Billy Baa, Scalloway Area
NewDEPOMOD Modelling Report

Report To	Scottish Environmental Protection Agency
Status	Version 1.0
Date	July 4, 2023

Scottish Sea Farms Ltd
Barcaldine Hatchery
Barcaldine
Oban, Argyll
PA37 1SQ
[redacted]
[redacted]

Contents

List of Figures

List of Tables

1 Executive Summary

This report has been prepared by Scottish Sea Farms Ltd. (SSF) to meet the deposition and in-feed treatment modelling requirements of the Scottish Environment Protection Agency (SEPA) for a new licence, to install equipment for a marine fish farm and for consent to use adequate sea lice treatments at a site named Billy Baa, under the Controlled Activities Regulations [2]. The report describes the site-specific methodology used within NewDEPOMOD to model the appropriate consent limits for the proposed Billy Baa site, following current SEPA guidance ([4], [5]), [7]. A summary of the results of this modelling, carried out using NewDEPOMOD, is presented in table 1.

Table 1.1: Site details, hydrographic input summary, and summarised results of the modelling.

Proposed Site Details		
Name		Billy Baa
Location		Scalloway area, Shetland
Number of Cages		10
Cage Circumference (m)		9 x 160, 1 x 120
Net Depth (m)		15
Group Layout		(2x5, 120m is cage 5)
Hydrographic Summary		
Sub-surface Currents	Average Speed (m/s)	0.050
	Residual Direction (°)	203
	Wind Influence	Moderate
Cage-bottom Currents	Average Speed (m/s)	0.034
	Residual Direction (°)	215
Near-bed Currents	Average Speed (m/s)	0.038
	Residual Direction (°)	030
Benthic Modelling - Standard Default Method Run		
Peak Biomass (tonnes)		4091
Stocking Density (kg/m^3)		14.25
In-feed Treatments		
Total Allowable Quantity – EmBz (g)		27.2
Equivalent Biomass (t)		77.7

2 Introduction

This report details the methodology, results and conclusions of work conducted by SSF for the purpose of assessing a potential site, Billy Baa, with regards to an application to install a circular cage group for the purpose of farming atlantic salmon. The report details the modelling of the site with software NewDEPOMOD, using the Standard Default Method described by SEPA [4].

The site is situated to the east of Fora Ness and South West of Russa Ness, near the Billy Baa in the Scalloway area to the west of the Shetland central mainland. The average bathymetry of the site is 45m, and wave exposure index is approximately 2.94 [1]. This modelling report is to accompany a CAR application for a site with maximum biomass of 4091 tonnes, to be contained in 10 circular cages, nine of which were circumference 160m and the final cage of circumference 120m.

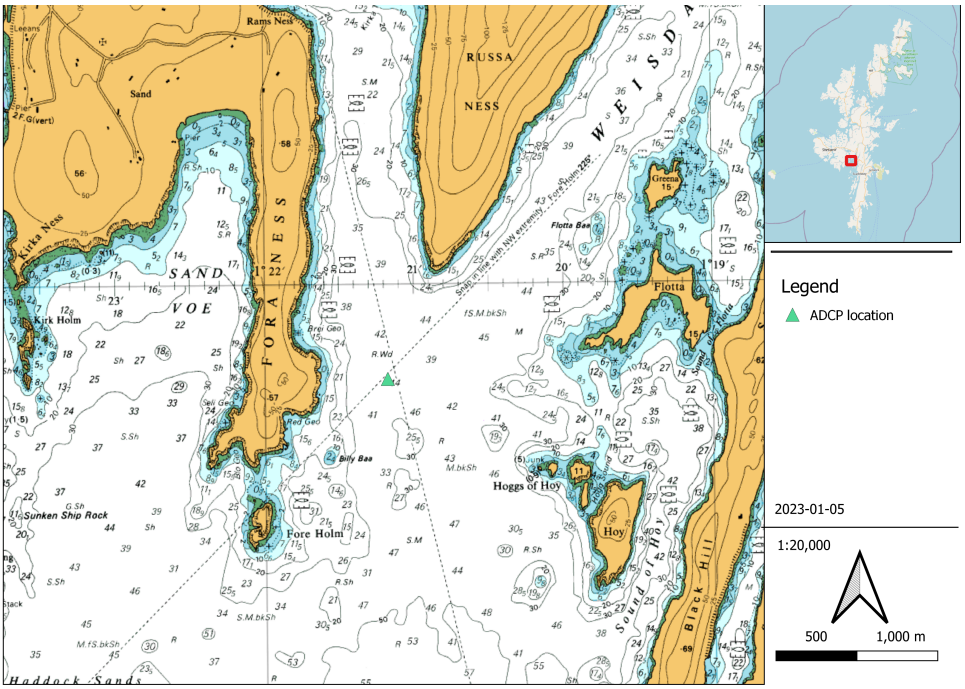

Figure 2.1: Location of the Billy Baa Site

SEPA guidance for new CAR applications involves modelling of proposed sites with software NewDEPOMOD, under hydrographic conditions that are specified as part of a 'standard default method' (SDM), and ascertaining whether the proposed site will comply with environmental regulations [4] [5].

3 Methodology

3.1 Standard Default Benthic Modelling

Modelling of the consent limits for biomass and in-feed treatments was initially undertaken in NewDEPOMOD version 1.4.2 Using SEPA default settings as detailed by by SEPA [4] [7]. Several different cage configurations were modelled, so as best to find one that provided economical quantities of biomass to be farmed whilst avoiding any excess in environmental impact. For each iteration of the model, it was run for a total of 365 days, with outputs every three hours for the final 90 days of the run. The average, minimum and maximum value intensity was calculated, as well as the total area of deposition.

3.2 In-Feed Treatment Modelling

When modelling for in-feed treatments, namely Emamectin Benzoate (EmBz), an initial model run was for a quantity of EmBz to treat one times the modelled maximum biomass. Assuming a pass was achieved for this run, the model will run through iterations, up to five times treatment quantity for maximum biomass, until a best pass is achieved. If an initial pass was not achieved, the model was instead run with lower quantities of EmBz, until a passing quantity was achieved. These model runs were for 118 days.

with outputs recorded for the last two days, every three hours. This quantity was compared with results for the existing site modelled for it's current consent of EmBz in order to ensure no unsuitable increase in environmental impact occurred [4].

4 Model Input Data

4.1 Bathymetric Data

Depth soundings were obtained from UKHO data, to confirm chart accuracy and compare against depth sounder readings and the depth recordings from the ADCP [8] (Figure 4.1).

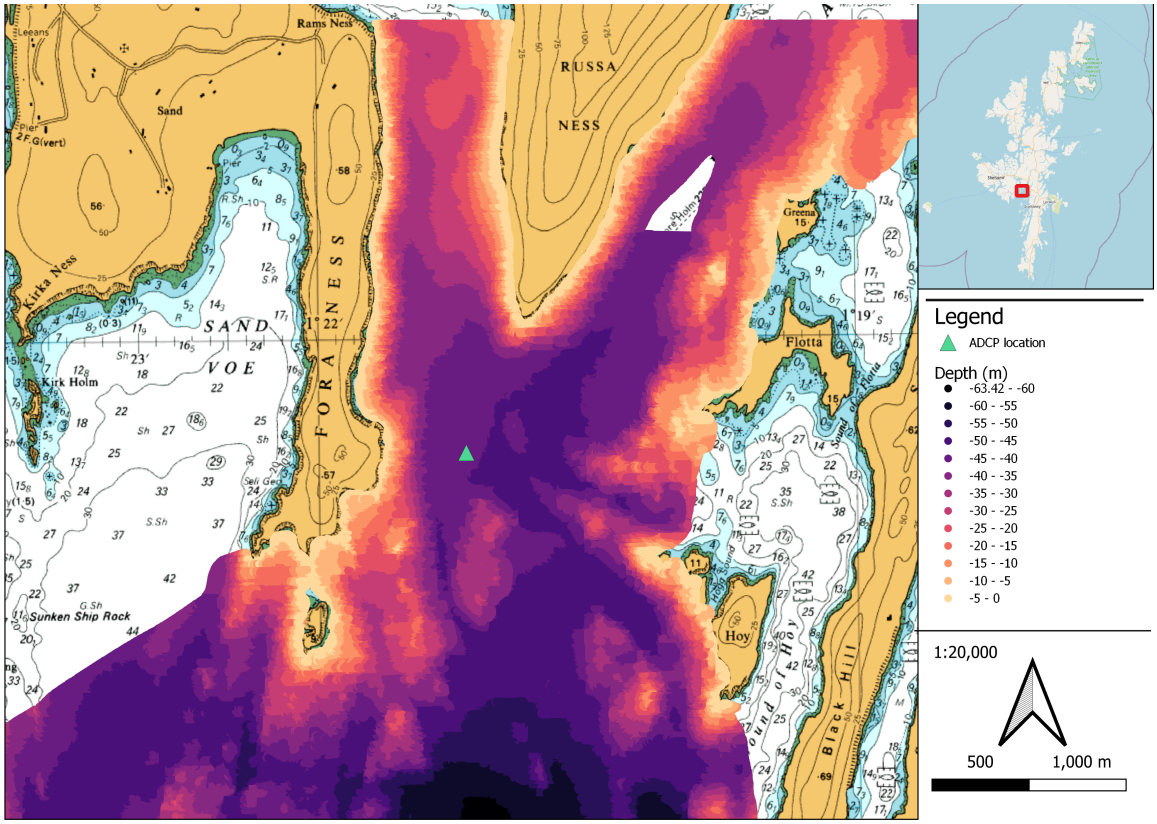

Figure 4.1: UKHO Bathymetry survey data.

As default SEPA settings were used for the modelling itself, flat bathymetry was created in MATLAB using the bathymetry data collected for the site, changing all water depths to 44.95m (the average depth at which the current meter was deployed at).

4.2 Cage Configuration

The proposed cage group configurations was inputted into NewDEPOMOD, as part of tehg model set up. The layout of this was for one group of 9 x 160m and 1 x 120m circumference circular cages, in 5 x 2 formation and a 125m grid. The 120m cage was placed within the middle of the grid on the western side. Further information on the site layout is provided in figure 4.2 and table 4.1.

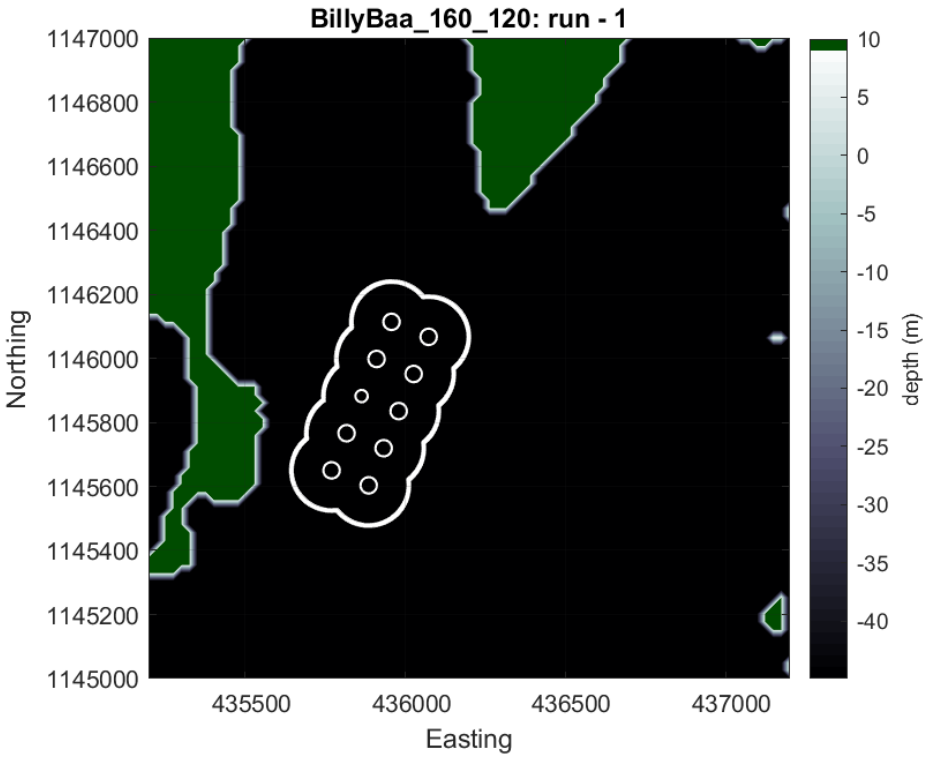

Figure 4.2: Proposed cage layout and configuration used in NewDEPOMOD modelling for Billy Baa.

Table 4.1: Cage configuration input used in NewDEPOMOD modelling of the proposed site layout.

Layout	Proposed
Origin X (m)	435770
Origin Y (m)	1145650
X spacing (m)	125
Y spacing (m)	125
Bearing	16.5
Cages X	2
Cages Y	5
Net Depth (m)	15
Cage circumference (m)	9 x 160, 1 x 120

4.3 Hydrographic Data

Current data was collected from 31/08/2022 – 21/12/2022 at the Billy Baa site using a Teledyne Workhorse Sentinel 600kHz Acoustic Doppler Current Profiler (ADCP). Methods for data collection and analysis followed current SEPA guidelines and are detailed in the Hydrographic Report provided alongside this CAR application [5] [6].

Prior to commencement of modelling, the data was corrected for declination of the magnetic field using a British geological survey calculator. The data for the surface, middle and bottom cells were processed in the SEPA hg-analysis spreadsheets [3].

The hydrography of this site is considered to be suitable for a site of this size and nature (table 4.2). The mean surface speed of the site was 0.050m/s, with a maximum surface recorded speed of 0.297m/s . The resuspension threshold of 0.095m/s was exceeded 4% of the time for the near bed data. This indicates that there will likely be only a small proportion of resuspension of waste material at the site, resulting in a slight degree of export of released solids from the grid.

Table 4.2: Summary statistics for ADCP deployment.

Bin height	Sub-surface Bin 21 (38.86 m from sensor)	Cage-bottom Bin 16 (29.86 m from sensor)	Near-bed Bin 1 (2.86 m from sensor)
Mean Speed (m s-1)	0.050	0.034	0.038
Mean Speed Ranked %	57	58	60
3 cm s-1 Ranked %	30	52	49
4.5 cm s-1 Ranked %	50	75	68
9.5 cm s-1 Ranked %	92	99	96
Residual Direction (°Grid)	203	215	030
Residual Speed (m s-1)	0.021	0.007	0.010
Longitudinal Residual (m s-1)	0.021	0.007	0.010
Lateral Residual (m s-1)	0.001	0.003	0.003
Longitudinal Amplitude (m s-1)	0.061	0.033	0.056
Lateral Amplitude (m s-1)	0.046	0.044	0.029
Ellipse Major Axis (°Grid)	200	195	015
Amplitude Anisotropy	1.34	1.34	1.93

4.4 Biomass and Feed Load

During the standard default NewDEPOMOD run of the proposed site, biomass was limited by the maximum consentable biomass (4091t), equivalent to a stocking density of 14 kg/m^3 and a net depth of 15m. Peak biomass feed load was derived from NewDEPOMOD, using peak biomass and the default Stock to Feed Ratio (SFR) of 0.7%. Table 4.3 details feed composition and consumption rates.

Table 4.3: Biomass and Feed load input used during NewDEPOMOD modelling.

Feed wasted (%)	3
Water content of feed (%)	9
Feed absorption (%)	85
Carbon content of feed (%)	49
Carbon content of faeces (%)	30

4.5 NewDEPOMOD Configuration

Default values were used, as recommended in the most recent SEPA guidance [4] [7], during the initial NewDEPOMOD runs.

5 Standard Default Method Modelling Results

5.1 Proposed Layout Benthic Run

The modelled run for the existing site limited the licensed biomass to 4091 tonnes, with a stocking density of 14kg/m^3, a net depth of 15m and a grid size of 125m. All cages were modelled as containing fish, with feed equally distributed throughout. Values for benthic mean intensity and area of impact are presented below in table 5.3, whilst the depositional results contours are presented in figure 5.1.

Table 5.1: Tabulated results for modelled run of proposed site layout.

Biomass (T)	Benthic Impacted Area (m^2)	100m mixing zone area (m^2)	Benthic Mixing Zone Mean Flux (g/m^2/yr)
4091	310000	261240	3967.5

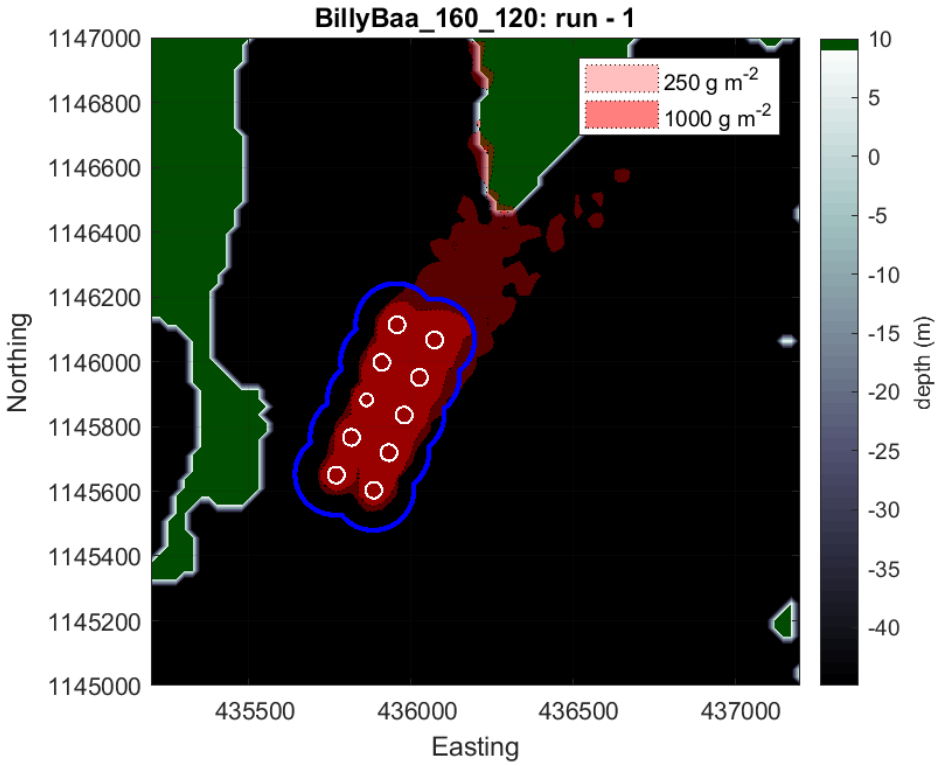

Figure 5.1: Average flux contour plot for model run of the proposed site.

Due to the site's high wave exposure of around 2.94, environmental quality standards of 4000g/m^2/yr benthic intensity and a benthic impacted area 120% the allowed mixing zone were used to determine if the model run complied with SEPA standards - the proposed configuration was found not to exceed either of these values in impacted area and intentisy of impact, therefore this setup was found to comply with SEPA guidance.

5.1.1 Transect and Sampling Stations

Four transects were identified on completion of the benthic modelling (figure 5.2). Sampling stations along these were spaced in such a way to best locate the mixing zone boundary and an IQI value of 0.64. The transects were oriented to best record the extent of the impacted area of the site as determined by the EQS boundary conditions (table 5.2).

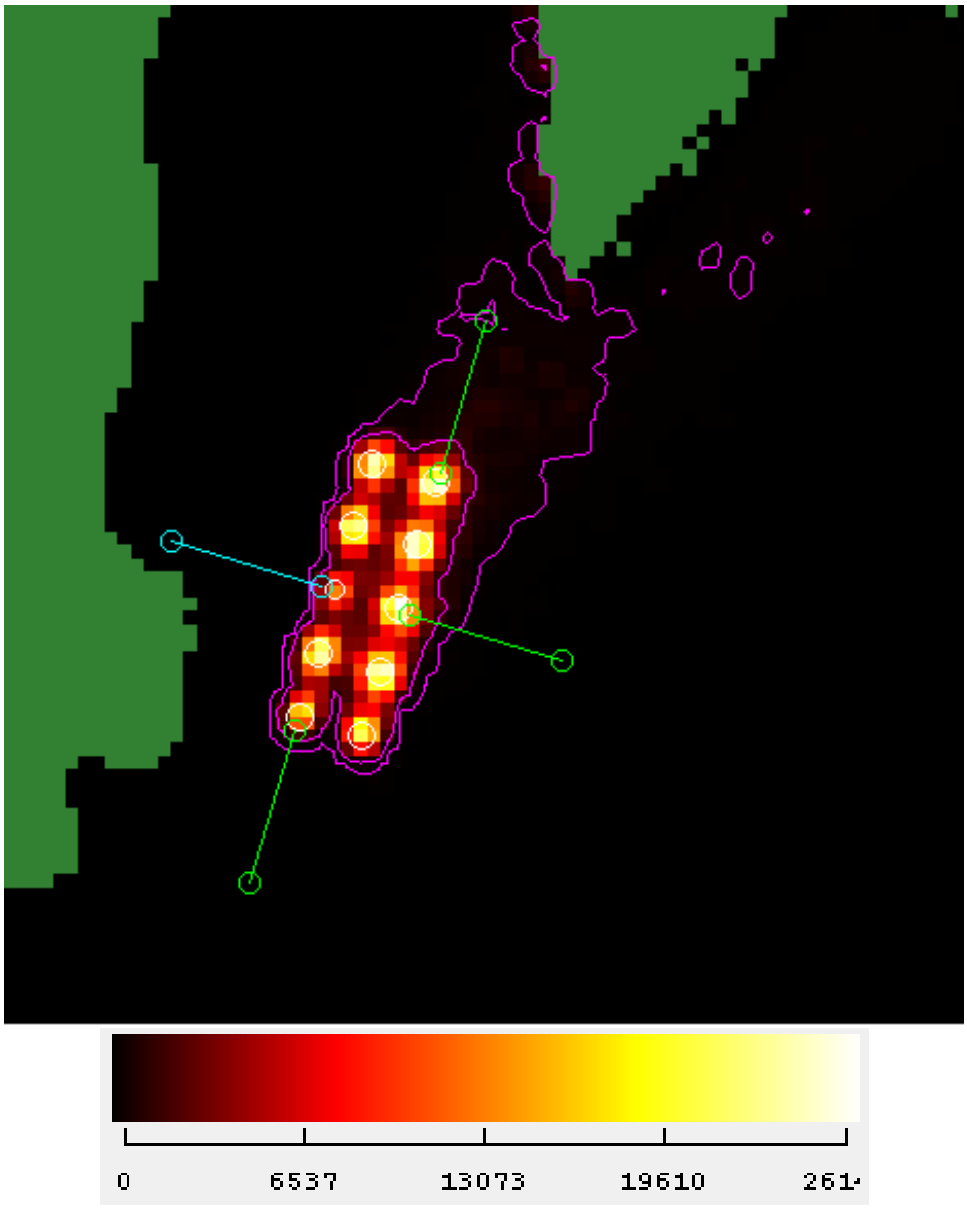

Figure 5.2: Location of sampling transects in relation to solids deposition (values in g/m^2/yr). The 250g/m^2/yr contour is also displayed.

Table 5.2: Details of transect orientations and starts and ends of each.

Transect	Bearing (°T)	Distance	Easting	Northing
1	16.5	0	436039	1146115
1	16.5	300	436124	1146403
2	106.5	0	435981	1145846
2	106.5	300	436269	1145761
3	196.5	0	435762	1145627
3	196.5	300	435677	1145339
4	286.5	0	435813	1145900
4	286.5	300	435526	1145985

These transects may be reconfigured in future, in which case, new transects will be submitted to SEPA in the environmental monitoring plan for the site.

5.2 In-feed Treatments

The NewDEPOMOD model was was run for the proposed site layout using a TAQ of EmBz equalling 1432g (giving an equivalent treatment quantity of 1 times maximum peak biomass of the proposed site).

SEPA applies a single criteria for the use of SLICE (EmBz) as an in-feed treatment. This is the mixing zone extent, which dictates that the total area which exceeds the pertinent EQS (designated as the 136ng/kg wet weight contour) should not exceed the 100m composite mixing zone area.

The results of this modelling predicted the impacted area exceeding this EQS to be much higher than the allowable area (261,240m^2), and so the proposed site was modelled for lower quantities until a passing quantity was achieved; this came to a TAQ of 27.2g EmBz, equivalent to a treatment of 0.019 the proposed biomass, or 77.7t (Figure 5.3).

Table 5.3: Tabulated results for modelled run of proposed site layout.

TAQ EmBz (g)	EmBz Impacted Area (m^2)	100m mixing zone area (m^2)	Overtreatment Factor
27.2g	248750	261240	0.019

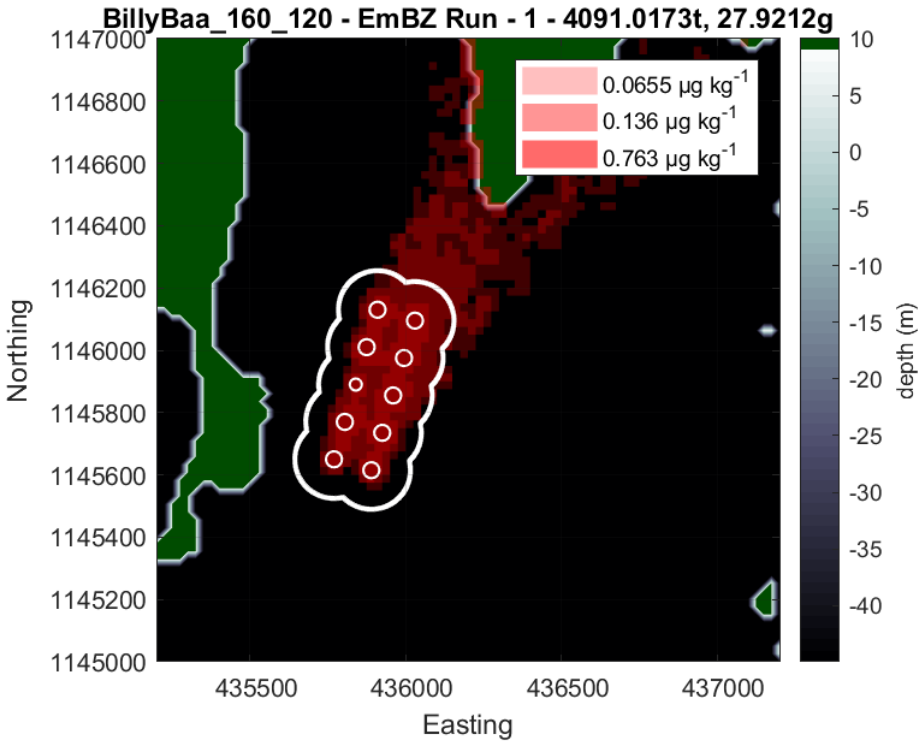

Figure 5.3: Modelled average EmBz deposition for the proposed site.

6 Discussion

The proposed biomass at Billy Baa, 4091 tonnes, is based on a SEPA defined limit to the benthic mixing zone mean intensity where it must not exceed 4000g/m^2/yr, where wave exposure is 2.8 or greater [4]. The proposed site is not expected to exceed this limit, with an intensity of impact of 3976.7g/m^2/yr predicted. The proposed site is also predicted to comply with SEPA's impacted area EQS, which is defined as 120% the allowable mixing zone where wave exposure is 2.8 or greater (261240m^2 => 313488m^2). In comparison, the modelled impacted area of the proposed Billy Baa site is 310000g/m^2.

The site is characterised by low to medium current velocities, and so a reasonable spatial footprint around the site is expected, with a small export of waste material from the model domain due to faster near bed speeds.

The resuspension frequency is low, with only 4% exceeding 0.095m/s at the near-bed cell. The near-bed residual direction is 030°T. NewDEPOMOD predicts an export of 11% of all released solids, and so it is likely that some waste will be exported from the modelled area and into the wider area, likely to be the Voes situated to the North of the site, though most deposition is likely to be directly below the site and in a footprint extending towards the headland of Russa Ness.

Based on the predicted footprint of the site modelled in the calibrated NewDEPOMOD runs, four transects with seven sampling stations each are proposed, in directions South, West, North and East from the cage group. Each transect will cover a distance of 300m, with seven sampling transects spaced out along them.

7 Conclusion

It is recommended that the proposed Billy Baa site can be allowed to carry a maximum biomass of 4091 tonnes, with recommended sampling stations as detailed in this report. In order to limit any increase in environmental impact due to the use of EmBz, the licensed use of this chemical should be 27.2g.

References

[1] Michael T. Burrows, Robin Harvey, and Linda Robb. "Wave exposure indices from digital coastlines and the prediction of rocky shore community structure". *Marine Ecology Progress Series* 353 (Jan. 2008), pp. 1–12.

[2] SEPA. "The Water Environment (Controlled Activities) (Scotland) Regulations 2011" (2011).

[3] British Geological Survey. *World Magnetic Model Calculator*. 2019. URL: `https://geomag.bgs.ac.uk/data_service/models_compass/wmm_calc.html`.

[4] SEPA. "Regulatory Modelling Guidance for the Aquaculture Sector (issue 1.1, July 2019)" (2019).

[5] SEPA. "Regulatory Modelling Process and Reporting Guidance for the Aquaculture Sector (issue 1.1, July 2019)" (2019).

[6] SEPA. "Hydrographic Data for Aquaculture Applications (published 16 September 2022)" (2022).

[7] SEPA. "Interim New Depomod Guidance (published 14 April 2023)" (2023).

[8] UK Hydrographic Office. *Seabed Mapping Service*. URL: `https://seabed.admiralty.co.uk/?x=-127911.91&y=8464339.61&z=8.91`.

Author	[redacted] (Environmental Modeller)
Company Address	Laurel House, Laurelhill Business Park, Stirling, Scotland FK7 9JQ
Company Reg No.	00958001
Date	July 4, 2023
Revision No.	Final 1.0