



Fish Holm NewDEPOMOD Modelling Report

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Contents

1	Executive Summary	4
2	Introduction	5
3	Methodology	6
3.1	Standard Default Benthic Modelling	6
3.2	In-Feed Treatment Modelling	6
4	Model Input Data	7
4.1	Bathymetric Data	7
4.2	Cage Configuration	8
4.3	Hydrographic Data	9
4.4	Biomass and Feed Load	10
4.5	NewDEPOMOD Configuration	10
5	Standard Default Method Modelling Results	11
5.1	Proposed Layout Benthic Run	11
5.2	In-feed Treatments	13
6	Discussion	14
7	Conclusion	15
	References	15

List of Figures

2.1	Location of the Fish Holm Site	5
4.1	UKHO Bathymetry survey data.	7
4.2	Proposed cage layout and configuration used in NewDEPOMOD modelling for Fish Holm. . .	8
5.1	Map of predicted deposition. Black circles: proposed pen layout. Green discs: predicted solid deposition 50-100 (light), 100-250 (mid) and 250-402 (darkest) $\text{g m}^{-2} \text{yr}^{-1}$. Map coordinates are OSGB 1936.	11
5.2	Map of modelled average EmBz deposition. Black circles: proposed pen layout. Pink discs: predicted EmBz deposition $\geq 0.136 \mu\text{g EmBz kg sediment}^{-1}$. Map coordinates are OSGB 1936.	13

List of Tables

1.1	Site details, hydrographic input summary, and summarised results of the modelling.	4
4.1	Cage configuration input used in NewDEPOMOD modelling of the proposed site layout. . . .	8
4.2	Summary statistics for ADCP deployment.	9
4.3	Biomass and Feed load input used during NewDEPOMOD modelling.	10
5.1	Tabulated results for modelled run of proposed site layout.	11
5.2	Tabulated results for modelled run of proposed site layout.	13

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) to vary the existing license at Fish Holm (CAR/L/1004202), to allow for installation of equipment for a marine fish farm and for consent to use adequate sea lice treatments at the site, 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 Fish Holm 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		Fish Holm
Location		Yell Sound, Shetland
Number of Cages		12
Cage Circumference (m)		160
Net Depth (m)		18
Group Layout		2 x 6
Hydrographic Summary		
Sub-surface Currents	Average Speed (m s^{-1})	0.162
	Residual Direction ($^{\circ}$)	355
	Wind Influence	Moderate
Cage-bottom Currents	Average Speed (m s^{-1})	0.166
	Residual Direction ($^{\circ}$)	346
Near-bed Currents	Average Speed (m s^{-1})	0.154
	Residual Direction ($^{\circ}$)	310
Benthic Modelling - Standard Default Method Run		
Peak Biomass (tonnes)		6000
Stocking Density (kg m^{-3})		13.64
In-feed Treatments		
Total Allowable Quantity – EmBz (g)		149.6
Equivalent Biomass (t)		427.5

2 Introduction

This report details the methodology, results and conclusions of work conducted by SSF for the purpose of assessing modifications to an existing site, Fish Holm, 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 Fish Holm near the entrance to Swinister Voe, on the East coast of the Shetland Mainland. The average bathymetry of the site is 60 m, and wave exposure index is approximately 3.5 [1]. This modelling report is to accompany a CAR application for a site with maximum biomass of 6000 tonnes, to be contained in 12 circular cages of circumference 160 m.

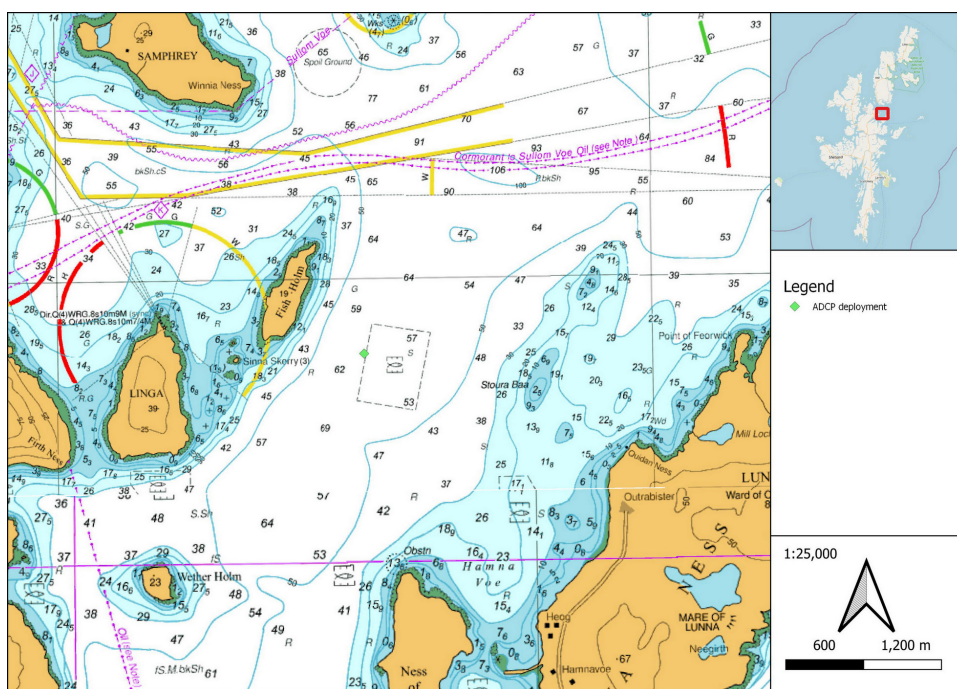


Figure 2.1: Location of the Fish Holm Site

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 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.

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).

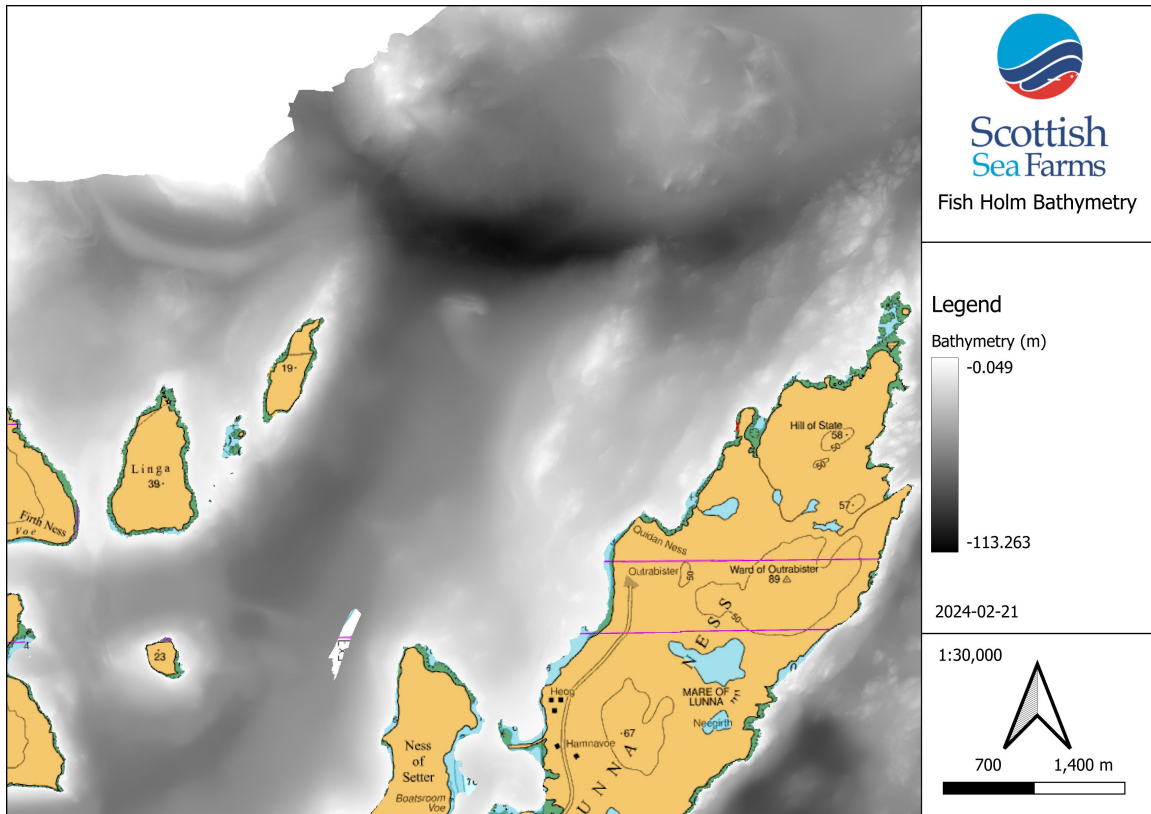


Figure 4.1: UKHO Bathymetry survey data.

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 66.98m (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 the model set up. The layout of this was for one group of 12 x 160 m circumference circular cages, in 2 x 6 formation and a 110 m grid. Further information on the site layout is provided in Figure 4.2 and Table 4.1.

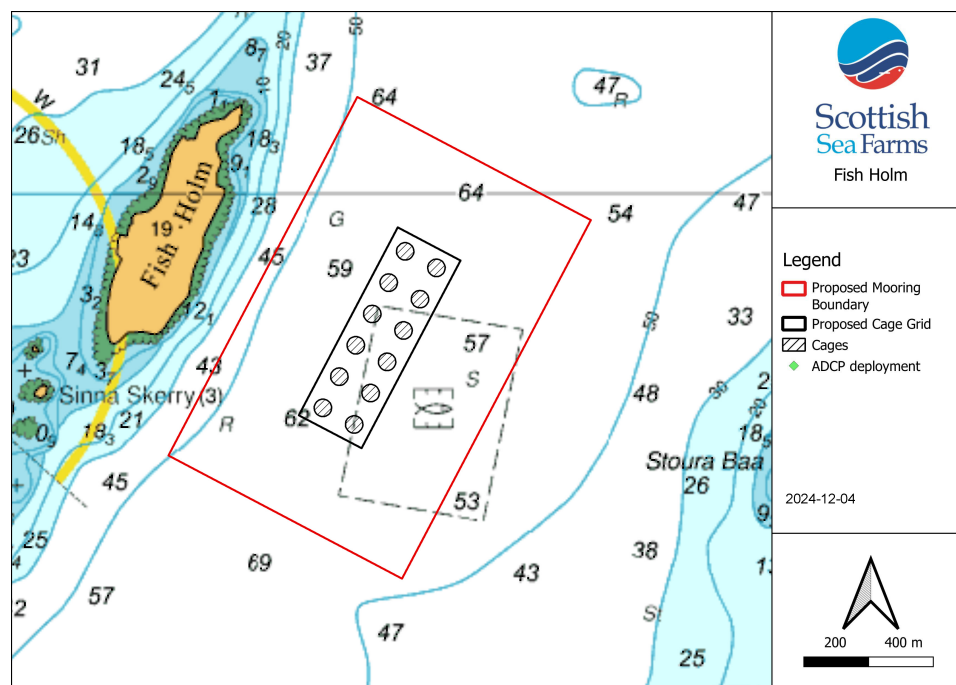


Figure 4.2: Proposed cage layout and configuration used in NewDEPOMOD modelling for Fish Holm.

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

Layout	Proposed
Origin X (m)	448207.6
Origin Y (m)	1173678.9
X spacing (m)	110
Y spacing (m)	110
Bearing	27
Cages X	2
Cages Y	6
Net Depth (m)	18
Cage circumference (m)	12 x 160

4.3 Hydrographic Data

Current data was collected from 21/04/2022 – 25/07/2022 at the Fish Holm site using a Nortek Signature 500khz 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 0.162 m s^{-1} , with a maximum surface recorded speed of 0.673 m s^{-1} . At the near bed bin, the resuspension threshold of 0.095 m s^{-1} was exceeded 76% of the time for the near bed data. This indicates that there is likely to be a high proportion of resuspension of waste material at the site, resulting in the majority of solids being exported from the grid.

Table 4.2: Summary statistics for ADCP deployment.

Bin height	Sub-surface Bin 32 (58.73 m from seabed)	Cage-bottom Bin 26 (47.93 m from seabed)	Near-bed Bin 1 (2.93 m from seabed)
Mean Speed (m s^{-1})	0.162	0.166	0.154
Mean Speed Ranked %	56	55	55
3 cm s^{-1} Ranked %	3	2	3
4.5 cm s^{-1} Ranked %	6	5	6
9.5 cm s^{-1} Ranked %	25	23	24
Residual Direction ($^{\circ}\text{Grid}$)	355	346	310
Residual Speed (m s^{-1})	0.073	0.060	0.052
Longitudinal Residual (m s^{-1})	0.072	0.059	0.043
Lateral Residual (m s^{-1})	-0.013	-0.014	-0.030
Longitudinal Amplitude (m s^{-1})	0.196	0.211	0.193
Lateral Amplitude (m s^{-1})	0.139	0.140	0.132
Ellipse Major Axis ($^{\circ}\text{Grid}$)	5	360	345
Amplitude Anisotropy	1.41	1.51	1.46

4.4 Biomass and Feed Load

During the standard default NewDEPOMOD run of the proposed site, biomass was limited by the maximum consentable biomass (6000 t), equivalent to a stocking density of 13.64 kg/m^3 and a net depth of 18 m. 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 6000 t, with a stocking density of 13.64 kg m⁻³, a net depth of 18 m and a grid size of 110 m. 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 5.1, 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 ⁻¹)
6000	71250	270097	284.2

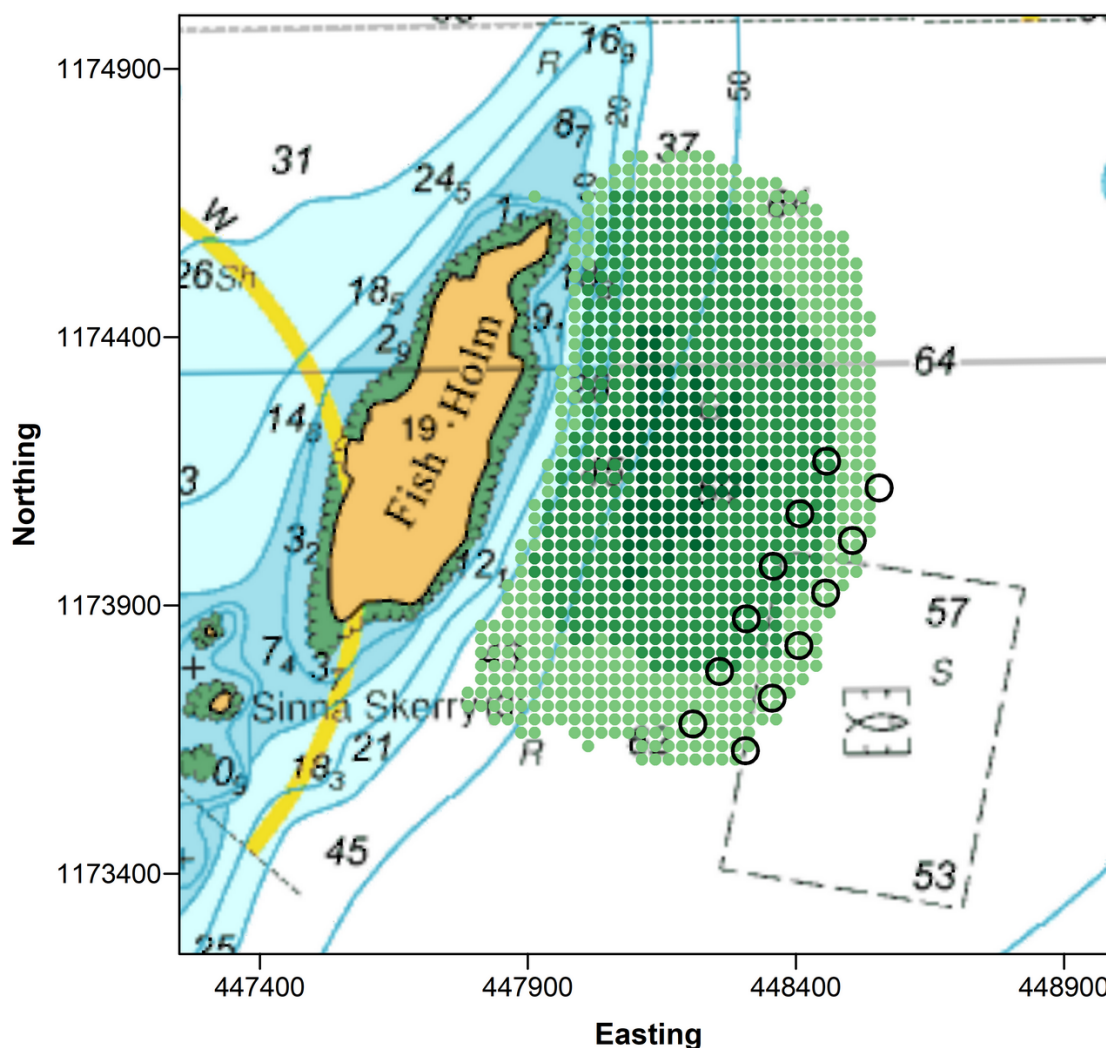


Figure 5.1: Map of predicted deposition. Black circles: proposed pen layout. Green discs: predicted solid deposition 50-100 (light), 100-250 (mid) and 250-402 (darkest) g m⁻² yr⁻¹. Map coordinates are OSGB 1936.

Due to the site's high wave exposure of around 3.5, environmental quality standards of $4000 \text{ g m}^{-2} \text{ yr}^{-1}$ 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 intensity of impact, therefore this setup was found to comply with SEPA guidance.

5.2 In-feed Treatments

The NewDEPOMOD model was run for the proposed site layout using a TAQ of EmBz equalling 149.6 g (giving an equivalent treatment quantity of 0.071 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 136 ng kg⁻¹ wet weight contour) should not exceed the 100 m composite mixing zone area.

The results of this modelling predicted the EmBz impacted area did not exceed this EQS (Table 5.2).

Table 5.2: 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
149.6	260625	270097	0.071

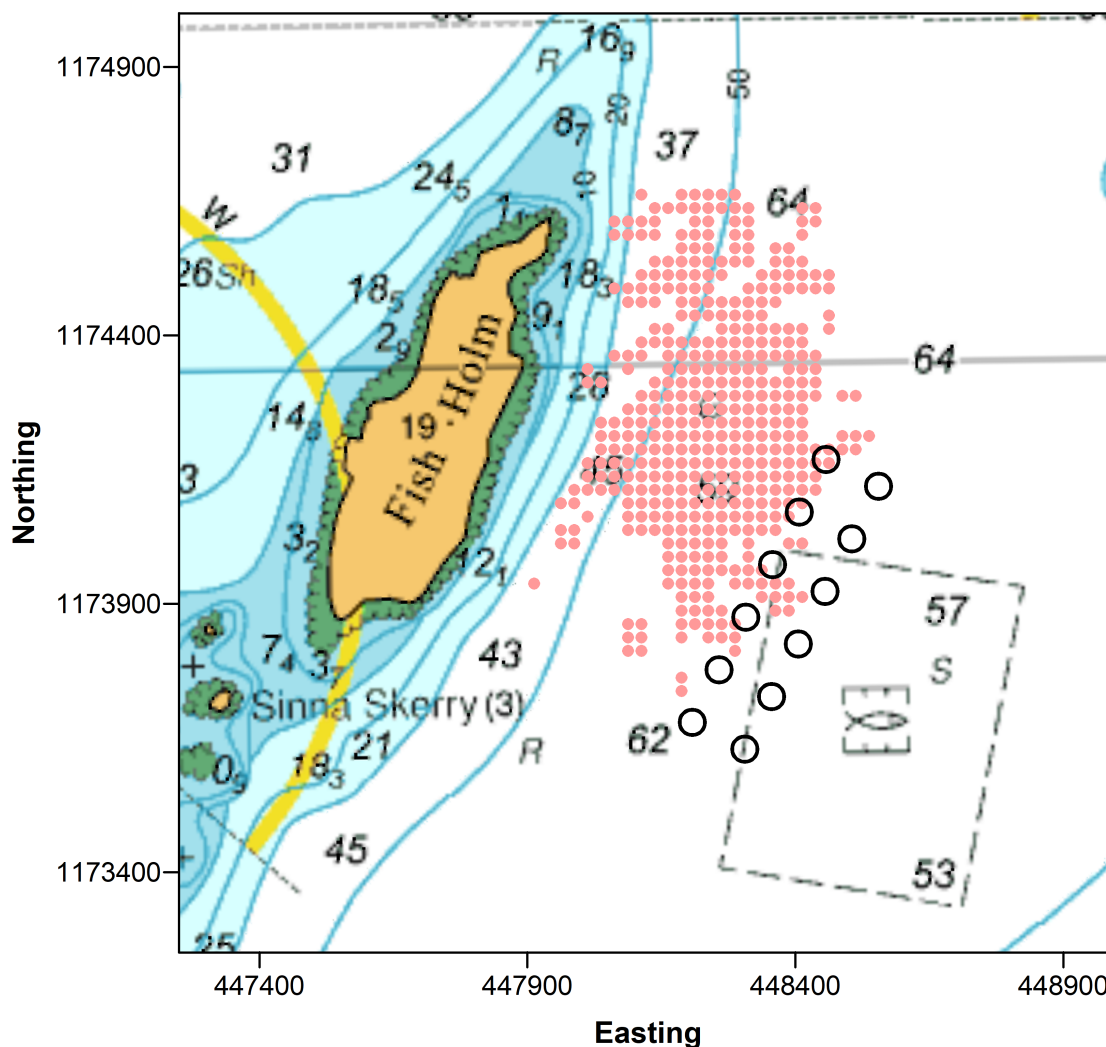


Figure 5.2: Map of modelled average EmBz deposition. Black circles: proposed pen layout. Pink discs: predicted EmBz deposition $\geq 0.136 \mu\text{g EmBz kg sediment}^{-1}$. Map coordinates are OSGB 1936.

6 Discussion

At the Fish Holm site, wave exposure index is 3.5. This is over the SEPA threshold of 2.8, meaning that a benthic mixing zone intensity EQS limit of $4000 \text{ g m}^{-2} \text{ yr}^{-1}$ is applied, in addition to the allowable impacted area (area over $250 \text{ g m}^{-2} \text{ yr}^{-1}$) being 120% of the usual allowable mixing zone. In this case, $\text{AMZ} = 270097 \text{ m}^2$, and therefore $120\% \times \text{AMZ} = 324116 \text{ m}^2$.

The modelled output predicts an area above $250 \text{ g m}^{-2} \text{ yr}^{-1}$ of 71250 m^2 , with a mean intensity of $284 \text{ g m}^{-2} \text{ yr}^{-1}$. This means that both the intensity and extent criteria are satisfied.

The site is characterised by fast current velocities, and so only a limited spatial footprint around the site is expected, with a high export of waste material from the model domain.

The resuspension frequency is high, with 76% exceeding 0.095 m s^{-1} at the near-bed cell. The near-bed residual direction is 310°G . It is likely that most waste will be exported from the modelled domain and into the wider area, likely dispersed into Yell Sound to the North of the site, with only minor deposition directly below the site.

7 Conclusion

It is recommended that the proposed Fish Holm site can be allowed to carry a maximum biomass of 6000 t. In order to limit any increase in environmental impact due to the use of EmBz, the licensed use of this chemical should be 361.2 g.

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

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