGrath Cove South	1	1	7-May-23	19:0000	-240
		2	2	8-May-23	16:00:00	-219
		3	2	8-May-23	19:0000	-216
		4	3	9-May-23	16:00:00	-195
		5	3	9-May-23	19:0000	-192
		6	4	10-May-23	16:00:00	-171
		7	4	10-May-22	19:0000	-168
		1	5	11-May-23	16:00:00	-147
		2	5	11-May-23	19:00:00	-144

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	McGrath Cove North	3	6	12-May-23	16:00:00	-123
		4	6	12-May-23	19:00:00	-120
		5	7	13-May-23	16:00:00	-99
		6	7	13-May-23	19:00:00	-96
		7	8	14-May-23	16:00:00	-75
	Belle Island	1	8	14-May-23	19:00:00	-72
		2	9	15-May-23	16:00:00	-51
		3	9	15-May-23	19:00:00	-48
		4	10	16-May-23	16:00:00	-27
		5	10	16-May-23	19:00:00	-24
		6	11	17-May-23	16:00:00	-3
		7	11	17-May-23	19:00:00	0
Neap	McGrath Cove South	1	1	19-Jun-23	04:00:00	-240
		2	2	20-Jun-23	01:00:00	-219
		3	2	20-Jun-23	04:00:00	-216
		4	3	21-Jun-23	01:00:00	-195
		5	3	21-Jun-23	04:00:00	-192
		6	4	22-Jun-23	01:00:00	-171
		7	4	22-Jun-23	04:00:00	-168
	McGrath Cove North	1	5	23-Jun-23	01:00:00	-147
		2	5	23-Jun-23	04:00:00	-144
		3	6	24-Jun-23	01:00:00	-123
		4	6	24-Jun-23	04:00:00	-120
		5	7	25-Jun-23	01:00:00	-99
		6	7	25-Jun-23	04:00:00	-96
		7	8	26-Jun-23	01:00:00	-75
	Belle Island	1	8	26-Jun-23	04:00:00	-72
		2	9	27-Jun-23	01:00:00	-51
		3	9	27-Jun-23	04:00:00	-48
		4	10	28-Jun-23	01:00:00	-27
		5	10	28-Jun-23	04:00:00	-24
		6	11	29-Jun-23	01:00:00	-3
		7	11	29-Jun-23	04:00:00	0

Table 3.4 BMA3ii—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Hickman's Point	1	1	4-May-23	16:00:00	-315
		2	1	4-May-23	19:00:00	-312
		3	2	5-May-23	16:00:00	-291
		4	2	5-May-23	19:00:00	-288
		5	3	6-May-23	16:00:00	-267
		6	3	6-May-23	19:00:00	-264
		7	4	7-May-23	16:00:00	-243
	South East Bight	1	4	7-May-23	19:00:00	-240
		2	5	8-May-23	16:00:00	-219
		3	5	8-May-23	19:00:00	-216
		4	6	9-May-23	16:00:00	-195
		5	6	9-May-23	19:00:00	-192
		6	7	10-May-23	16:00:00	-171
		7	7	10-May-23	19:00:00	-168
	Spoon Cove	1	8	11-May-23	16:00:00	-147
		2	8	11-May-23	19:00:00	-144
		3	9	12-May-23	16:00:00	-123
		4	9	12-May-23	19:00:00	-120
		5	10	13-May-23	16:00:00	-99
		6	10	13-May-23	19:00:00	-96
		7	11	14-May-23	16:00:00	-75
	Steamers Head	1	11	14-May-23	19:00:00	-72
		2	12	15-May-23	16:00:00	-51
		3	12	15-May-23	19:00:00	-48

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		4	13	16-May-23	16:00:00	-27
		5	13	16-May-23	19:00:00	-24
		6	14	17-May-23	16:00:00	-3
		7	14	17-May-23	19:00:00	0
Neap	Hickman's Point	1	1	16-Jun-23	01:00:00	-315
		2	1	16-Jun-23	04:00:00	-312
		3	2	17-Jun-23	01:00:00	-291
		4	2	17-Jun-23	04:00:00	-288
		5	3	18-Jun-23	01:00:00	-267
		6	3	18-Jun-23	04:00:00	-264
		7	4	19-Jun-23	01:00:00	-243
	South East Bight	1	4	19-Jun-23	04:00:00	-240
		2	5	20-Jun-23	01:00:00	-219
		3	5	20-Jun-23	04:00:00	-216
		4	6	21-Jun-23	01:00:00	-195
		5	6	21-Jun-23	04:00:00	-192
		6	7	22-Jun-23	01:00:00	-171
		7	7	22-Jun-23	04:00:00	-168
	Spoon Cove	1	8	23-Jun-23	01:00:00	-147
		2	8	23-Jun-23	04:00:00	-144

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		3	9	24-Jun-23	01:00:00	-123
		4	9	24-Jun-23	04:00:00	-120
		5	10	25-Jun-23	01:00:00	-99
		6	10	25-Jun-23	04:00:00	-96
		7	11	26-Jun-23	01:00:00	-75
	Steamers Head	1	11	26-Jun-23	04:00:00	-72
		2	12	27-Jun-23	01:00:00	-51
		3	12	27-Jun-23	04:00:00	-48
		4	13	28-Jun-23	01:00:00	-27
		5	13	28-Jun-23	04:00:00	-24
		6	14	29-Jun-23	01:00:00	-3
		7	14	29-Jun-23	04:00:00	0

Table 3.5 BMA3iii—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Spyglass	1	1	4-May-23	16:00:00	-315
		2	1	4-May-23	19:00:00	-312
		3	2	5-May-23	16:00:00	-291
		4	2	5-May-23	19:00:00	-288
		5	3	6-May-23	16:00:00	-267
		6	3	6-May-23	19:00:00	-264
		7	4	7-May-23	16:00:00	-243
	Cinq Island	1	4	7-May-23	19:00:00	-240
		2	5	8-May-23	16:00:00	-219
		3	5	8-May-23	19:00:00	-216

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		4	6	9-May-23	16:00:00	-195
		5	6	9-May-23	19:00:00	-192
		6	7	10-May-23	16:00:00	-171
		7	7	10-May-23	19:00:00	-168
	Tilt Point	1	8	11-May-23	16:00:00	-147
		2	8	11-May-23	19:00:00	-144
		3	9	12-May-23	16:00:00	-123
		4	9	12-May-23	19:00:00	-120
		5	10	13-May-23	16:00:00	-99
		6	10	13-May-23	19:00:00	-96
		7	11	14-May-23	16:00:00	-75
	Iron Skull	1	11	14-May-23	19:00:00	-72
		2	12	15-May-23	16:00:00	-51
		3	12	15-May-23	19:00:00	-48
		4	13	16-May-23	16:00:00	-27
		5	13	16-May-23	19:00:00	-24
		6	14	17-May-23	16:00:00	-3
		7	14	17-May-23	19:00:00	0
Neap	Spyglass	1	1	16-Jun-23	01:00:00	-315
		2	1	16-Jun-23	04:00:00	-312
		3	2	17-Jun-23	01:00:00	-291
		4	2	17-Jun-23	04:00:00	-288
		5	3	18-Jun-23	01:00:00	-267
		6	3	18-Jun-23	04:00:00	-264
		7	4	19-Jun-23	01:00:00	-243
	Cinq Island	1	4	19-Jun-23	04:00:00	-240
		2	5	20-Jun-23	01:00:00	-219
		3	5	20-Jun-23	04:00:00	-216
		4	6	21-Jun-23	01:00:00	-195
		5	6	21-Jun-23	04:00:00	-192
		6	7	22-Jun-23	01:00:00	-171
		7	7	22-Jun-23	04:00:00	-168
	Tilt Point	1	8	23-Jun-23	01:00:00	-147

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		2	8	23-Jun-23	04:00:00	-144
		3	9	24-Jun-23	01:00:00	-123
		4	9	24-Jun-23	04:00:00	-120
		5	10	25-Jun-23	01:00:00	-99
		6	10	25-Jun-23	04:00:00	-96
		7	11	26-Jun-23	01:00:00	-75
	Iron Skull	1	11	26-Jun-23	04:00:00	-72
		2	12	27-Jun-23	01:00:00	-51
		3	12	27-Jun-23	04:00:00	-48
		4	13	28-Jun-23	01:00:00	-27
		5	13	28-Jun-23	04:00:00	-24
		6	14	29-Jun-23	01:00:00	-3
		7	14	29-Jun-23	04:00:00	0

Table 3.6 BMA4—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Dog Cove	1	1	4-May-23	16:00:00	-315
		2	1	4-May-23	19:00:00	-312
		3	2	5-May-23	16:00:00	-291
		4	2	5-May-23	19:00:00	-288
		5	3	6-May-23	16:00:00	-267
		6	3	6-May-23	19:00:00	-264
		7	4	7-May-23	16:00:00	-243
	Red Cove	1	4	7-May-23	19:00:00	-240
		2	5	8-May-23	16:00:00	-219
		3	5	8-May-23	19:00:00	-216
		4	6	9-May-23	16:00:00	-195
		5	6	9-May-23	19:00:00	-192
		6	7	10-May-23	16:00:00	-171
		7	7	10-May-23	19:00:00	-168
	Salmonier	1	8	11-May-23	16:00:00	-147
		2	8	11-May-23	19:00:00	-144
		3	9	12-May-23	16:00:00	-123
		4	9	12-May-23	19:00:00	-120
		5	10	13-May-23	16:00:00	-99
		6	10	13-May-23	19:00:00	-96
		7	11	14-May-23	16:00:00	-75
	Murphy's Point	1	11	14-May-23	19:00:00	-72
		2	12	15-May-23	16:00:00	-51
		3	12	15-May-23	19:00:00	-48
		4	13	16-May-23	16:00:00	-27
		5	13	16-May-23	19:00:00	-24
		6	14	17-May-23	16:00:00	-3
		7	14	17-May-23	19:00:00	0
Neap	Dog Cove	1	1	16-Jun-23	01:00:00	-315
		2	1	16-Jun-23	04:00:00	-312
		3	2	17-Jun-23	01:00:00	-291
		4	2	17-Jun-23	04:00:00	-288

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		5	3	18-Jun-23	01:00:00	-267
		6	3	18-Jun-23	04:00:00	-264
		7	4	19-Jun-23	01:00:00	-243
	Red Cove	1	4	19-Jun-23	04:00:00	-240
		2	5	20-Jun-23	01:00:00	-219
		3	5	20-Jun-23	04:00:00	-216
		4	6	21-Jun-23	01:00:00	-195
		5	6	21-Jun-23	04:00:00	-192
		6	7	22-Jun-23	01:00:00	-171
		7	7	22-Jun-23	04:00:00	-168
	Salmonier	1	8	23-Jun-23	01:00:00	-147
		2	8	23-Jun-23	04:00:00	-144
		3	9	24-Jun-23	01:00:00	-123
		4	9	24-Jun-23	04:00:00	-120
		5	10	25-Jun-23	01:00:00	-99
		6	10	25-Jun-23	04:00:00	-96
		7	11	26-Jun-23	01:00:00	-75
	Murphy's Point	1	11	26-Jun-23	04:00:00	-72
		2	12	27-Jun-23	01:00:00	-51
		3	12	27-Jun-23	04:00:00	-48
		4	13	28-Jun-23	01:00:00	-27
		5	13	28-Jun-23	04:00:00	-24
		6	14	29-Jun-23	01:00:00	-3
		7	14	29-Jun-23	04:00:00	0

Table 3.7 BMA5—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Harvey Hill North	1	1	4-May-23	16:00:00	-315
		2	1	4-May-23	19:00:00	-312
		3	2	5-May-23	16:00:00	-291
		4	2	5-May-23	19:00:00	-288
		5	3	6-May-23	16:00:00	-267
		6	3	6-May-23	19:00:00	-264

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		7	4	7-May-23	16:00:00	-243
	Harvey Hill East	1	4	7-May-23	19:00:00	-240
		2	5	8-May-23	16:00:00	-219
		3	5	8-May-23	19:00:00	-216
		4	6	9-May-23	16:00:00	-195
		5	6	9-May-23	19:00:00	-192
		6	7	10-May-23	16:00:00	-171
		7	7	10-May-23	19:00:00	-168
	Harvey Hill South	1	8	11-May-23	16:00:00	-147
		2	8	11-May-23	19:00:00	-144
		3	9	12-May-23	16:00:00	-123
		4	9	12-May-23	19:00:00	-120
		5	10	13-May-23	16:00:00	-99
		6	10	13-May-23	19:00:00	-96
		7	11	14-May-23	16:00:00	-75
	Broad Cove	1	11	14-May-23	19:00:00	-72
		2	12	15-May-23	16:00:00	-51
		3	12	15-May-23	19:00:00	-48
		4	13	16-May-23	16:00:00	-27
		5	13	16-May-23	19:00:00	-24
		6	14	17-May-23	16:00:00	-3
		7	14	17-May-23	19:00:00	0
Neap		1	1	16-Jun-23	01:00:00	-315

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Harvey Hill North	2	1	16-Jun-23	04:00:00	-312
		3	2	17-Jun-23	01:00:00	-291
		4	2	17-Jun-23	04:00:00	-288
		5	3	18-Jun-23	01:00:00	-267
		6	3	18-Jun-23	04:00:00	-264
		7	4	19-Jun-23	01:00:00	-243
	Harvey Hill East	1	4	19-Jun-23	04:00:00	-240
		2	5	20-Jun-23	01:00:00	-219
		3	5	20-Jun-23	04:00:00	-216
		4	6	21-Jun-23	01:00:00	-195
		5	6	21-Jun-23	04:00:00	-192
		6	7	22-Jun-23	01:00:00	-171
		7	7	22-Jun-23	04:00:00	-168
	Harvey Hill South	1	8	23-Jun-23	01:00:00	-147
		2	8	23-Jun-23	04:00:00	-144
		3	9	24-Jun-23	01:00:00	-123
		4	9	24-Jun-23	04:00:00	-120
		5	10	25-Jun-23	01:00:00	-99
		6	10	25-Jun-23	04:00:00	-96
		7	11	26-Jun-23	01:00:00	-75
	Broad Cove	1	11	26-Jun-23	04:00:00	-72
		2	12	27-Jun-23	01:00:00	-51
		3	12	27-Jun-23	04:00:00	-48
		4	13	28-Jun-23	01:00:00	-27
		5	13	28-Jun-23	04:00:00	-24
		6	14	29-Jun-23	01:00:00	-3
		7	14	29-Jun-23	04:00:00	0

Table 3.8 BMA8—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Deer Cove	1	1	4-May-23	16:00:00	-315
		2	1	4-May-23	19:00:00	-312
		3	2	5-May-23	16:00:00	-291

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		4	2	5-May-23	19:00:00	-288
		5	3	6-May-23	16:00:00	-267
		6	3	6-May-23	19:00:00	-264
		7	4	7-May-23	16:00:00	-243
	Blackfish Cove	1	4	7-May-23	19:00:00	-240
		2	5	8-May-23	16:00:00	-219
		3	5	8-May-23	19:00:00	-216
		4	6	9-May-23	16:00:00	-195
		5	6	9-May-23	19:00:00	-192
		6	7	10-May-23	16:00:00	-171
		7	7	10-May-23	19:00:00	-168
	Strickland Cove	1	8	11-May-23	16:00:00	-147
		2	8	11-May-23	19:00:00	-144
		3	9	12-May-23	16:00:00	-123
		4	9	12-May-23	19:00:00	-120
		5	10	13-May-23	16:00:00	-99
		6	10	13-May-23	19:00:00	-96
		7	11	14-May-23	16:00:00	-75
	Seal Nest Cove	1	11	14-May-23	19:00:00	-72
		2	12	15-May-23	16:00:00	-51
		3	12	15-May-23	19:00:00	-48
		4	13	16-May-23	16:00:00	-27
		5	13	16-May-23	19:00:00	-24
		6	14	17-May-23	16:00:00	-3
		7	14	17-May-23	19:00:00	0
Neap	Deer Cove	1	1	16-Jun-23	01:00:00	-315
		2	1	16-Jun-23	04:00:00	-312
		3	2	17-Jun-23	01:00:00	-291
		4	2	17-Jun-23	04:00:00	-288
		5	3	18-Jun-23	01:00:00	-267
		6	3	18-Jun-23	04:00:00	-264
		7	4	19-Jun-23	01:00:00	-243
		1	4	19-Jun-23	04:00:00	-240

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Blackfish Cove	2	5	20-Jun-23	01:00:00	-219
		3	5	20-Jun-23	04:00:00	-216
		4	6	21-Jun-23	01:00:00	-195
		5	6	21-Jun-23	04:00:00	-192
		6	7	22-Jun-23	01:00:00	-171
		7	7	22-Jun-23	04:00:00	-168
	Strickland Cove	1	8	23-Jun-23	01:00:00	-147
		2	8	23-Jun-23	04:00:00	-144
		3	9	24-Jun-23	01:00:00	-123
		4	9	24-Jun-23	04:00:00	-120
		5	10	25-Jun-23	01:00:00	-99
		6	10	25-Jun-23	04:00:00	-96
		7	11	26-Jun-23	01:00:00	-75
	Seal Nest Cove	1	11	26-Jun-23	04:00:00	-72
		2	12	27-Jun-23	01:00:00	-51
		3	12	27-Jun-23	04:00:00	-48
		4	13	28-Jun-23	01:00:00	-27
		5	13	28-Jun-23	04:00:00	-24
		6	14	29-Jun-23	01:00:00	-3
		7	14	29-Jun-23	04:00:00	0

Table 3.9 BMA9—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Goblin	1	1	4-May-23	16:00:00	-315
		2	1	4-May-23	19:00:00	-312
		3	2	5-May-23	16:00:00	-291
		4	2	5-May-23	19:00:00	-288
		5	3	6-May-23	16:00:00	-267
		6	3	6-May-23	19:00:00	-264
		7	4	7-May-23	16:00:00	-243
	Butter Cove	1	4	7-May-23	19:00:00	-240
		2	5	8-May-23	16:00:00	-219
		3	5	8-May-23	19:00:00	-216

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		4	6	9-May-23	16:00:00	-195
		5	6	9-May-23	19:00:00	-192
		6	7	10-May-23	16:00:00	-171
		7	7	10-May-23	19:00:00	-168
	Pass My Can	1	8	11-May-23	16:00:00	-147
		2	8	11-May-23	19:00:00	-144
		3	9	12-May-23	16:00:00	-123
		4	9	12-May-23	19:00:00	-120
		5	10	13-May-23	16:00:00	-99
		6	10	13-May-23	19:00:00	-96
		7	11	14-May-23	16:00:00	-75
	Jervis Island	1	11	14-May-23	19:00:00	-72
		2	12	15-May-23	16:00:00	-51
		3	12	15-May-23	19:00:00	-48
		4	13	16-May-23	16:00:00	-27
		5	13	16-May-23	19:00:00	-24
		6	14	17-May-23	16:00:00	-3
		7	14	17-May-23	19:00:00	0
Neap	Goblin	1	1	16-Jun-23	01:00:00	-315
		2	1	16-Jun-23	04:00:00	-312
		3	2	17-Jun-23	01:00:00	-291
		4	2	17-Jun-23	04:00:00	-288
		5	3	18-Jun-23	01:00:00	-267
		6	3	18-Jun-23	04:00:00	-264
		7	4	19-Jun-23	01:00:00	-243
	Butter Cove	1	4	19-Jun-23	04:00:00	-240
		2	5	20-Jun-23	01:00:00	-219
		3	5	20-Jun-23	04:00:00	-216
		4	6	21-Jun-23	01:00:00	-195
		5	6	21-Jun-23	04:00:00	-192
		6	7	22-Jun-23	01:00:00	-171
		7	7	22-Jun-23	04:00:00	-168
		1	8	23-Jun-23	01:00:00	-147

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Pass My Can	2	8	23-Jun-23	04:00:00	-144
		3	9	24-Jun-23	01:00:00	-123
		4	9	24-Jun-23	04:00:00	-120
		5	10	25-Jun-23	01:00:00	-99
		6	10	25-Jun-23	04:00:00	-96
		7	11	26-Jun-23	01:00:00	-75
	Jervis Island	1	11	26-Jun-23	04:00:00	-72
		2	12	27-Jun-23	01:00:00	-51
		3	12	27-Jun-23	04:00:00	-48
		4	13	28-Jun-23	01:00:00	-27
		5	13	28-Jun-23	04:00:00	-24
		6	14	29-Jun-23	01:00:00	-3
		7	14	29-Jun-23	04:00:00	0

Table 3.10 BMA10—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Indian Tea Point	1	1	28-Apr-23	16:00:00	-459
		2	1	28-Apr-23	19:00:00	-456
		3	2	29-Apr-23	16:00:00	-435
		4	2	29-Apr-23	19:00:00	-432
		5	3	30-Apr-23	16:00:00	-411
		6	3	30-Apr-23	19:00:00	-408
		7	4	1-May-23	16:00:00	-387
		8	4	1-May-23	19:00:00	-384
		9	5	2-May-23	16:00:00	-363
		10	5	2-May-23	19:00:00	-360
	Wallace Cove	1	6	3-May-23	16:00:00	-339
		2	6	3-May-23	19:00:00	-336
		3	7	4-May-23	16:00:00	-315
		4	7	4-May-23	19:00:00	-312
		5	8	5-May-23	16:00:00	-291
		6	8	5-May-23	19:00:00	-288
		7	9	6-May-23	16:00:00	-267

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		8	9	6-May-23	19:00:00	-264
		9	10	7-May-23	16:00:00	-243
		10	10	7-May-23	19:00:00	-240
	Dennis Arm	1	11	8-May-23	16:00:00	-219
		2	11	8-May-23	19:00:00	-216
		3	12	9-May-23	16:00:00	-195
		4	12	9-May-23	19:00:00	-192
		5	13	10-May-23	16:00:00	-171
		6	13	10-May-23	19:00:00	-168
		7	14	11-May-23	16:00:00	-147
		8	14	11-May-23	19:00:00	-144
		9	15	12-May-23	16:00:00	-123
		10	15	12-May-23	19:00:00	-120
	Wild Cove	1	16	13-May-23	16:00:00	-99
		2	16	13-May-23	19:00:00	-96
		3	17	14-May-23	16:00:00	-75
		4	17	14-May-23	19:00:00	-72
		5	18	15-May-23	16:00:00	-51
		6	18	15-May-23	19:00:00	-48
		7	19	16-May-23	16:00:00	-27
		8	19	16-May-23	19:00:00	-24
		9	20	17-May-23	16:00:00	-3
		10	20	17-May-23	19:00:00	0
Neap	Indian Tea Point	1	1	10-Jun-23	01:00:00	-459
		2	1	10-Jun-23	04:00:00	-456
		3	2	11-Jun-23	01:00:00	-435
		4	2	11-Jun-23	04:00:00	-432
		5	3	12-Jun-23	01:00:00	-411
		6	3	12-Jun-23	04:00:00	-408
		7	4	13-Jun-23	01:00:00	-387
		8	4	13-Jun-23	04:00:00	-384
		9	5	14-Jun-23	01:00:00	-363
		10	5	14-Jun-23	04:00:00	-360

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Wallace Cove	1	6	15-Jun-23	01:00:00	-339
		2	6	15-Jun-23	04:00:00	-336
		3	7	16-Jun-23	01:00:00	-315
		4	7	16-Jun-23	04:00:00	-312
		5	8	17-Jun-23	01:00:00	-291
		6	8	17-Jun-23	04:00:00	-288
		7	9	18-Jun-23	01:00:00	-267
		8	9	18-Jun-23	04:00:00	-264
		9	10	19-Jun-23	01:00:00	-243
		10	10	19-Jun-23	04:00:00	-240
	Dennis Arm	1	11	20-Jun-23	01:00:00	-219
		2	11	20-Jun-23	04:00:00	-216
		3	12	21-Jun-23	01:00:00	-195
		4	12	21-Jun-23	04:00:00	-192
		5	13	22-Jun-23	01:00:00	-171
		6	13	22-Jun-23	04:00:00	-168
		7	14	23-Jun-23	01:00:00	-147
		8	14	23-Jun-23	04:00:00	-144
		9	15	24-Jun-23	01:00:00	-123
		10	15	24-Jun-23	04:00:00	-120
	Wild Cove	1	16	25-Jun-23	01:00:00	-99
		2	16	25-Jun-23	04:00:00	-96
		3	17	26-Jun-23	01:00:00	-75
		4	17	26-Jun-23	04:00:00	-72
		5	18	27-Jun-23	01:00:00	-51
		6	18	27-Jun-23	04:00:00	-48
		7	19	28-Jun-23	01:00:00	-27
		8	19	28-Jun-23	04:00:00	-24
		9	20	29-Jun-23	01:00:00	-3
		10	20	29-Jun-23	04:00:00	0

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Table 3.11 BMA11—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Mare Cove	1	1	8-May-23	16:00:00	-219
		2	1	8-May-23	19:00:00	-216
		3	2	9-May-23	16:00:00	-195
		4	2	9-May-23	19:00:00	-192
		5	3	10-May-23	16:00:00	-171
		6	3	10-May-23	19:00:00	-168
		7	4	11-May-23	16:00:00	-147
		8	4	11-May-23	19:00:00	-144
		9	5	12-May-23	16:00:00	-123
		10	5	12-May-23	19:00:00	-120
	Bob Locke	1	6	13-May-23	16:00:00	-99
		2	6	13-May-23	19:00:00	-96
		3	7	14-May-23	16:00:00	-75
		4	7	14-May-23	19:00:00	-72
		5	8	15-May-23	16:00:00	-51
		6	8	15-May-23	19:00:00	-48
		7	9	16-May-23	16:00:00	-27
		8	9	16-May-23	19:00:00	-24
		9	10	17-May-23	16:00:00	-3
		10	10	17-May-23	19:00:00	0
Neap	Mare Cove	1	11	20-Jun-23	01:00:00	-219
		2	1	20-Jun-23	04:00:00	-216
		3	2	21-Jun-23	01:00:00	-195
		4	2	21-Jun-23	04:00:00	-192
		5	3	22-Jun-23	01:00:00	-171
		6	3	22-Jun-23	04:00:00	-168
		7	4	23-Jun-23	01:00:00	-147
		8	4	23-Jun-23	04:00:00	-144
		9	5	24-Jun-23	01:00:00	-123
		10	5	24-Jun-23	04:00:00	-120
	Bob Locke	1	6	25-Jun-23	01:00:00	-99
		2	6	25-Jun-23	04:00:00	-96

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		3	7	26-Jun-23	01:00:00	-75
		4	7	26-Jun-23	04:00:00	-72
		5	8	27-Jun-23	01:00:00	-51
		6	8	27-Jun-23	04:00:00	-48
		7	9	28-Jun-23	01:00:00	-27
		8	9	28-Jun-23	04:00:00	-24
		9	10	29-Jun-23	01:00:00	-3
		10	10	29-Jun-23	04:00:00	0

Table 3.12 BMA12—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	The Gorge	1	1	28-Apr-23	16:00:00	-459
		2	1	28-Apr-23	19:00:00	-456
		3	2	29-Apr-23	16:00:00	-435
		4	2	29-Apr-23	19:00:00	-432
		5	3	30-Apr-23	16:00:00	-411
		6	3	30-Apr-23	19:00:00	-408
		7	4	1-May-23	16:00:00	-387
		8	4	1-May-23	19:00:00	-384
		9	5	2-May-23	16:00:00	-363
		10	5	2-May-23	19:00:00	-360
	Rencontre Bay	1	6	3-May-23	16:00:00	-339
		2	6	3-May-23	19:00:00	-336
		3	7	4-May-23	16:00:00	-315
		4	7	4-May-23	19:00:00	-312
		5	8	5-May-23	16:00:00	-291
		6	8	5-May-23	19:00:00	-288
		7	9	6-May-23	16:00:00	-267
		8	9	6-May-23	19:00:00	-264
		9	10	7-May-23	16:00:00	-243
		10	10	7-May-23	19:00:00	-240
	Little Bay	1	11	8-May-23	16:00:00	-219
		2	11	8-May-23	19:00:00	-216

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		3	12	9-May-23	16:00:00	-195
		4	12	9-May-23	19:00:00	-192
		5	13	10-May-23	16:00:00	-171
		6	13	10-May-23	19:00:00	-168
		7	14	11-May-23	16:00:00	-147
		8	14	11-May-23	19:00:00	-144
		9	15	12-May-23	16:00:00	-123
		10	15	12-May-23	19:00:00	-120
	Devil Bay	1	16	13-May-23	16:00:00	-99
		2	16	13-May-23	19:00:00	-96
		3	17	14-May-23	16:00:00	-75
		4	17	14-May-23	19:00:00	-72
		5	18	15-May-23	16:00:00	-51
		6	18	15-May-23	19:00:00	-48
		7	19	16-May-23	16:00:00	-27
		8	19	16-May-23	19:00:00	-24
		9	20	17-May-23	16:00:00	-3
		10	20	17-May-23	19:00:00	0
Neap	The Gorge	1	1	10-Jun-23	01:00:00	-459
		2	1	10-Jun-23	04:00:00	-456
		3	2	11-Jun-23	01:00:00	-435
		4	2	11-Jun-23	04:00:00	-432
		5	3	12-Jun-23	01:00:00	-411
		6	3	12-Jun-23	04:00:00	-408
		7	4	13-Jun-23	01:00:00	-387
		8	4	13-Jun-23	04:00:00	-384
		9	5	14-Jun-23	01:00:00	-363
		10	5	14-Jun-23	04:00:00	-360
	Rencontre Bay	1	6	15-Jun-23	01:00:00	-339
		2	6	15-Jun-23	04:00:00	-336
		3	7	16-Jun-23	01:00:00	-315
		4	7	16-Jun-23	04:00:00	-312
		5	8	17-Jun-23	01:00:00	-291

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		6	8	17-Jun-23	04:00:00	-288
		7	9	18-Jun-23	01:00:00	-267
		8	9	18-Jun-23	04:00:00	-264
		9	10	19-Jun-23	01:00:00	-243
		10	10	19-Jun-23	04:00:00	-240
	Little Bay	1	11	20-Jun-23	01:00:00	-219
		2	11	20-Jun-23	04:00:00	-216
		3	12	21-Jun-23	01:00:00	-195
		4	12	21-Jun-23	04:00:00	-192
		5	13	22-Jun-23	01:00:00	-171
		6	13	22-Jun-23	04:00:00	-168
		7	14	23-Jun-23	01:00:00	-147
		8	14	23-Jun-23	04:00:00	-144
		9	15	24-Jun-23	01:00:00	-123
		10	15	24-Jun-23	04:00:00	-120
	Devil Bay	1	16	25-Jun-23	01:00:00	-99
		2	16	25-Jun-23	04:00:00	-96
		3	17	26-Jun-23	01:00:00	-75
		4	17	26-Jun-23	04:00:00	-72
		5	18	27-Jun-23	01:00:00	-51
		6	18	27-Jun-23	04:00:00	-48
		7	19	28-Jun-23	01:00:00	-27
		8	19	28-Jun-23	04:00:00	-24
		9	20	29-Jun-23	01:00:00	-3
		10	20	29-Jun-23	04:00:00	0

Table 3.13 BMA13—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Chaleur Bay	1	1	3-May-23	16:00:00	-339
		2	1	3-May-23	19:00:00	-336
		3	2	4-May-23	16:00:00	-315
		4	2	4-May-23	19:00:00	-312

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		5	3	5-May-23	16:00:00	-291
		6	3	5-May-23	19:00:00	-288
		7	4	6-May-23	16:00:00	-267
		8	4	6-May-23	19:00:00	-264
		9	5	7-May-23	16:00:00	-243
		10	5	7-May-23	19:00:00	-240
	Friar Cove	1	6	8-May-23	16:00:00	-219
		2	6	8-May-23	19:00:00	-216
		3	7	9-May-23	16:00:00	-195
		4	7	9-May-23	19:00:00	-192
		5	8	10-May-23	16:00:00	-171
		6	8	10-May-23	19:00:00	-168
		7	9	11-May-23	16:00:00	-147
		8	9	11-May-23	19:00:00	-144
		9	10	12-May-23	16:00:00	-123
		10	10	12-May-23	19:00:00	-120
	Shooter Point	1	11	13-May-23	16:00:00	-99
		2	11	13-May-23	19:00:00	-96
		3	12	14-May-23	16:00:00	-75
		4	12	14-May-23	19:00:00	-72
		5	13	15-May-23	16:00:00	-51
		6	13	15-May-23	19:00:00	-48
		7	14	16-May-23	16:00:00	-27
		8	14	16-May-23	19:00:00	-24
		9	15	17-May-23	16:00:00	-3
		10	15	17-May-23	19:00:00	0
Neap	Chaleur Bay	1	1	15-Jun-23	01:00:00	-339
		2	1	15-Jun-23	04:00:00	-336
		3	2	16-Jun-23	01:00:00	-315
		4	2	16-Jun-23	04:00:00	-312
		5	3	17-Jun-23	01:00:00	-291
		6	3	17-Jun-23	04:00:00	-288
		7	4	18-Jun-23	01:00:00	-267

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		8	4	18-Jun-23	04:00:00	-264
		9	5	19-Jun-23	01:00:00	-243
		10	5	19-Jun-23	04:00:00	-240
	Friar Cove	1	6	20-Jun-23	01:00:00	-219
		2	6	20-Jun-23	04:00:00	-216
		3	7	21-Jun-23	01:00:00	-195
		4	7	21-Jun-23	04:00:00	-192
		5	8	22-Jun-23	01:00:00	-171
		6	8	22-Jun-23	04:00:00	-168
		7	9	23-Jun-23	01:00:00	-147
		8	9	23-Jun-23	04:00:00	-144
		9	10	24-Jun-23	01:00:00	-123
		10	10	24-Jun-23	04:00:00	-120
	Shooter Point	1	11	25-Jun-23	01:00:00	-99
		2	11	25-Jun-23	04:00:00	-96
		3	12	26-Jun-23	01:00:00	-75
		4	12	26-Jun-23	04:00:00	-72
		5	13	27-Jun-23	01:00:00	-51
		6	13	27-Jun-23	04:00:00	-48
		7	14	28-Jun-23	01:00:00	-27
		8	14	28-Jun-23	04:00:00	-24
		9	15	29-Jun-23	01:00:00	-3
		10	15	29-Jun-23	04:00:00	0

Table 3.14 BMA14—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Aviron North	1	1	3-May-23	16:00:00	-339
		2	1	3-May-23	19:00:00	-336
		3	2	4-May-23	16:00:00	-315
		4	2	4-May-23	19:00:00	-312
		5	3	5-May-23	16:00:00	-291
		6	3	5-May-23	19:00:00	-288
		7	4	6-May-23	16:00:00	-267

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		8	4	6-May-23	19:00:00	-264
		9	5	7-May-23	16:00:00	-243
		10	5	7-May-23	19:00:00	-240
	Aviron South	1	6	8-May-23	16:00:00	-219
		2	6	8-May-23	19:00:00	-216
		3	7	9-May-23	16:00:00	-195
		4	7	9-May-23	19:00:00	-192
		5	8	10-May-23	16:00:00	-171
		6	8	10-May-23	19:00:00	-168
		7	9	11-May-23	16:00:00	-147
		8	9	11-May-23	19:00:00	-144
		9	10	12-May-23	16:00:00	-123
		10	10	12-May-23	19:00:00	-120
	Foots Cove	1	11	13-May-23	16:00:00	-99
		2	11	13-May-23	19:00:00	-96
		3	12	14-May-23	16:00:00	-75
		4	12	14-May-23	19:00:00	-72
		5	13	15-May-23	16:00:00	-51
		6	13	15-May-23	19:00:00	-48
		7	14	16-May-23	16:00:00	-27
		8	14	16-May-23	19:00:00	-24
		9	15	17-May-23	16:00:00	-3
		10	15	17-May-23	19:00:00	0
Neap	Aviron North	1	1	15-Jun-23	01:00:00	-339
		2	1	15-Jun-23	04:00:00	-336
		3	2	16-Jun-23	01:00:00	-315
		4	2	16-Jun-23	04:00:00	-312
		5	3	17-Jun-23	01:00:00	-291
		6	3	17-Jun-23	04:00:00	-288
		7	4	18-Jun-23	01:00:00	-267
		8	4	18-Jun-23	04:00:00	-264
		9	5	19-Jun-23	01:00:00	-243
		10	5	19-Jun-23	04:00:00	-240

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Aviron South	1	6	20-Jun-23	01:00:00	-219
		2	6	20-Jun-23	04:00:00	-216
		3	7	21-Jun-23	01:00:00	-195
		4	7	21-Jun-23	04:00:00	-192
		5	8	22-Jun-23	01:00:00	-171
		6	8	22-Jun-23	04:00:00	-168
		7	9	23-Jun-23	01:00:00	-147
		8	9	23-Jun-23	04:00:00	-144
		9	10	24-Jun-23	01:00:00	-123
		10	10	24-Jun-23	04:00:00	-120
	Foots Cove	1	11	25-Jun-23	01:00:00	-99
		2	11	25-Jun-23	04:00:00	-96
		3	12	26-Jun-23	01:00:00	-75
		4	12	26-Jun-23	04:00:00	-72
		5	13	27-Jun-23	01:00:00	-51
		6	13	27-Jun-23	04:00:00	-48
		7	14	28-Jun-23	01:00:00	-27
		8	14	28-Jun-23	04:00:00	-24
		9	15	29-Jun-23	01:00:00	-3
		10	15	29-Jun-23	04:00:00	0

Table 3.15 BMA15—Treatment Schedule for the Spring and Neap Tide Simulation Period

Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
Spring	Shoal Cove	1	1	3-May-23	16:00:00	-339
		2	1	3-May-23	19:00:00	-336
		3	2	4-May-23	16:00:00	-315
		4	2	4-May-23	19:00:00	-312
		5	3	5-May-23	16:00:00	-291
		6	3	5-May-23	19:00:00	-288
		7	4	6-May-23	16:00:00	-267
		8	4	6-May-23	19:00:00	-264
		9	5	7-May-23	16:00:00	-243
		10	5	7-May-23	19:00:00	-240

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
	Gnat's Island	1	6	8-May-23	16:00:00	-219
		2	6	8-May-23	19:00:00	-216
		3	7	9-May-23	16:00:00	-195
		4	7	9-May-23	19:00:00	-192
		5	8	10-May-23	16:00:00	-171
		6	8	10-May-23	19:00:00	-168
		7	9	11-May-23	16:00:00	-147
		8	9	11-May-23	19:00:00	-144
		9	10	12-May-23	16:00:00	-123
		10	10	12-May-23	19:00:00	-120
	Denny Island	1	11	13-May-23	16:00:00	-99
		2	11	13-May-23	19:00:00	-96
		3	12	14-May-23	16:00:00	-75
		4	12	14-May-23	19:00:00	-72
		5	13	15-May-23	16:00:00	-51
		6	13	15-May-23	19:00:00	-48
		7	14	16-May-23	16:00:00	-27
		8	14	16-May-23	19:00:00	-24
		9	15	17-May-23	16:00:00	-3
		10	15	17-May-23	19:00:00	0
Neap	Shoal Cove	1	1	15-Jun-23	01:00:00	-339
		2	1	15-Jun-23	04:00:00	-336
		3	2	16-Jun-23	01:00:00	-315
		4	2	16-Jun-23	04:00:00	-312
		5	3	17-Jun-23	01:00:00	-291
		6	3	17-Jun-23	04:00:00	-288
		7	4	18-Jun-23	01:00:00	-267
		8	4	18-Jun-23	04:00:00	-264
		9	5	19-Jun-23	01:00:00	-243
		10	5	19-Jun-23	04:00:00	-240
	Gnat's Island	1	6	20-Jun-23	01:00:00	-219
		2	6	20-Jun-23	04:00:00	-216
		3	7	21-Jun-23	01:00:00	-195

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Dispersion Run	Farm	Pen #	Treatment Day	Date	Time	Hours from Final Treatment
		4	7	21-Jun-23	04:00:00	-192
		5	8	22-Jun-23	01:00:00	-171
		6	8	22-Jun-23	04:00:00	-168
		7	9	23-Jun-23	01:00:00	-147
		8	9	23-Jun-23	04:00:00	-144
		9	10	24-Jun-23	01:00:00	-123
		10	10	24-Jun-23	04:00:00	-120
	Denny Island	1	11	25-Jun-23	01:00:00	-99
		2	11	25-Jun-23	04:00:00	-96
		3	12	26-Jun-23	01:00:00	-75
		4	12	26-Jun-23	04:00:00	-72
		5	13	27-Jun-23	01:00:00	-51
		6	13	27-Jun-23	04:00:00	-48
		7	14	28-Jun-23	01:00:00	-27
		8	14	28-Jun-23	04:00:00	-24
		9	15	29-Jun-23	01:00:00	-3
		10	15	29-Jun-23	04:00:00	0

3.5 Decay Rate

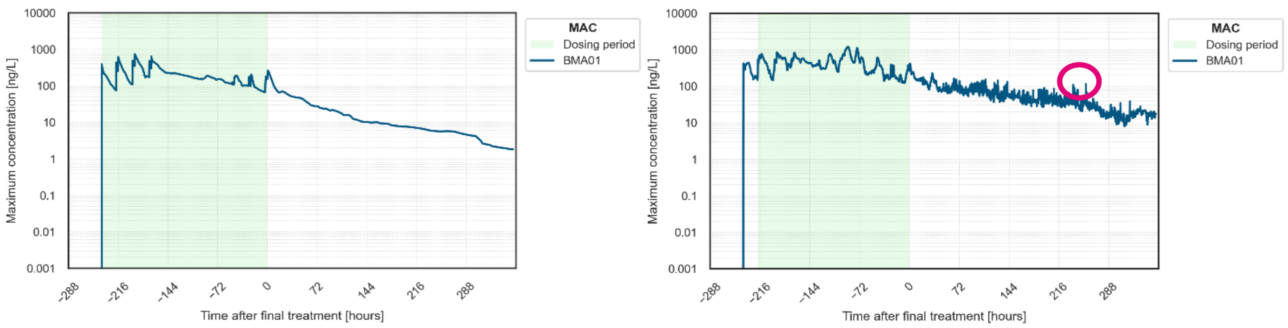
A half-life of 5.6 days was applied to represent Azamethiphos decay (SEPA, 2023), this equated to the time required for half of the substance to decay (equivalent to a decay rate of 0.12377 per day).

3.6 Pre-Assessment; Tracers vs Particles

In a pre-assessment, both tracers (Eulerian approach) and particles (Lagrangian approach) were evaluated to determine the ‘fit for purpose’ approach for quantifying Azamethiphos dispersion in this exercise. These two approaches have been previously applied in similar contexts for assessing Azamethiphos dispersion (BMT, 2023a, 2023b, Cook Aquaculture Scotland, 2021). The assessment compared all BMAs, focusing on the differences between tracer and particle methods, as well as the impact of varying model grid resolutions.

For near-field dispersion, tracers are prone to numerical dilution when applied to low-resolution grids. In contrast, the numerical behaviour of particles remains unaffected by grid resolution. To illustrate these differences, two representative BMAs were selected for further analysis: BMA1, a low-resolution site, and BMA5, a high-resolution site used for model calibration. MAC plots were generated for this analysis.

For both sites (BMA1—0 and BMA5—Figure 3.4) the tracer and particle approaches showed similar modelling results. The maximum concentrations obtained from both approaches were within a comparable range, although the particle method produced slightly higher values, resulting in more conservative estimates. However, the particle approach exhibited some unrealistic concentrations, as highlighted by circles in the figures. Specifically, areas where concentrations exceeded 100 ng/L should not increase after initially decreasing in the same location. Further investigation using spatial maps revealed that particles tended to accumulate in poorly flushed areas, re-concentrated, leading to these unrealistic concentrations. As a result, for this 'fit for purpose' assessment, tracers were chosen to model all outcomes for the dissolving chemical including maximum area exceedance values and maximum allowable concentration plots.



Maximum Allowable Concentration for BMA1 During Neap Tide; Left—Tracer Approach and Right—Particle Approach

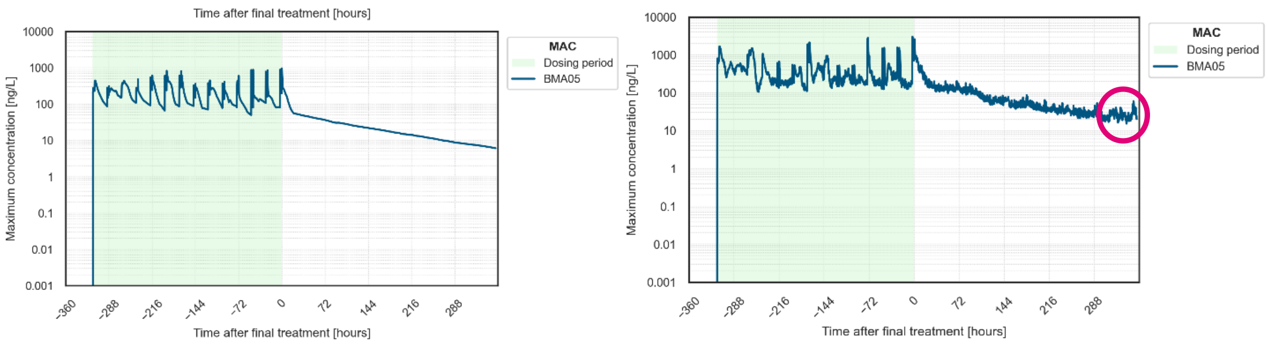


Figure 3.4 Maximum Allowable Concentration for BMA5 During Neap Tide; Left—Tracer Approach; Right—Particle Approach

3.7 Scalar Diffusivity

In TUFLOW-FV, the horizontal scalar diffusivity refers to the ‘global horizontal scalar diffusivity’ that is used to calculate the rate at which a scalar quantity, such as temperature or concentration, is mixed and transported in the horizontal direction due to turbulent eddies and mixing processes (TUFLOW, 2020). The horizontal scalar diffusivity is typically calibrated using field data or laboratory experiments to ensure that it accurately represents the actual horizontal diffusion properties of the fluid being modelled. However, for this study, a value of 0.2 m^2/s was applied due to the lack of experimental measurements in the context of modelling Azamethiphos bath treatments. The ‘global vertical scalar diffusivity limit’ of 0.0–1.0 m^2/s was uniformly applied to the whole model domain. Reported values for horizontal dispersion from dye patch studies in coastal waters vary significantly, ranging from 0.02 to 2.17 m^2/s (Elliott et al., 1997; Morales et al., 1997). The chosen value of 0.2 m^2 / s falls within this range and is considered appropriate for coastal and estuarine environments, particularly under moderate current conditions.

3.8 Mass Balance

To assess mass balance and the effects of numerical dispersion, 100 mg of tracer mass was released at the ocean boundary, while maintaining the initial concentration of the tracer at 100 mg/L throughout the model domain. The model was simulated for three months (01/03/2023 to 01/06/2023), with zero tracer decay rates.

4 Results

4.1 Modelled Flow Fields

Figure 4.1 shows the velocity flow fields within the southern coastal waters of Newfoundland for the peak flood tidal phase during the neap and spring tidal cycles. All flow velocities exceeding 0.2 m/s are represented in the right end of the colour ramp, marked in green. The region exhibits a channel-like morphology, with hydrodynamics primarily driven through natural channels. The embayments in ‘Bays West’ show relatively higher current speeds, reaching up to 0.2 m/s, compared to the embayments in ‘Bays East’, where currents rarely exceed 0.1 m/s. This difference in flow dynamics results in slower flushing times in the ‘Bays East’ bay compared to ‘Bays West’.

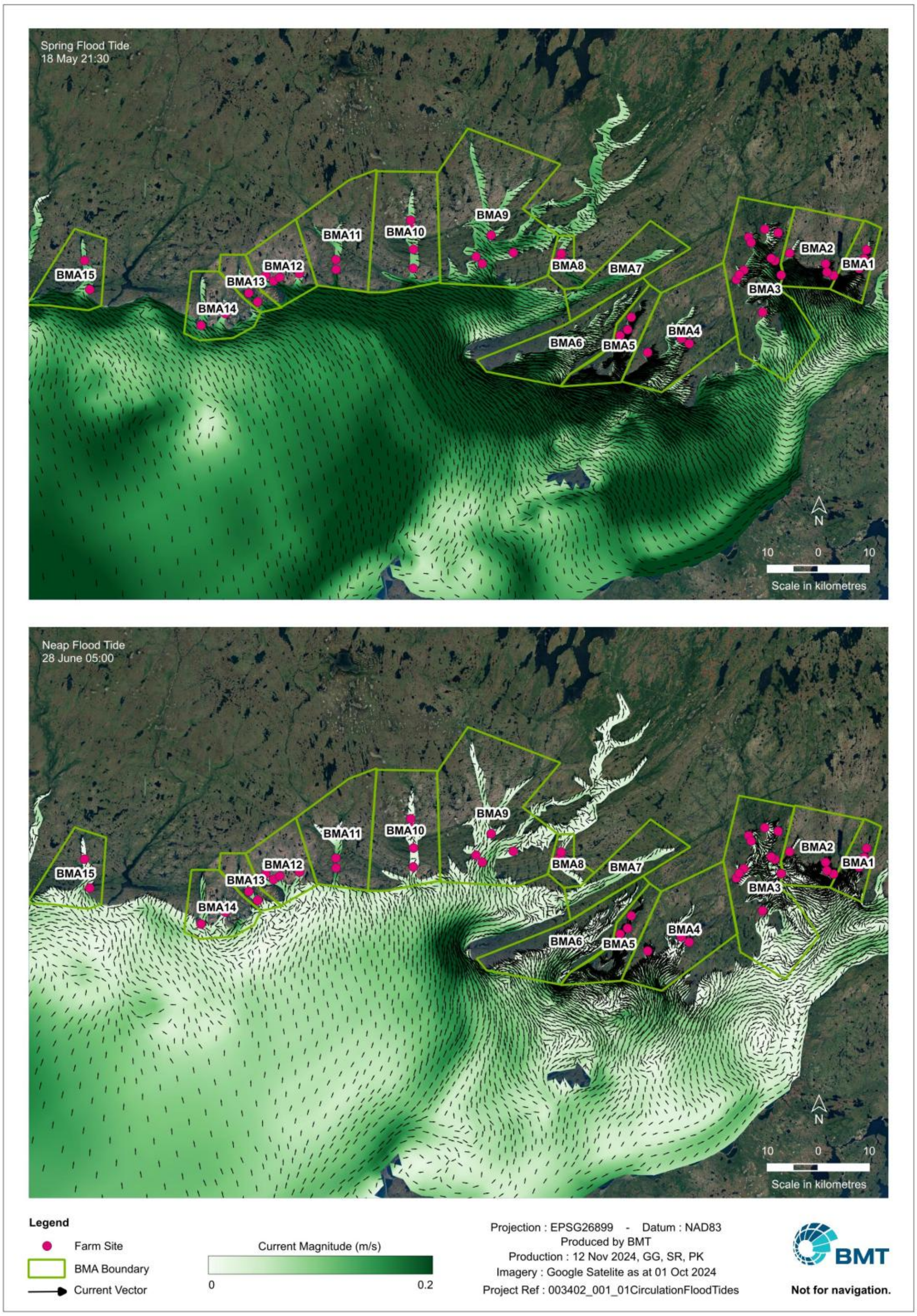


Figure 4.1 Modelled Flow Field Across the South Coast of Newfoundland at Peak Flooding Tides for the Spring and Neap Tidal Cycles. Grey Lines Represent Flow Vectors

4.2 Exposure Zones

MAC have been plotted for all BMAs. As outlined in Section 3.4.2, BMA2 and BMA2B were combined into a single BMA, while BMA3 was subdivided into three BMAs (BMA3i, BMA3ii, BMA3iii) for modelling purposes. The *x*-axis represents time in hours, with '0' indicating the time of the final bath treatment. The light-green shaded area corresponds to the treatment period.

The MAC within the model domain was based on the cumulative discharges from all farms within a BMA and the dispersion characteristics of that BMA.

4.2.1 BMA1 Exposure Zone Profile (Figure 4.2 and Figure 4.3)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Hobby farm.
- During the neap tide simulation, the affected area never exceeded 5 km², and for spring tides, it never exceeded 3 km².
- The maximum concentration during the neap tide scenario was 740 ng/L, while for the spring tide scenario, it was 670 ng/L.
- The peak concentration occurred during the treatments of the first farm, Benny's Cove, and then gradually declined over time.

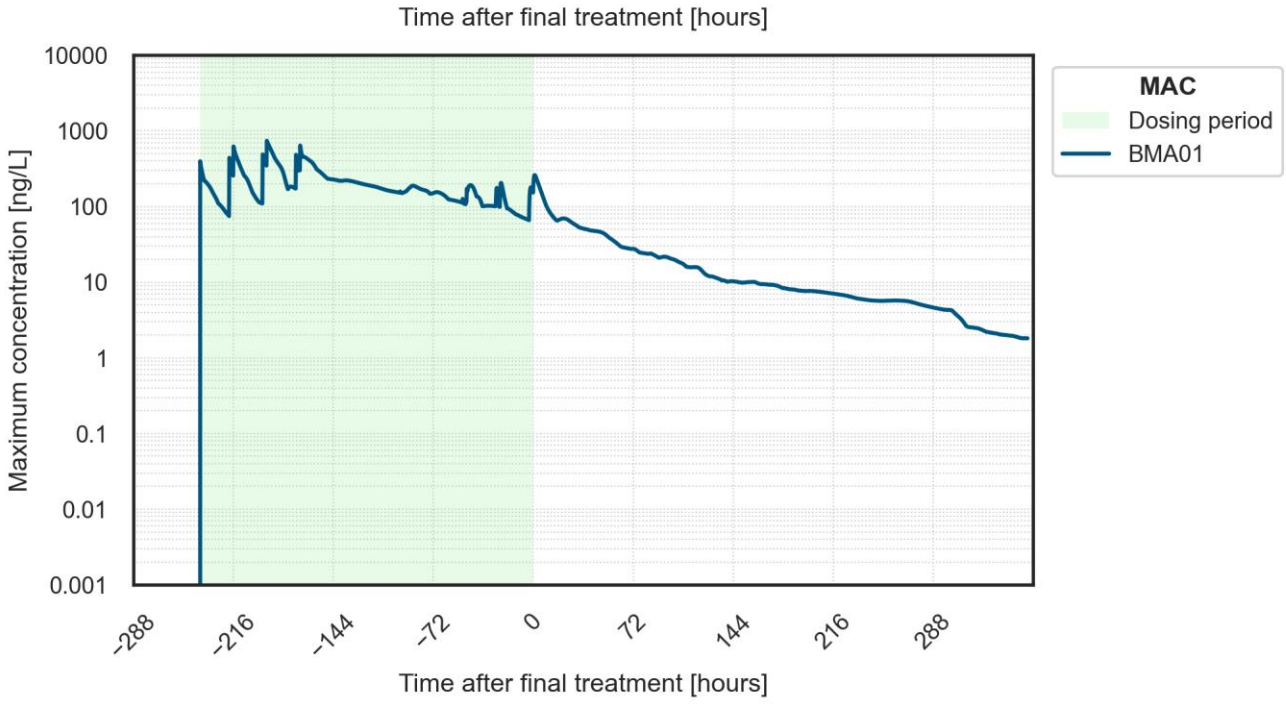


Figure 4.2 Maximum Allowable Concentration for BMA1 During Neap Tide

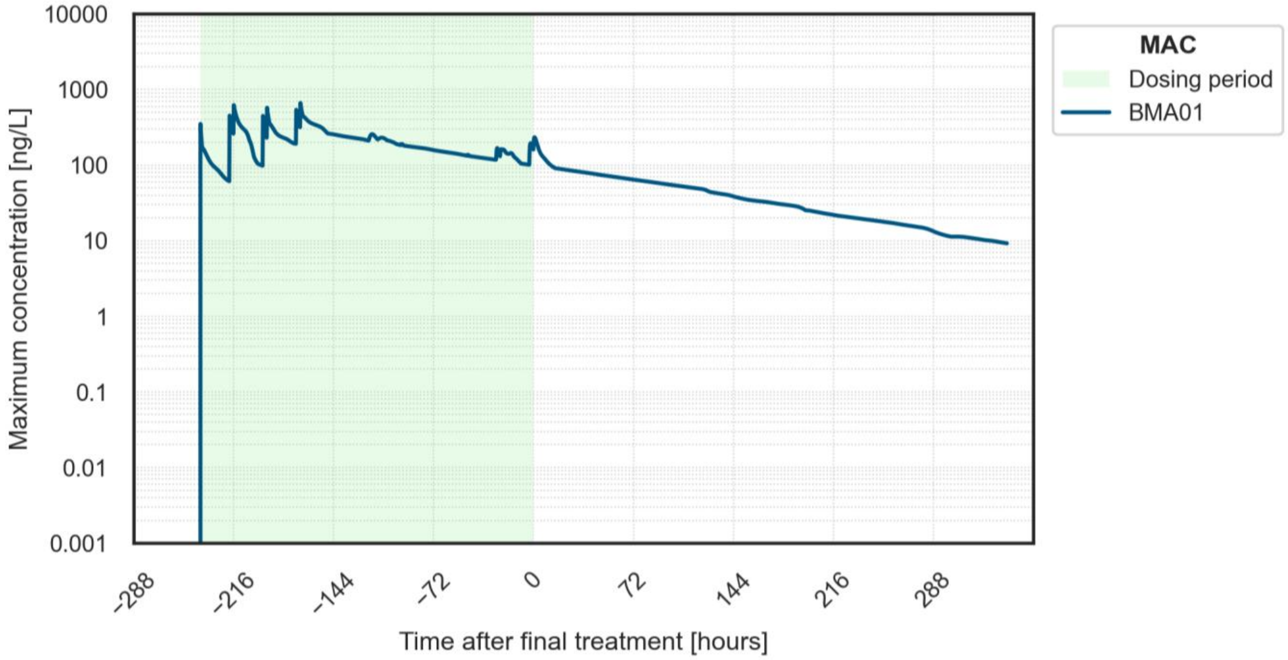


Figure 4.3 Maximum Allowable Concentration for BMA1 During Spring Tide

4.2.2 BMA2 + 2B Exposure Zone Profile (Figure 4.4 and Figure 4.5)

- In both plots, '0' represents the time of the final treatment at pen #7 of the Rencontre East farm.
- During the neap tide simulation, the affected area never exceeded 4 km², and for spring tides, it never exceeded 5 km².
- The maximum concentration during the neap tide scenario was 2000 ng/L, while for the spring tide scenario, it was 2200 ng/L.
- The peak concentration occurred during the treatment of the third farm, Little Burdock Cove, and then gradually declined over time.

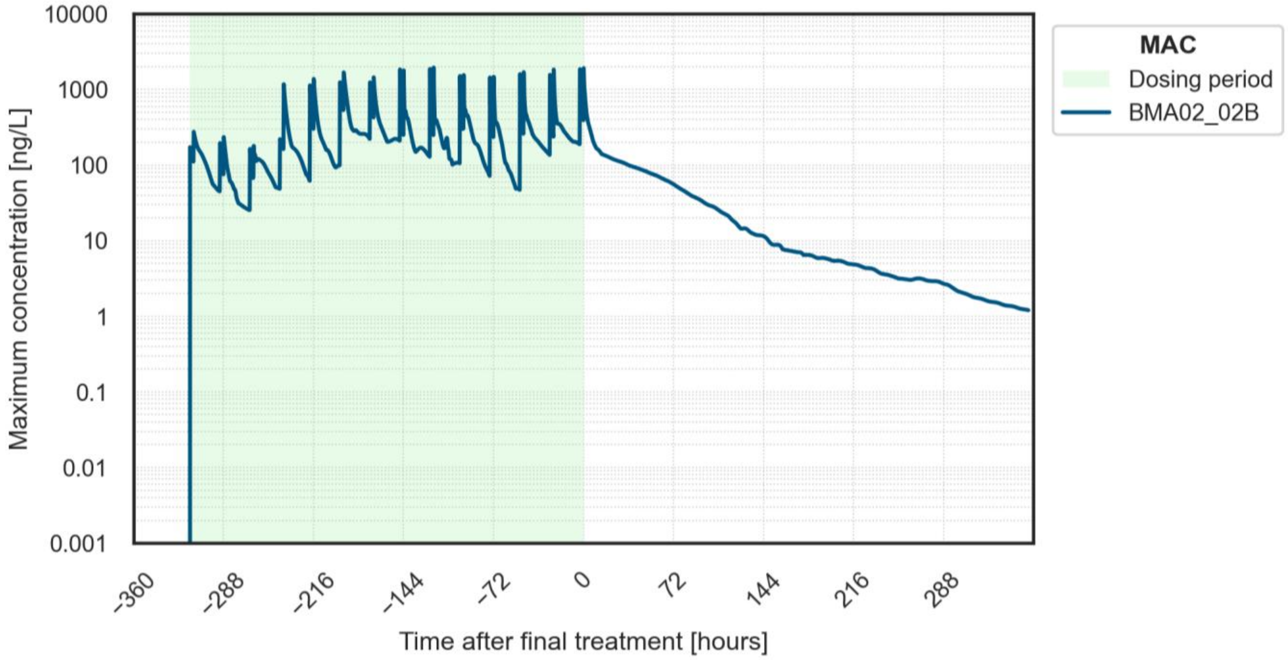


Figure 4.4 Maximum Allowable Concentration for BMA2 + 2B During Neap Tide

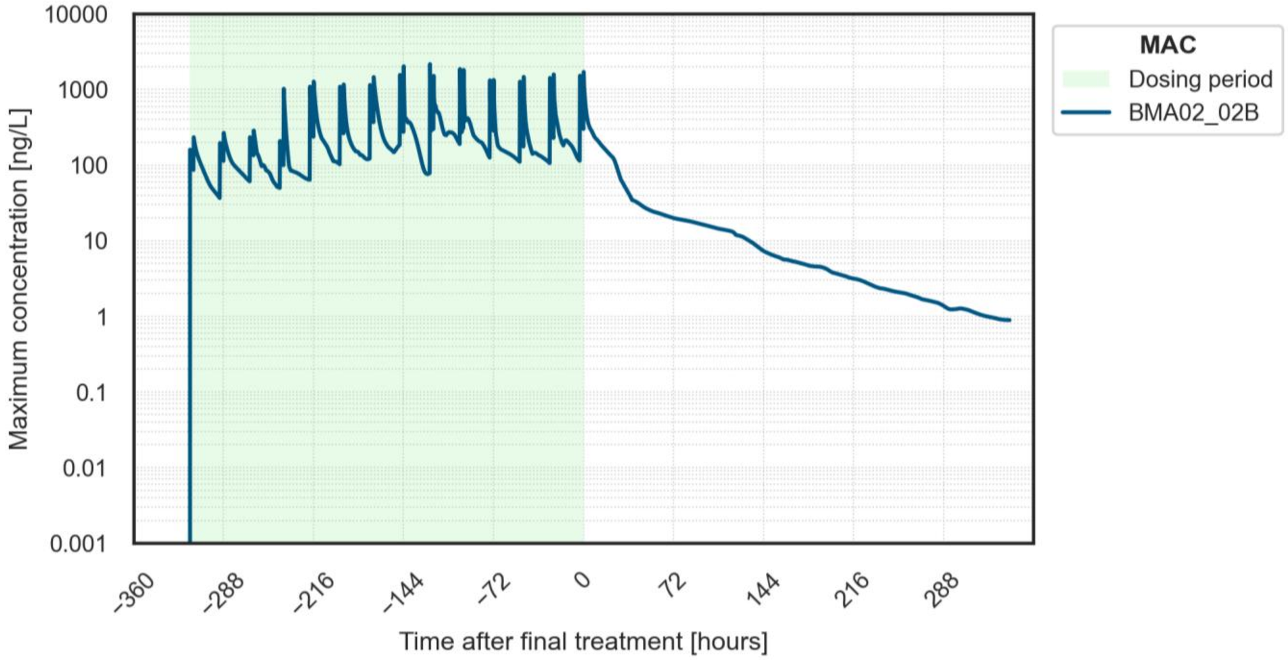


Figure 4.5 Maximum Allowable Concentration for BMA2 + 2B During Spring Tide

4.2.3 BMA3i Exposure Zone Profile (Figure 4.6 and Figure 4.7)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Belle Island farm.
- During the neap tide simulation, the affected area never exceeded 2 km² and for spring tides it never exceeded 3 km².
- The maximum concentration during the neap tide scenario was 300 ng/L, while for the spring tide scenario, it was 450 ng/L.
- The peak concentration occurred during the treatment of the first farm, McGrath Cove South and then gradually declined over time.

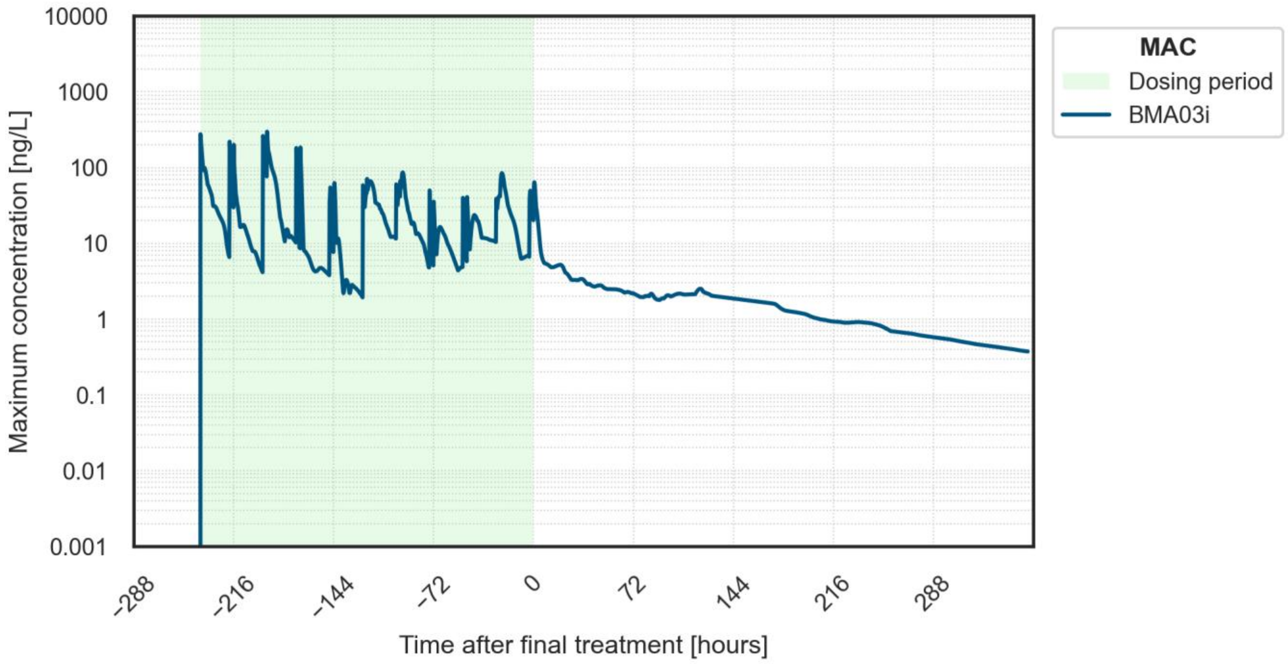


Figure 4.6 Maximum Allowable Concentration for BMA3i During Neap Tide

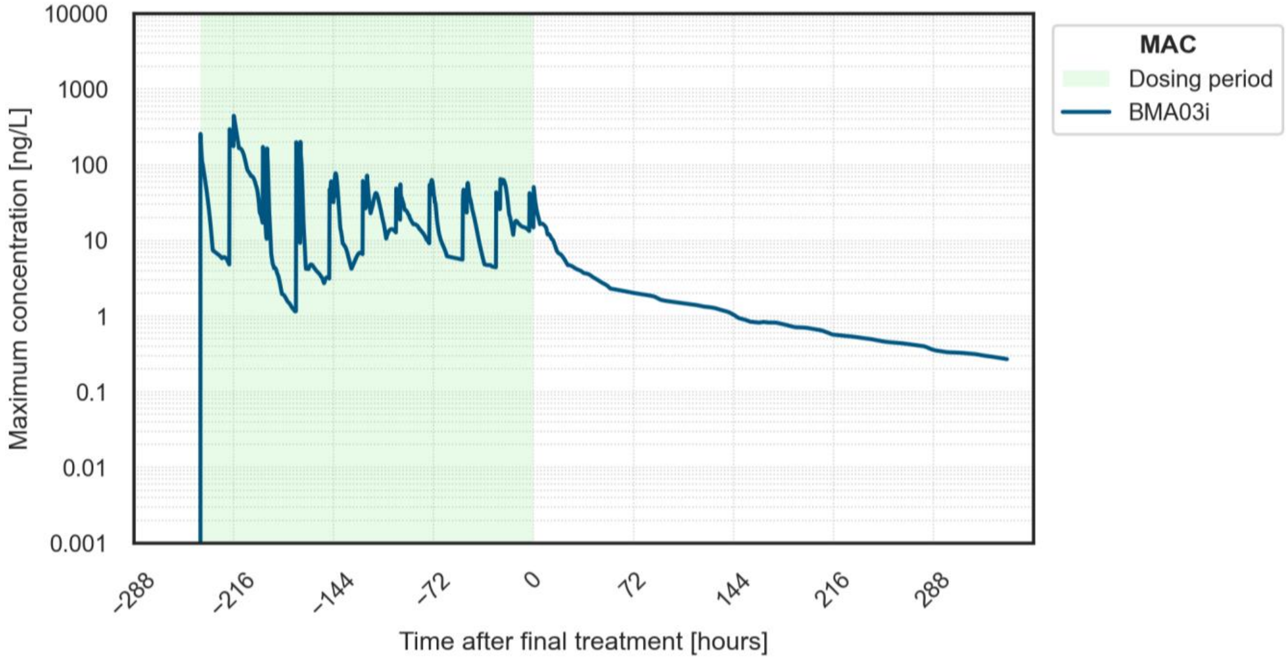


Figure 4.7 Maximum Allowable Concentration for BMA3i During Spring Tide

4.2.4 BMA3ii Exposure Zone Profile (Figure 4.8 and Figure 4.9)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Steamers Head farm.
- During the neap tide simulation, the affected area never exceeded 5 km², and for spring tides, it never exceeded 4 km².
- The maximum concentration during the neap tide scenario was 490 ng/L, while for the spring tide scenario, it was 660 ng/L.
- The peak concentration occurred during the treatment of the first farm, Hickman's Point and then gradually declined over time.

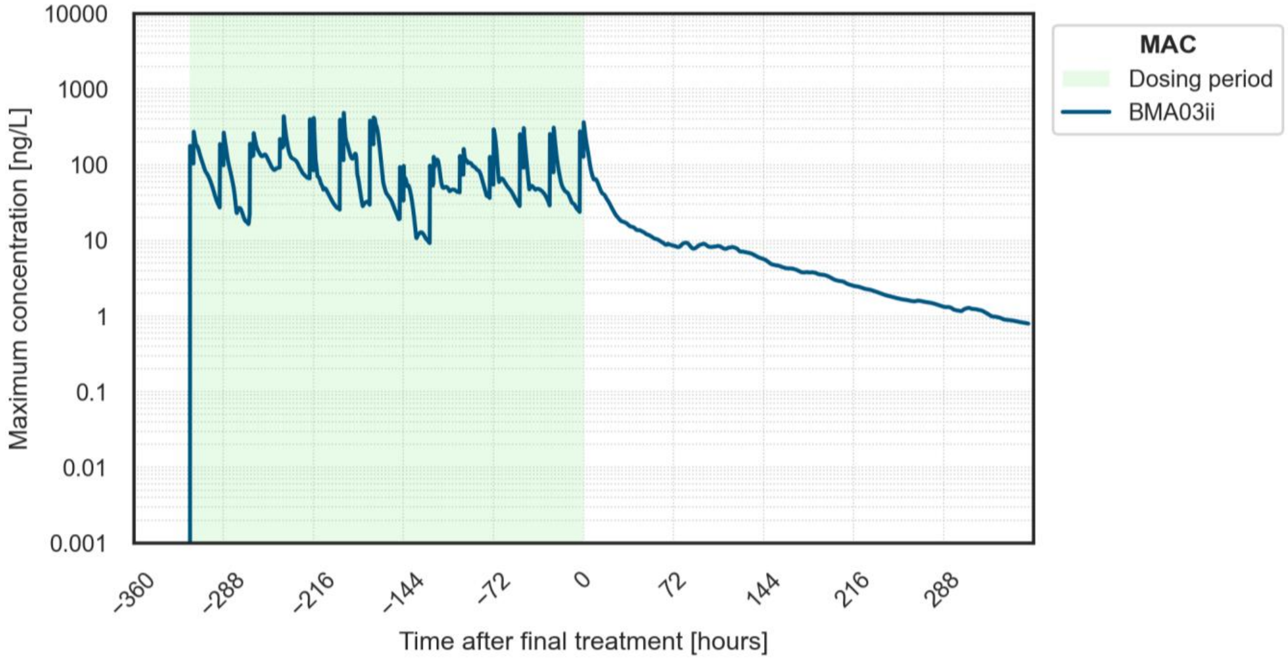


Figure 4.8 Maximum Allowable Concentration for BMA3ii During Neap Tide

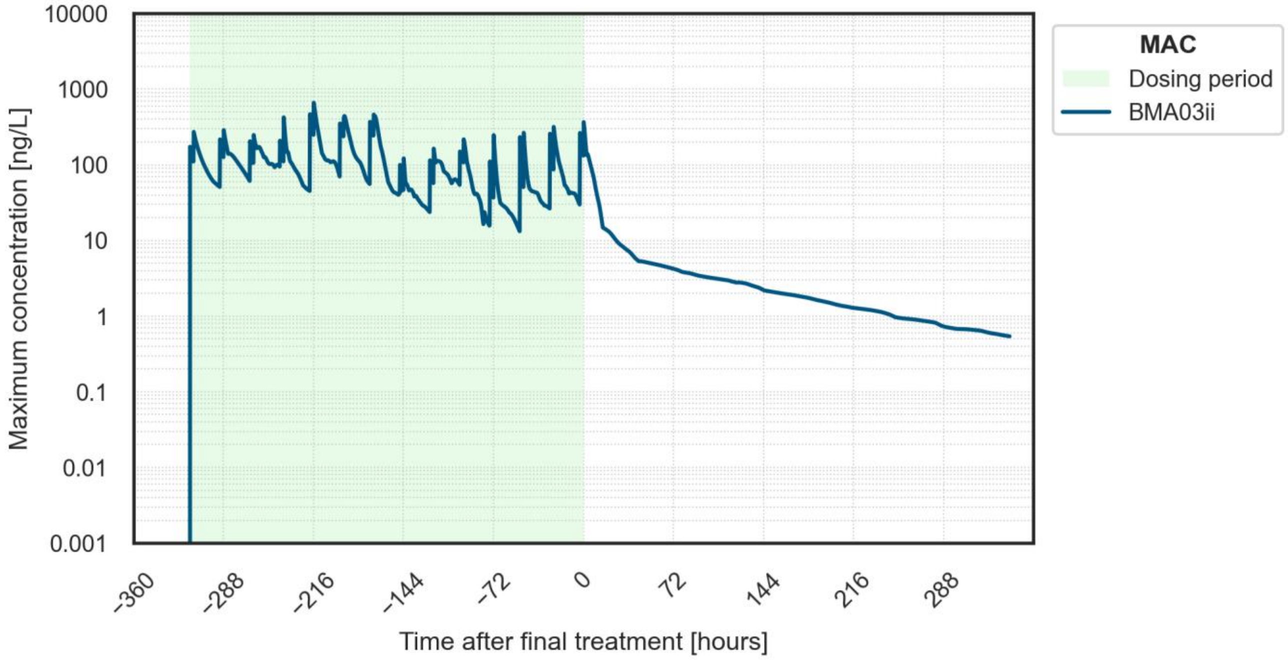


Figure 4.9 Maximum Allowable Concentration for BMA3ii During Spring Tide

4.2.5 BMA3iii Exposure Zone Profile (Figure 4.10 and Figure 4.11)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Iron Skull farm.
- For both the neap and spring tide simulations, the affected area never exceeded 4 km².
- The maximum concentration during the neap tide scenario was 880 ng/L, while for the spring tide scenario, it was 670 ng/L.
- The peak maximum concentration occurred during the treatment of the second farm, Cinq Island and then gradually declined over time.

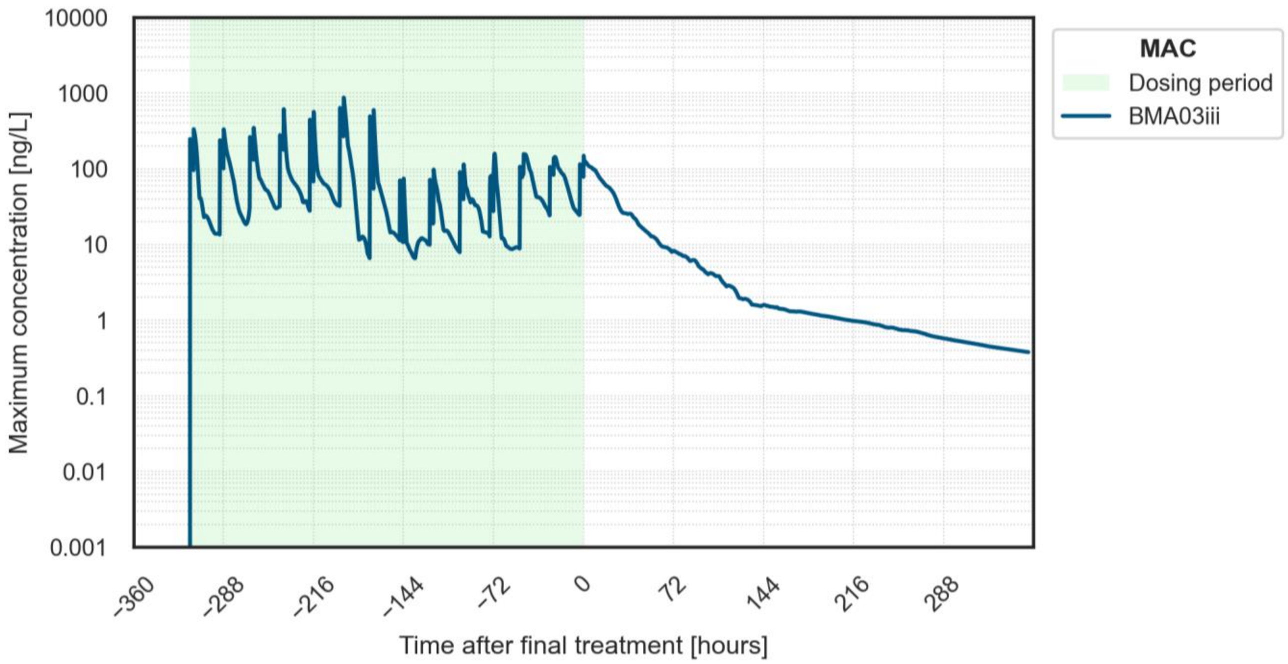


Figure 4.10 Maximum Allowable Concentration for BMA3iii During Neap Tide

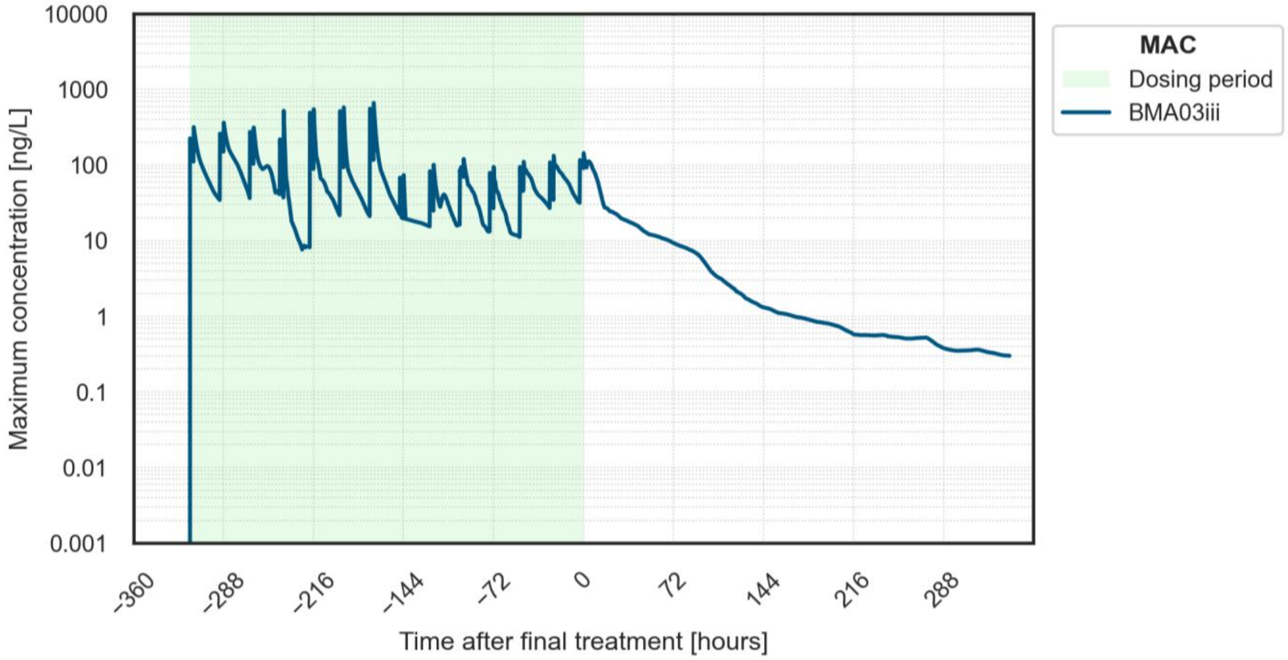


Figure 4.11 Maximum Allowable Concentration BMA3iii During Spring Tide

4.2.6 BMA4 Exposure Zone Profile (Figure 4.12 and Figure 4.13)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Murphy's Point farm.
- During the neap tide simulation, the affected area never exceeded 3 km², and for spring tides, it never exceeded 2 km².
- The maximum concentration during the neap tide scenario was 720 ng/L, while for the spring tide scenario, it was 670 ng/L.
- The peak concentration occurred during the treatment of the last farm, Murphy's Point and then gradually declined over time.

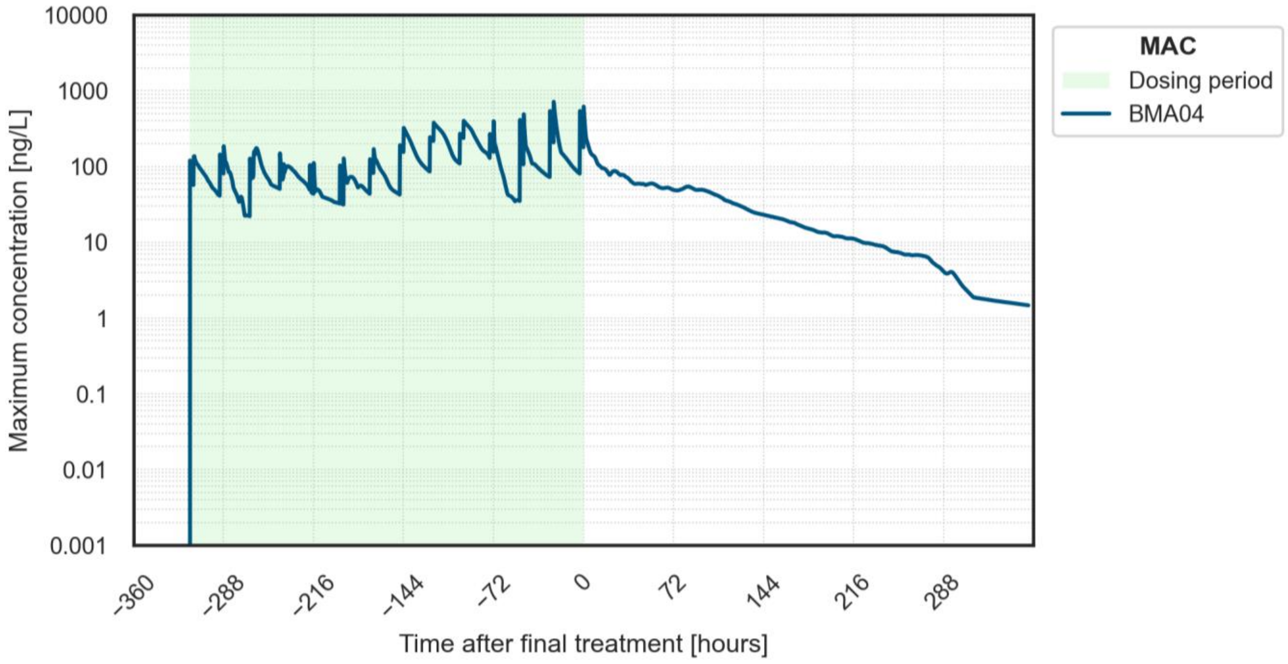


Figure 4.12 Maximum Allowable Concentration for BMA4 During Neap Tide

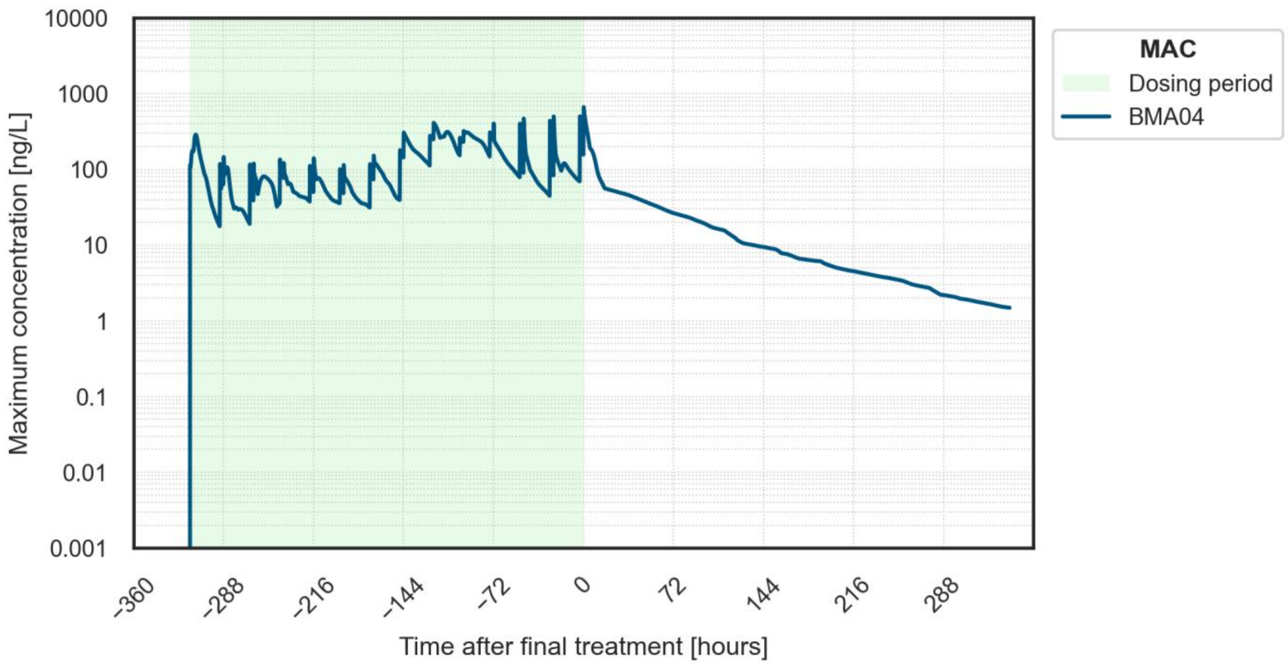


Figure 4.13 Maximum Allowable Concentration for BMA4 During Spring Tide

4.2.7 BMA5 Exposure Zone Profile (Figure 4.14 and Figure 4.15)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Broad Cove farm.
- For both the neap and spring tide simulations, the affected area never exceeded 2 km².
- The maximum concentration during the neap tide scenario was 970 ng/L, while for the spring tide scenario, it was 1100 ng/L.
- The peak maximum concentration occurred during the treatment of the last farm, Broad Cove and then gradually declined over time.

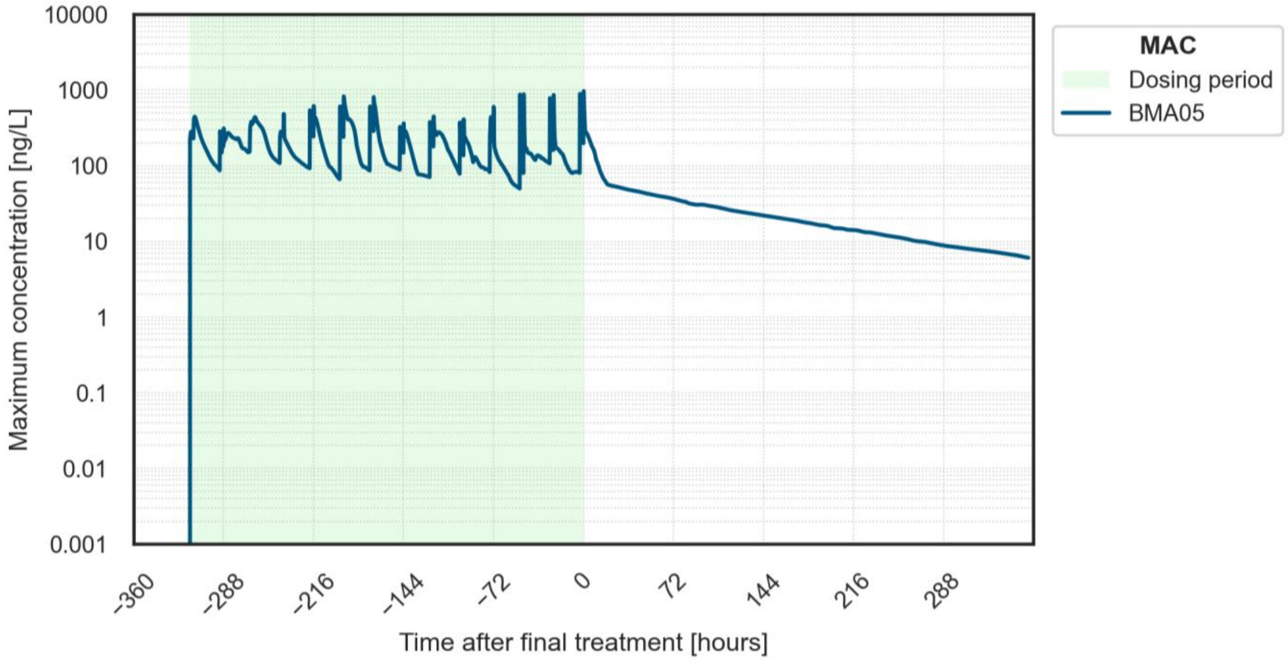


Figure 4.14 Maximum Allowable Concentration for BMA5 During Neap Tide

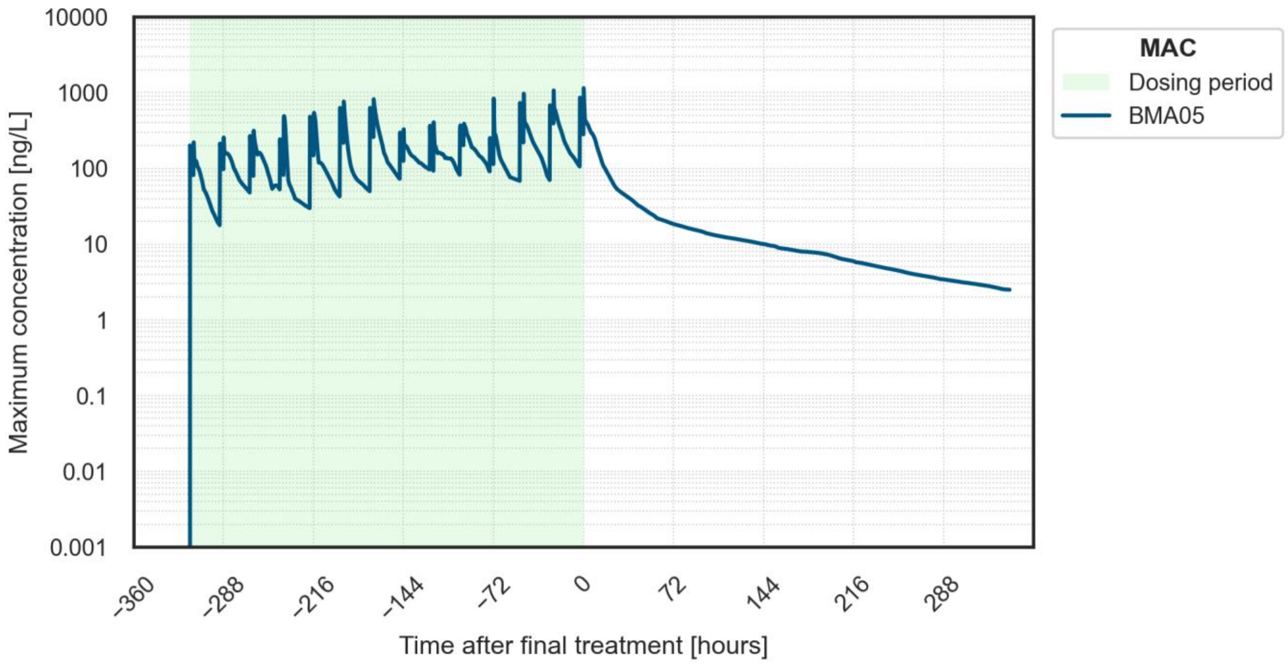


Figure 4.15 Maximum Allowable Concentration for BMA5 During Spring Tide

4.2.8 BMA8 Exposure Zone Profile (Figure 4.16 and, Figure 4.17)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Seal Nest Cove farm.
- During the neap tide simulation, the affected area never exceeded 4 km² and for spring tides it never exceeded 5 km².
- The maximum concentration during the neap tide scenario was 160 ng/L, while for the spring tide scenario, it was 190 ng/L.
- The peak maximum concentration occurred during the treatment of the third farm, Strickland Cove and then gradually declined over time.

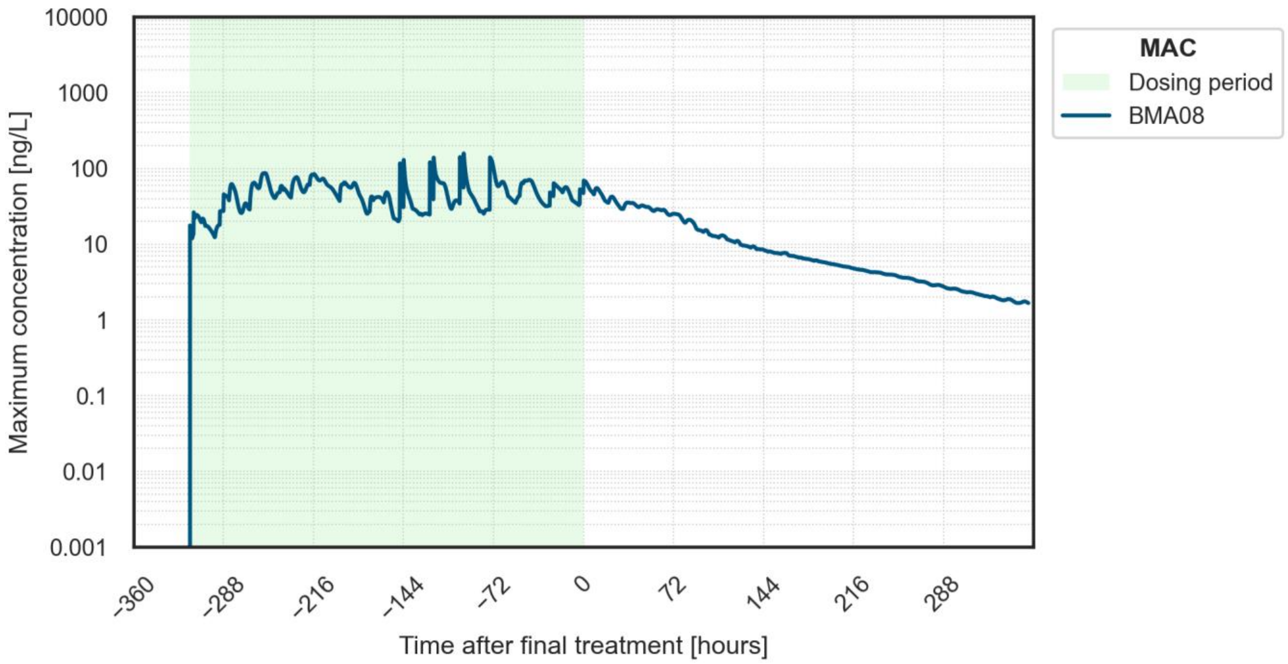


Figure 4.16 Maximum Allowable Concentration for BMA8 During Neap Tide

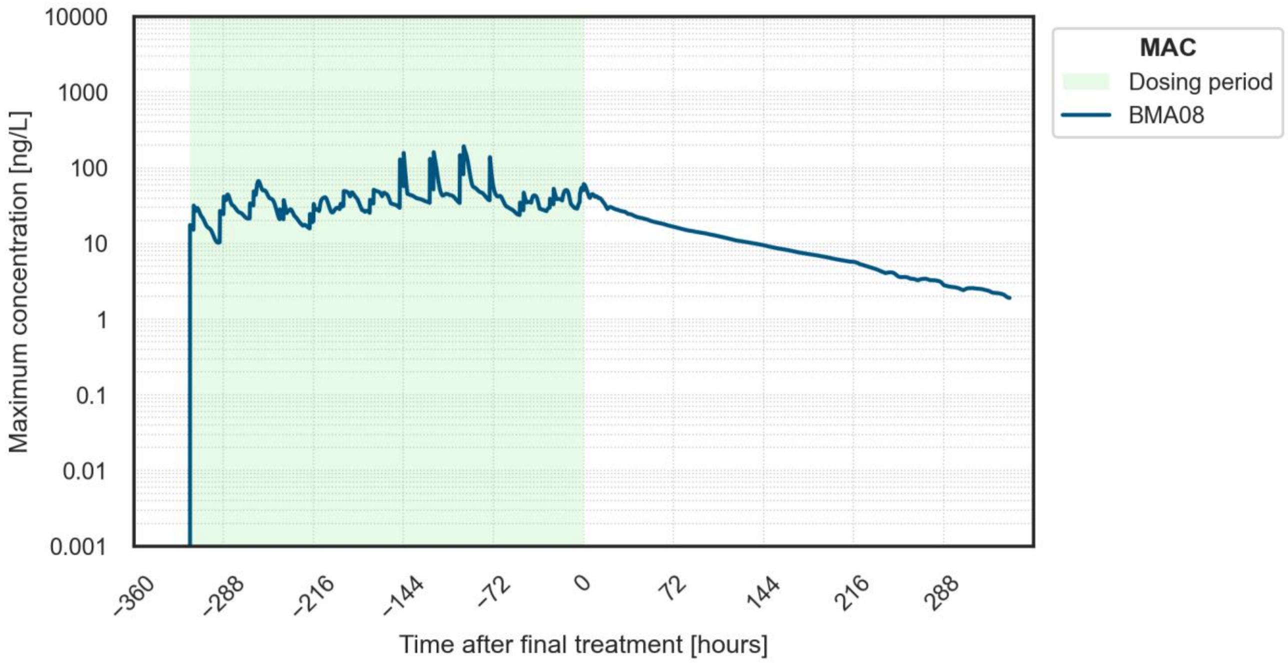


Figure 4.17 Maximum Allowable Concentration for BMA8 During Spring Tide

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4.2.9 BMA9 Exposure Zone Profile (Figure 4.18 and Figure 4.19)

- In both plots, '0' represents the time of the final treatment at Pen 7 of the Jervis Island farm.
- For both the neap and spring tide simulations, the affected area never exceeded 3 km².
- The maximum concentration during the neap tide scenario was 96 ng/L, while for the spring tide scenario, it was 110 ng/L.
- The peak maximum concentration occurred during the treatment of the second farm, Butter Cove and then gradually declined over time.

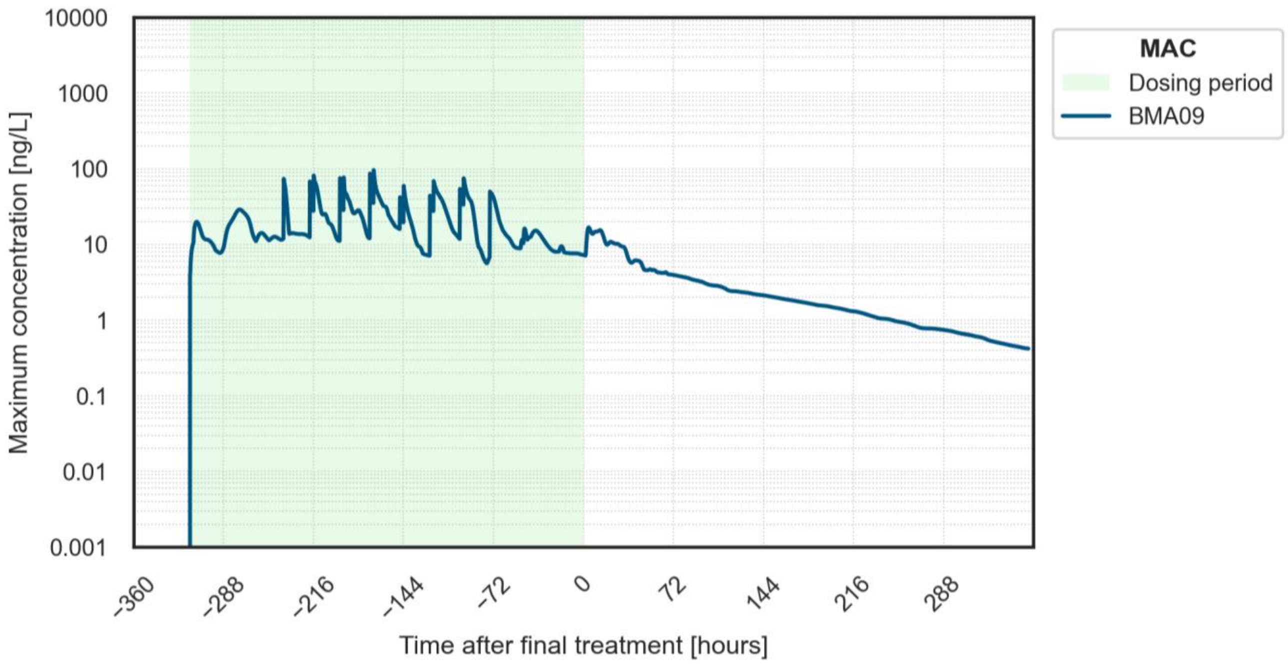

Figure 4.18 Maximum Allowable Concentration for BMA9 During Neap Tide

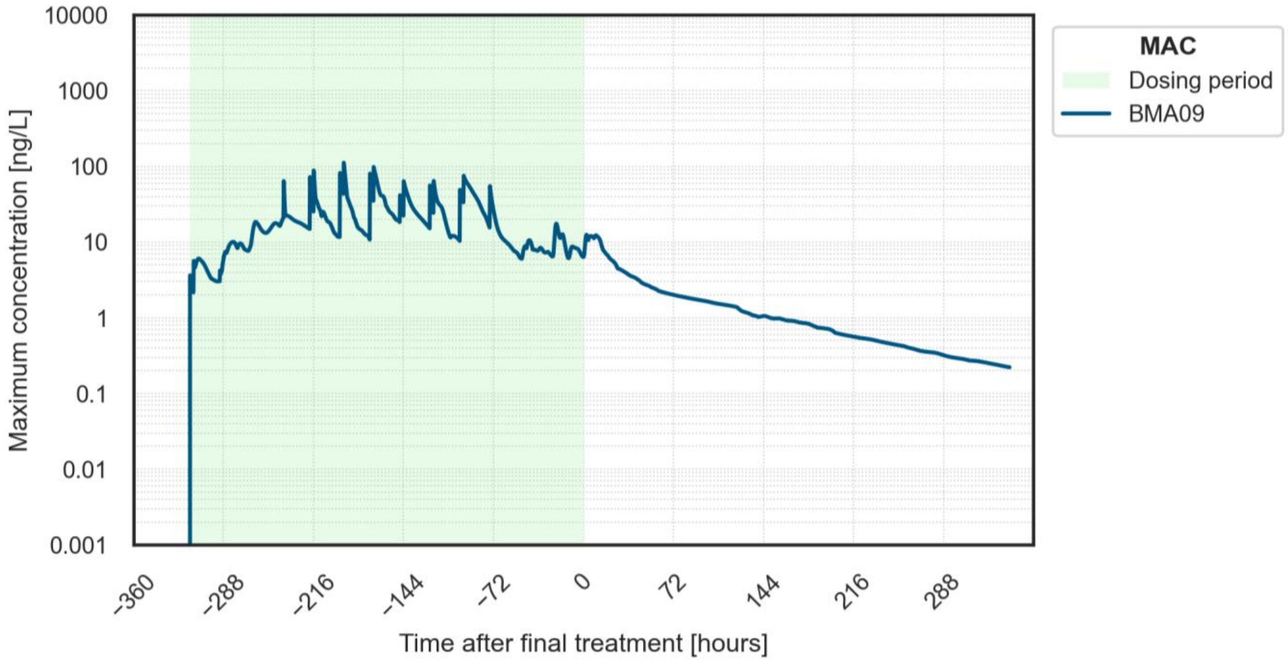

Figure 4.19 Maximum Allowable Concentration for BMA9 During Spring Tide

4.2.10 BMA10 Exposure Zone Profile (Figure 4.20 and Figure 4.21)

- In both plots, '0' represents the time of the final treatment at Pen 10 of the Wild Cove farm.
- During the neap tide simulation, the affected area never exceeded 5 km² and for spring tides it never exceeded 4 km².
- The maximum concentration during the neap tide scenario was 110 ng/L, while for the spring tide scenario, it was 95 ng/L.
- The peak maximum concentration occurred during the treatment of the second farm, Wallace Cove and then gradually declined over time.

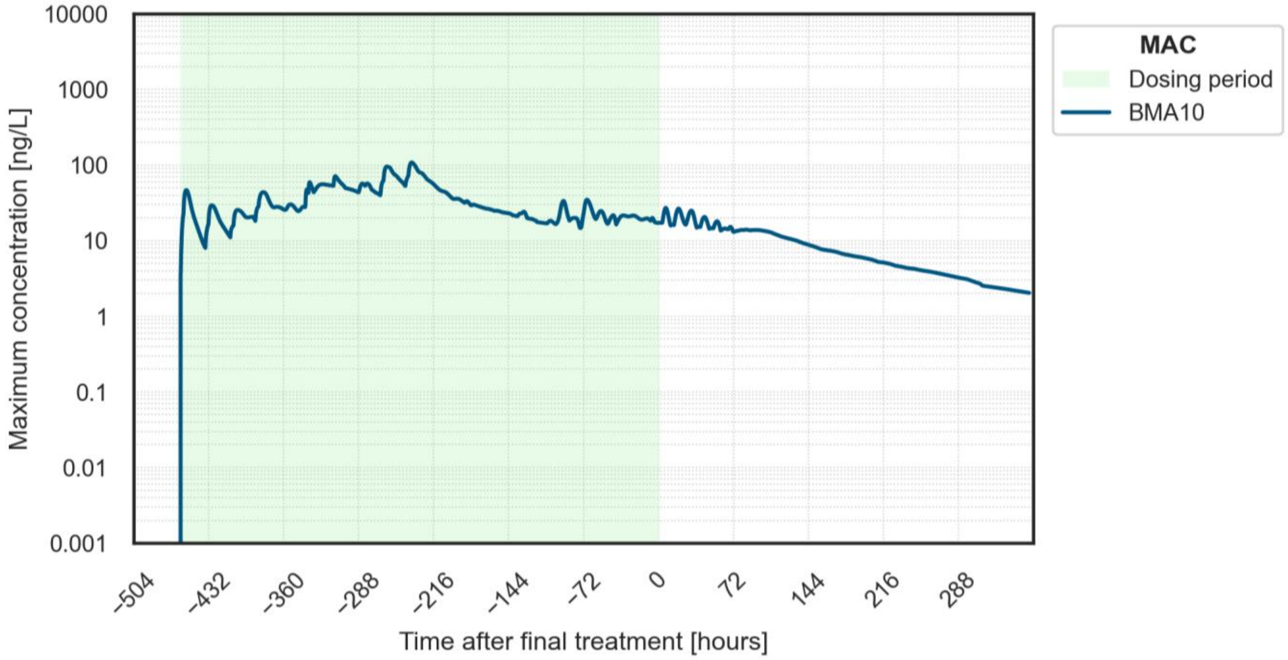

Figure 4.20 Maximum Allowable Concentration for BMA10 During Neap Tide

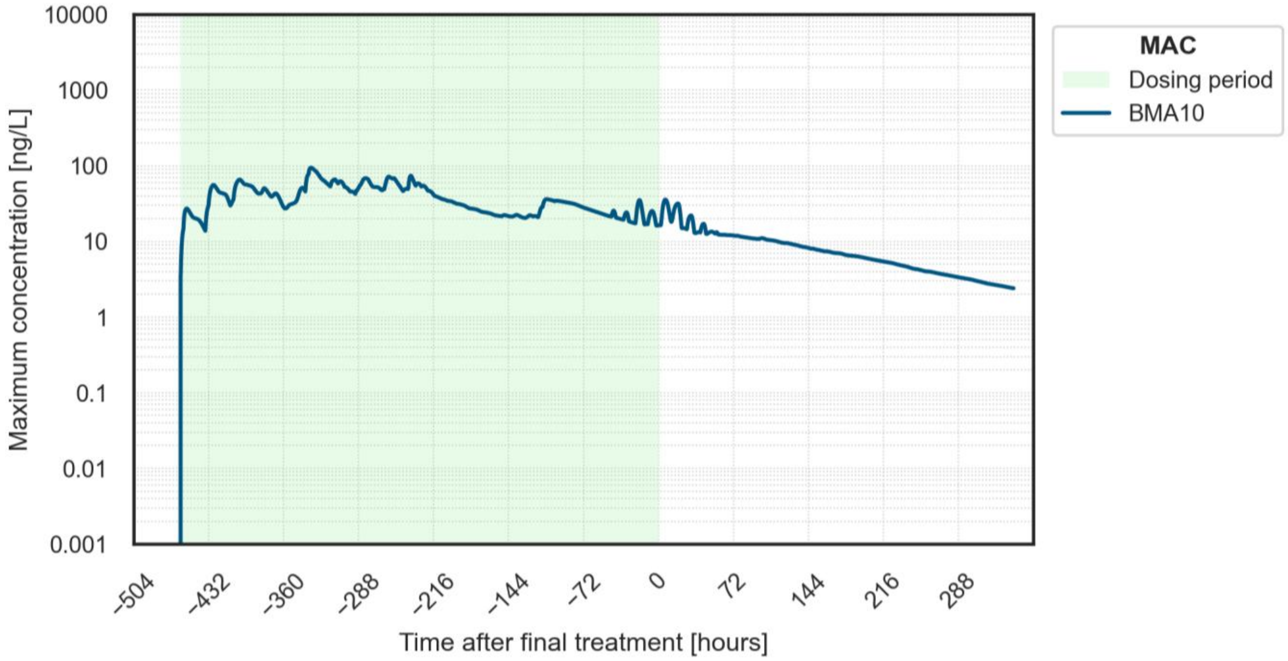

Figure 4.21 Maximum Allowable Concentration for BMA10 During Spring Tide

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4.2.11 BMA11 Exposure Zone Profile (Figure 4.22 and Figure 4.23)

- In both plots, '0' represents the time of the final treatment at Pen 10 of the Bob Locke farm.
- During the neap tide simulation, the affected area never exceeded 3 km² and for spring tides it never exceeded 4 km².
- The maximum concentration during the neap tide scenario was 17 ng/L, while for the spring tide scenario, it was 18 ng/L.
- The peak maximum concentration occurred during the treatment of the second farm, Bob Locke and then gradually declined over time.

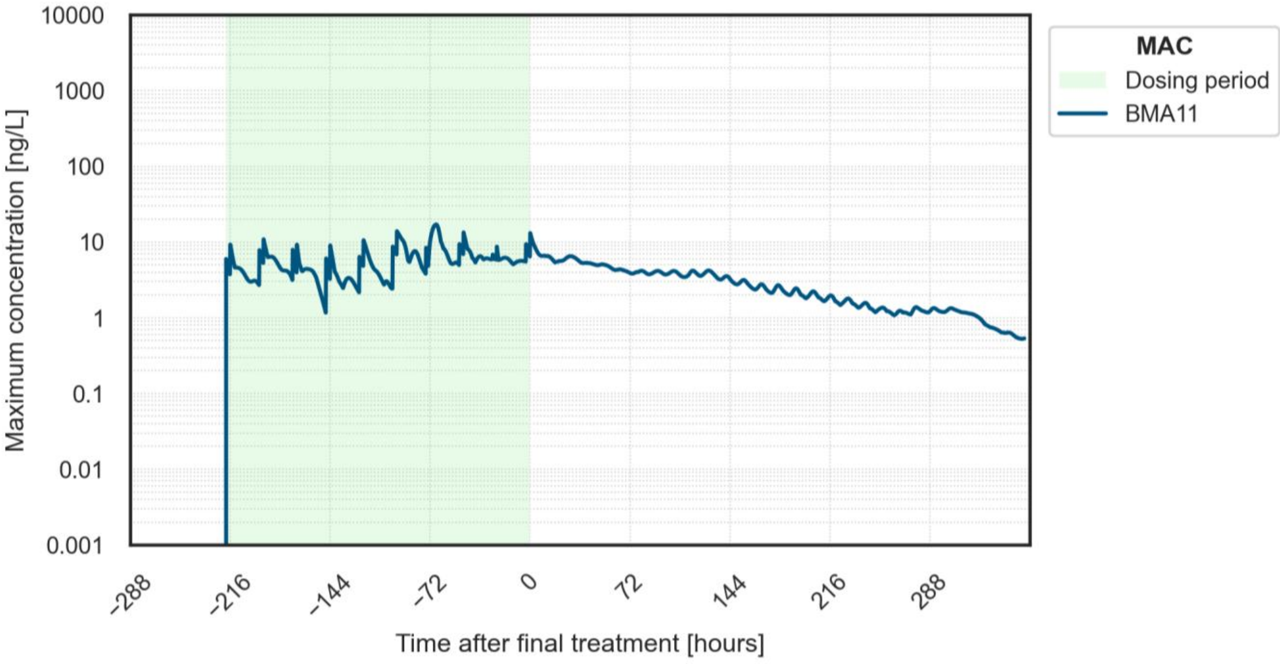

Figure 4.22 Maximum Allowable Concentration for BMA11 for Neap Tide

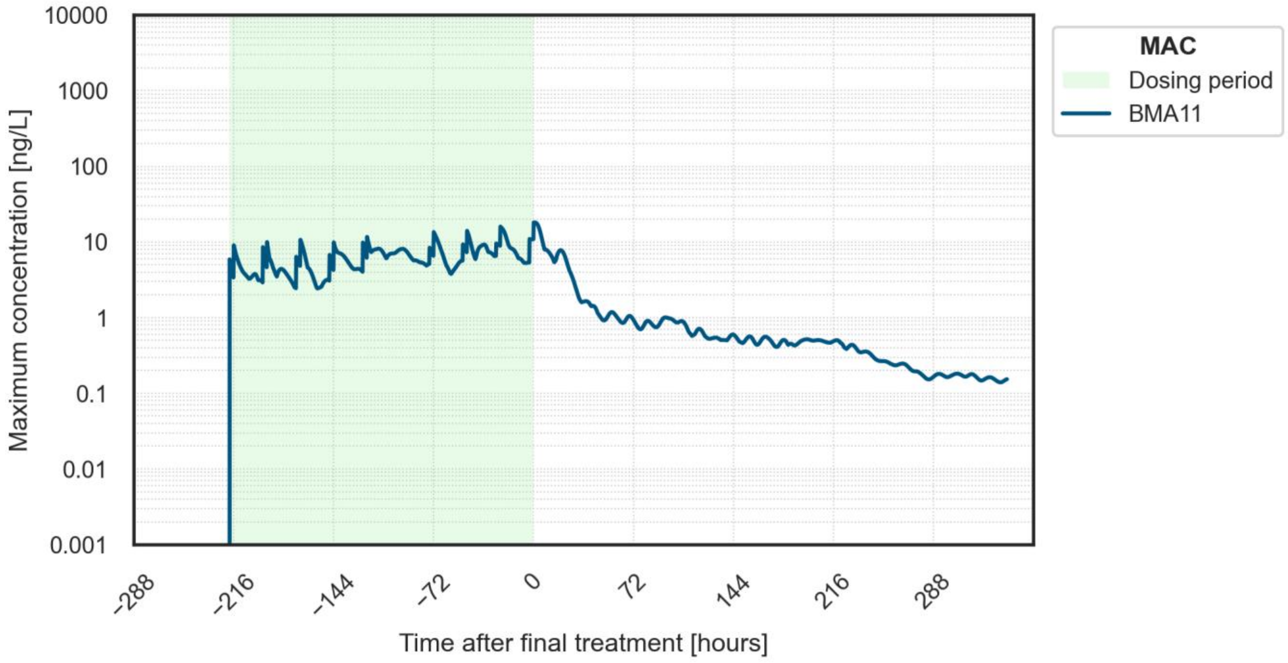

Figure 4.23 Maximum Allowable Concentration for BMA11 During Spring Tide

4.2.12 BMA12 Exposure Zone Profile (Figure 4.24 and Figure 4.25)

- In both plots, '0' represents the time of the final treatment at Pen 10 of the Devil Bay farm.
- For both the neap and spring tide simulations, the affected area never exceeded 3 km^2.
- The maximum concentration during the neap tide scenario was 97 ng/L, while for the spring tide scenario, it was 110 ng/L.
- The peak maximum concentration occurred during the treatment of the second farm, Recontre Bay and then gradually declined over time.

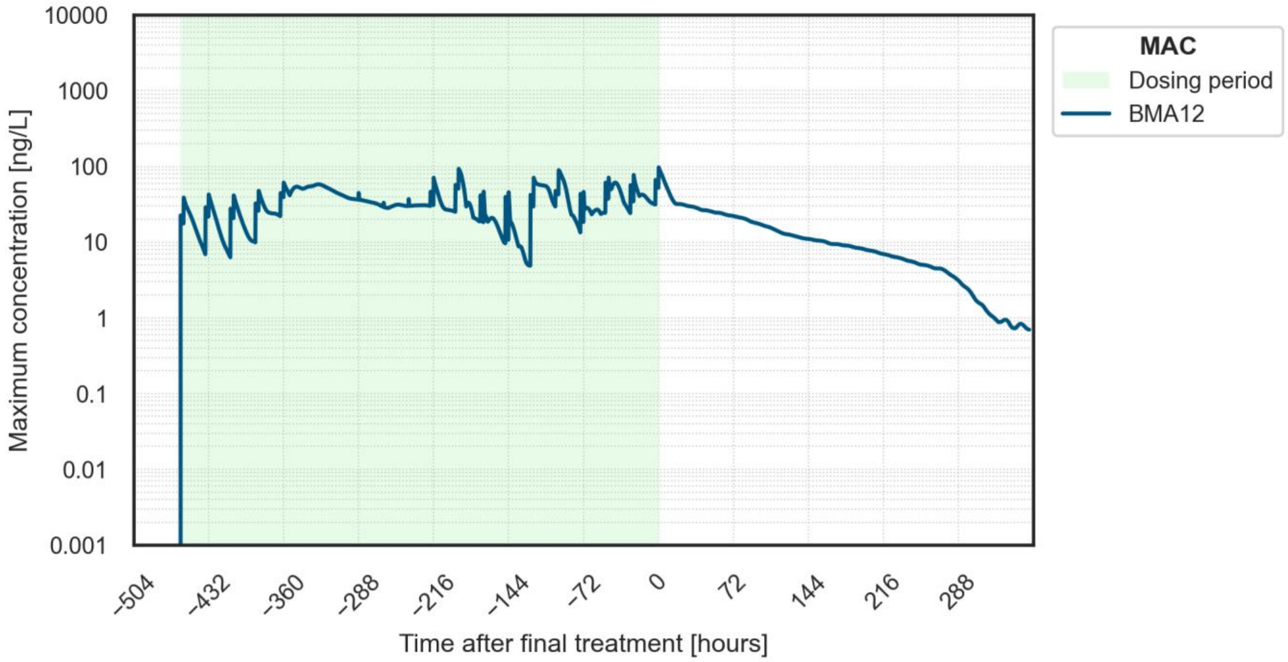

Figure 4.24 Maximum Allowable Concentration for BMA12 During Neap Tide

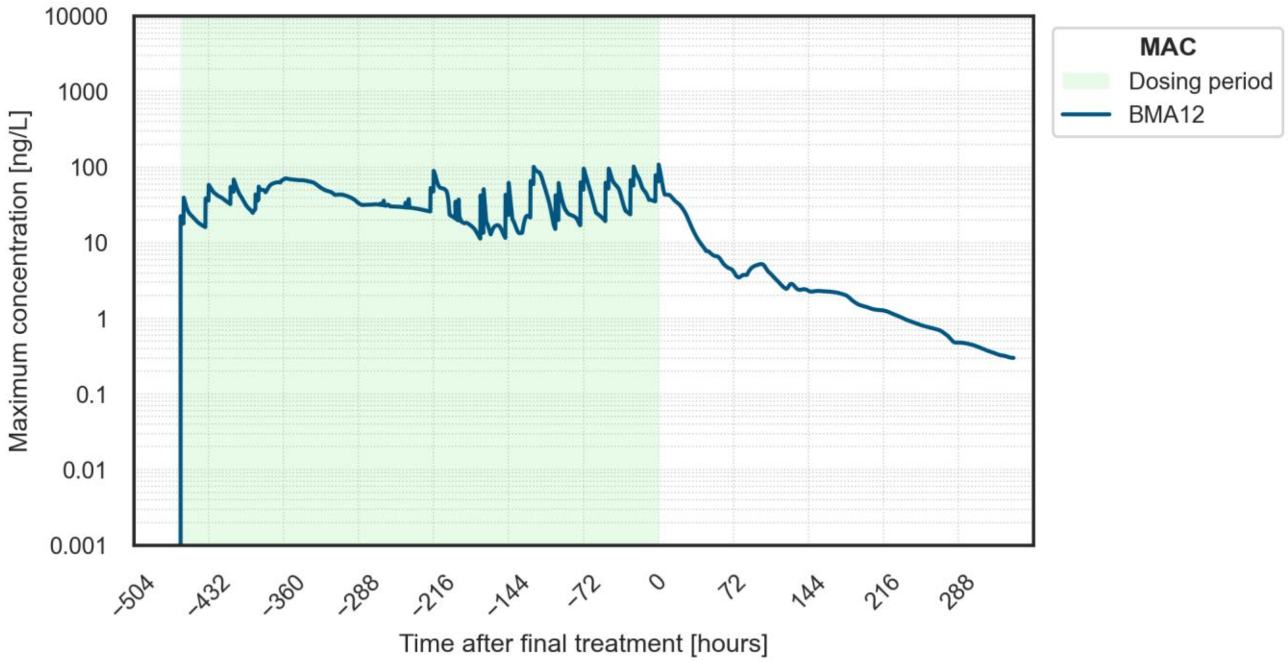

Figure 4.25 Maximum Allowable Concentration for BMA12 During Spring Tide

4.2.13 BMA13 Exposure Zone Profile (Figure 4.26 and Figure 4.27)

- In both plots, '0' represents the time of the final treatment at Pen 10 of the Shooter Point farm.
- For both the neap and spring tide simulations, the affected area never exceeded 4 km².
- The maximum concentration during the neap tide scenario was 75 ng/L, while for the spring tide scenario, it was 97 ng/L.
- The peak maximum concentration occurred during the treatment of the second farm, Friar Cove and then gradually declined over time.

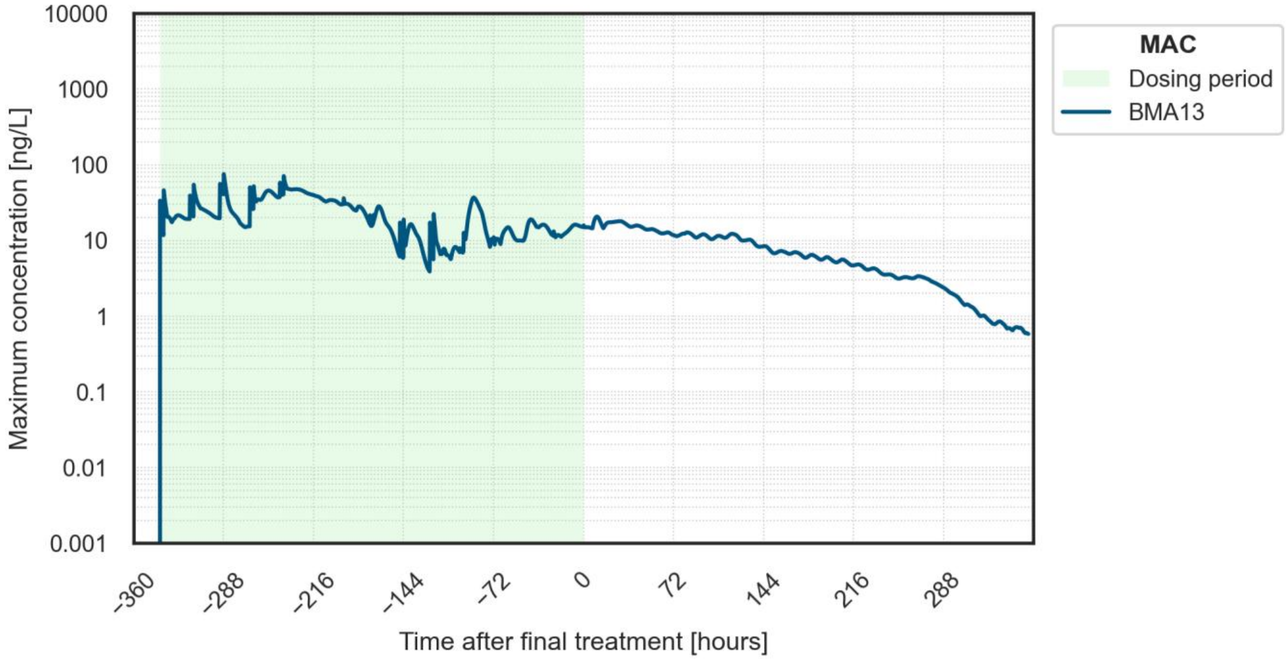

Figure 4.26 Maximum Allowable Concentration for BMA13 During Neap Tide

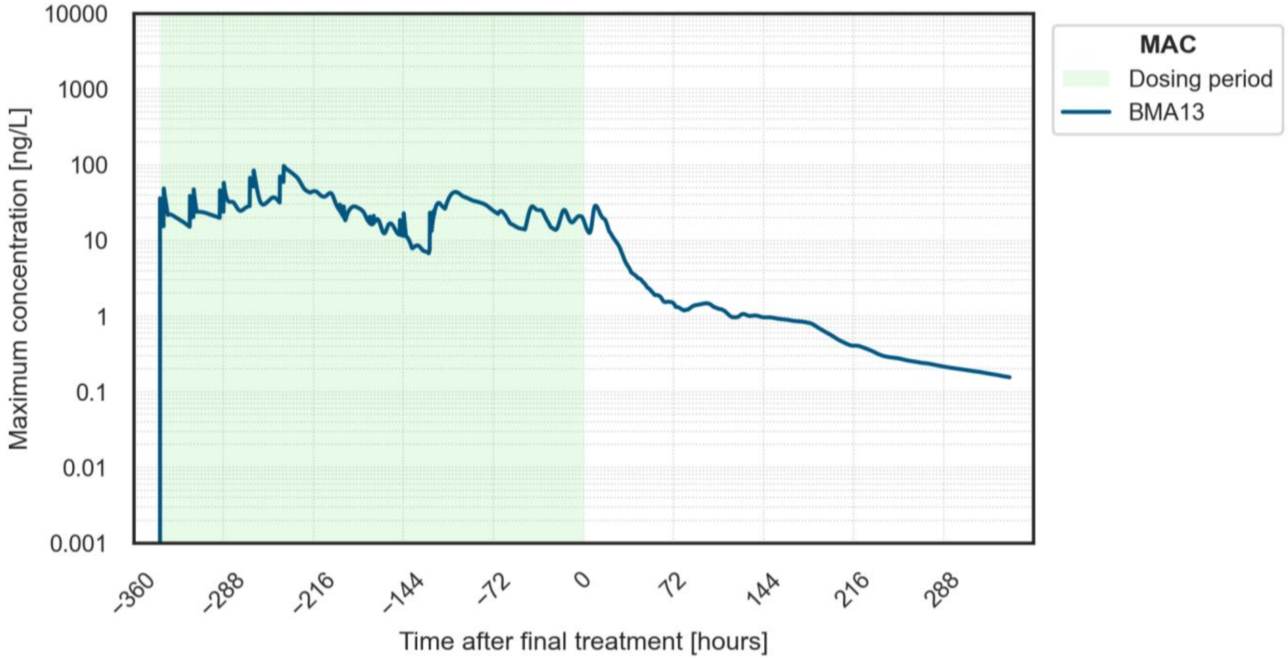

Figure 4.27 Maximum Allowable Concentration for BMA13 During Spring Tide

4.2.14 BMA14 Exposure Zone Profile (Figure 4.28 and Figure 4.29)

- In both plots, '0' represents the time of the final treatment at Pen 10 of the Foots Cove farm.
- During the neap tide simulation, the affected area never exceeded 4 km² and for spring tides it never exceeded 3 km².
- The maximum concentration during the neap tide scenario was 110 ng/L, while for the spring tide scenario, it was 110 ng/L.
- The maximum concentration was below 6 ng/L after 72 hours of the final treatment for both neap and spring conditions.
- The peak maximum concentration occurred during the treatment of the second farm, Aviron South and then gradually declined over time after the completion of all treatments.

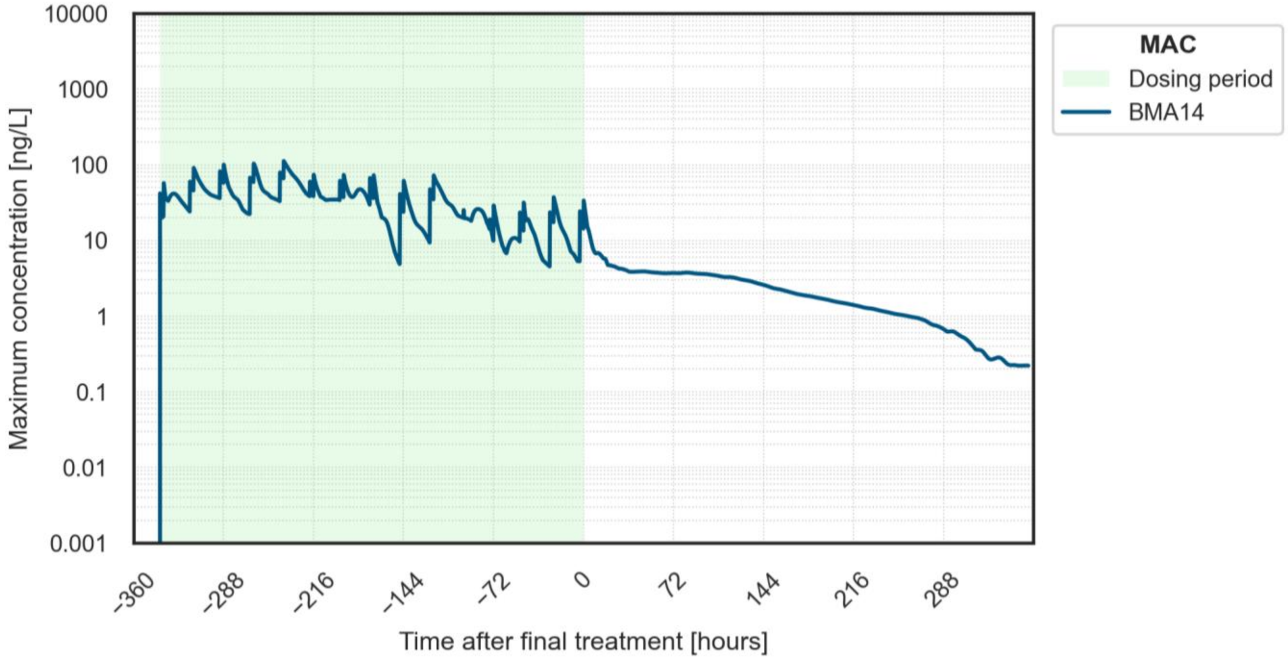

Figure 4.28 Maximum Allowable Concentration for BMA14 During Neap Tide

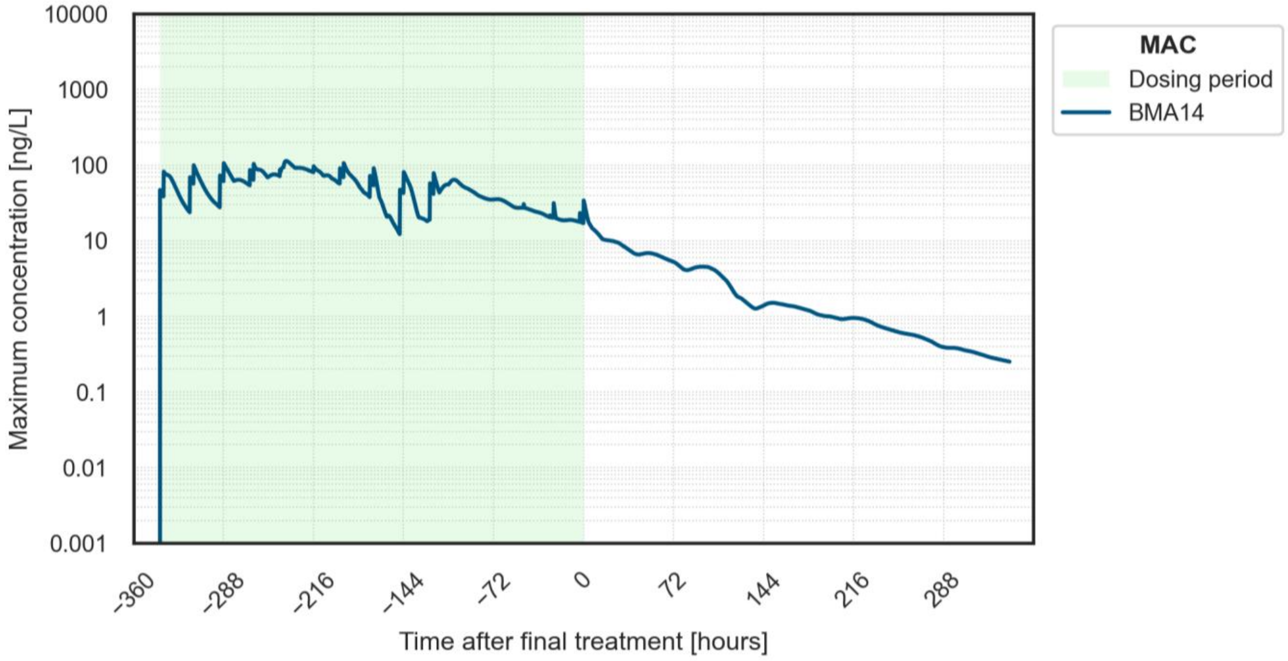

Figure 4.29 Maximum Allowable Concentration for BMA14 During Spring Tide

4.2.15 BMA15 Exposure Zone Profile (Figure 4.30 and Figure 4.31)

- In both plots, '0' represents the time of the final treatment at Pen 10 of the Denny Island farm.
- During the neap tide simulation, the affected area never exceeded 7 km² and for spring tides it never exceeded 4 km².
- The maximum concentration during the neap tide scenario was 100 ng/L, while for the spring tide scenario, it was 100 ng/L.
- The maximum concentration was below 10 ng/L after 72 hours of the final treatment for both neap and spring conditions.
- The peak maximum concentration occurred during the treatment of the second farm, Gnat's Island and then gradually declined over time after the completion of all treatments.

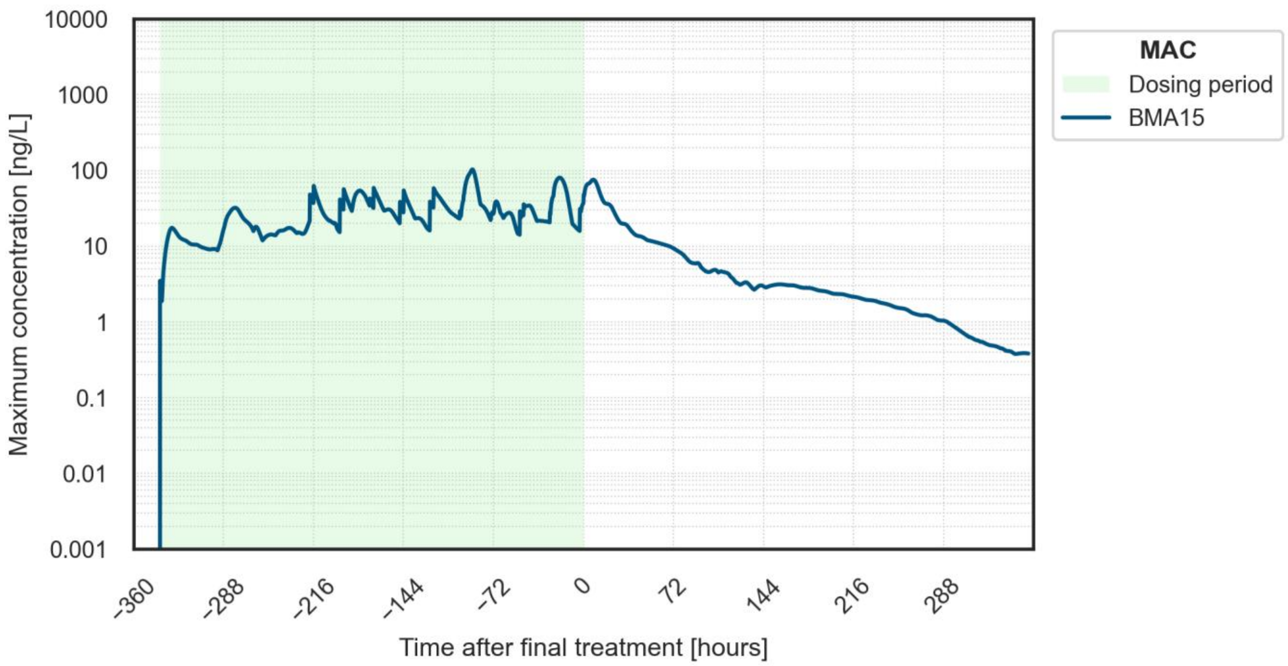

Figure 4.30 Maximum Allowable Concentration for BMA15 During Neap Tide

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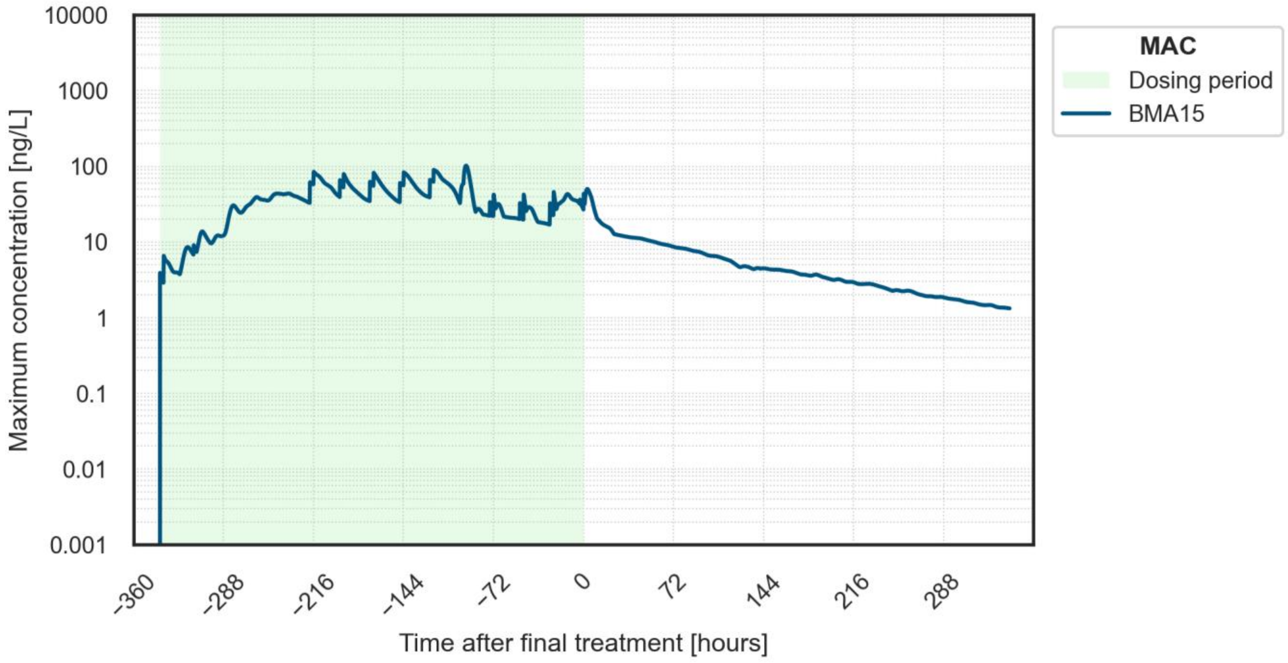

Figure 4.31 Maximum Allowable Concentration for BMA15 During Spring Tide

4.3 Summary of Maximum Azamethiphos Concentration

Table 4.1 summarises the maximum Azamethiphos concentrations for both neap and spring tide scenarios across each BMA. The highest concentration was recorded in BMA2+2B during the spring scenario, reaching 2200 ng/L. In contrast, the lowest maximum concentration was observed in BMA11, with 17 ng/L during the neap scenario. Farms located in Bays West consistently remained below 110 ng/L across all farms, while Bays East recorded relatively higher maximum concentrations.

Table 4.1 Maximum Azamethiphos Concentration [ng / L] During Each Scenario for Each BMA

BMA	Neap Scenario	Spring Scenario
01	740	670
02 + 2B	2000	2200
03i	300	450
03ii	490	660
03iii	880	670
04	720	670
05	970	1100
08	160	190
09	96	110
10	110	95
11	17	18

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BMA	Neap Scenario	Spring Scenario
12	97	110
13	75	97
14	110	110
15	100	100

4.4 Summary of Maximum Area Exceedance

Table 4.2 summarises the maximum area exceedance, which is maximum area within each BMA where bath treatment concentration exceeds 100 ng/L during the treatment duration for both neap and spring tide scenarios across each BMA. The highest affected area was recorded in BMA15 during the neap scenario, reaching 6.823 km^2. In contrast, the lowest affected area was observed in BMA5, with 1.431 km^2 during the spring scenario. For the majority of sites, the affected area is smaller during spring tides. This may be because the stronger tidal currents during spring tides lead to more extensive mixing and flushing. This increased water movement can disperse the bath treatment more effectively, reducing its concentration and potential impact in a particular area, thereby minimising the affected zone.

Table 4.2 Maximum area exceedance [area exceeding 100 ng / L of Azamethiphos in km^2]

BMA	Neap Scenario	Spring Scenario
01	4.448	2.563
02 + 2B	3.826	5.023
03i	1.799	2.105
03ii	4.161	3.866
03iii	3.468	3.753
04	3.036	1.502
05	1.905	1.431
08	3.072	4.224
09	2.350	2.175
10	4.391	3.590
11	2.498	4.019
12	2.325	2.325
13	3.973	3.423
14	3.965	2.124
15	6.823	3.145

4.5 Marine Sensitive Area

Simulated Azamethiphos concentrations were examined throughout the dosing periods and afterward at nearby marine sensitive areas. All simulated concentrations remained below 0.01 ng/L except for at Sandbanks Provincial Park, located near BMA15, which recorded the maximum concentration of 0.05 ng/L (Table 4.3).

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Table 4.3 Maximum Azamethiphos Concentration [ng/L] During Each Scenario for Each Marine Sensitive Area

Provincial Protected Area	Neap Scenario	Spring Scenario
Big Barasway Wildlife Reserve	< 0.01	< 0.01
Sandbanks Provincial Park	0.05	< 0.01
Fortune Head Ecological Reserve	< 0.01	< 0.01
Frenchman's Cove Provincial Park	0.01	< 0.01

4.6 Mass Balance

A mass balance analysis was undertaken during a three-month simulation and the timeseries of volume, tracer mass, and concentration within the model domain were plotted (Figure 4.32). The results revealed that the residual tracer concentration remained negligible, accounting for less than 0.2 % throughout the entire three-month period. These findings provide strong evidence supporting the accuracy and reliability of the simulation. They also confirm that mass conservation is effectively maintained within the computational domain during the advection-dispersion calculations.

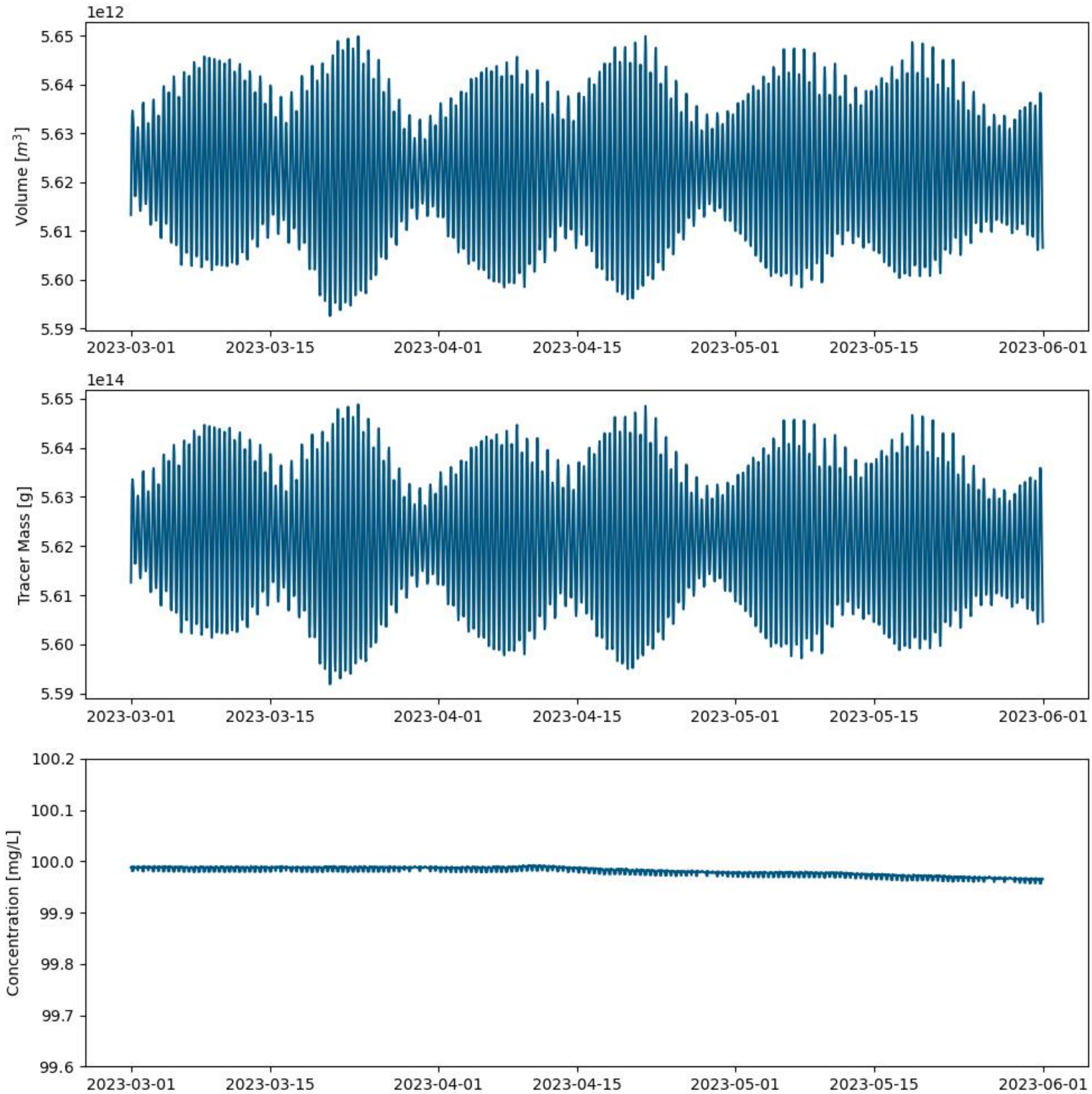

Figure 4.32 Mass Balance Plots for Volume, Tracer Mass and Tracer Concentration in the Model Domain

5 Discussion

5.1 Hydrodynamic Calibration and Validation

- Hydrodynamic calibration and validation are critical steps in ensuring the accuracy and reliability of dispersion models for fish health products like Azamethiphos. These processes are essential for several reasons (BMT 2022, 2023a, 2023b, Page et al., 2023a):
    - Accuracy in water movement prediction;
    - Regulatory compliance;
    - Enhanced risk assessment;
    - Conservative modelling approach; and
    - Optimised resolution.
- DFO advises that if model outputs are intended for decision-making purposes, the model should be validated using field observations that are pertinent to the specific type and area of application (Page et al., 2023a).

5.2 Neap and Spring Scenarios

Simulating both neap and spring tides is crucial for assessing Azamethiphos dispersion under varying tidal conditions. Spring tides, with stronger currents, enhance dispersion, while neap tides, with weaker currents, may result in slower dispersion and higher localised concentrations. This range of conditions helps ensure that potential worst-case scenarios are captured, providing a more comprehensive understanding of environmental risks.

5.3 Tracers for Dispersion Modelling

In this study an advection dispersion model using passive tracers was applied to simulate the fate and transport of bath treatment. While passive scalars rather than sinking particles, have been used previously to model pesticides (BMT, 2023a, BMT 2023b, Falconer and Hartnett, 1993, Paige et al., 2015), they can introduce numerical mixing artifacts. A pre-assessment comparing particles and tracers demonstrated that both methods yield similar model outcomes. It was concluded that tracers serve as a reliable approach for modelling the dispersion footprint of the pesticides, ensuring consistent and realistic diffusion patterns, particularly in complex topographies with limited data.

- For modelling purposes, each Bay Management Area (BMA) was assigned a single tracer type to assess the dispersion effects of each BMA on neighbouring BMAs. A total of 15 tracers were employed in this exercise.
- The underlying assumption in all models reviewed by the Canadian DFO is that the release of pesticides generates a patch containing the treatment pesticide, which varies in size, shape, location, and concentration over time (Page et al., 2023a). These characteristics of the patch can be used to determine the following exposure parameters: spatial extent, location, and duration of exposure. The TUFLOW FV - TRACER model employed in this study aligns with these assumptions.

5.4 Diffusivity

- Dispersion of Azamethiphos is influenced by horizontal and vertical diffusivity coefficients.

- Based on BMT's previous work in aquaculture modelling space (BMT,2023a, 2023b, 2022) it has been determined that, given the highly conservative approach applied in this exercise, minor changes in diffusivity would have a negligible impact on dispersion characteristics; thus, they have been omitted from consideration.

- Further, pre-assessment using particles provided reasonable cross-validation of the tracer model outcomes.

- However, for new farm sites, it is advisable to test the sensitivity of diffusivity when feasible, as it has an impact upon the size and concentration of treatment plumes which can be significant depending on hydrodynamic conditions.

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6 Conclusions and Recommendations

- This report outlines the methodology and results of the simulation of Azamethiphos, a fish health treatment product, across 53 farm sites along the south coast of Newfoundland, Canada. The work detailed in this report addresses the dispersion dynamics of Azamethiphos at each BMA and quantifies the individual exposure zones. Additionally, it included an objective study of the dispersion characteristics of the BMAs relative to local marine sensitive areas. The key objective was to provide technical information to support Mowi Canada East's Environmental Impact Statement by providing insights into the potential exposure zones for Azamethiphos.

- Results clearly demonstrated that different BMAs exhibit varying dispersion characteristics. For example, modelled results from BMAs 1 to 5 display relatively larger dispersion footprints compared to BMAs 8 to 15, primarily due to the poor flushing characteristics in the region. The highest modelled concentration was recorded in BMA2+2B during the spring scenario, reaching 2,200 ng/L. In contrast, the lowest maximum concentration was observed in BMA11, with a value of 17 ng/L during the neap scenario. Farms located in Bays West consistently remained below 110 ng/L across all sites. Independent of the location, simulation period representing spring or neap tides and / or hydrodynamic conditions Azamethiphos treatment dispersed rapidly for all 53 farms.

- Simulated Azamethiphos concentrations were analysed throughout the dosing periods and for 14 days once the treatment had ceased. The areas observed included the nearby Sandbanks Provincial Park. This is the only marine sensitive area within the vicinity, located approximately 35 km from Denny Island farm located in BMA15. The maximum concentration recorded in all simulations was 0.05 ng/L, highlighting the low likelihood of any impact on this sensitive receptor.

This numerical modelling study aimed at understanding Azamethiphos dispersion, provides valuable insights into the spatial extent, location, and duration of exposure. This study serves as a 'fit for purpose' modelling assessment, offering an initial understanding of the dispersion characteristics in the region. Once definitive threshold values are established, rigorous site-specific calibrations will be recommended for future studies to better understand local dispersion dynamics. This type of work also supports the development of targeted treatment plans that are optimised for the welfare of farmed fish, wild fish, and the broader environment.

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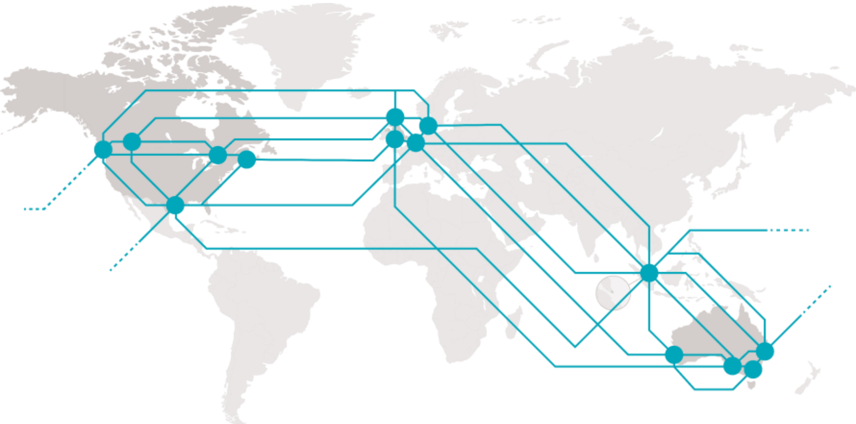

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