NewDEPOMOD MODELLING REPORT

Caolas Finfish Pen Site, Loch Portain, North Uist

Prepared for

Loch Duart Ltd

Badcall Salmon House
Scourie
Sutherland
IV27 4TH

TransTech
Environmental

TransTech Limited
Caerthann House
Connel
Argyll PA37 1PQ
Scotland

Quality Assurance

The data presented within this document have undergone a quality assurance review which follows established TransTech Ltd procedures. The information and results presented herein constitute an accurate representation of these data.

Document Details

Author: [redacted]

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List of Abbreviations

ADCP	Acoustic Doppler Current Profiler	IQI	Infaunal Quality Index
CD	Chart Datum	MZ	Mixing Zone
CLP	Caolas Loch Portain	OSGB36	Ordnance Survey Great Britain 1936
EMBZ	Emamectin Benzoate	SEPA	Scottish Environment Protection Agency
EQS	Environmental Quality Standard	UI	User Interface
GMT	Greenwich Mean Time	vdsp	Resuspension dispersion coefficient Z

EXECUTIVE SUMMARY

This report has been prepared to meet the requirements of SEPA for assessing an application to modify the Caolas pen site.

The proposal is to replace all 14 of the existing 80 m circumference pens with twelve 100 m circles in a 60 m x 60 m mooring grid. This will result in an increase in biomass from the currently consented 1,060.0 tonnes to 1,720.0 tonnes.

The solids modelling for the existing and modified site has been undertaken using the NewDEPOMOD User Interface (v1.4.2-snapshot 8.5 (36) 2023-05-23 11:12:30 [SEPA]).

Five SEPA default runs with a resuspension dispersion coefficient Z of 0.003310 were performed pre and post modification.

Given the site's location the Wave Exposure Index (WEI) is >2.8 and therefore the permitted mean intensity is ≤4,000 g/m^2. For the pre and post modification runs mean intensity was 752.7 and 1,474.6 g/m^2 respectively. However, the model appears to be underpredicting the size of the 0.64 Infaunal Quality Index (IQI) footprint i.e., for the existing site the surveyed footprint is c. 64,000 m^2 whereas the model prediction is c. 44,250 m^2.

It is appreciated that SEPA often prefers the use of default settings to assess mean intensity compliance. However, to be robust, the model was calibrated against IQI benthic survey data to replicate as closely as possible the 250 g/m^2 (0.64 IQI) footprint. For what is deemed to be appropriate calibration settings mean intensity at the existing site rose by approximately 23.9% to 932.3 g/m^2 and for the modified site there was an approximate 69.7% increase to 2,501.8 g/m^2. These values are still significantly lower than SEPA's 4,000 g/m^2 threshold, even when not considering the additional ≤15% that is permitted for the modification of an existing site, such as Caolas, that has good benthic survey results.

250 g/m^2 deposition for the existing and modified site does not exceed the 100 m mixing zone Indeed, for the modified site, after calibration, this was 62.3%.

Therefore, in conclusion, although the proposed modification is predicted to increase the intensity of waste on the seabed in close proximity to the cage group, the proposal is considered compliant with SEPA requirements.

SEPA's interim[(1)] Emamectin benzoate (EMBZ) Environmental Quality Standard (EQS) requires the area which exceeds 136 ng/kg (0.136 µg/kg) not to exceed the 100 m mixing zone area. As per SEPA requirements, the model was run for 118 days. However, a useable pass was not achieved for mean deposition after 116-118 days. Thus, EMBZ has been scoped out of this document.

1. INTRODUCTION

This report has been prepared to meet the specific requirements of the Scottish Environment Protection Agency for the assessment of applications for biomass consent. These must comply with the Environmental Quality Standards that are in place to protect the marine environment.

All hydrographic data used for the modelling was collected by Loch Duart and has been validated by SEPA for NewDEPOMOD modelling.

The methods described in this report closely adhere to those set out in SEPA's NewDEPOMOD modelling guidance for the aquaculture sector[(2)], and the results are reported to satisfy consent application requirements.

Information on the existing Caolas site and its proposed modification is given below.

Pen group details pre and post modification

	Pre modification	Post modification
Biomax:	1,060.0 tonnes	1,720.0 tonnes
NE pen centre position:	94739.0353 E, 869468.4823 N	94751.1600 E, 869457.9434 N
Group centre position:	94829.6125 E, 869346.3317 N	94829.2352 E, 869326.3978 N
Number of pens (for production):	14	12
Pen group configuration:	2 x 7	2 x 6
Pen dimensions:	80 m circle	100 m circle
Working depth:	12.0 m	12.0 m
Maximum stocking density:	12.388721029781 kg/m^3	15.0098315671512 kg/m^3
Grid size (x by y):	50 m x 50 m	60 m x 60 m
Pen group orientation:	133.98º	138.00º

Hydrographic data

Please refer to report previously submitted to SEPA, entitled "CLP_2023v1_Hydrographic_Report.pdf", dated 3 May 2023.

Wave exposure index[(3)]

3.22 and 3.29 at north and south ends respectively of modified pen group.

Given that the WEI exceeds 2.8, the site is considered to be moderately exposed and therefore, the permitted mean intensity is 4,000 g/m^2.

2. NEWDEPOMOD MODELLING

2.1 Project set-up

For the modelling of the existing and modified site, projects were named 2023v1_CLP_Existing and 2023v1_CLP_Modified. Calibration runs were also performed and for these projects the file names were followed by _Calib.

For both pen layouts, the relevant files were set up in their respective directories with the bathymetry, pen information and flowmetry entered for each project as described below.

2.2 Flowmetry

The Acoustic Doppler Current Profiler (ADCP) bin heights used in the modelling and a summary of the data for these are provided in table 1.

Table 1. Current meter data summary.

Period Used in Model	Bin Height (above seabed)	Mean speed (m/s)	Residual speed (m/s)	Residual direction (°Grid N)
22/11/2022 16:11:57 GMT to 20/02/2023 16:11:57 GMT (6481 20 minute records)	Sub-Surface	0.0420	0.0084	185.6
	Net-Bottom	0.0351	0.0058	307.3
	Near-Bed	0.0428	0.0098	22.2

As per TransTech's "CLP_2023v1_ND_Modelling_Method_Statement.pdf" dated 3 May 2023, the depth for the ADCP deployments has been entered into the depomodflowmetryproperties file as -27.87 and the bin heights were at meter depths of -25.02, -10.02 and -5.02.

Where sites have significant residual current speeds greater than 35-40% of the mean flow speed, particularly at the bed, material can move beyond the model boundaries. In this case SEPA requires the risk to be mitigated. One approach is to subtract the residual *u* and *v* components from the *u* and *v* components of each individual flow record in the dataset.

However, for Caolas, the residual flow (0.0098 m/s) for the bottom bin during 15-day current meter dataset is 22.9% of the mean speed (0.0428 m/s). As such, there was no need to process the data to remove the residual *u* and *v* components from the *u* and *v* components of each individual flow record in the dataset.

The model was run with the residual and a resuspension dispersion coefficient Z (vdsp) calculated from the mean speed of 0.003310.

2.3 Bathymetry/grid generation

A depomodbathymetryproperties file at a grid of 80 x 80 elements, georeferenced to OSGB36 datum, was used in the modelling, with a uniform depth of 27.87 m to represent that at which the ADCP was deployed. The 2 km^2 bathymetry file covered an area 93810 E to 95810 E and 868360 N to 870360 N.

2.4 Pen input

The pen locations and orientations were provided by Loch Duart and set-up in the UI from which the depomodcagesxml file was generated. These were then checked by looking at their profile/coordinates in the UI and GIS to ensure that they were in the correct position.

The UI pen layout plots are provided in figures 1 and 2.

Figure 1. Pre modification pen layout.

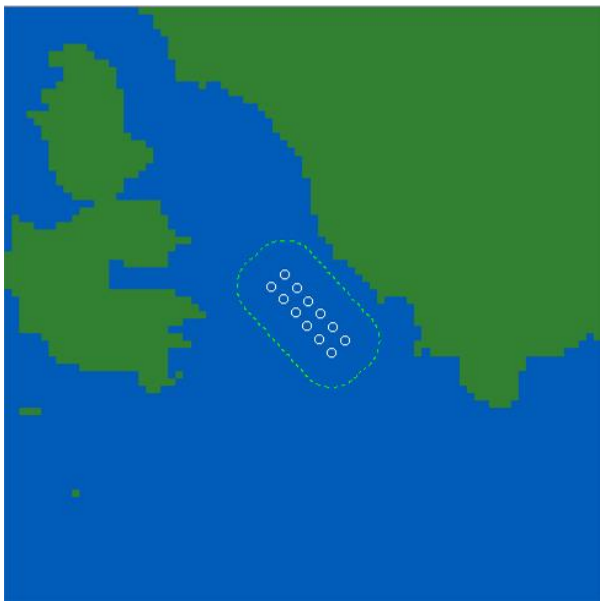


Figure 2. Post modification pen layout.

2.5 Location of Caolas site

A location plan of the existing and proposed modified Caolas site is provided in figure 3 below.

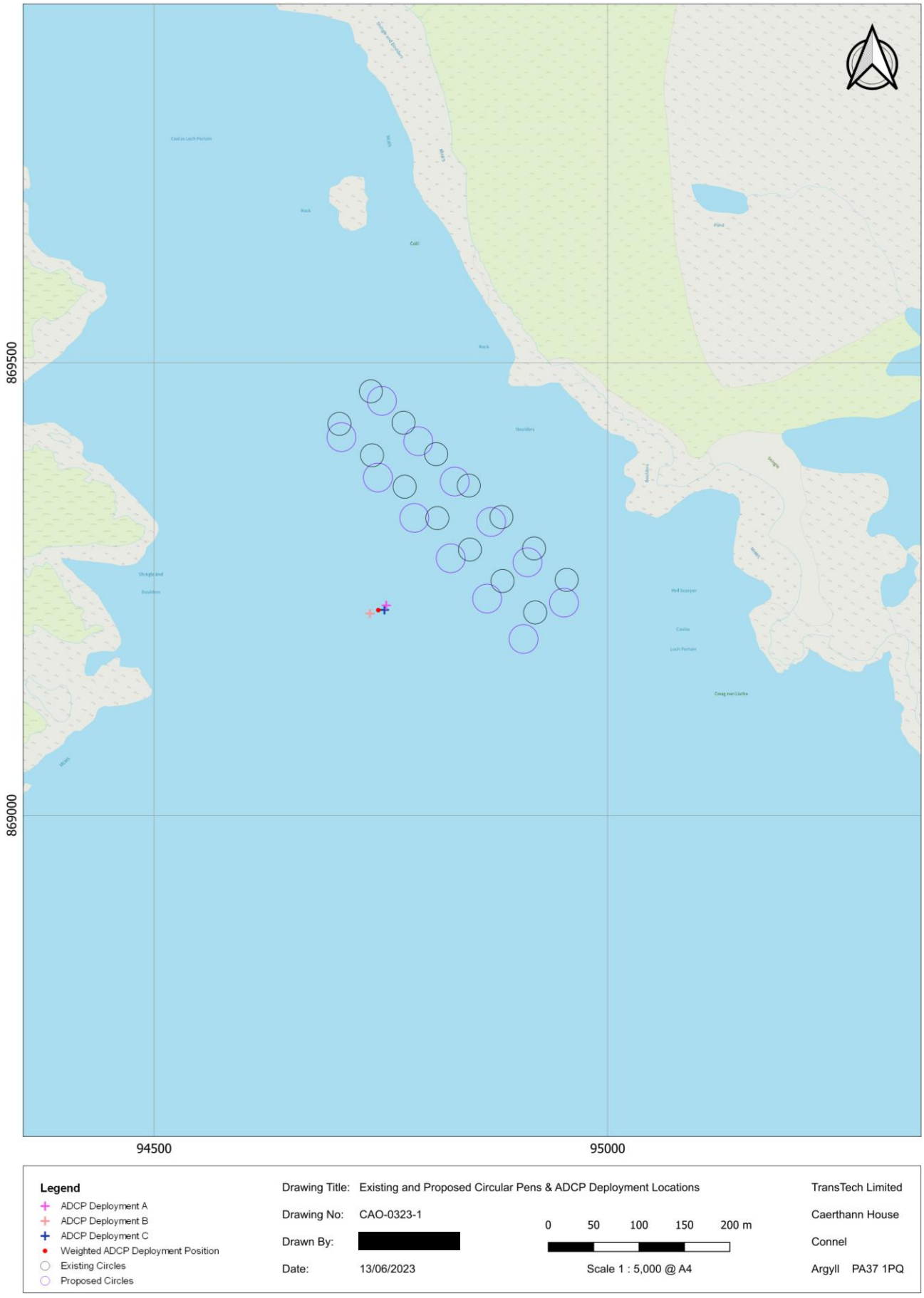


Figure 3. Location plan of existing and proposed site and ADCP deployment locations.

3. RESULTS

3.1 Benthic Runs for Existing Site with SEPA Default Settings

Note that the results presented below are for the current consent for which SEPA has TransTech's modelling on record.

The nature of the NewDEPOMOD model means that each time it is run with identical configuration parameters the results differ because the model contains random processes (settling velocities and walk/release points of sediment from bed cells). As such, for each benthic scenario five model runs were performed, and the average calculated.

In accordance with SEPA requirements, the results reported are for time-averaged output from the model runs (i.e., avg.depomodresultssur file). For the reported benthic runs this is days 275-365.

The benthic results for mean intensities within the 250 g/m^2 mixing zone (from 2023v1_CLP_Existing-Cages depomod results log) are shown in table 2.

Table 2. Summary of benthic results for 1,060 tonnes at existing site with SEPA default settings.

Modelling:	Existing Site: c. 1,060 T** (14 x 80 m circumference pens with 12 m deep nets, stocking density of c. 12.388721029781 kg/m^3) with SEPA defaults & vdsp of 0.003310				
Benthic run reference as per consented biomass application*:	ES1	ES2	ES3	ES4	ES5
Mixing zone contour area (m^2): [Eqs.benthic.mixingZone.area]	133,185				
Mixing zone mean intensity (g/m^2): [Eqs.benthic.mixingZone.boundary.contour.approx.meanFlux]	754.5	762.7	733.3	753.7	759.2
Average mean intensity for the 5 runs (g/m^2):	752.7				
250 g/m^2 mixing zone area for the 25 m^2 cells (m^2): [Eqs.benthic.mixingZone.approx.contourArea]	43,750	44,375	45,625	43,125	44,375
Average of 250 g/m^2 mixing zone areas (m^2) for the 5 runs:	44,250				
Average of 250 g/m^2 mixing zone areas (m^2) for the 5 runs as % of mixing zone contour area:	33.2				

* The results for the above runs are contained within the ES1 to ES5 directories in 2023v1_CLP_Existing\depomod\results which accompanies this report.

** Note that the cage positions were amended slightly and only after these runs were performed was it realised that the UI does not store the stocking density to the same number of decimal places as originally input so the modelled biomax was in fact 1060.1094 tonnes. This is not deemed to have a significant bearing on the results and this was rectified for the 1105 tonnes calibration run (§3.4).

The 250 g/m^2 contour area for Runs ES2 and ES5 was closest to the average of all 5 runs. An example of the 250 g/m^2 44,375 m^2 footprint for these runs is shown in figure 4.

Figure 4. Run ES5 (average for days 275-365): 44,375 m^2 mixing zone area and 250 g/m^2 contour. UI plot also shown.

3.2 Benthic Runs for Modified Site with SEPA Default Settings

The modified site was modelled using the same default run settings as those used for the existing site, albeit with the proposed modified pens, biomass, net depth and stocking density.

Five benthic runs were performed and the predicted mean intensities within the mixing zone (from 2023v1_CLP_Modified-Cages depomod results log) are provided in table 3.

Table 3. Summary of benthic results for 1,720 tonnes at modified site with SEPA default settings.

Modelling:	Modified Site: 1,720 T (12 x 100 m circumference pens with 12 m deep nets, stocking density of 15.0098315671512 kg/m^3) with SEPA defaults & vdsp of 0.003310				
Benthic run reference*:	MS1	MS2	MS3	MS4	MS5
Mixing zone contour area (m^2): [Eqs.benthic.mixingZone.area]	142,729				
Mixing zone mean intensity (g/m^2): [Eqs.benthic.mixingZone.boundary.contour.approx.meanFlux]	1,471.6	1,480.8	1,443.7	1,453.4	1,523.6
Average mean intensity for the 5 runs (g/m^2):	1,474.6				
250 g/m^2 mixing zone area for the 25 m^2 cells (m^2): [Eqs.benthic.mixingZone.approx.contourArea]	85,000	86,250	89,375	86,875	86,250
Average of 250 g/m^2 mixing zone areas (m^2) for the 5 runs:	86,750				
Average of 250 g/m^2 mixing zone areas (m^2) for the 5 runs as % of mixing zone contour area:	60.8				

* The results for the above runs are contained within the MS1 to MS5 directories in 2023v1_CLP_Modified\depomod\results which accompanies this report.

For the SEPA defaults runs, the average mean intensity at the existing site is 752.7 g/m^2 and the average mean intensity for the proposed modification is 1,474.6 g/m^2. Therefore, for the modified site there is an increase of c. 95.9% but nevertheless mean intensity remains significantly lower than the 4,000 g/m^2 EQS.

The mixing zone area for MS4 was closest to the average for all 5 runs. The 250 g/m^2 footprint and the 86,875 m^2 mixing zone area for this run is shown in figure 5.

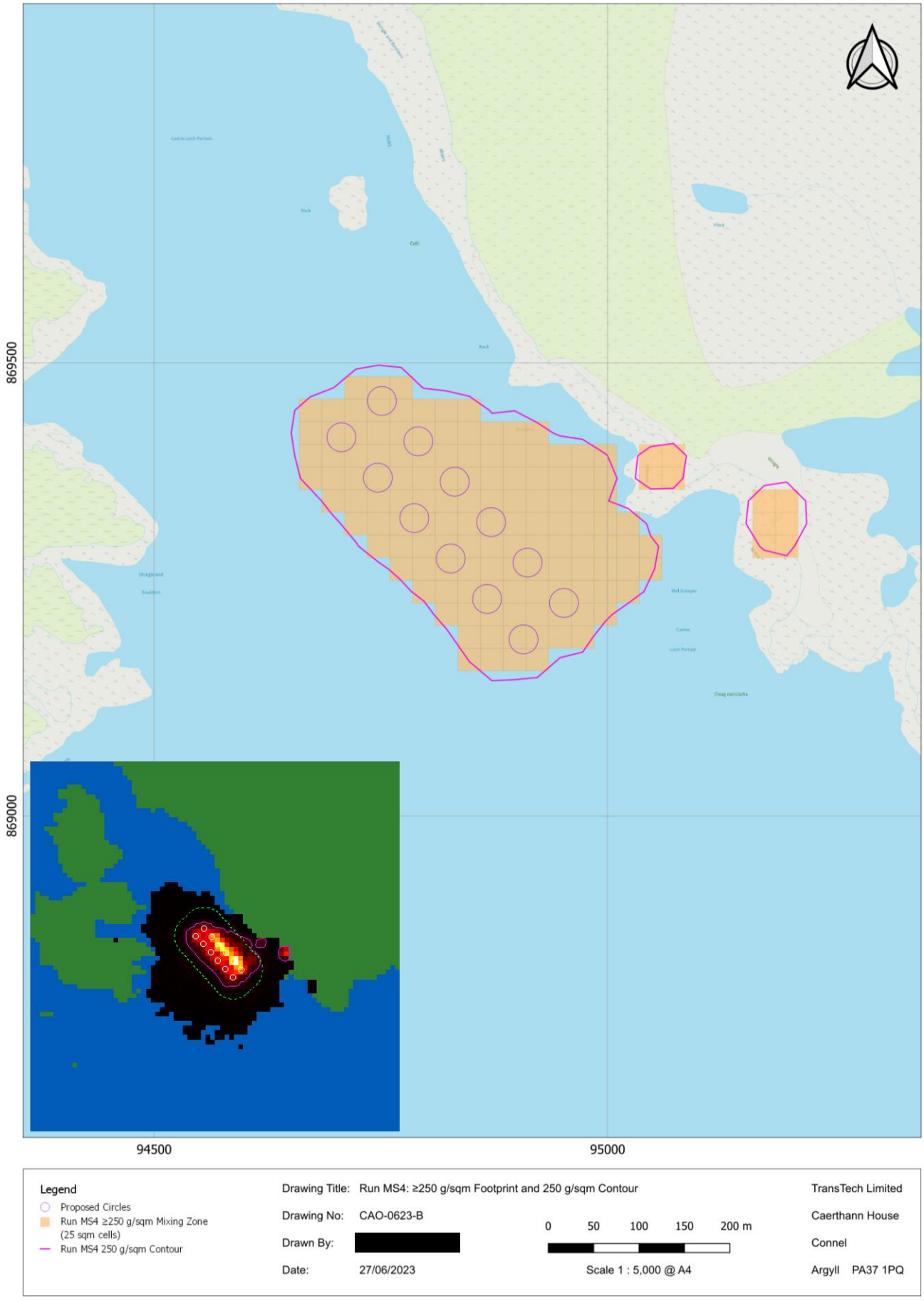


Figure 5. Run MS4 (average for days 275-365): 86,875 m^2 mixing zone area and 250 g/m^2 contour. UI plot also shown.

3.3 Model Calibration

To improve NewDEPOMOD's predictions for benthic deposition at the modified site the model was calibrated for the existing site.

To do so, a new project was created which was named 2023v1_CLP_Existing_Calib.

The IQI benthic results for the 2021/2022 production cycle were obtained from the Pharmaq Analytiq's submission to SEPA (MPFF-EMSR-v6 Caolas Loch Portain 2022). The extents of the 0.64 IQI ellipse area for the 2022 survey were obtained by configuring and running Kraken[4] in RStudio (figures 1 and 2). Kraken gives the 5th percentile area as 64,416 m^2 (figure 6).

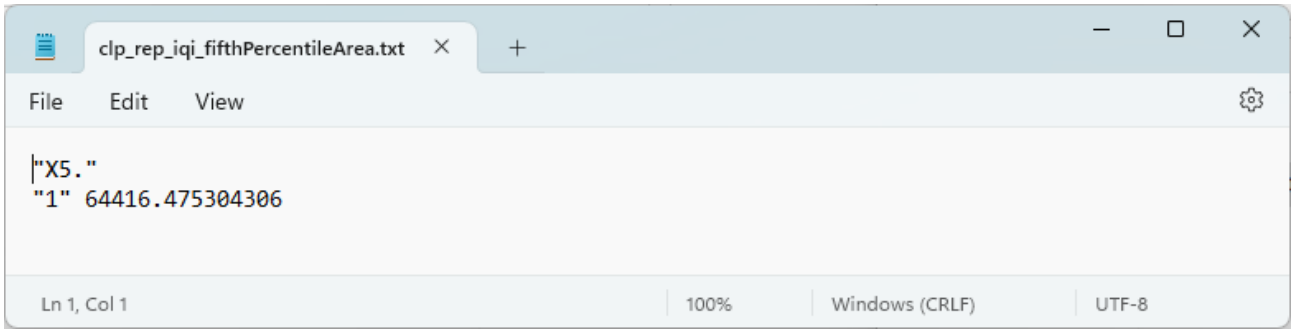


Figure 6. Kraken 5th percentile area output.

The existing site was then modelled using modified parameters to achieve the closest match to the ellipse area.

The same parameters were then used to model the modified site. The project for the modified site was named 2023v1_CLP_Modified_Calib.

There is little information available on the accepted methods for calibration of the NewDEPOMOD model. Indeed, few published SEPA accepted model calibration reports are available given the infancy of the regulatory framework and the relative newness of the model.

3.4 Benthic Calibration Runs for Existing Site

The biomax during the 2021/2022 production cycle was 1,105 tonnes. To achieve a comparable mixing zone area to the Kraken ellipse the only revision required was to the resuspension transport coefficient Z (vdsp) as shown in table 4.

Table 4. Summary of benthic calibration run results for existing site.

Modelling:	Calibration Runs for Existing Site: 1,105 T (14 x 80 m circumference pens with 12 m deep nets, stocking density: 12.914657299913 kg/m^3)

Benthic run reference*:	ESC1	ESC2	ESC3	ESC4	ESC5	**ESC6**
Resuspension transport coefficient Z (m^2/s):	0.001	0.002	0.0025	0.003	0.0028	**0.0029**
Mixing zone contour area (m^2): [Eqs.benthic.mixingZone.area]	133,185					
Mixing zone mean intensity (g/m^2): [Eqs.benthic.mixingZone.boundary.contour.approx.meanFlux]	4,922.4	2911.3	1,910.6	922.5	1,134.0	**932.3**
250 g/m^2 mixing zone area for the 25 m^2 cells (m^2): [Eqs.benthic.mixingZone.approx.contourArea]	73,125	73,750	68,750	56,875	69,375	**66,250**
Kraken ellipse area of 64,416 m^2 as % of 250 g/m^2 mixing zone area for the 25 m^2 cells (m^2):	88.1	87.3	93.7	113.3	92.9	**97.2**
Eqs.BenthicImpactedAreaEQS.eqsResult:	HIGH	LOW		HIGH		
Eqs.benthic.pass:	LOW					
Eqs.control.eqsResult:	LOW					
Eqs.critical.eqsResult:	HIGH		LOW		HIGH	
Eqs.warning.eqsResult:	HIGH	LOW				

* The results for the above runs are contained within the ESC1 to ESC6 directories in 2023v1_CLP_Existing_Calib\depomod\results.

The mixing zone area for ESC6 was closest to the Kraken ellipse area of 64,416 m^2 (figure 7).

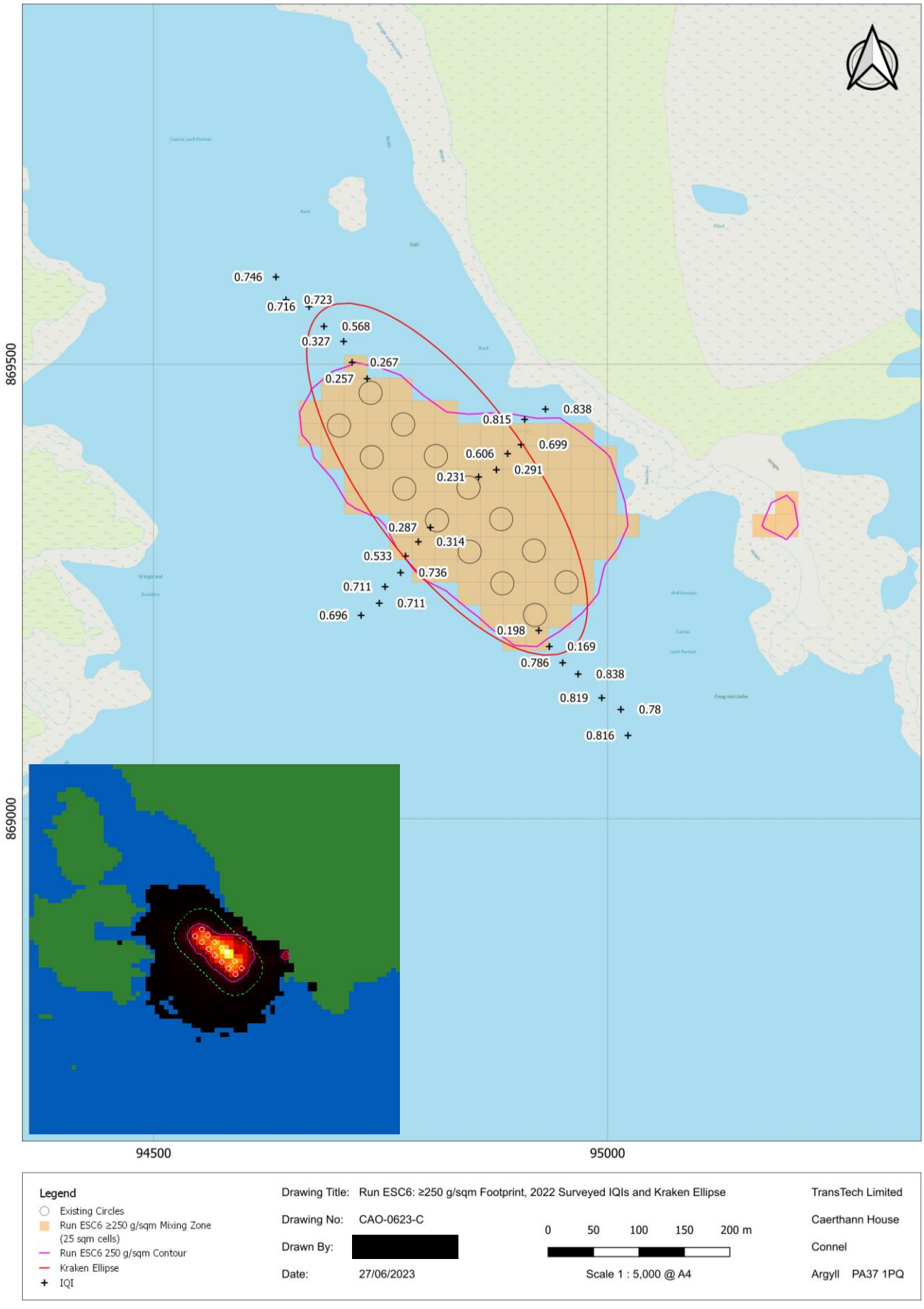


Figure 7. Run ESC6 (average for days 275-365): 66,250 m^2 mixing zone area, 250 g/m^2 contour, 2022 benthic survey IQIs and 0.64 IQI ellipse from Kraken (NB: this is the RStudio plotted ellipse (area = 64,416 m^2) which is slightly larger than the 5th percentile area of 64,416 m^2). UI plot also shown.

3.5 Benthic Runs for Modified Site Using Run ESC6 Calibration Settings for Existing Site

The results for the modified site using the calibration settings for the existing site are presented below (table 5).

Table 5. Summary of benthic results for modified site with calibration settings.

Modelling:	Modified Site: 1,720 T (12 x 100 m circumference pens with 12 m deep nets, stocking density of 15.0098315671512 kg/m^3) with Run ESC6 calibration settings				
Benthic run reference*:	MSC1	MSC2	MSC3	MSC4	MSC5
Mixing zone contour area (m^2): [Eqs.benthic.mixingZone.area]	142,729				
Mixing zone mean intensity (g/m^2) [Eqs.benthic.mixingZone.boundary.contour.approx.meanFlux]:	2,474.9	2,499.9	2,474.4	2,532.5	2,527.5
Average mean intensity for the 5 runs** (g/m^2):	*2,501.8 (168.3% higher than calibration Run ESC6 (*932.3*, table 4) albeit this was for 1,105 T as opposed to the consented biomass of 1,060 T)*				
250 g/m^2 mixing zone area for the 25 m^2 cells (m^2): [Eqs.benthic.mixingZone.approx.contourArea]	90,000	88,750	91,875	87,500	86,250
Average 250 g/m^2 mixing zone area (m^2):	88,875				
Average of 250 g/m^2 mixing zone areas (m^2) for the 5 runs as % of mixing zone contour area:	62.3				
Eqs.BenthicImpactedAreaEQS.eqsResult:	HIGH				
Eqs.benthic.pass:	LOW				
Eqs.control.eqsResult:	LOW				
Eqs.critical.eqsResult:	HIGH				
Eqs.warning.eqsResult:	LOW				

* The results for the above runs are contained within the MSC1 to MSC5 directories in 2023v1_CLP_Modified_Calib\depomod\results.

** % difference in mean intensity although it is acknowledged that SEPA generally only requires this for the default benthic runs (§3.1 and §3.2).

The mixing zone area for MSC2 was closest to the average for all 5 runs. The 250 g/m^2 footprint and the 88,750 m^2 mixing zone area for this run is provided in figure 8.

Figure 8. Run MSC2 (average for days 275-365): 250 g/m^2 modelled footprint and this run's 88,750 m^2 mixing zone area along with the UI's display of this.

4. CONCLUSIONS

SEPA default runs were performed pre and post modification. For these runs the modified site complies with SEPA EQS for mean intensity, albeit it is underpredicting the 0.64 IQI depositional footprint i.e., for the existing site the surveyed footprint is c. 64,000 m^2 whereas the model prediction is c. 44,250 m^2.

For the pre and post modification benthic runs using default settings, mean intensity does not exceed SEPA's 4,000 g/m^2 threshold i.e., the average of the 5 runs performed is 752.7 and 1,474.6 g/m^2 respectively. It is appreciated that SEPA often prefers the use of default settings to assess mean intensity compliance.

However, to be robust, solids were also modelled using calibration settings. For what is deemed to be appropriate settings mean intensity at the existing site rose by approximately 23.9% to 932.3 g/m^2 and for the modified site there was an approximate 69.7% increase to 2,501.8 g/m^2. Also, the calibration run at the existing site was for 1,105 tonnes as opposed to the consented biomass of 1,060 tonnes. The mean intensity values are still significantly lower than SEPA's 4,000 g/m^2 threshold, even when not considering the additional ≤15% that is permitted for the modification of an existing site, such as Caolas, that has good benthic survey results.

250 g/m^2 deposition for the existing and modified site does not exceed the 100 m mixing zone Indeed, for the modified site, after calibration, this was 62.3%.

Although the proposed modification is predicted to increase the intensity of waste on the seabed in close proximity to the cage group, the proposal is considered compliant with SEPA requirements.

FILES ACCOMPANYING THIS REPORT

- Results reported herein contained within the following directories:

  ES Runs: 2023v1_CLP_Existing\depomod\results

  MS Runs: 2023v1_CLP_Modified\depomod\results

  ESC Runs: 2023v1_CLP_Existing_Calib\depomod\results

  MSC Runs: 2023v1_CLP_Modified_Calib\depomod\results

- Also provided is:

  2023v1_CLP_modelling_metadata_template_v6.xlsx

FILES THAT HAVE BEEN PREVIOUSLY SUBMITTED TO SEPA

- Hydrographic report and associated SEPA validated datasets which were used for the modelling:

  CLP_2023v1_Hydrographic_Report.pdf, 3 May 2023.

  B - hgdata_analysis_v7.xls.

  M - hgdata_analysis_v7.xls.

  S - hgdata_analysis_v7.xls.

- Method statement for TransTech's modelling of the Caolas site:

  CLP_2023v1_ND_Modelling_Method_Statement.pdf, 3 May 2023.

- Marine Pen Fish Farm Monitoring Survey Results for 2021/2022 production cycle. Report by Pharmaq Analytiq Ltd:

  MPFF-EMSR-v6 Caolas Loch Portain 2022.xlsx, 23 March 2023.

REFERENCES

(1) SEPA Position Statement. Interim position statement for protecting the water environment in relation to emamectin benzoate in finfish farm regulation. Scottish Environment Protection Agency. March 2023.

(2) New Depomod Draft Guidance. Scottish Environment Protection Agency. April 2023.

(3) Wave Exposure Index (Wave Fetch Model). The Scottish Association for Marine Science. WMS layer. Date last updated: Tuesday, May 26, 2015.
Website link.

(4) Kraken IQI Ellipse Calculator. Website link.

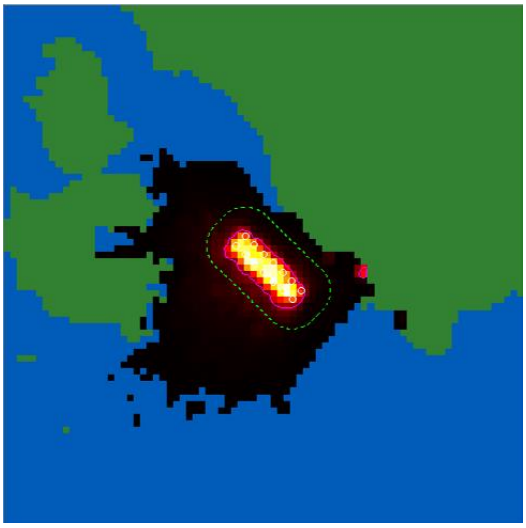
BIBLIOGRAPHY

- NewDEPOMOD User Guide. Scottish Association for Marine Science. 8 February 2022.

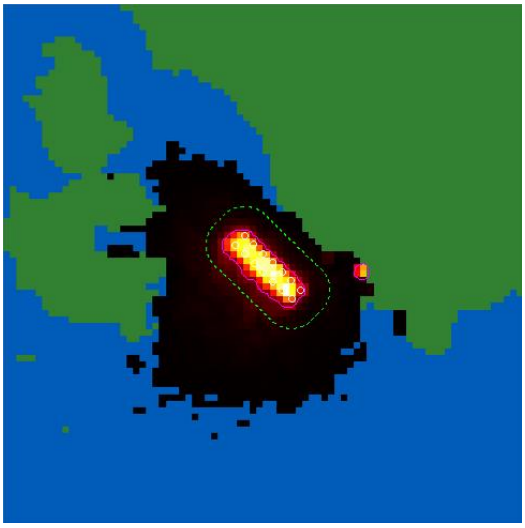
APPENDIX A: Plots for Benthic Runs using SEPA Defaults – Existing Site

Plots of the benthic runs for the existing site (CLP_Existing-Cages-NONE-N-solids-g0-avg.depomodresultssur) are provided below:

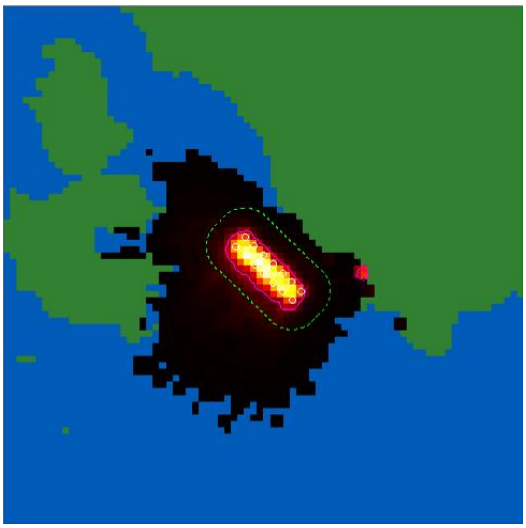
Existing Site (14 circular pens): 1,060 tonnes (stocking density c. 12.388721029781 kg/m^3) with SEPA defaults & vdsp of 0.003310. 250 g/m^2 contour and mean intensity:



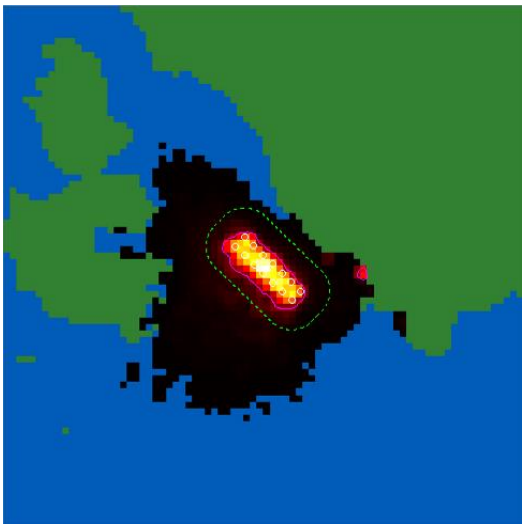
Run ES1



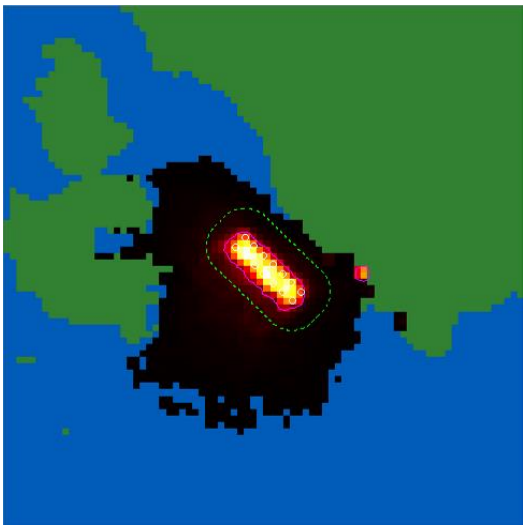
Run ES2



Run ES3



Run ES4

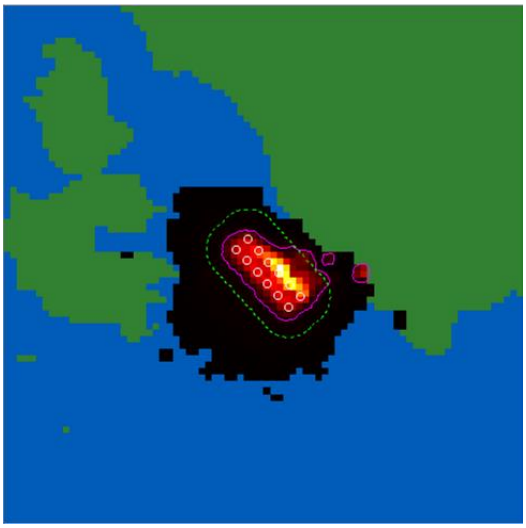


Run ES5

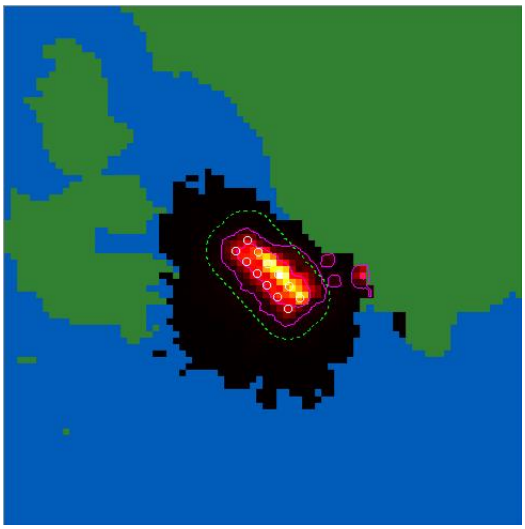
APPENDIX B: Plots for Benthic Runs using SEPA Defaults – Modified Site

Plots of the benthic runs for the proposed modification (2023v1_CLP_Modified-Cages-NONE-N-solids-g0-avg.depomodresultssur) are provided below:

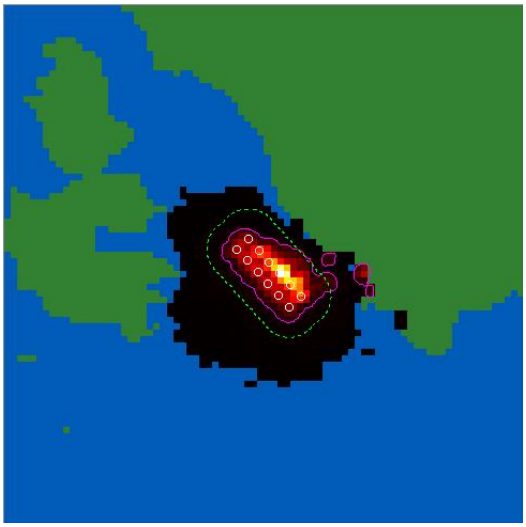
Modified Site (12 circular pens): 1,720 tonnes (stocking density 15.0098315671512 kg/m^3) with SEPA defaults & vdsp of 0.003310. 250 g/m^2 contour and mean intensity:



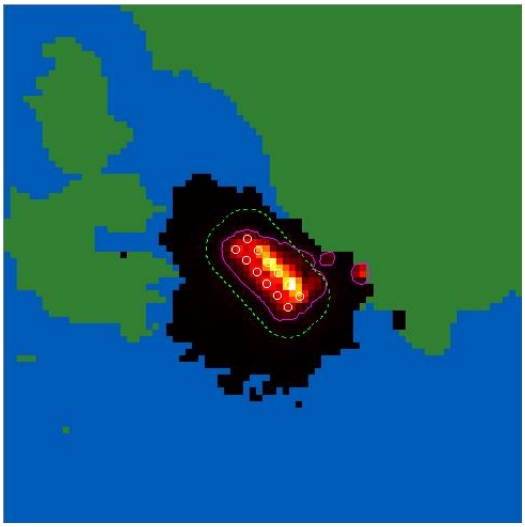
Run MS1



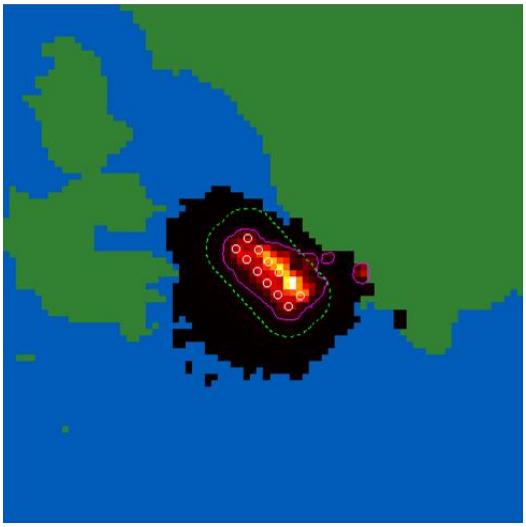
Run MS2



Run MS3



Run MS4

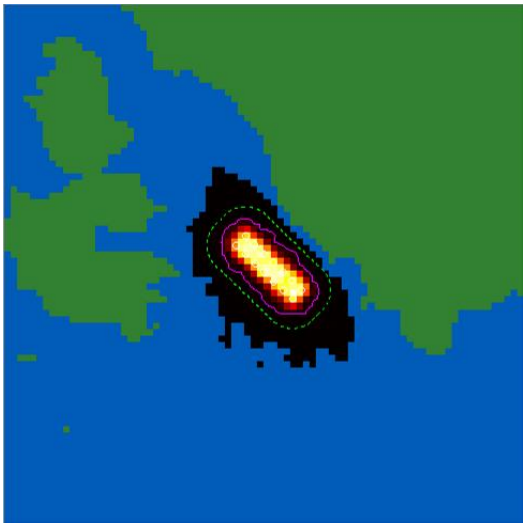


Run MS5

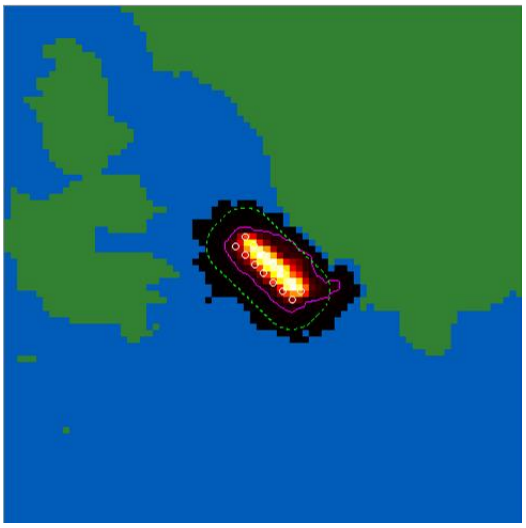
APPENDIX C: Plots for Benthic Calibration Runs – Existing & Modified Site

Plots of the calibration runs for the existing site (CLP_Existing_Calib-Cages-NONE-N-solids-g0-avg.depomodresultssur) are provided below.

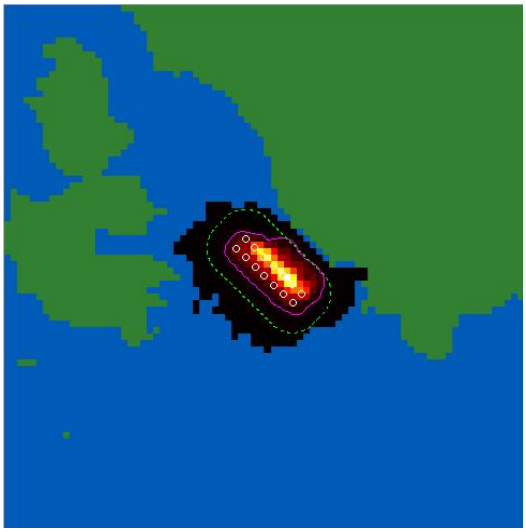
Existing Site (14 circular pens): 1,105 tonnes (stocking density 12.9146572999134 kg/m^3) with calibration settings provided in table 4. 250 g/m^2 contour & mean intensity:



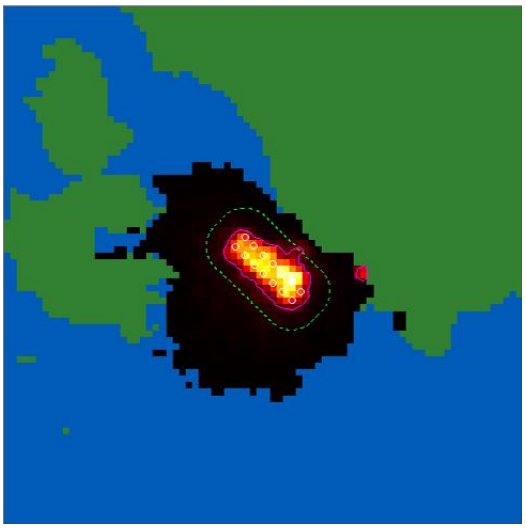
Run ESC1



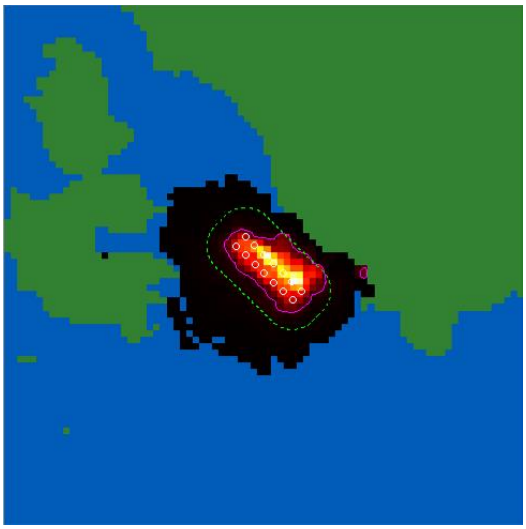
Run ESC2



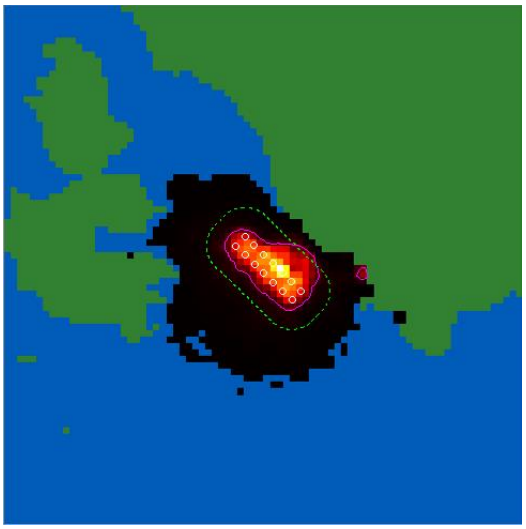
Run ESC3



Run ESC4



Run ESC5

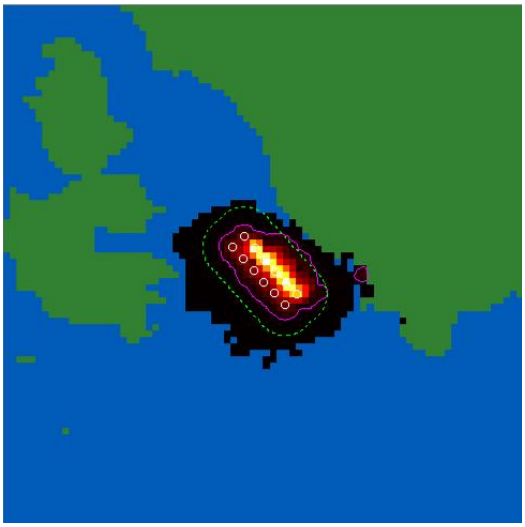


Run ESC6

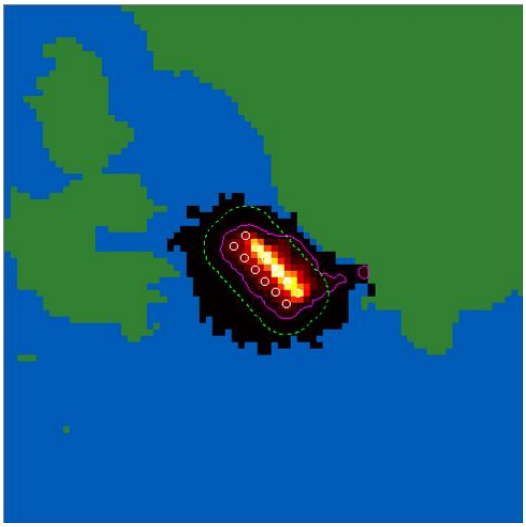
Plots of the calibration runs for the modified site (2023v1_CLP_Modified-Cages_Calib-NONE-N-solids-g0-avg.depomodresultssur) are provided below.

Modified Site (12 circular pens): 1,720 tonnes (stocking density 15.0098315671512 kg/m^3) with calibration settings provided in table 4 for Run ESC6. 250 g/m^2 contour & mean intensity:

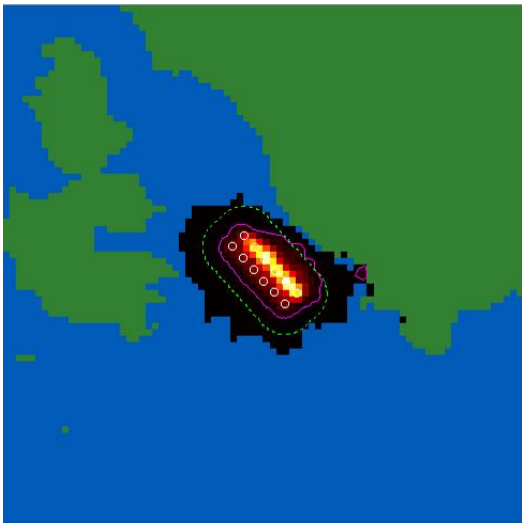
Run MSC1



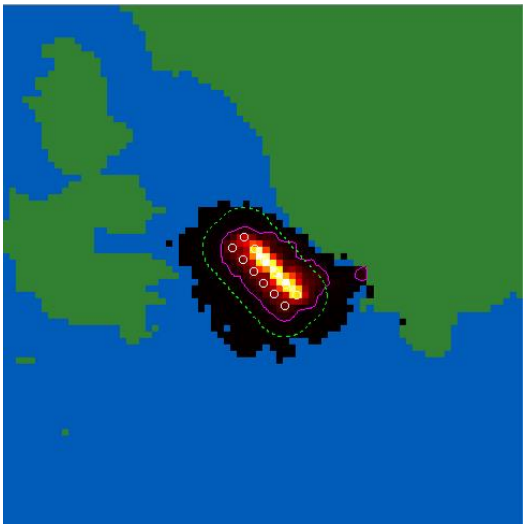
Run MSC2



Run MSC3



Run MSC4



Run MSC5

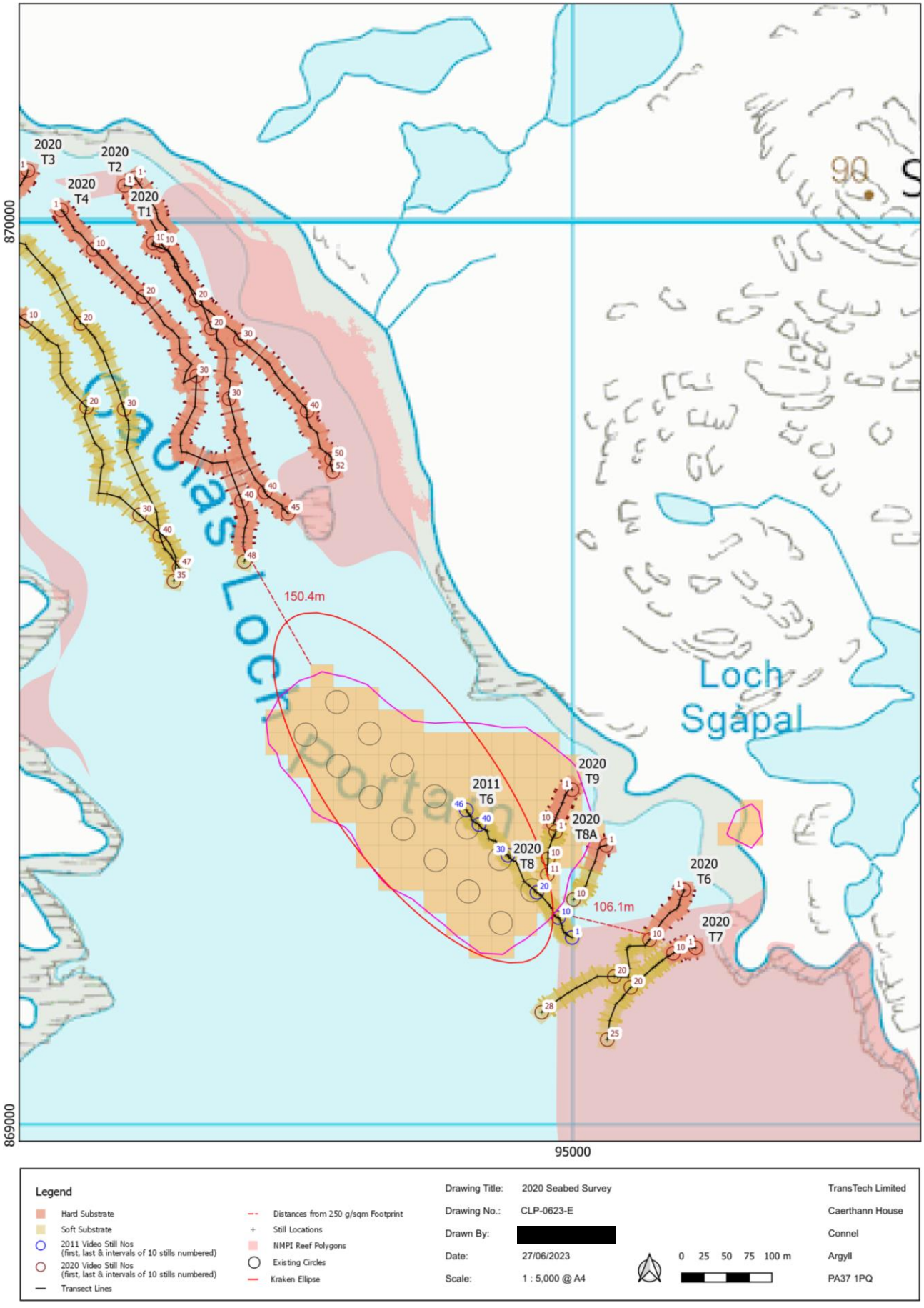
APPENDIX D: Benthic Calibration Run Footprints in Relation to Nearby Reef Features

As SEPA may be aware, in 2020 we were involved in mapping rov survey data for the hard substrate that could support reefs in proximity to Caolas. The rov work was comissioned by Loch Duart because the NMPI polygons aren't particularly accurate. Numerous transects were surveyed by Anderson Marine Surveys and the hard substrate found closest to the existing and proposed pens is provided in the drawings below.

Although we appreciate that the NewDEPOMOD modelling we have undertaken has focused on calibrating the model to achieve a similair sized 0.64 IQI benthic footprint at the existing site to that surveyed in 2022, and not the precise direction the footprint is predicted to travel in, any potential impact on reef features requires consideration.

Indeed, when viewing the Kraken ellipse (see figure 7 and the drawing on the following page) it indicates that in reality the 0.64 IQI footprint extends further northwest and east of its modelled northwesterly extent. This indicates that waste will travel in a predominantly northwesterly direction which implies that the hard substrate to the east will be at low risk. There is some hard substrate to the north of the modified pen group. However, given that the nearest proposed pen edge is 200.4 m from its start, this suggests that there is unlikely to be any significant imapct on reef features in this area or those further north of the site.

HARD SUBSTRATE IN PROXIMITY TO EXISTING PENS:



HARD SUBSTRATE IN PROXIMITY TO PROPOSED PENS: