BAKKAFROST

ESTABLISHED 1968

The Finest Salmon from SCOTLAND

NewDEPOMOD and BathAuto Modelling Report

North Gravir, Isle of Lewis

Date	**7 March 2024**
Revision No.	**A1**
Author	**Liz Comer**
Approved By	**Penny Hawdon**

Table of Contents

1 Summary 5
2 Introduction 7
2.1 Site context 7
2.2 Site details 8
2.3 Site exposure 9
2.4 Modelling context 9
3 NewDepomod setup 10
3.1 Model hydrodynamics 10
Full-tide 10
Astronomic tide 14
3.2 Model bathymetry 14
3.3 Pen inputs 16
Feed and faeces 16
In-feed treatments 16
3.4 NewDepomod configuration 17
3.5 BathAuto configuration 17
4 Model outputs 18
4.1 Full- tide 18
Design Run 18
4.2 Sensitivity 20
Astro Tide 20
4.3 In-feed treatments 21
4.4 Bath treatments 21
5 Conclusion 22
5.1 Sediment dispersal 22
5.2 In-feed treatments 22
5.3 Bath treatments 22

Table of Figures

Figure 2.1: Location of the North Gravir site 8
Figure 2.2: Proposed site layout 9
Figure 3.1: Sampled velocity profiles for the hydrographic deployments used in this assessment. Deployment 1 is shown on the left and 2 on the right. 11
Figure 3.2: Water column velocities for an unedited velocity profile 11
Figure 3.3: Re-constructed astronomic time series at North Gravir 14
Figure 3.4: Bathymetry data available at the North Gravir site. 15
Figure 3.5: Interpolated bathymetry on the model grid with cages displayed 16
Figure 4.1: Full-tide, scoping runs used to define maximum permissible tonnage. 18
Figure 4.2: Average deposition throughout the model domain for simulated design runs 19
Figure 4.3: Reconstructed, Astronomic tide simulation outputs 20

Table of Tables

Table 1.1: Summary of modelling results 5
Table 2.1: Summary of North Gravir site information 8
Table 3.1: 90-day observed dataset summary data 10
Table 3.2: Directional roses of recorded velocities 13
Table 3.3: BathAuto – Key parameters 17
Table 4.1: Model runs assessing the impact of 4,680 T 19
Table 4.2: Model runs assessing the impact of 37g of EmBz 21
Table 4.3. Results of bath treatment modelling at North Gravir 21

List of Abbreviations

Terms	Definition
2D	Two-dimensional simulations along horizontal plane
3D	Three-dimensional simulations along horizontal and vertical plane
CAR	Controlled Activities Regulations
CTD	Conductivity, Temperature, Depth
EmBZ	Emamectin Benzoate (SLICE active ingredient)
EQS	Environmental Quality Standard
g/m^2/yr	Grams per square metre per year (deposition)
IQI	Infaunal Quality Index
mCD	Meters below Chart Datum (local)
NB	*Nota Bene:* Note Well
NDM	NewDepomod (simulation software)
OS	Ordnance Survey
SDM	Standard Default Method
SEPA	Scottish Environmental Protection Agency
BFS	Bakkafrost Scotland
T	Tonnes (biomass)
TAQ	Total Allowable Quantity
WEI	Wave Exposure Index
μ	Statistical mean
λ	Half-life

1 Summary

This report was written by The Bakkafrost Scotland (BFS) to meet the requirements of the Scottish Environment Protection Agency (SEPA) for a proposed new site, under the Controlled Activities Regulations ((CAR) 2011), updated by contemporary (July 2019[1]) and Interim (April 2022[2])) guidance. This report describes the methodology used to model the peak biomass and specific medicine quantities accepted by SEPA as permissible under CAR. A summary of the results of the proposed licenced quantities, assessed using SEPA default NewDepomod and BathAuto setups, are presented in Table 1.1.

Table 1.1: Summary of modelling results

Site details		
Site name		North Gravir
Site location		Isle of Lewis
Site configuration details		
Number of pens		5
Pen circumference		200 m
Net depth		15 m
Group layout		One group of 1x5
Hydrographic summary		
Sub-surface currents	Average speed and direction	0.159 m/s –180 °
	Average residual current	0.035m/s
Cage-bottom currents	Average speed and direction	0.155m/s – 177 °
	Average residual current	0.032m/s
Near-bed currents	Average speed and direction	0.128 m/s – 175 °
	Average residual current	0.027 m/s
Benthic modelling		
Peak biomass		4,680 T
Stocking density		19.60 kg/m^3
Bath treatments		

[1] SEPA (2019) *AQUACULTURE MODELLING: Regulatory Modelling Guidance for the Aquaculture Sector*: July 2019 – Version 1.1
[2] SEPA (2022) *AQUACULTURE MODELLING: Interim NewDepomod Guidance*: April 2022.

Deltamethrin: permissible in 3 hours/ No. Pens	43.4 g / 6.8
Azamethiphos: permissible in 3 hours/ No. Pens	638.6 g / 2.0
Azamethiphos: permissible in 24 hours/ No. Pens	318.7 g / 1.0
In-feed treatments	
EmBz: TAQ	37 g

2 Introduction

This modelling report was written by BFS to describe the application of observed hydrographic data (totalling a minimum of 90 days, collected in August and October 2021) and scoping NewDepomod simulations using SEPA's prescribed Standard Default Method to risk assess the benthic impact of the proposed finfish site, North Gravir. The proposed site is located on the east coast of the Isle of Lewis (Figure 2.1). The report will outline modelling exercises that are intended to support the consented biomass and future benthic sampling, should the site be permitted:

- Solid (feed and faeces) dispersal
- In-feed treatment dispersal

An additional modelling exercise was undertaken to review the permissible quantities of bath treatments informed by the 90-day hydrographic dataset, the results of which are presented in this report.

The modelling undertaken outlines permissible quantities of biomass and medicines (both in-feed and bath) by using modern data and contemporary standardised assessment methodologies. This enables proposed operations to be undertaken sustainably and in accordance with appropriate environmental regulations. It should be noted that although NewDepomod has been applied successfully at sites around the Scottish coastline, the skill of the model in predicting benthic impact at North Gravir is unknown.

2.1 Site context

The proposed finfish site, North Gravir, is located on the east coast of the Isle of Lewis (see Figure 2.1) and is influenced by a semi-diurnal, macrotidal tidal regime with a mean spring range of 4.1 m (Loch Shell[3]). The site is considered exposed to significant sea swell to the northeast, where a significant fetch exists through the North Minch to the Northeast Atlantic. The proposed farm is 550 m east of the Isle of Lewis shoreline in water depths between - 48 and - 64 mCD. In the absence of significant freshwater influence (with no significant discharges in the vicinity or the proposed site) the site is considered well mixed and flushed by tidal and frictional wave related currents.

[3] *2022. Admiralty Total Tide. Euronav Navigation Systems*

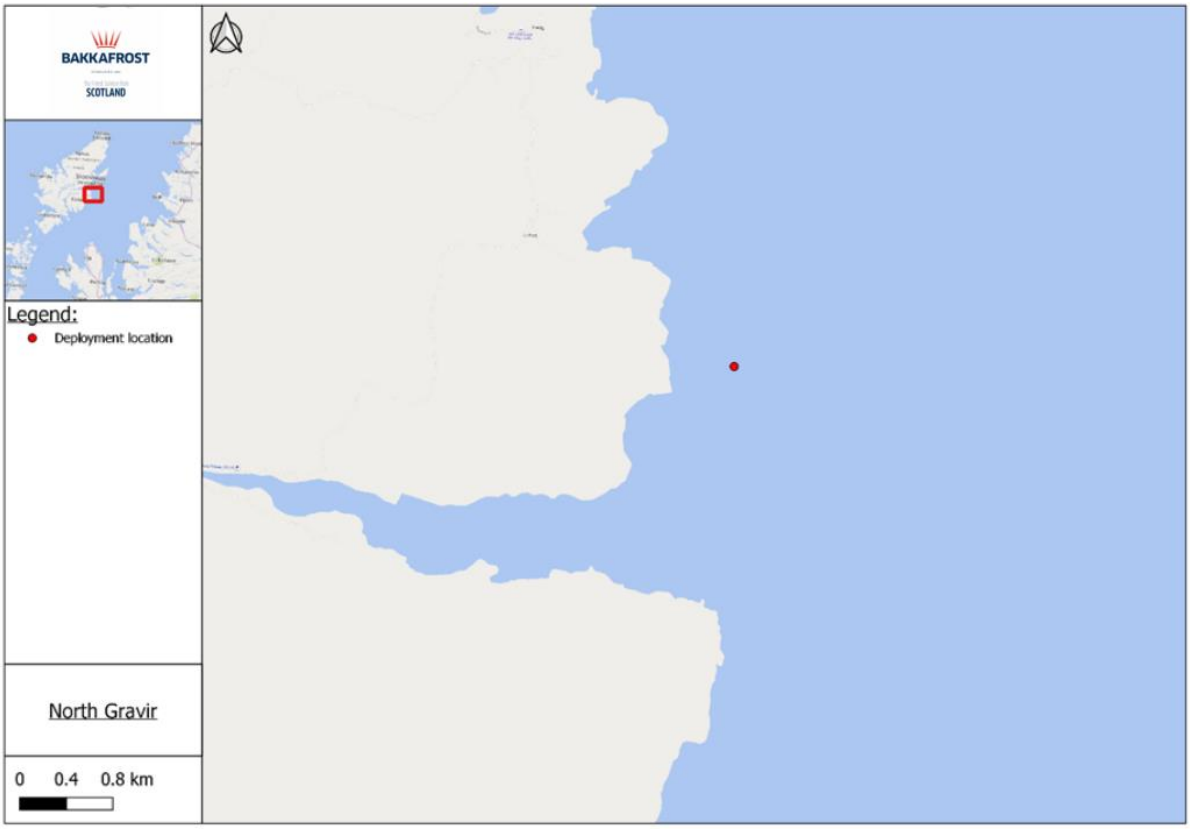


Figure 2.1: Location of the North Gravir site

2.2 Site details

The site is proposed to have 5 x 200 m circular pens, held in a 120 m grid, arranged in a 1 x 5 layout and with a net depth of 15 m. The proposed biomass is 4,680 T. Details of the site are provided in Table 2.1 with a graphical representation of the site provided in Figure 2.2.

Table 2.1: Summary of North Gravir site information

Site Details	
Group Location	143036 E, 915999 N
Number of Pens	5
Pen Circumference (m)	200
Grid Matrix (m)	120 x 120
Net Depth (m)	15
Configuration	1 x 5
Orientation (°)	007 W
Distance from shore (m)	550
Depth at Site (mCD)	48 - 64

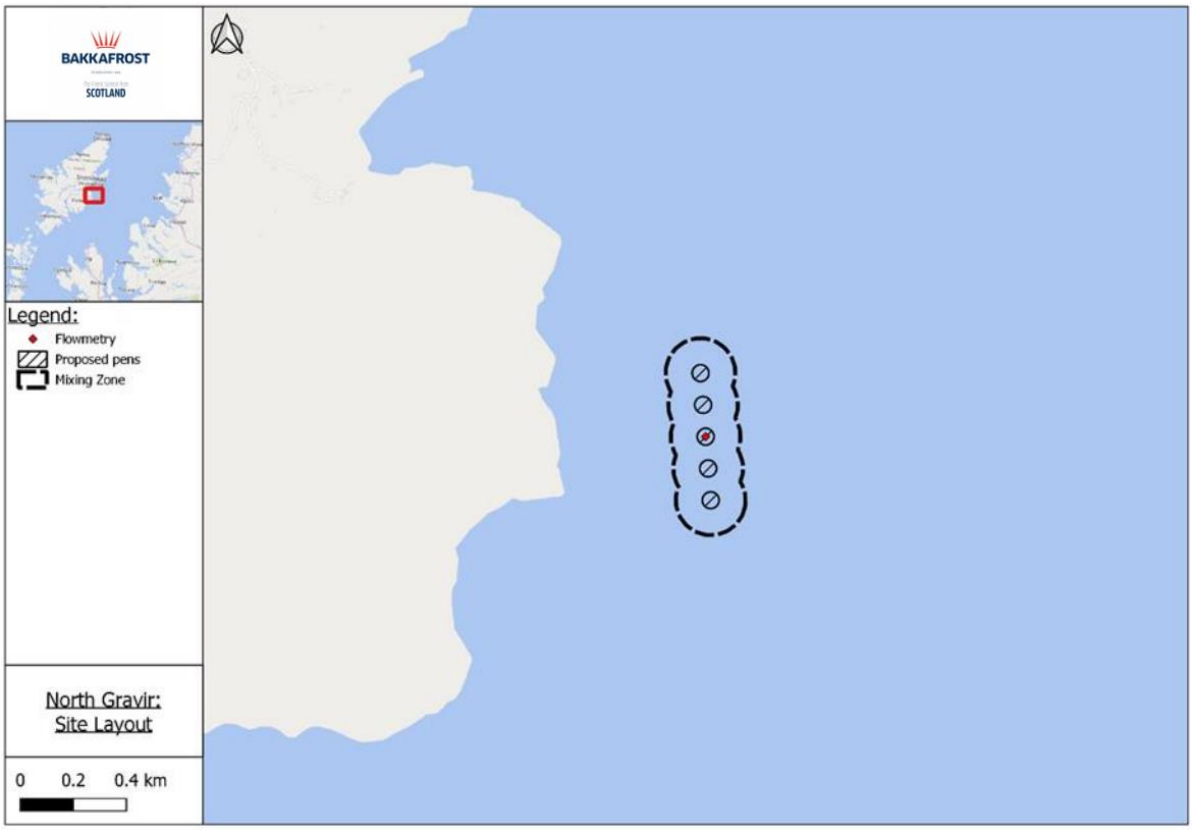


Figure 2.2: Proposed site layout

2.3 Site exposure

The site at North Gravir has a Wave Exposure Index (WEI) of 3.82-3.83 as derived from the Marine Scotland wave exposure index[4]. As this is in excess of SEPA's recommended threshold of 2.8, the site is considered a moderately exposed site. As a result, the average Mixing Zone intensity threshold here is uplifted to 4,000 g/m^2/yr and the permitted Mixing Zone is elevated to 120%[2] under SEPA's Standard Default approach.

2.4 Modelling context

There is currently no farm located at North Gravir. The model simulations in this report are the initial iteration of simulations undertaken representing this prospective site within NewDepomod, and so default parameters derived from SEPA's Guidance released in 2019[1] and 2022[2] are applied. This report presents a risk assessment undertaken using a minimum of 90 days of hydrographic data to identify the maximum biomass permissible at the site and the appropriate quantities of in feed medicines suitable for licencing.

[4]MarineScotland (2020) MAPS NMPI, part of Scotland's environment. [Accessed online 28/02/2020: https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=780]

3 NewDepomod setup

3.1 Model hydrodynamics

Modelling was undertaken using data collected by BFS spanning two separate data collection exercises, consisting of one 62.7-day deployment in August 2021 and one 63.3-day deployment in October 2021. These datasets were stitched together, by filling the gaps with repeated data replicating the spring-neap and flood-ebb cycles, to create a seamless 128.3-day time-period in 20-minute timesteps. This data was trimmed to represent 90-days of seamless hydrographic data. The data collected is discussed in greater detail in following sections and the accompanying hydrographic report[5]. A summary of observed data from the three bins used in NewDepomod simulations is provided in Table 3.1 and the water column velocities are visible in Figure 3.2.

Table 3.1: 90-day observed dataset summary data

Location	Average velocity (m/s)	Major axis direction (º)	Residual current magnitude (m/s)	Average depth (m)
Sub-surface	0.159	180	0.035	6.5
Cage-bottom	0.155	177	0.032	13.3
Near-bed	0.128	175	0.027	55.3

NB: The current meter position and depth was derived from the current meter deployments weighted averages, as per SEPA's regulations (HG data for Aquaculture)[6].

Residual currents at the bed were estimated to be 0.027 m/s i.e. 21.09% of mean velocity. As this is below SEPA's guidance threshold of 35% for the application of a de-trended hydrography, a Full-tide dataset was used to drive simulations under the Standard Default Method. Astronomic tide simulations (using harmonic analysis data) were undertaken here and are presented for reference.

Full-tide

The Full-tide velocity profiles from both deployments can be seen in Figure 3.1, with the time series for the complete stitched dataset shown in Figure 3.2. The water column demonstrates little vertical shear throughout the water column with only very slight decreases in the calculated in 25th, 50th and 75th percentile velocities with depth. This trend in velocity is anticipated to follow a log profile according to the *Logarithmic* or *Power law* induced by friction at the seabed. The friction induced tail is evident in the lower water column where marked variation is noticed between cell observations. In the absence of CTD (Conductivity, Temperature, Depth) casts and with no identifiable significant source of freshwater the water column was assumed to be well mixed with hydrography typical of exposed, well mixed systems of the Scottish west coast.

[5]BFS. (2022). *Hydrographic Report: North Gravir, Isle of Lewis, A1*
[6]SEPA (2022*), HG Data for Aquaculture Applications– April 2022*

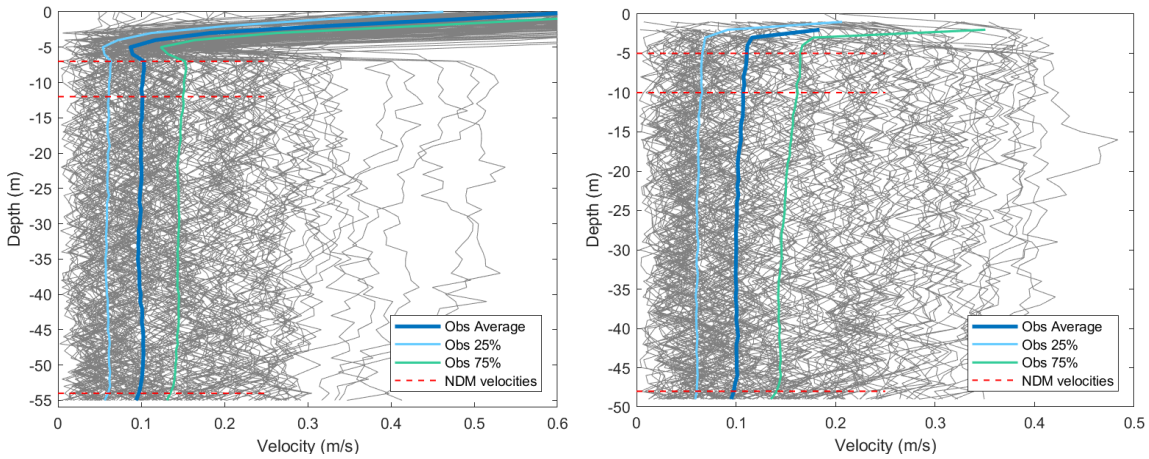


Figure 3.1: Sampled velocity profiles for the hydrographic deployments used in this assessment. Deployment 1 is shown on the left and 2 on the right.

The velocities in the three directional bins selected for the modelling are demonstrated in Figure 3.2 and the observations are considered largely representative of conditions observed at the site and no significant difference in velocity magnitude between the two datasets used in dataset generation was noted. There is limited difference in the mean velocity magnitude in the upper two bins selected and the average current speed is 0.03 m/s slower at the bed than the surface. This slight decrease in velocity with depth and the water column velocities visible in Figure 3.2 demonstrates limited, vertical shear throughout the water column. The observed data does show an evident spring/neap cycle in the velocities with periods of low velocities observed bi-weekly. The dataset is thus considered appropriate for application within the NewDepomod simulations according to the Standard Default Method. However, this cannot be considered fully representative of the 365 days simulated (due to the omission of extreme events) but an approximation of conditions.

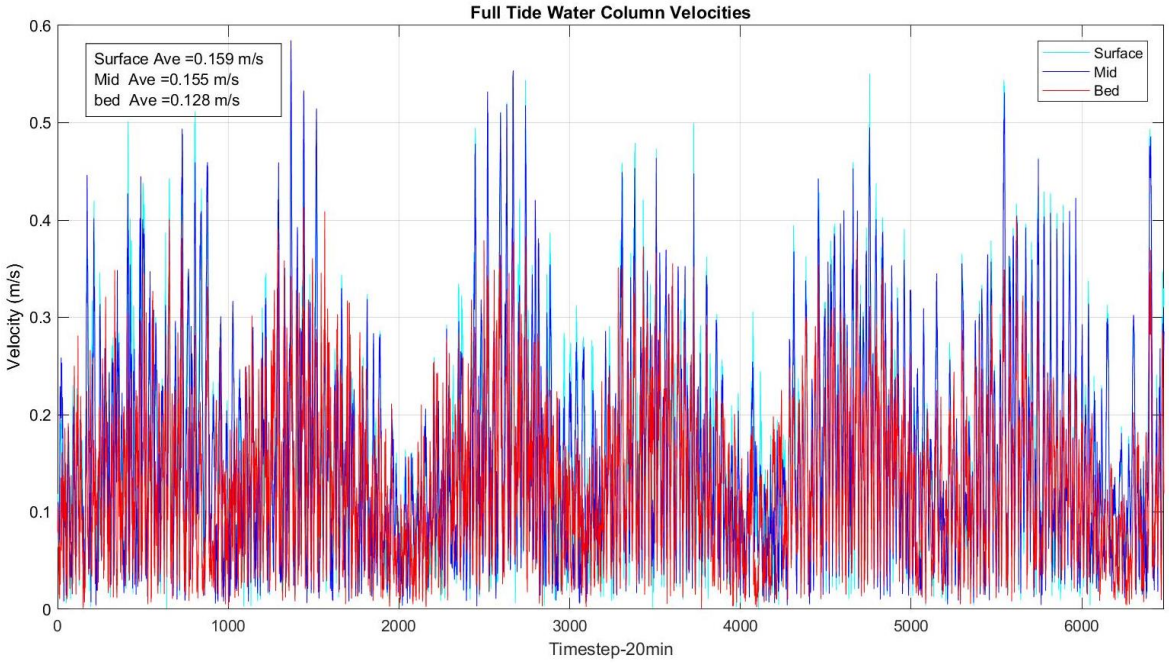


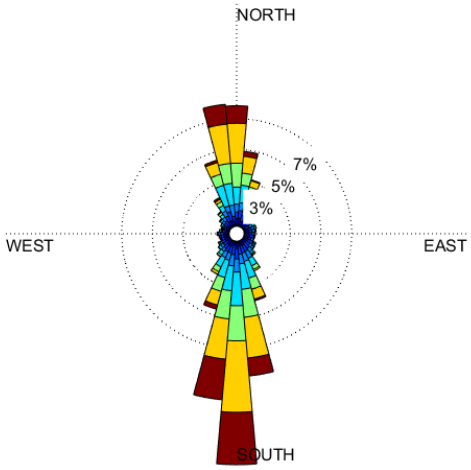
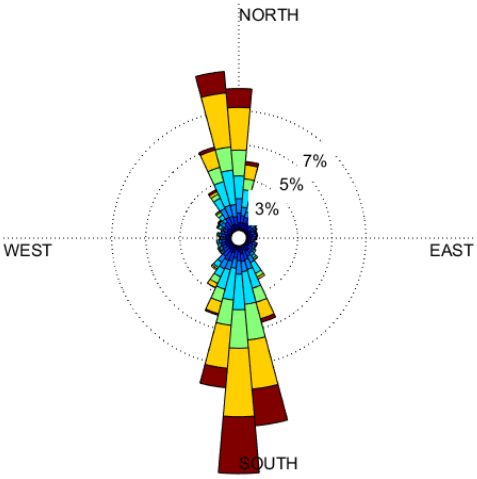
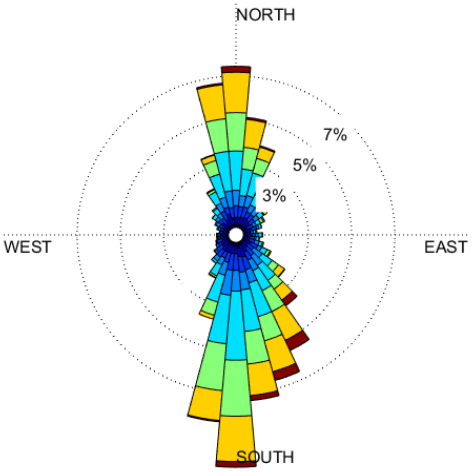
Figure 3.2: Water column velocities for an unedited velocity profile

Table 3.2 illustrates the directional frequency and magnitude of observed conditions in each of the three depth “bins” used in the modelling. These roses illustrate a strong bi-modal flow corresponding

to the tidal phases and the shoreline orientation at the site. At all three bins the flow is largely asymmetrical along a north and south axis, with the latter dominating in frequency. The directional rose at the near-bed indicates that there is more variation in flow direction with low frequencies of flow around the north and south axis.

The peak bed-speed for the observed dataset is in excess of 0.40 m/s and the dataset exceeds an inferred critical resuspension threshold of 0.085 m/s, 66.9% of the time. As a result, few sediments are consolidated within the bed model and sediments are readily re-suspended and dispersed throughout a wide area of the seabed.

Table 3.2: Directional roses of recorded velocities

Reading location	Directional Rose, frequency and magnitude (m/s) 0.025 - 0.05 · 0.075 - 0.1 · 0.15 - 0.2 · 0.3 - 0.5 0 - 0.025 · 0.05 - 0.075 · 0.1 - 0.15 · 0.2 - 0.3
Sub-surface	
Cage bottom	
Near-bed	

Astronomic tide

A harmonic analysis was undertaken in MATLAB's U-tide[7] analysis toolbox to identify the harmonic tidal signal, removing the episodic currents. This was applied to the modelling as a sensitivity test to isolate the role of astronomic currents and determine the influence of episodic currents in the re-distribution of benthic sediments at North Gravir. The astronomic currents displayed a similar magnitude of shear to the observed timeseries; however, the modelling illustrates less variability and lower average current speeds.

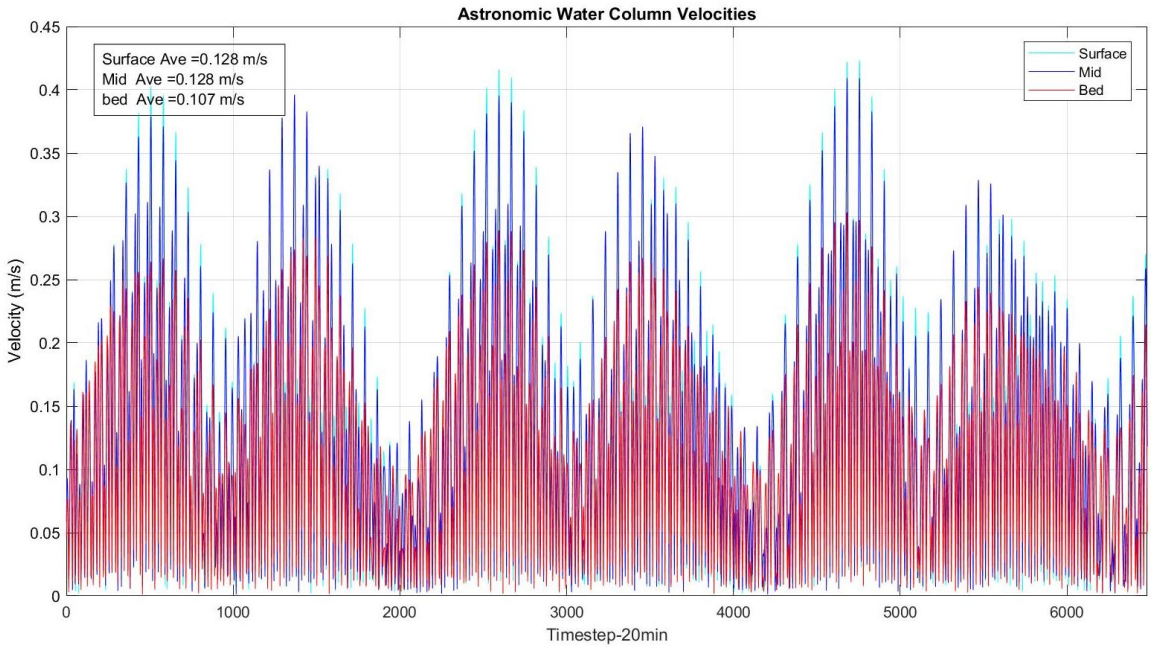


Figure 3.3: Re-constructed astronomic time series at North Gravir

3.2 Model bathymetry

Model bathymetry was available for the site at North Gravir, which was generated from Admiralty data collected and stored as part of the "Maritime and Coastguard Agency (MCA) Bathymetric Survey HI1352, North Minch, (30/10/2011 to 05/12/2011)" bathymetry dataset (licenced under the Open Government Licence v3.0)[8] and an OS shoreline shapefile displayed in Figure 3.4. At the time of writing the Standard Default Method (SDM) risk assessment approach requires a uniform bathymetry to be applied within the model domain. As per the SDM requirements, a depth was applied based on the recorded depth of the current meter data, providing that the difference between the depth under the proposed site and flowmetry is not >10 m. This depth was -55.3 m, relative to chart datum. The average depth under the proposed pen layout is -54.7 mCD, and so the current meter depth was deemed appropriate for this site. The average water depth is calculated using the weighted average depth at deployment (mCD) from the individual deployments, as per SEPA regulations (HG data for Aquaculture[6]).

[7] Codiga, D.L., (2011). *Unified tidal analysis and prediction using the UTide Matlab functions* (p. 59). Narragansett, RI: Graduate School of Oceanography, University of Rhode Island.

[8] Admiralty Maritime Data Solutions (2021). Seabed Mapping Service. [online] Available at: <https://seabed.admiralty.co.uk/> [Accessed 12 August 2021].

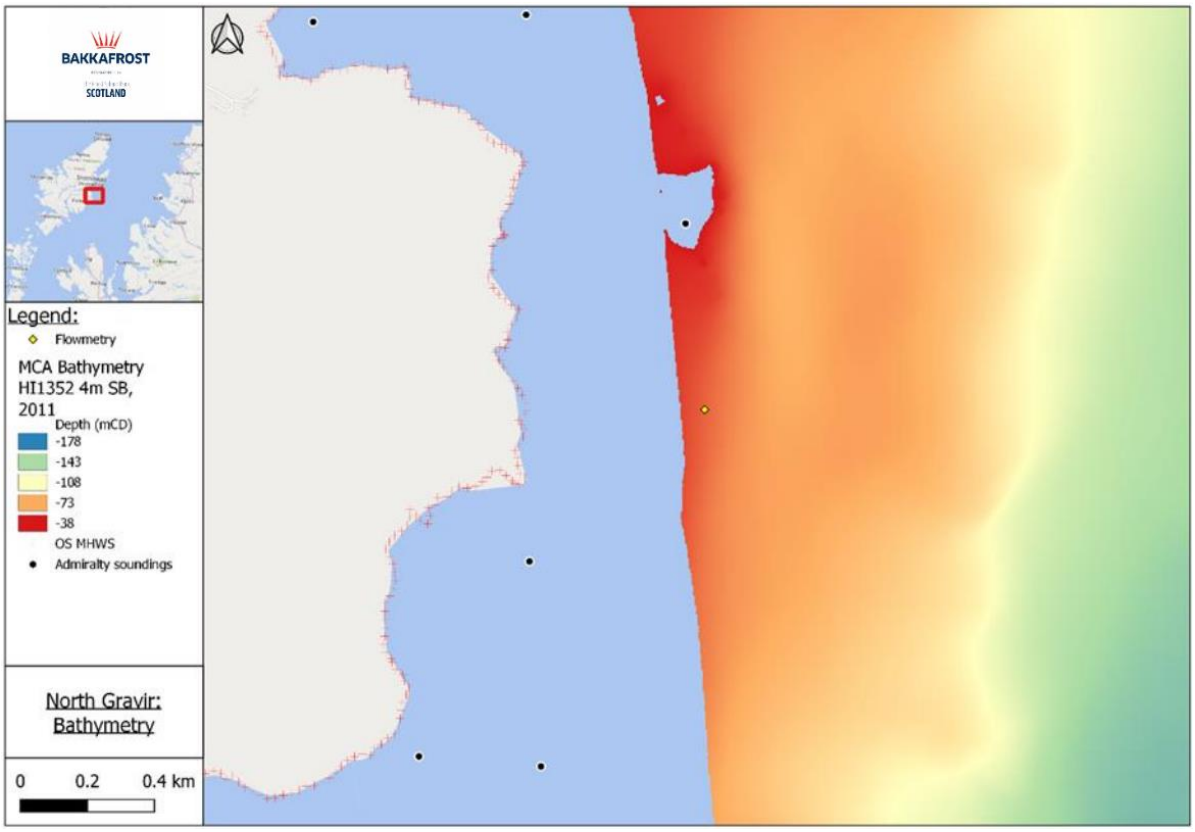


Figure 3.4: Bathymetry data available at the North Gravir site.

The bathymetry was interpolated to the model grid and is displayed in Figure 3.5. The domain centre was taken as the flowmetry position. As shown in Figure 3.5, the bathymetry at the site slopes eastwards from the proposed site to depths in excess of -100 mCD. The proposed site is to be located between the -40 and -70 mCD contours. It is likely that this sloping bathymetry will have a significant impact on the dispersal of sediments, eliciting increased dispersal in deeper water. This however is not represented in the Standard Default Method.

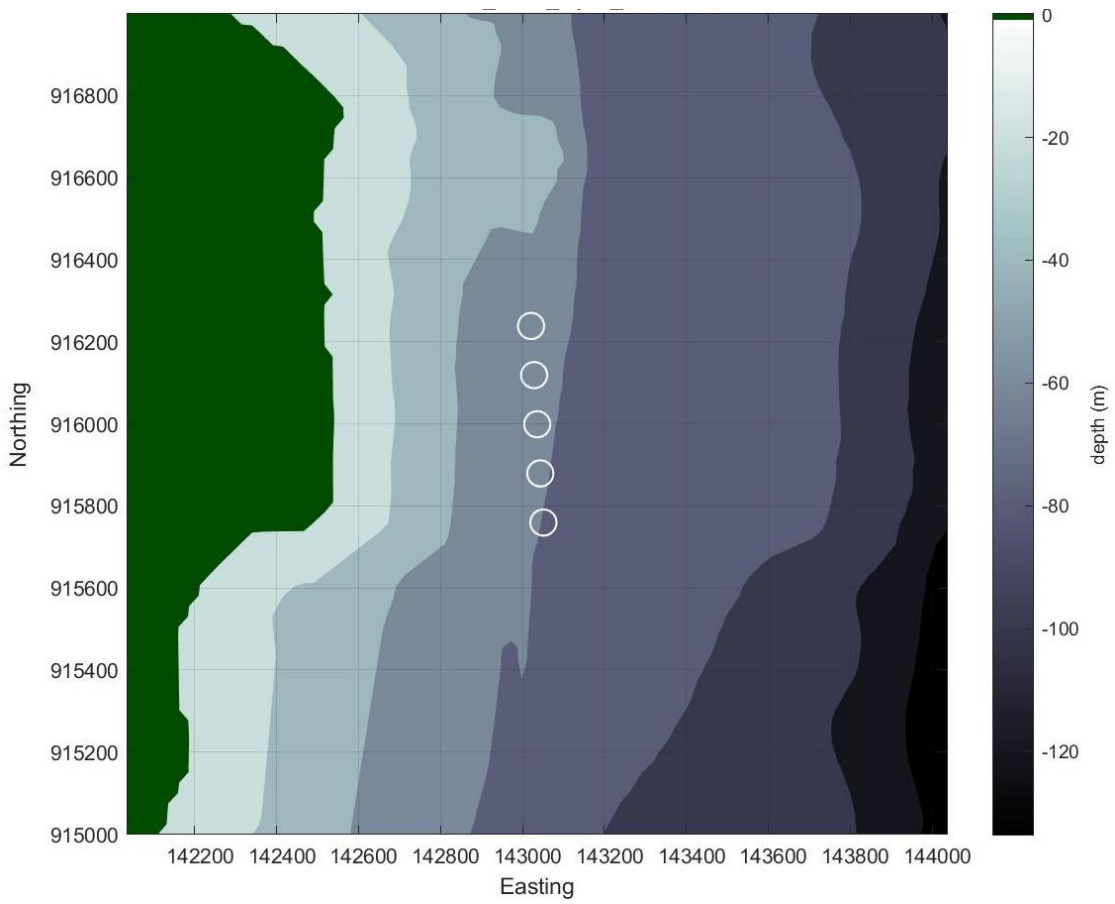


Figure 3.5: Interpolated bathymetry on the model grid with cages displayed

3.3 Pen inputs

Standard feed rates were used as per the SEPA Standard Default Method. These rates were related directly to the simulated biomass. For the Standard Default Method runs presented here, peak biomass feed rates are 7 kg t^{-1} d^{-1} for 365 days.

Feed and faeces

Default feed and faeces rates were input corresponding to the consented biomass of the site. As per the Standard Default Method outlined by SEPA, feed rated associated with peak biomass were input for 365 days with a 3 % wastage rate.

In-feed treatments

The only in-feed treatment proposed to be administered at the North Gravir site is Emamectin Benzoate (EmBz) and subsequently the only assessment undertaken to review the impact of in-feed treatments was to assess EmBz impact. At the time of writing, SEPA guidance assesses the input of EmBz based on an updated Mixing Zone threshold of 136 ng/kg wet weight (equivalent to 272 ng/kg dry weight) for EmBz, 118 days following treatment (when concentrations peak)[2].

3.4 NewDepomod configuration

All model parameters, not specified within this document, were in accordance with the SEPA Standard Default Method for both solid dispersal and in-feed treatments. This includes the degradation of EmBz particles (λ = 250 days).

3.5 BathAuto configuration

An assessment was undertaken into the dispersal of bath treatments (administered in the pens and allowed to diffuse throughout the environment post-treatment) following the administration of two bath treatment chemicals. The assessments were undertaken using the conservative, spreadsheet based BathAuto (v5) modelling package with key parameters as outlined in Table 3.3 below. For this assessment, summary hydrographic data from the full observed dataset was applied and the average bathymetry depth (derived from available bathymetry) was applied to approximate conditions over a larger area than NewDepomod simulations.

Table 3.3: BathAuto – Key parameters

	Variable	Parameter
Waterbody characteristics	Loch/Strait/Open water	Open Water
	Loch area (km^2)	9,999.00
	Loch length (km)	9,999.00
	Distance to head (km)	9,999.00
	Distance to shore (km)	0.55
	Average water depth (m)	54.7
Pen & stocking info	Number of pens	5
	Pen shape	Round
	Diameter/Width (m)	63.7
	Working depth (m)	15
	Stocking density (kg/m^3)	19.6
Treatment info	No. of pens possible to treat in 3 hours	2
	Initial Treatment Depth (m)	1
	Treatment Depth Reduction Increment (m)	0.5
Hydrographic data	Mean current speed (m/s)	0.162
	Residual Parallel Component U (m/s)	0.021
	Residual Normal Component V (m/s)	0.003
	Tidal Amplitude Parallel Component U (m/s)	0.263
	Tidal Amplitude Normal Component V (m/s)	0.065

4 Model outputs

NewDepomod model outputs for both the Full-tide and astronomic (Astro) tidal cycles are presented below. These assessments are reviewed on criteria outlined by SEPA, based on a Mixing Zone (area encompassed from 100 m radius from pen edge) area of 177,000 m^2 and average depositional intensity within the Mixing Zone of less than 4,000 $g/m^2/yr$.

4.1 Full- tide

The Full-tide model output was identified as the appropriate hydrographic dataset to apply to the site at North Gravir. To identify the maximum permissible biomass at the site using the conservative Standard Default Method in NewDepomod, multiple iterations were undertaken (Figure 4.1) to determine the appropriate tonnage, which was identified to fall between 4,600 and 4,800 T. The biomass iterations at the site demonstrate that the biomass options are significantly lower than the depositional intensity thresholds.

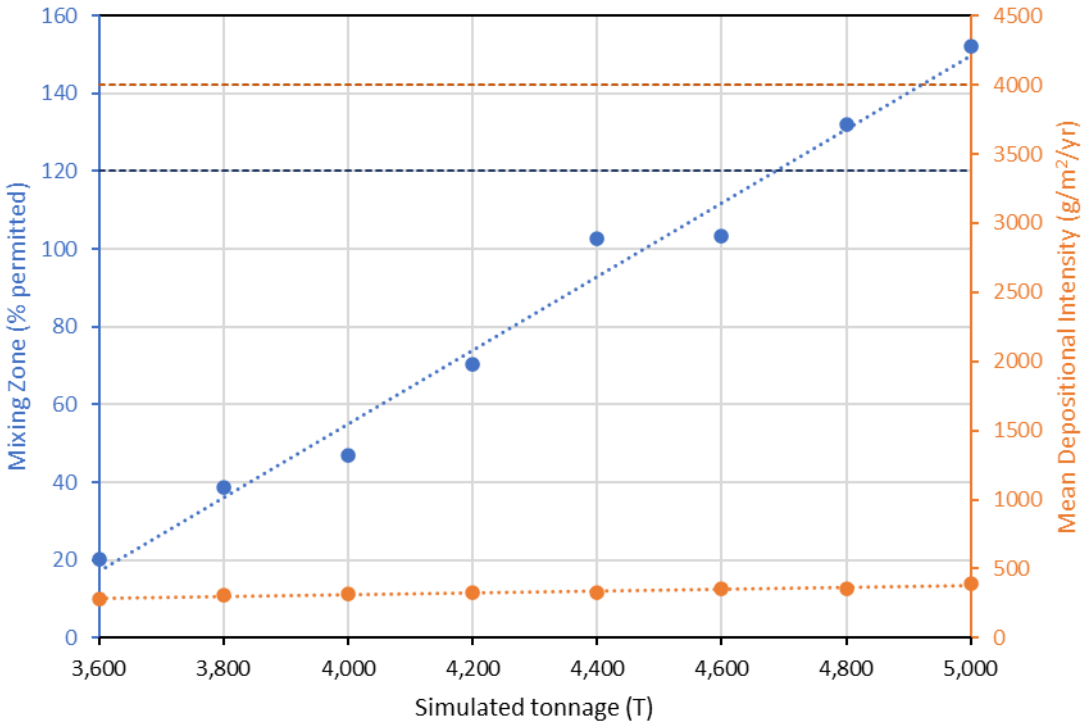


Figure 4.1: Full-tide, scoping runs used to define maximum permissible tonnage.

The analysis undertaken determines that, according to the risk assessment using the Standard Default Method in NewDepomod, a peak biomass of 4,680 T is permissible, with a Mixing Zone area less than 120%. For all iterations, the mean depositional intensity within the Mixing Zone does not exceed 390 $g/m^2/yr$, which is lower than the 4,000 $g/m^2/yr$ threshold. This risk assessment approach is widely considered to be a conservative risk assessment method, applying two to four times the observed feed rates.

4.1.1 Design Run

The iterative process, outlined above, found the peak biomass for the site to be 4,680 T within the 5 pens outlined in Section 2.5. To appropriately risk assess this proposed farm setup, five additional model simulations were undertaken at this biomass. The results of these simulations are provided in Figure 4.2 with the average depositional intensity from each model run shown in Figure 4.2. Model IDs correspond to model runs provided with this report. The average peak simulated deposition in all five model runs was 369.8 $g/m^2/yr$ and the average within the Mixing Zone was 360.2 $g/m^2/yr$, satisfying SEPA's requirements of a simulated average deposition of less than 4,000 $g/m^2/yr$.

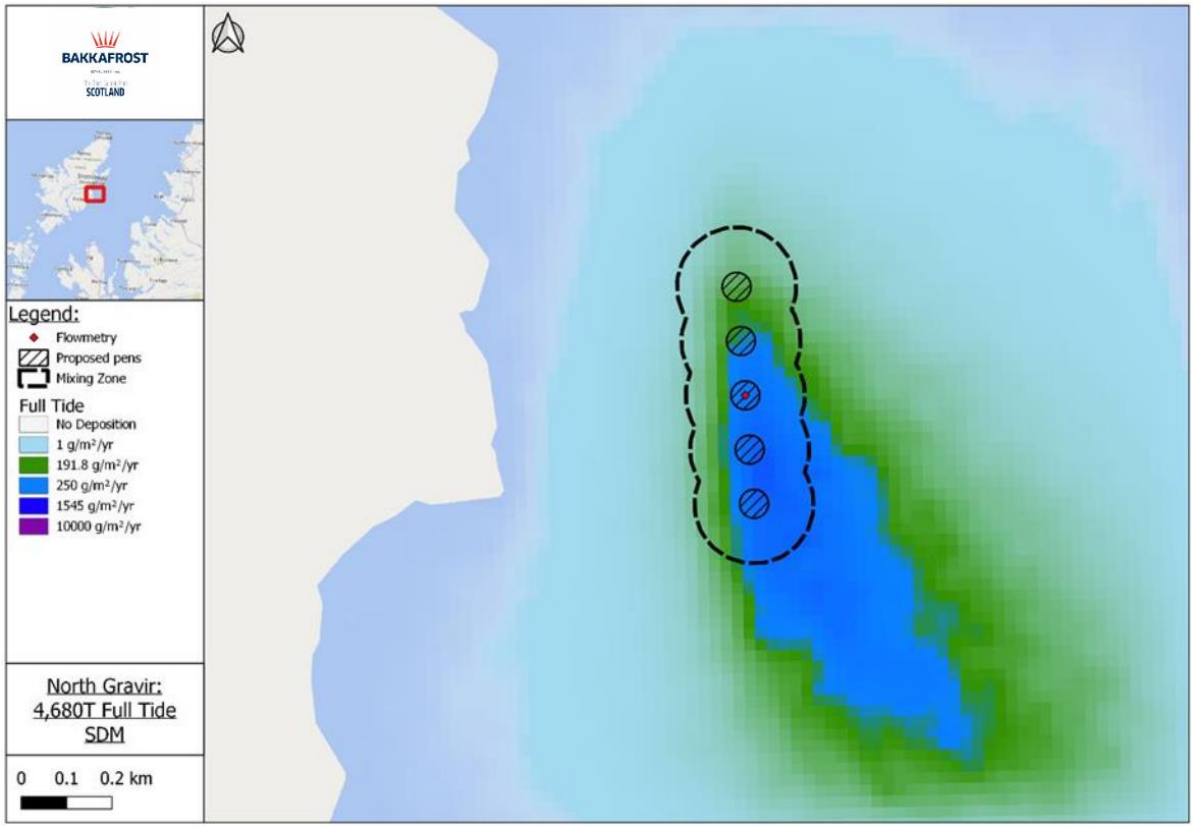


Figure 4.2: Average deposition throughout the model domain for simulated design runs

Table 4.1: Model runs assessing the impact of 4,680 T

Run ID	Average Mixing Zone deposition (g/m²/yr)	Mixing Zone area (% of permissible)
Solids-2	369.80	113.98
Solids-3	361.59	115.75
Solids-4	345.18	128.14
Solids-5	366.26	112.92
Solids-6	357.96	115.05
μ	**360.16**	**117.17**

Table 4.1 displays an average Mixing Zone of 117.2%, with an individual iteration deviating as low as 112.9%. This average Mixing Zone percentage is considered appropriate and conservative because it is lower than the permitted quantities recommended by SEPA (120%).

The observed dataset produces a south-south-eastward dispersal plume distributing sediments away from the Isle of Lewis shoreline. Deposition is concentrated to the southeast of the pens, with higher rates of deposition (approximately 800 g/m²/yr) simulated under the southern pen footprint. It is likely this is influenced by the resuspension events at the site causing sediments deposited on the pen footprint to be resuspended and redistributed toward the southeast. The simulation does demonstrate a moderately widespread dispersal of sediments, with a lower concentration, due to the high frequency of symmetry in the direction of flow and high frequency of resuspension events. The eastward sloping shoreline is likely to cause increased distribution downslope. However, there is currently no site at the proposed location, so it is not possible to validate the results against observations. As a result, the Standard Default Method applied in NewDepomod is considered the best estimation of the impact of the proposed North Gravir site.

4.2 Sensitivity

The sensitivity of the modelling to the hydrographic dataset used to force the model was reviewed to determine the impact on model function as a result of the modification of the observed hydrographic dataset. To review this, the model was forced using a reconstructed astronomic time series, derived from the 90 days of consecutive hydrographic data ("Astro Tide"). The result of this assessment is presented in this section.

Astro Tide

Forcing using the astronomic tide was also undertaken, primarily to better understand the role of normal tidal flow and episodic currents (particularly the sub-surface flow) on the benthic deposition. The modelling produced a larger Mixing Zone (130.3%) and depositional intensity (710.8 g/m^2/yr) than the Full Tide dataset, as displayed in Figure 4.3.

This model setup results in the dispersion of feed and faeces toward the south, similar to the Full Tide dataset, although not in the same quantity and there is less of an impact to the east. Although there is a significant reduction in the average bed flow, the Astronomic dataset still contains a high occurrence of high velocity events. As a result, sediments are still moderately dispersed from the immediate pen footprint. This is along a similar axis to the Full Tide simulations, although with less of an eastward component, and it is suggested that the Astronomic currents play a role in dispersing sediments from the farm footprint, dispersing these sediments throughout the area.

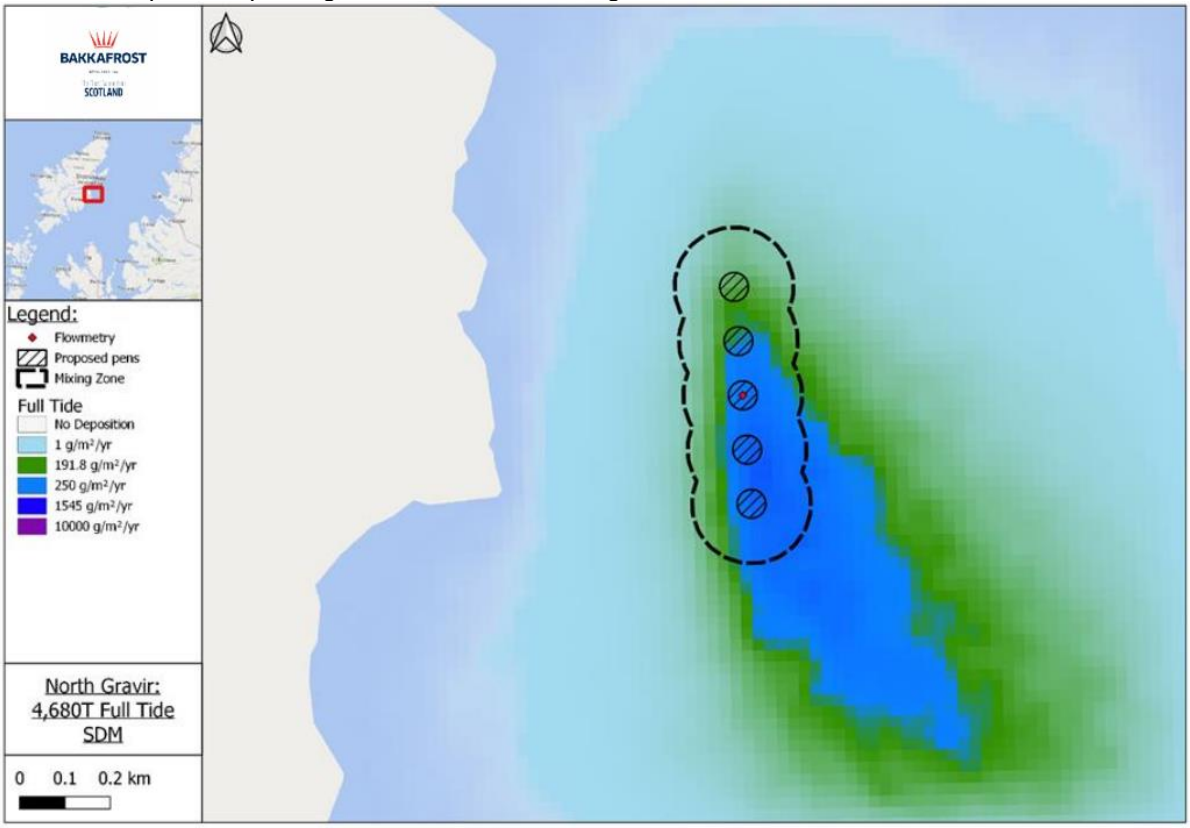


Figure 4.3: Reconstructed, Astronomic tide simulation outputs

This sensitivity test demonstrates that the site is moderately flushed by astronomic currents which causes sediments to be deposited to the south, and dispersal of these sediments along a near-symmetrical axis, preventing a high degree of consolidation on the bed. This finding also suggests that the episodic non-astronomic signals are responsible for some of the sediment dispersal noted in the full tide model run.

4.3 In-feed treatments

In-feed treatments were simulated using the Full-tide hydrographic dataset as per SEPA guidance 3. The modelling output was iterated to find the quantity of Emamectin Benzoate (EmBz) to administer to satisfy mixing zone area requirements (136 ng/kg wet weight). The total amount of EmBz permissible for the site was determined to be 37 g. To appropriately risk assess the benthic impact, additional model simulations were undertaken at this quantity. The results of these simulations are provided in Table 4.2.

Table 4.2: Model runs assessing the impact of 37g of EmBz

Run ID	Mixing Zone area (% of permissible)
EmBz-2	96.99
EmBz-3	90.97
EmBz-4	93.09
EmBz-5	87.79
EmBz-6	101.95
μ	***94.158***

Table 4.2 displays an average Mixing Zone of 94.16%, with an individual iteration deviating as low as 87.79%.

4.4 Bath treatments

Bath treatment modelling was undertaken by BFS for the use of Deltamethrin and Azamethiphos. Results are displayed in Table 4.3, which were derived using BathAuto (v5) and the Environmental Quality Score (EQS) compliance of two medicines was determined and is presented in Table 4.3.

Table 4.3. Results of bath treatment modelling at North Gravir

Medicine	Permissible quantity – 3 hours	No. of pens – 3 hours	Permissible quantity – 24 hours	No. of pens – 24 hours
Deltamethrin	43.4 g	6.8	-	-
Azamethiphos	638.6 g	2.0	318.7 g	1.0

These quantities are considered highly conservative as the BathAuto methodology does not integrate any horizontal shear and reviews the releases as a dispersal plume simulating material to disperse slower than in the physical environment and omits interaction with shoreline features and bathymetry. The treatment values presented in Table 4.3 are thus considered conservative in the absence of more detailed modelling. BFS are open to discussions with SEPA if more detailed modelling would be required for the assessment of bath treatments.

5 Conclusion

The release of organic matter (waste feed and faeces), in-feed and bath treatments has been simulated using two software packages (NewDepomod and BathAuto). The model simulations were undertaken with NewDepomod, using 90 days of hydrographic data, to assess a proposed pen arrangement. BathAuto simulations have also been undertaken to determine a conservative estimate of permissible quantities of bath treatment quantities at the site. Conclusions drawn from the simulations are outlined below.

5.1 Sediment dispersal

The model simulations undertaken using NewDepomod for the proposed 5 pens at North Gravir demonstrates that a peak biomass of 4,680 T comfortably satisfies SEPA's regulatory requirements (using a 90-day Full-tide hydrographic dataset), in respect of Mixing Zone area and depositional intensity. The modelling demonstrates this tonnage is considered to have minimal impact on the benthic environment with a Mixing zone of 117% of the permitted and a low depositional intensity (360/4,000 g/m^2/yr). Additionally, the simulations undertaken are considered a conservative estimate of the potential impact of the proposed farm, based on research undertaken by SEPA to develop the Standard Default Method risk assessment approach within NewDepomod.

5.2 In-feed treatments

The in-feed treatment, EmBz, was modelled in NewDepomod using the SEPA's Standard Default Method, with 90-days of de-trended hydrographic data. Model simulations identified that 37 g of EmBz, administered as an in-feed treatment satisfy contemporary requirements for benthic quality.

5.3 Bath treatments

An observed, 90-day hydrographic dataset was used to drive simulations of bath medicine dispersal in BathAuto v5. This modelling recommended that the bath treatment consent for Deltamethrin be set at 43.4 g in three hours, and for Azamethiphos be set at 638.6 g in three hours and 318.7 g in twenty-four hours. This is considered a highly conservative assessment of bath treatment quantities and may reviewed for Final application submission.