

Aquaculture Modelling Screening & Risk Identification Report: BAY OF CLEAT NORTH (BOCN1)



Scope of report

As part of the SEPA Aquaculture Regulatory Framework it is recommended that a proposed application for a marine fin fish aquaculture site should undergo a Screening Modelling and Risk Identification process. SEPA carries out this work and this is described on the SEPA aquaculture website Pre-application section:

(<https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/>)

This report presents information arising from that process. Screening modelling methods are outlined and maps and tables describing the modelled impacts are shown. Risks arising from consideration of the model output are listed. Conclusions and recommendations are made regarding the proposed site.

Executive summary

SEPA has received a proposal to vary an existing marine fin fish aquaculture site called Bay of Cleat North (BOCN1). The site is located Papa Sound (Orkney), at location: 347160.5 1047734 (Easting, Northing). This proposed location is approximately 190m away from the current location of the farm. The existing maximum biomass is 960t at this location and the proposed weight of fish to be farmed is 2885t.

Following screening modelling and risk identification we have concluded the following:

- It is possible that discharges from Bay of Cleat North (BOCN1) will be able to comply with the relevant aspects of the SEPA Aquaculture Regulatory Framework.
- Features at risk, identified at this stage, do not appear to influence the feasibility of the proposed site with respect to the regulatory framework. These risks should be examined using a detailed marine model.
- Bay of Cleat North (BOCN1) is suitable to progress to the next stage of the pre-application process outlined on the SEPA website.

Aquaculture Modelling Screening & Risk Identification Report: Bay of Cleat North (BOCN1)

- NewDepomod modelling must be undertaken for the proposed site. Default NewDepomod modelling should be undertaken prior to any marine modelling, to ensure the local impacts of the proposed biomass are acceptable. Calibrated NewDepomod modelling, using 4 transect monitoring is required at this site.

List of abbreviations

SEPA Scottish Environment Protection Agency

List of chemical abbreviations

AZA Azamethiphos

Contents

1	Introduction.....	1
1.1	The objectives of screening modelling and risk identification	1
1.2	Screening modelling methods	3
2	Screening modelling.....	7
2.1	Site proposal	7
2.2	Dispersion and erosion capacity maps.....	7
2.3	Sediment influence maps and analysis.....	9
2.4	Bath medicine influence maps and analysis	11
3	Risk Identification	21
3.1	Identified features which require attention	21
3.2	Additional comments on identified features	22
3.3	Risks identified from contextual site data	23
4	Conclusions of screening modelling and risk identification.....	24
4.1	Conclusions	24
4.2	Recommendations	26
5	References.....	28

List of Figures

Figure 1. Pentland Firth and Orkney Waters model grid.....	6
Figure 2: Modelled average water speed (metres per second – m/s) in the sea area surrounding the proposed site (Bay of Cleat North (BOCN1)).....	15
Figure 3: Modelled percentage of time the water flow speed is above 0.095 m/s in the sea area surrounding the proposed site (Bay of Cleat North (BOCN1)).....	16
Figure 4: Modelled average sediment intensity over one month for the proposed site only (Bay of Cleat North (BOCN1)).....	17
Figure 5: Modelled average sediment intensity over one month for the proposed site (Bay of Cleat North (BOCN1)) and other relevant sites.	18
Figure 6: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site only (Bay of Cleat North (BOCN1)).	19
Figure 7: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site (Bay of Cleat North (BOCN1)) and other relevant sites.....	20
Figure 8. Shapefiles of identified features around the proposed site (Bay of Cleat North (BOCN1)).	22

List of Tables

Table 1: Sediment influence information for each site.	11
Table 2: Azamethiphos influence information for each site.	13
Table 3: Table of identified features	21
Table 4: Table of licenced biomass from farms identified as likely to add to cumulative risks.	23

1 Introduction

Screening Modelling and Risk Identification are important steps in the SEPA regulatory framework for marine pen fish farms. They are carried out by SEPA at the pre-application stage, which is described in detail at:

<https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/>.

This document briefly describes the objectives of screening and risk identification and summarises the methods used. Screening output for the proposed site is then presented with comments. Risks identified from the screening output are detailed. Conclusions and recommendations about the suitability of the proposed site are then made.

1.1 The objectives of screening modelling and risk identification

A summary of the modelling methods employed during screening modelling is outlined in section 1.2. The objectives of screening modelling and risk identification are outlined below.

1.1.1 Screening modelling

Marine Modelling technology can be used to simulate and predict the potential influence of discharges on the marine environment. SEPA will require the majority of proposed farms to conduct detailed marine modelling, as outlined in our Aquaculture Modelling guidance [1] and on the SEPA Website.

Marine modelling can also be used at an earlier stage to provide an initial estimate of the influence of material discharged from a proposed site.

SEPA will carry out marine modelling at the screening and risk identification stage. This is a simplified version of the detailed modelling required of the applicant. However, it will be sufficient to perform an initial risk assessment of a proposal. Screening marine modelling will also include discharges from other relevant aquaculture sites and major sources.

The objectives of the simplified screening modelling are to:

- Produce maps of the predicted dispersive and erosive capacity of the sea areas in the vicinity of aquaculture sites
- Produce maps of the predicted spread of sediment discharged from aquaculture sites
- Produce maps of the predicted spread of bath treatment medicines from aquaculture sites
- Present an analysis of the potential influence of sediment and bath treatment discharges from the proposed site alongside existing sites within the surrounding sea area
- Present information on the sensitive features and sites of interest within the surrounding sea area, which must be addressed during pre-application work
- Present a summary of the suitability of the proposal with respect to the dispersal of waste and how this may be modelled.

1.1.2 Risk identification

Maps and analysis of screening output will be compared to information relating to sensitive features and relevant areas of interest. These may include:

- Marine Protected Area (MPA)
- Special Area of Conservation (SAC)
- Priority Marine Feature (PMF)
- Any site identified via consideration of other permitted or regulatory activities.

SEPA Staff will meet to discuss screening model output and the relevant sensitive features information. Following this meeting, a list of identified risks will be added to this report.

1.1.3 Conclusion of screening modelling and risk identification

Following the identification of risks, SEPA will present a summary of the suitability of the proposal with respect to the:

- Dispersal of waste from the proposed site and other sources
- Risks posed to sensitive features
- Likely level of modelling that will be required to address the risks identified.

1.2 Screening modelling methods

Marine models divide the sea up into a “grid” of boxes or triangles (often called cells). Each of these is given a water depth. For the screening modelling presented in this report the Marine Scotland “Pentland Firth and Orkney Waters” (PFOW) has been used. An image of the PFOW model grid is shown in Figure 1. This grid has been set up within a marine modelling software package called MIKE 21 which is manufactured by the company DHI A/S (<https://www.dhigroup.com/>).

Marine models carry out calculations across a grid to work out how seawater moves and mixes in response to tidal and weather forces. Marine models can also be used to simulate how seawater moves and mixes due to salinity and temperature differences across an area, particularly in response to inputs of freshwater from rivers. For pollutant influence assessments the mixing (dispersion) of dissolved (bath medicine) and particulate (sediment) pollutants can also be estimated. Calculations within a marine model can be performed in three dimensions (3D), where the grid is split into layers to better represent how properties of the sea change with depth. Two dimensional (2D) models can also be created where processes over the water depth are simplified. The amount of mixing in a marine model can be varied using settings in the software.

Screening modelling is currently carried out with 2D models using average mixing settings in the model software. In many areas, this approach will be sufficient to make an initial estimate of the influence of a proposed site. Our screening assessment will take into account factors which may limit a 2D approach. We will also consider whether a particular location is adequately represented by the available models.

1.2.1 Water movement and mixing modelling

Water movement and mixing modelling (hydrodynamics) has been carried out to generate one month of results. The boundaries (edge(s) of) the model have been driven using the “wider domain” Scottish Shelf Model [2]. Wind forces and freshwater inputs have been applied to the model from the same source. The results generated are an estimate of the average water movement and mixing conditions within the model area.

1.2.2 Sediment waste modelling

Screening modelling provides a precautionary and **indicative** estimate of the size, location and intensity of waste organic material released from aquaculture sites.

The release of sediment from sources within the model area is simulated using one month of hydrodynamic results along with particle tracking modelling technology. Virtual particles are continually introduced to the model grid to represent the potential dispersion of sediment from the sources. Particles in the model are moved and mixed by the hydrodynamics. Additionally, particles are assigned simplified properties, which allow them to settle through the water and be re-suspended (eroded and lifted) from the sea bed.

1.2.3 Bath medicine modelling

Screening modelling provides a precautionary and **indicative** estimate of the size, location and concentration of bath medicine releases.

The release of bath treatment medicine from sources within the model area is simulated using hydrodynamic results along with particle tracking modelling technology. Virtual particles are introduced to the model grid to represent the potential dispersion of bath medicines from the sources. Particles in the model are moved and mixed by the hydrodynamics. Releases of bath medicines are simulated under worst case mixing (dispersion) conditions, which occur under neap tides. The maximum treatment amount likely to be used at each site is released into the model at the same time and plumes are tracked over the following 96 hours (4 days). Treatment amounts used at screening have been derived from an analysis of historical data. Additionally, all bath medicine particles are concentrated within the top 5 m of the sea area. As all bath medicines are likely to disperse in a similar way, only Azamethiphos (AZA) has been modelled at the screening stage.

1.2.4 Nutrient assessment

Whilst nutrients are not directly modelled during screening, the dispersion of bath medicine releases will give an indication of the likely level of nutrient dispersion. This will be considered alongside any pre-existing nutrient assessment information that may be available.

1.2.5 Analysis of modelling output

SEPA processes the screening modelling output and places it into a standard analysis application built in TIBCO Spotfire. The application allows for the production of standard maps and tables, which are presented below.

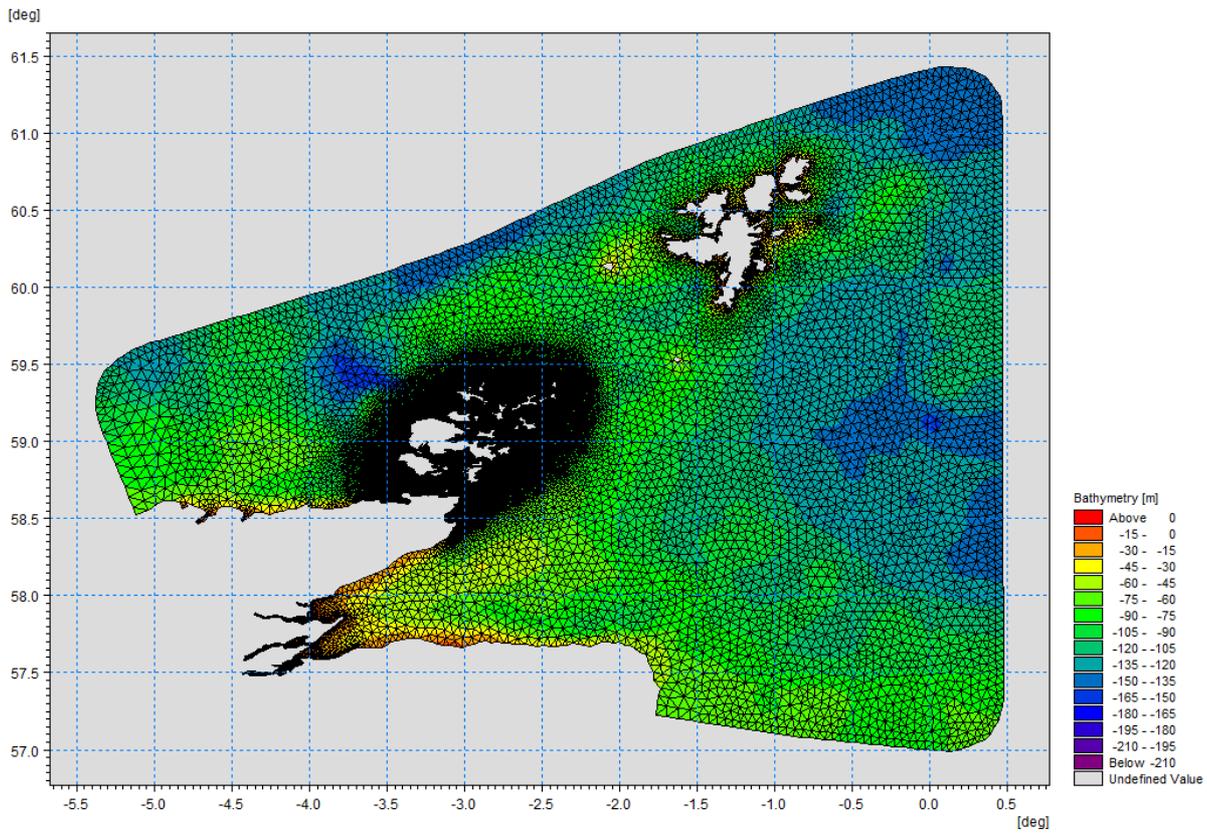


Figure 1. Pentland Firth and Orkney Waters model grid

2 Screening modelling

2.1 Site proposal

SEPA has received a proposal to vary an existing marine fin fish aquaculture site called Bay of Cleat North (BOCN1). The site is located Papa Sound (Orkney), at location: 347160.5 1047734 (Easting, Northing). This proposed location is approximately 190m away from the current location of the farm. The existing maximum biomass is 960t at this location and the proposed weight of fish to be farmed is 2885t.

For the screening modelling presented here all relevant licenced sites and current applications have been modelled in conjunction with the proposed site.

2.2.1 Accuracy of model in the area surrounding the proposal

The Pentland Firth and Orkney Waters model used for screening modelling has a moderate resolution in this area. Comparison against various sources of observed current meter data indicates that the model provides a moderate description of the physical processes in the vicinity of the proposed site, yet it is possible the screening model slightly overestimates the mean current speeds at this site.

2.2 Dispersion and erosion capacity maps

Modelled water movement in a sea area can be analysed and presented to show the capacity of the water to move and disperse discharged substances. It is also possible to show the capacity available to erode substances from the seabed. This information is a useful guide to the potential size of a marine fin fish aquaculture farm at a particular location.

Marine fin fish aquaculture farms using open-net pens will benefit from operating in locations where there are strong, repeating, water currents to erode and disperse waste.

For the purposes of screening we consider locations which meet the following water flow criteria to be generally suitable for larger farms:

Locations with average water flow speeds of greater than, or equal to, 0.12 metres per second (0.23 knots)

Locations where water flow speeds are often above the threshold of 0.095 meters per second (0.18 knots).

Locations with these properties are likely to disperse discharged material rapidly, and regularly erode sediment discharged to the seabed. In general, we would look for these properties to be maintained over a large area around a proposed site.

The thresholds stated above are indicative.

A map of modelled average water flow speed for the area surrounding the proposed site is shown in Figure 2. The average water flow speed in each cell of the model grid (see section 1.2) has been assigned a shade. The key for the shading is shown in the top left of the figure. Grid cells that have average speeds less than 0.12 m/s (metres per second) are marked on the figure. The greater the shading, the slower the average current speed and the lower the capacity for dispersion.

Figure 3 is a map of the percentage of time the modelled water flow speed in a grid cell is above 0.095 m/s (metres per second). The greater the shading, the lower the capacity for material to be eroded from the seabed.

Licensed aquaculture farms in the vicinity of the proposed site are also marked on Figure 2 and Figure 3. Discharges of material from these sites have been included in the screening modelling.

Based on the maps of the modelled water flow properties we can make the following observations about the proposed site location:

- It lies in a moderate dispersion area.
- It lies in an area where water flow has a moderate capacity to erode material on the seabed.

2.3 Sediment influence maps and analysis

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged sediment on the surrounding sea area.

Figure 4 shows a map of the modelled average sediment intensity over one month (time average) for the proposed site only. Grid cells within the model that are influenced by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m²).

Values less than 1 g/m² have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average intensity in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) intensity value shown on the map. White shaded cells are similar to the minimum intensity value shown on the map.

- The average and median sediment intensity over the area of influence is 4.79g/m² and 3.25g/m² respectively.
- There are no cells influenced by the proposed site.

Figure 5 shows a map of the modelled average sediment intensity over one month for the proposed site and other relevant sites. Grid cells within the model that are influenced by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m²). The shading key is shown in the top left of the figure and is in a similar format as that shown in Figure 4. The average sediment intensity, after including all relevant sites, is increased.

- The average and median sediment intensity over the area of influence is 3.80g/m² and 1.70 g/m² respectively.
- Cells influenced by other modelled sites do not appear to lie close to the proposed site.

2.3.2 Sediment influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential sediment influence from the modelled sites.

- The total area of sediment influenced by the seven sites modelled is estimated to be 0.53 square kilometres (km²).
- As shown in Figure 5, the average and median intensity over this area is 3.80 and 1.70 g/m² respectively.
- The total weight of fish that generates this modelled influence is 12525 tonnes.

Table 1 shows the information for each individual site modelled. It is important to note that the total area of influence for all sites is not the sum of the numbers in Table 1. The total area of influence worked out above takes into account that the individual areas of influence from different sites will overlap.

Table 1: Sediment influence information for each site.

Site Name	Average Intensity (g/m ²)	Area of Influence (km ²)	Median Intensity (g/m ²)	Max weight Of Fish (tonnes)
BOCN1	4.79	0.25	3.25	2885
BOC1	0	0	0	165
MCTE1	0	0	0	3850
OUSN1	2.32	0.07	2.33	500
SCA1	0	0	0	165
SKLW1	1.44	0.04	1.44	4000
VESN1	0	0	0	960

There are no Environmental Standards for sediment intensity. However, we consider that:

- underneath farm pens, an intensity of 2000 g/m² or less is likely to lead to an acceptable sea bed ecological outcome
- at the edge of the mixing zone, an intensity of 250 g/m² or less is likely to lead to an acceptable sea bed mixing zone outcome

The estimate of influence detailed above is indicative. The values presented are lower than the sediment intensity values given above. However, we recognise that low sediment concentrations may be useful for the identification of risks.

2.4 Bath medicine influence maps and analysis

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged bath medicine on the surrounding sea area. Results presented are for the AZA medicine (see section 1.2.3).

Figure 6 shows a map of the modelled average AZA concentration over four days for the proposed site only. Grid cells within the model which experience an AZA influence are shaded according to the concentration of AZA in nanograms per litre (ng/l).

Values less than 10 ng/l have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

Please note that the Environmental Standard for Azamethiphos with the lowest concentration is 40 ng/l. This must be met 72 hours after the material has been discharged. The estimate of influence detailed here is precautionary. In the information presented below areas of influence above 40 ng/l have been quoted. However the average and median concentrations are quoted for the entire area of influence above 10 ng/l.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average concentration in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) concentration shown on the map. White shaded cells are similar to the minimum concentration value shown on the map.

- The average and median concentration over the total area of influence is 16.15 ng/l and 15.24 ng/l respectively.
- Cells influenced by the proposed site do not appear to lie close to other modelled farm sites.

Figure 7 shows a map of the modelled average AZA influence over four days for the proposed site and other relevant sites. The average AZA influence, after including all relevant sites, is increased.

- The average and median AZA concentration over the total area of influence is 16.44 ng/l and 15.13 ng/l respectively.
- Cells influenced by other modelled sites do not appear to lie close to the proposed site.

2.4.2 Bath medicine influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential AZA influence from the modelled sites.

- The area of AZA influenced above 40 ng/l from all sites modelled is estimated to be 0 square kilometres (km²).
- As shown in Figure 7, the average and median concentration over the total area of influence is 16.44 and 15.13 ng/l respectively.
- The total weight of fish that generates this modelled influence is 12525 tonnes.

Table 2 shows the information for each individual site modelled. It is important to note that the total area of influence above 40ng/l for all sites quoted above is not the sum of the numbers in Table 2. The total area of influence worked out above takes into account that the individual areas of influence above 40 ng/l from different sites will overlap.

Table 2: Azamethiphos influence information for each site.

Site Name	Average Conc. (ng/l)	Area of Influence Above 40 ng/l (km ²)	Median Conc. (ng/l)	Weight Of Fish (tonnes)
BOCN1	16.15	0	15.24	2885
BOC1	0	0	0	165
MCTE1	17.39	0	16.32	3850
OUSN1	0	0	0	500
SCA1	0	0	0	165
SKLW1	16.53	0	14.41	4000
VESN1	15.13	0	14.28	960

Please note that the Environmental Standard for Azamethiphos with the lowest concentration is 40 ng/l. This must be met 72 hours after the material has been discharged. The estimate of influence detailed above is precautionary. The values presented are close to the 40 ng/l standard. Detailed modelling will be required to demonstrate compliance with all Environmental Standards.

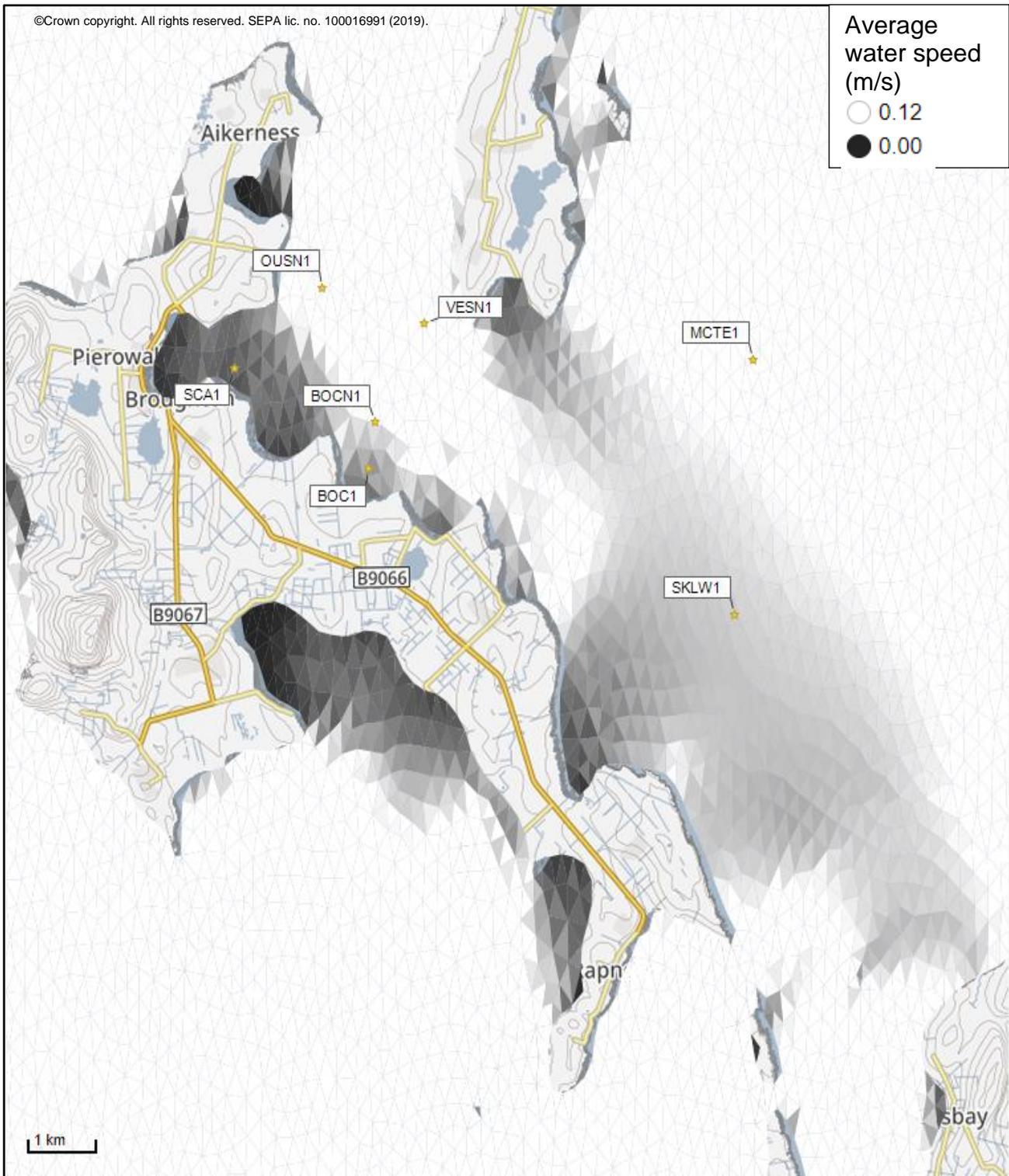


Figure 2: Modelled average water speed (metres per second – m/s) in the sea area surrounding the proposed site (Bay of Cleat North (BOCN1)).

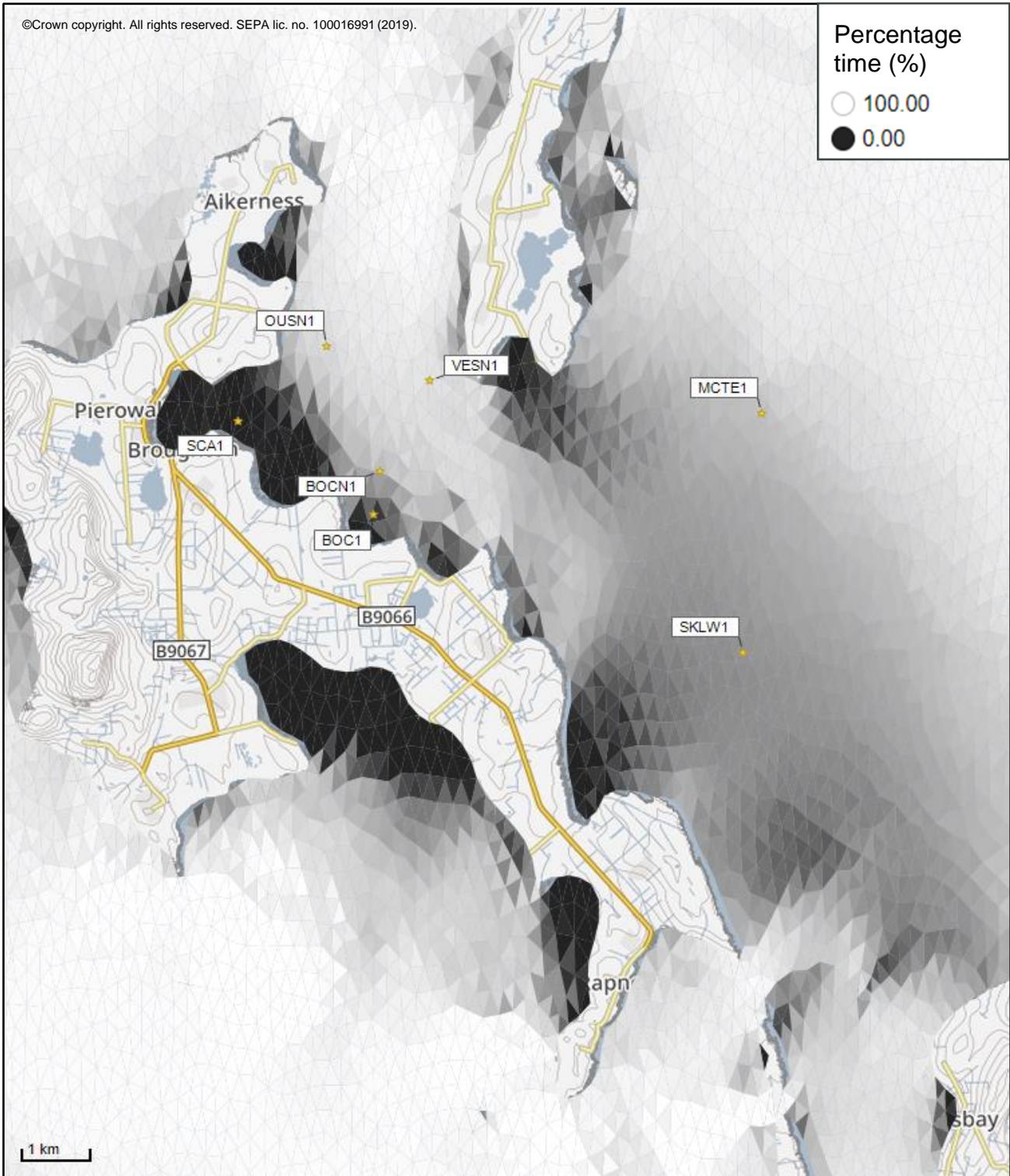


Figure 3: Modelled percentage of time the water flow speed is above 0.095 m/s in the sea area surrounding the proposed site (Bay of Cleat North (BOCN1)).

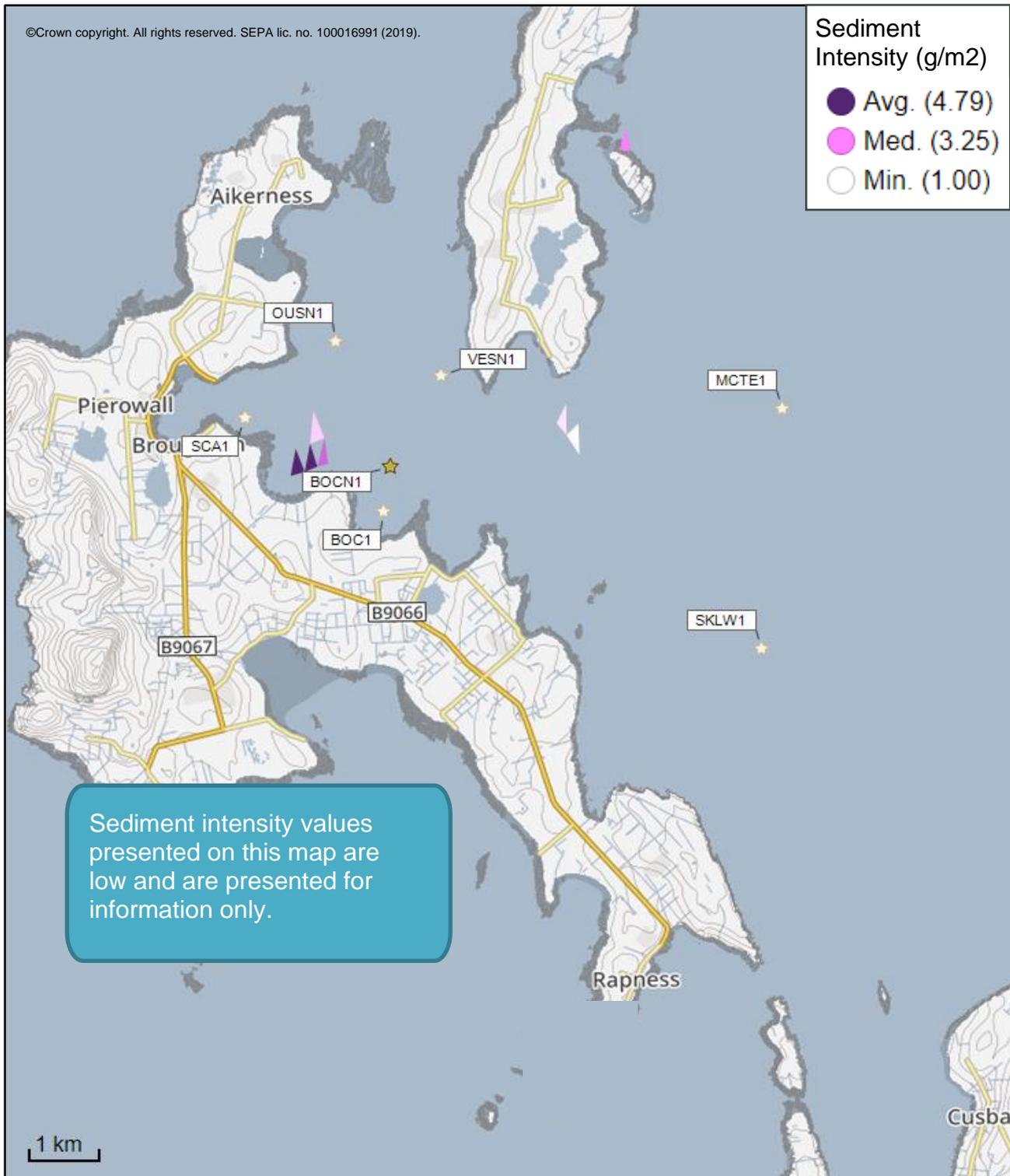


Figure 4: Modelled average sediment intensity over one month for the proposed site only (Bay of Cleat North (BOCN1)).

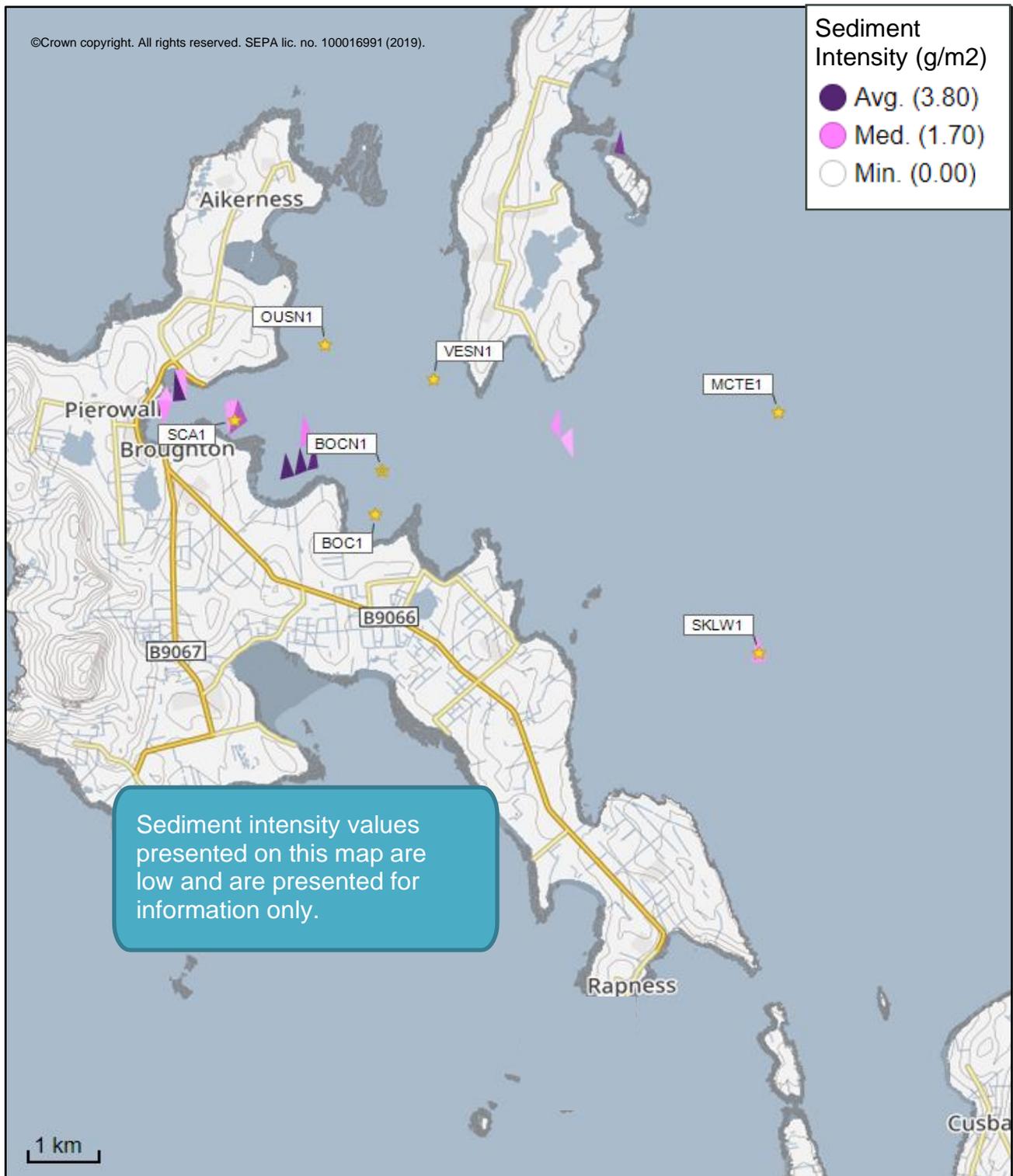


Figure 5: Modelled average sediment intensity over one month for the proposed site (Bay of Cleat North (BOCN1)) and other relevant sites.

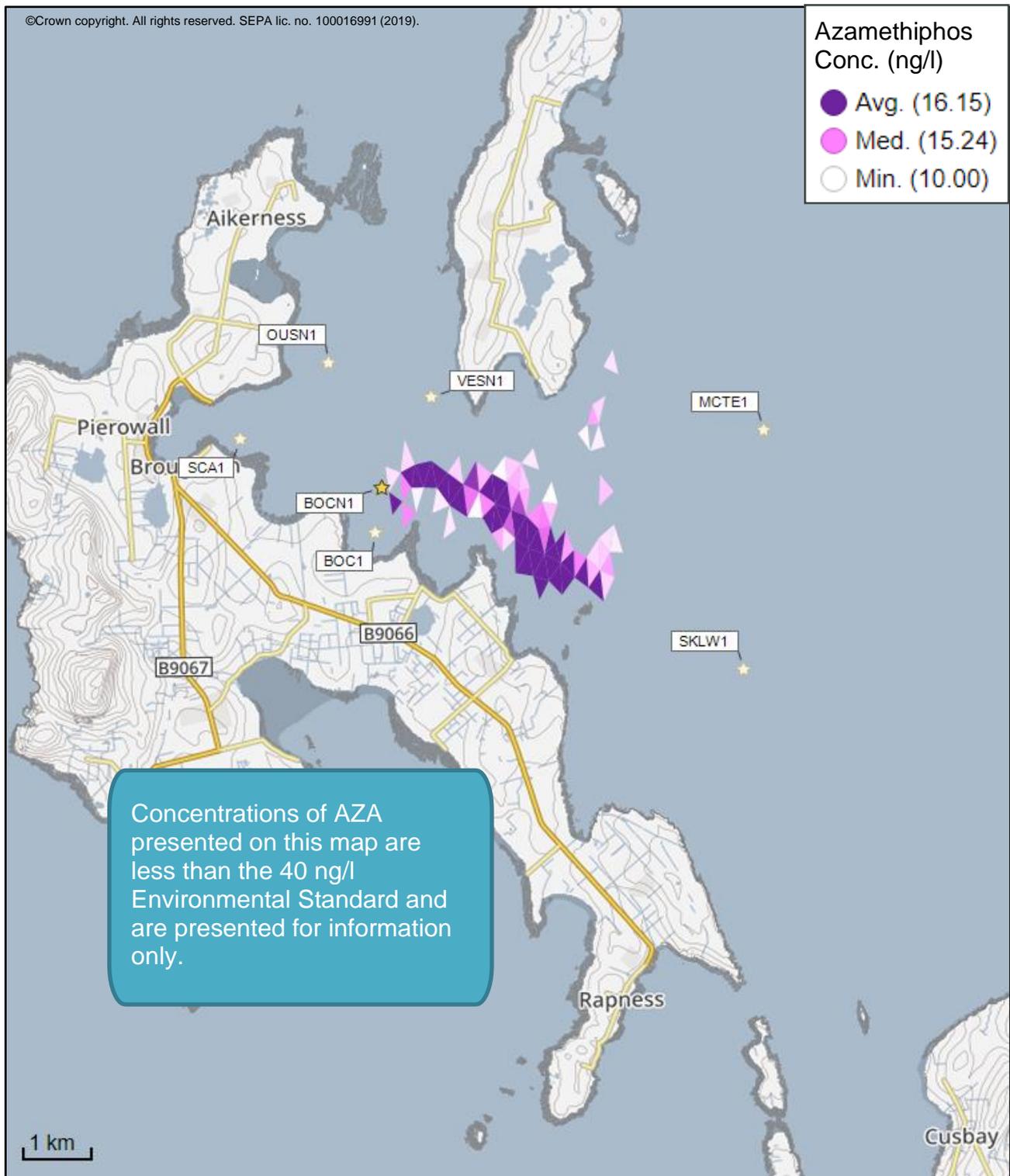


Figure 6: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site only (Bay of Cleat North (BOCN1)).

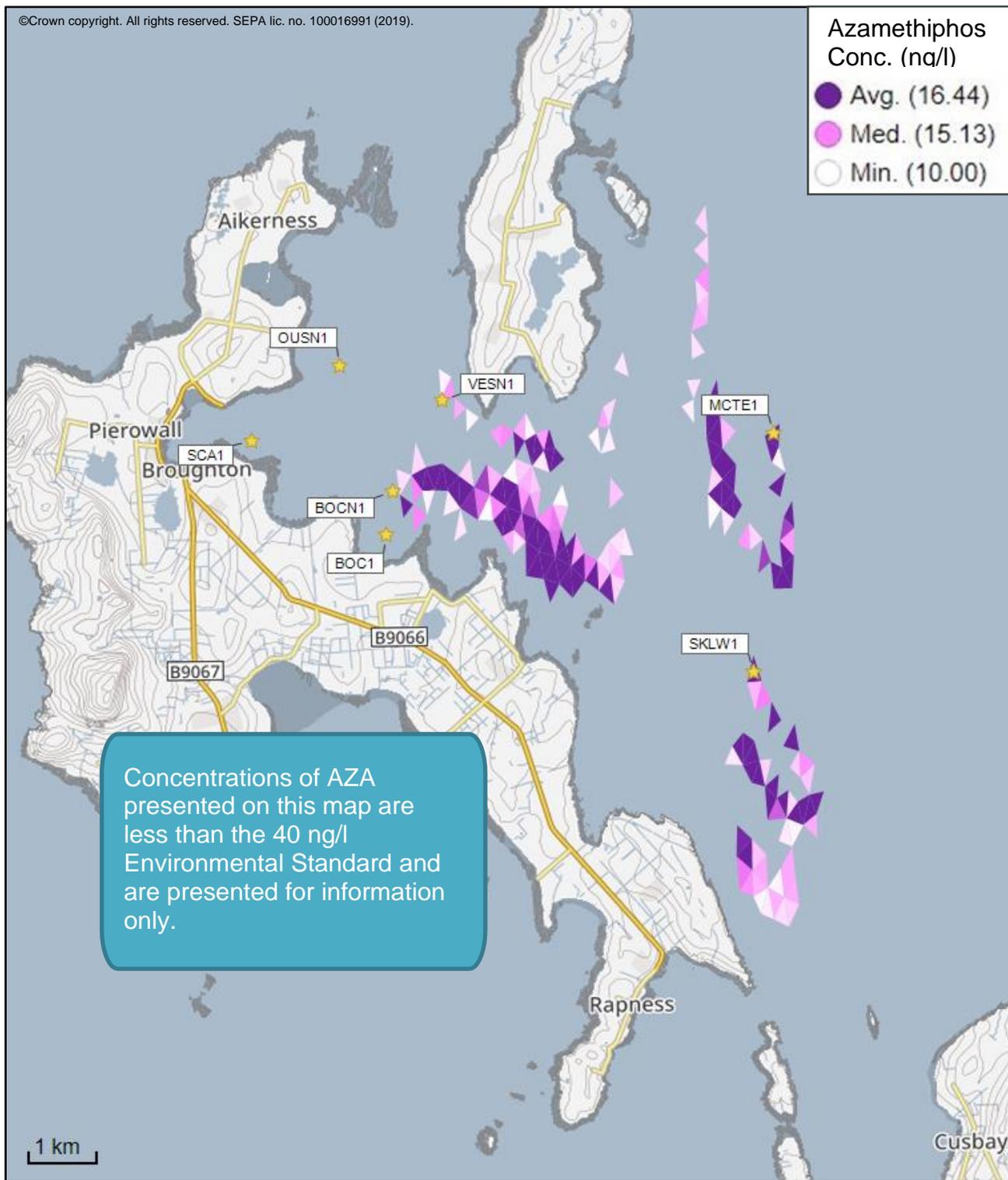


Figure 7: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site (Bay of Cleat North (BOCN1)) and other relevant sites.

3 Risk Identification

The screening modelling output summarised in section 2 is compared against available information on features of interest (see section 1.1.2). Features which require attention are presented with any additional comments. Identified features will need to be considered during the pre-application phase.

These should be addressed in the applicant "Method Statement". Please refer to the Modelling Method Statement section on the SEPA Website.

(<https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/>)

3.1 Identified features which require attention

3.1.1 Table of identified features

Based on screening output the following features of interest have been identified.

Table 3: Table of identified features

No.	Feature Name	Feature Type	Location (Easting, Northing)	Brief Reason For Identification
1	Maerl Beds	PMF	Shapefile 1	At risk from solids and bath influence
2	Seagrass Beds	PMF	347626.9 1049999 348099.9 1050704 348103.5 1050802	At risk from bath influence
3	Kelp Beds	PMF	350076.4 1049388 350274.4 1049610 350405.5 1050298	At risk from bath influence

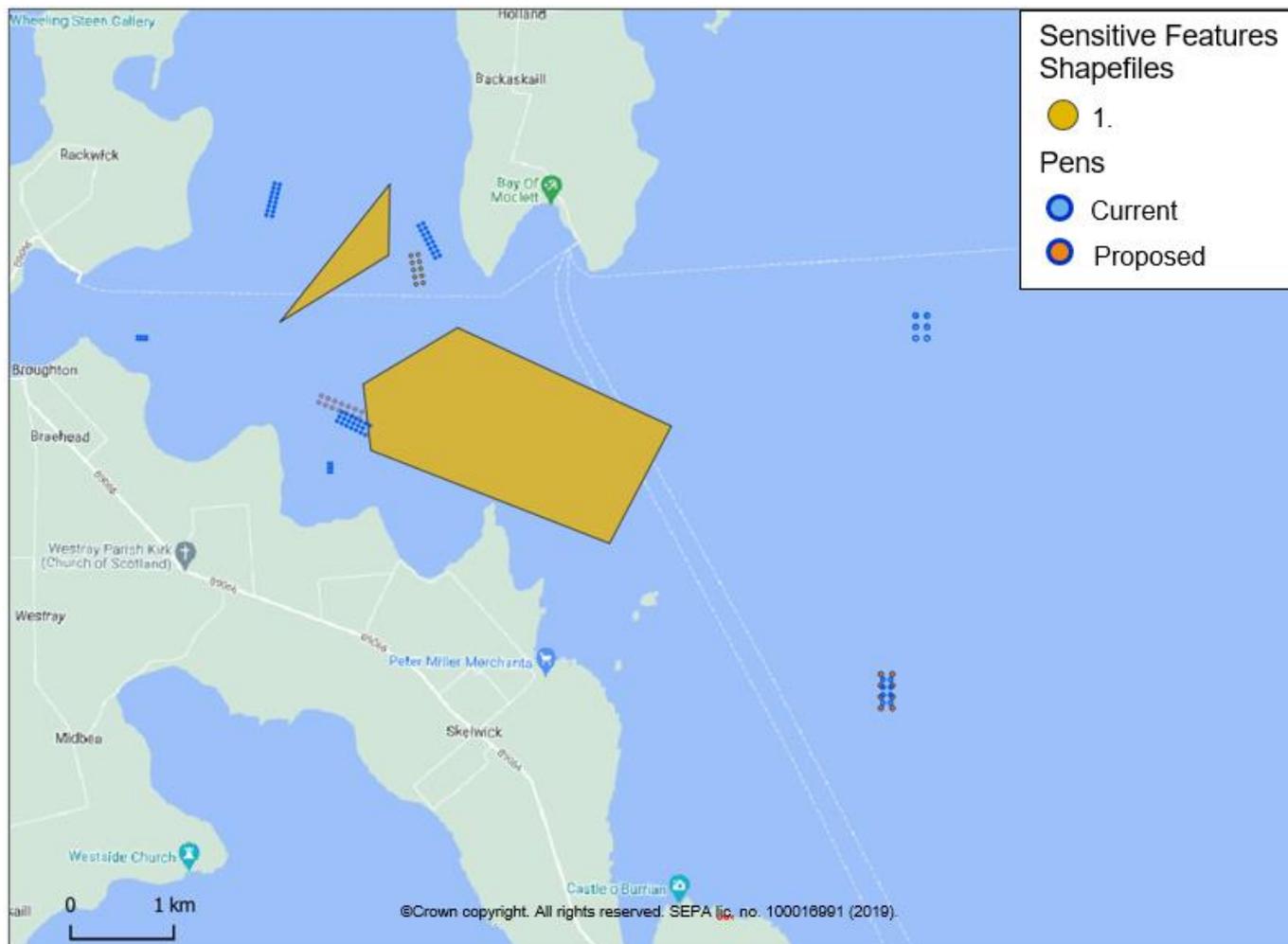


Figure 8 Shapefiles of identified features around the proposed site (Bay of Cleat North (BOCN1)).

3.2 Additional comments on identified features

Screening modelling does not predict significant sediment or bath influence from Bay of Cleat North (BOCN1), however due to the large tonnage at this site, higher resolution Marine Modelling of sediment will be required to ensure the risk to the wider environment is low.

Furthermore, several features of interest have been identified, which require further attention during pre-application work. These are outlined in section 3. Further detailed modelling will need to demonstrate that the influence on these features is low. Given the resuspension dampening of maerl, this modelling should show conservatism.

The conservative nature of the simple BathAuto model in areas of high current speeds, means quantities of bath medicines may be limited to impractical amounts for this site. Use of marine modelling of bath influence will enable more realistic bath medicine treatment quantities to be determined. Features identified as at risk within this area will need to be addressed in any marine modelling. Due to the very dispersive nature of this area, discharges from all sites in the screening modelling will need to be included for solids, to ensure interactions between these sites are low, however dye/drogue calibration will not be required.

3.3 Risks identified from contextual site data

Should this application proceed, the total licenced biomass in this area would be 12525t.

Table 4: Table of licenced biomass from farms identified as likely to add to cumulative risks.

Site Name	Location (Easting, Northing)	Biomass (tonnes)	Last Production Cycle
BOCN1	347160.5, 1047734	2885	Proposed Currently Stocked (Since Apr 2022)
BOC1	347052, 1047086	165	Fish last on site Jun 2021
MCTE1	352753, 1048518	3850	Not stocked since record began (New Site 2023)
OUSN1	346400, 1049600	500	Currently Stocked (Since Feb 2022)
SCA1	345100, 1048500	165	Fish last on site Dec 2010
SKLW1	352422, 1044977	4000	Currently Stocked (Since Jan 2023)
VESN1	347900,1049074	960	Fish last on site Apr 2023

The results from the 2023 Bay of Cleat North (BOCN1) monitoring survey (biomass 486.8t) have yet to be evaluated. The 2022 survey result with a biomass of 195t was classed as satisfactory. This site has no history of attaining unsatisfactory or borderline compliant survey results.

4 Conclusions of screening modelling and risk identification

Following screening modelling and risk identification we make a number of conclusions and recommendations.

4.1 Conclusions

4.1.1 Screening Modelling

- According to screening modelling, the proposed site (Bay of Cleat North (BOCN1)) is in an area of high dispersion and has a relatively high capacity for erosion of material on the sea bed.
- From sediment and bath treatment modelling:
 - Information presented in section 2 indicates that the relative influence of Bay of Cleat North (BOCN1) is likely to be similar to other sites for a similar tonnage.
 - The influence on the surrounding sea area from Bay of Cleat North (BOCN1) is likely to be low.
 - The areas of influence from Bay of Cleat North (BOCN1), and other sites modelled do not appear to interact.
 - It is likely that discharges of bath medicines from Bay of Cleat North (BOCN1) will be dispersed to low levels over a moderate area.
 - Bay of Cleat North (BOCN1) is likely to result in a small increase in the total influence of all sites modelled. This is mostly separate from areas of influence generated by existing sites.
- Due to the relatively high dispersion nature of the waters surrounding the site, nutrient discharges from Bay of Cleat North (BOCN1) are unlikely to have a strong influence on the surrounding sea area.

4.1.2 Risk identification

Although the modelled influence from Bay of Cleat North (BOCN1) appears to be low, the large tonnage proposed at this site means the risk to the wider environment from sediment and bath influence needs to be assessed using further detailed marine modelling. This includes several features of interest, which require further attention during pre-application work. These are outlined in section 3. Further detailed modelling will need to demonstrate that the influence on these features is low. Given the predicted low risk from screening, a 2D model will suffice.

The conservative nature of the simple BathAuto model in areas of high current speeds, means quantities of bath medicines may be limited to impractical amounts for this site. Use of marine modelling of baths will enable more realistic bath medicine treatment quantities to be determined. Cumulative modelling of identified sites will be required for solids but not for baths.

4.2 Recommendations

4.2.1 Site suitability

Consideration of screening modelling and risk identification suggests that it is possible that discharges from the proposed site will be able to comply with the relevant aspects of the SEPA Aquaculture Regulatory Framework. This must be demonstrated with a detailed marine model.

It is also possible that the site will be able to comply with our mixing zone regulatory framework. This will need to be demonstrated using the NewDepomod model.

Features at risk, identified at this stage, do not appear to influence the feasibility of the proposed site, with respect to the regulatory framework. These risks should be examined using a detailed marine model.

Following the engagement meeting(s), this report will be revised and this should allow to the applicant to submit a method statement which address the issues raised in this document.

4.2.2 Further modelling

- Due to the risks associated with the large tonnage proposed at this site, 2D marine modelling of sediment and bath medicine plumes should be carried out (cumulative modelling of discharges from the sites identified in this screening report, is required for solids but not baths). This marine modelling will also help with the calibration of NewDepomod, should this site wish to expand in the future.
- The resolution of the marine model should be relatively fine around the proposed site and any identified features.

- NewDepomod modelling must be undertaken for the proposed site. Default NewDepomod modelling should be undertaken prior to any marine modelling, to ensure the local impacts of the proposed biomass are acceptable. Calibrated NewDepomod modelling, using 4 transect monitoring data, is required at this site.
- Due to the high dispersion at this site, calibration of marine modelling with dye/drogue data is not required.

5 References

- [1] *Regulatory Modelling Guidance For The Aquaculture Sector. Published on SEPA website.*
- [2] <http://marine.gov.scot/information/wider-domain-scottish-shelf-model>.

For information on accessing this document in an alternative format or language, please contact SEPA by emailing equalities@sepa.org.uk

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