

AQUACULTURE MODELLING



Regulatory Modelling Process and Reporting Guidance for the Aquaculture Sector

July 2019 – Version 1.1

Scope of Report

SEPA has outlined a process for Aquaculture permit applicants to follow. This can be found on the SEPA website. This document gives additional guidance on regulatory modelling process and reporting for the Aquaculture sector and should be used in conjunction with information on the SEPA website.

This document will make reference to modelling guidance detailed in the document titled “Regulatory Modelling Guidance for the Aquaculture Sector”. Text in blue boxes are identified as important information.

Questions regarding Aquaculture Modelling and this guidance should be directed to: aquaculture.modelling@sepa.org.uk

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1 Introduction

SEPA has outlined a process for Aquaculture permit applicants to follow at the pre-application stage. This can be found on the Aquaculture section of the SEPA website. This document gives additional information about the modelling reporting requirements for each step in the process and how SEPA will respond. This document will make reference to modelling guidance detailed in the document titled “Regulatory Modelling Guidance for the Aquaculture Sector” [1].

Following this introduction, each section in this document mirrors the pre- application process steps on the SEPA website.

1.1 Reporting Quality Requirements

Data, files and reports should be provided to SEPA at each step in the process. We have provided guidance on the important aspects of these in the sections below. As part of our regulatory approach we will assess if the material provided is suitable for the permit application process. If the supplied material is not suitable then we will ask the applicant to revise it.

It is essential for the applicant to supply material to SEPA which is complete and takes account of the guidance in this document. Material should, as far as is possible, be free of errors. If material provided to SEPA does not meet our requirements we will indicate this to the applicant and expect them to check it. It will not be possible for SEPA to provide an extensive list of issues to be fixed.

1.2 Applicant Staff and Contractor Suitability

Applicants are responsible for ensuring that staff or contractors are suitably qualified and experienced to undertake data collection, modelling and reporting. Where staff accrue experience of preparing modelling material, this should be captured by applicants and used to train additional, or future replacement, staff.

SEPA is happy to share any existing tools we have generated (e.g., MATLAB Scripts) which may assist the applicant in producing modelling material. SEPA is not responsible for providing detailed assistance to ensure that staff or contractors are able to produce the required modelling material.

1.3 Previous Modelling Guidance and the Method Statement

Modelling guidance previously issued by SEPA was highly prescriptive. Our new regulatory approach [1] provides more general guidance on how modelling should be used to support the permitting process.

SEPA expects applicants to familiarise themselves with our modelling guidance and prepare a comprehensive Method Statement describing the modelling work to be undertaken.

1.4 Supplying Data and Reports to SEPA

Data, Modelling Files and Reports should be supplied to SEPA on electronic media (e.g., DVD, USB Drive, file hosting/sharing platform). Guidance on the electronic folder structure required for supplying material to SEPA can be found in Appendix A.

A number of Excel spreadsheet and text file templates are available to assist with the supply of material to SEPA. These can be downloaded from the “Modelling Data Collection Reporting” box in the Aquaculture Pre-Application section of the SEPA website. The name of the file for download is: “Modelling Data Collection Reporting Templates.zip”.

Reference will be made to the templates in this document.

2 Pre-Application Proposal

Purpose:

To record the start of the pre-application process and capture information required for Screening Modelling and Risk Identification.

2.1.1 Information Required for Screening Modelling

When contacting SEPA with a pre-application proposal please supply the following information:

- Proposed farm location: Centre of pen group or groups
- Cage number and layout (with pen co-ordinates)
- Biomass and feed rate
- Anticipated medicine consent requirements
- Planned changes to other nearby sites (e.g., new site applications, plans to consolidate sites)

2.1.2 Supply of Additional Information

It is possible that an applicant may already have data and information relating to the proposed site. This could include:

- Current meter data
- Depth data
- NewDepomod modelling
- Marine modelling
- Pre-existing information regarding local sensitive features or other potential risks

If supplementary data and information are available to assist the screening process please supply these to SEPA with the pre-application proposal.

3 Screening Modelling and Risk Identification Report

Purpose:

For SEPA to carry out an initial assessment of the proposal to determine what further risk assessment work needs to be carried out. This includes screening modelling by SEPA modelling.

3.1 Screening Modelling

SEPA will use the data and information supplied in the pre-application proposal to produce an **indicative** assessment of the likely impact of the farm on the surrounding area. Marine modelling tools will be run for one month using average:

- Tidal conditions
- Wind conditions
- Freshwater input conditions.

These results will be analysed to produce **indicative** information about the scale and intensity of the likely farm impact. A brief report summarising key outputs will be produced and this will be used to carry out an initial identification of the risks posed by the proposed site.

Screening modelling will not provide a comprehensive assessment of the risks posed by the pre-application proposal. However, it will provide an initial assessment of the influence a proposal may have on the surrounding area. Crucially, screening output will help to shape the work required to provide a comprehensive assessment of risk.

3.2 Risk Identification

Screening modelling output will be considered alongside other information relating to the marine environment, e.g., Priority Marine Features. Following this internal SEPA process, risks identified will be included in the screening report.

3.3 Screening Modelling and Risk Identification Output

A Screening Modelling and Risk Identification Report will be provided to the applicant within four weeks of the receipt of a pre-application proposal. This report will include:

- Maps and tables of screening model output.
- Maps and tables summarising the initial risk identification.
- Feedback on the scale and complexity of the modelling required to address the identified risks.
- Feedback on the modelling uncertainties which we think may affect the proposal.
- Feedback on the suitability of the proposal with respect to the dispersive capacity objectives of the Aquaculture Sector Plan.
- Feedback on any supplementary information supplied with the proposal.

SEPA anticipates that the Screening Modelling and Risk Identification Report will form the basis of the Local Community Engagement meeting.

4 Engagement Meeting with SEPA, the Applicant and Local Communities

Purpose:

To engage local communities early in the pre-application process and identify additional risks posed by the proposal.

4.1 Engagement Case Review

Feedback from the engagement meeting(s) will be considered by an internal SEPA process. Additional screening modelling may be carried out to address any additional risks identified. The Screening Modelling and Risk Identification Report will then be updated to reflect any additional risks which may need to be addressed by applicant modelling. This will be provided to the applicant within four weeks of the Engagement Meeting.

The final Screening and Risk Identification Report should be used as the basis for the Modelling Method Statement.

5 Modelling Method Statement

Purpose:

For SEPA to judge whether the applicant is proposing modelling work which will address the agreed risks. For the applicant to understand the modelling information required by SEPA so that all the risks identified can be assessed.

5.1 Method Statement Content

Applicants should use the final Screening and Risk Identification Report to prepare a method statement. The method statement must propose modelling which allows identified risks to be addressed and can demonstrate that relevant environmental standards will be met. Please refer to “Regulatory Modelling Guidance for the Aquaculture Sector” [1] for further information.

As a guide, we suggest that the method statement should include the following:

1. A description of the site and the proposals for site operation.
2. A description of the hydrographic setting including a description of the local bathymetry, flow patterns, etc.
3. A description of the environmental risks and regulatory questions associated with the site and proposed farm operation. Including the basic SEPA environmental quality standards, but possibly also include others such as sensitive features or interacting discharges (for example other fish farms in the same water body).
4. Mentioning of the site’s current performance (technical variations only).
5. A description of the proposed modelling methods and an explanation of why these methods are appropriate for addressing the identified environmental risks.
6. A description of the required data and how this will be sourced. For Marine modelling this should include the required boundary water level and bathymetry data as well as calibration/ validation data (e.g., dye tracing, temperature and salinity data etc.).
7. Short description of flow and bathymetry data used for NewDepomod and BathAuto modelling (if appropriate). If any calibration/validation data is used provide information on proposed methods.
8. For calibrated/validated modelling, detail how this will be approached, what data will be used and why this is suitable (NewDepomod and Marine modelling).
9. For Marine modelling, a technical description of the proposed model build including explanations for critical modelling choices such as boundary locations, grid size and cell size, resolution and calibration/validation procedures.
10. Marine modelling: A description of the various modelling scenarios used to represent the operation of the farm. This may include, for example, information on feed loadings and simulation time periods and other sensitivity tests undertaken.

All applicants will be expected to carry out marine modelling unless the proposed site is likely to pose a low risk to the surrounding area. The applicant is responsible for providing a justification for this within the method statement.

6 Modelling Data Collection Reporting

Purpose:

For the applicant to collect and provide to SEPA the agreed required current meter data, and other data, which will be used for modelling.

6.1 General Reporting Requirements

A Modelling Data Collection report should be provided to SEPA for assessment. Guidance on the structure and content of the report can be found in Appendix B.

6.2 Current Meter Data Reporting

6.2.1 Initial Current Meter Data Checks

Prior to the submission of the full 90 day current meter data record to SEPA, and final Modelling Data Collection report, we would advise applicants to send data from their initial current meter deployment for checks. This will help to ensure that full 90 day data sets are suitable for further use in the permitting process. Please send the data directly to: aquaculture.modelling@sepa.org.uk

6.2.2 Full Current Meter Data Checks

Once the full 90 day record is complete, please send this to SEPA for final checks before it is used in the permitting process and included in the Modelling Data Collection report. Please send the data directly to: aquaculture.modelling@sepa.org.uk

6.2.3 Current Meter Formatting

Please refer to the templates in “Modelling Data Collection Reporting Templates.zip” (see section 1.4).

1. Raw current meter data (.mat files, Excel files exported from current meters like .pd0, .000 from TRDI, .rds, .bin files from Aanderaa)
2. Processed HG data in the following format in an Excel spreadsheet: time (dd/mm/yyyy HH:MM:SS,GMT), Speed (m/s), Direction (deg), u (m/s), v (m/s), depth (m). The different bins/ depths should be either in separate spreadsheets or separate tabs, marked with surface, middle, bottom, e.g. CurrentMeterData_siteName_Surface2013.xlsx, CurrentMeterData_siteName_Middle2013.xlsx, CurrentMeterData_siteName_Bottom2013.xlsx
3. Summary of current data used in modelling (in report): mean speed (m/s), major axis (deg), residual speed (m/s), residual direction (deg), residual u (m/s), residual v (m/s), parallel amplitude (m/s), normal amplitude (m/s); summary tab in either CurrentMeterData_siteName_Surface2013.xlsx, CurrentMeterData_siteName_Middle2013.xlsx, CurrentMeterData_siteName_Bottom2013.xlsx

Definition of Summary Metrics

Mean speed

The mean of all flow speeds in the time series

Major axis

Direction of the major axis of the tidal ellipse. This represents the direction in which the time series data varies predominantly and can be determined via principle components analysis.

Residual speed

The net flow speed described by the time series, defined as the cumulative vector displacement divided by the number of observations.

Residual direction

The net flow direction, defined as the direction of the cumulative displacement vector.

Parallel amplitude

A measure of the average flow speed which considers the oscillatory nature of tidal flows. This metric represents the amplitude of a sine wave which approximates the dataset in representing the variations in flow speed along the direction of the major axis. This, together with the normal amplitude, describe the radii of the tidal ellipse.

Normal amplitude

Similar to the parallel amplitude but representing variations in flow speed perpendicular to the direction of the major axis.

Anisotropy

The ratio of the parallel and normal amplitudes. This metric describes how elongated the tidal ellipse is.

Each of these measures can be calculated using SEPA's HGAnalysis worksheet.

4. Describe bin numbers for each depth and their respective height above bed, see modelling_metadata_template.xlsx

6.3 Bathymetry Data Reporting

Bathymetry data used in modelling exercises should be submitted to SEPA on electronic media in .xyz format. Please refer to the *bathymetry.xyz* template in "Modelling Data Collection Reporting Templates.zip" (see section 1.4).

6.4 Reporting of Additional Modelling Data

Additional modelling data such as dye or water level data should match the format of other data specified above as far as possible.

7 NewDepomod Modelling Reporting

Purpose:

For the applicant to undertake the agreed NewDEPOMOD modelling to assess local impacts.

7.1 General Reporting Requirements

NewDepomod modelling should be described in an accompanying written report and all modelling files submitted to SEPA on electronic media (see section 1.4). Guidance on the structure and content of the NewDepomod report can be found in Appendix C.

The following information should be included in the report:

1. A summary describing the goals, approach and outcomes of the NewDepomod modelling including predicted sustainable discharge quantities.
2. A brief description of the site in terms of proposed (and if applicable, existing) pen dimensions and layout, as well as proposed (and if applicable, existing) biomasses/stocking densities and other discharge quantities.
3. A brief description of the hydrographic context including summary statistics describing flow conditions and bathymetry.
4. A description of the modelling approach used (standard default, validated, uniform or varying flow, etc.).
5. A description of how the model domain and input (e.g. flow, bathymetry) data has been chosen and assembled.
6. A description of the modelling results. This should include a description of the pertinent modelling runs, the basis for their configuration, the hydrographic and operational scenarios represented, and the predicted outcomes.
7. For the standard default method, runs representing nominal scenarios using the proposed farm operation, should be described.
8. For validated modelling, the report should describe:
 - a. the model runs used for calibration and validation
 - b. the methods by which the optimum model configuration was identified
 - c. the error margins achieved in the validated model
 - d. the model runs which represent scenarios using the proposed farm operation
9. All pertinent model runs referenced in the report (e.g. calibration, validation or proposed farm operation) should be clearly identified by the run identifiers used in the NewDepomod project files.
10. The outcomes of the modelling based around the proposed farm operation should be contextualised in terms of any limitations or uncertainties that can be identified regarding the modelling approach, the input data and/or the suite of scenarios presented.

Plots to be submitted:

- Site map with pen location and current meter position
- Bathymetry plot and pen layout with current meter position
- Plots with benthic (solids) deposition
- Plots with in-feed (EmBZ) deposition

7.2 NewDepomod Data Reporting

NewDepomod data files supplied to SEPA should take account of the following points:

1. Run numbers NewDepomod: modelling report & *modelling_metadata_template.xlsx*
2. Fill in submission template with pen details, current meter locations & file names, Depomod run files, and monitoring locations, *modelling_metadata_template.xlsx*
3. Bathymetry data, csv file: *bathymetry.xyz*
4. Depth sounding data: *depthSounding.xlsx*
5. Model calibration/ validation data (if a validated Depomod model is used for a site)

8 Marine Modelling Reporting

Purpose:

For the applicant to undertake the agreed marine modelling to assess the wider scale risks. For the applicant to demonstrate to SEPA what level of impact the proposal will have on particular features.

8.1 General Reporting Requirements

Marine modelling should be described in an accompanying written report and **all modelling files submitted to SEPA** on electronic media (see section 1.4). In addition, all input and calibration data used should be submitted on electronic media. Guidance on the structure and content of the NewDepomod report can be found in Appendix D.

The following information should be considered when preparing the marine modelling report:

1. A summary describing the goals, approach and outcomes of the marine model including any headline conclusions
2. A description of the site in terms the hydrographic context and the proposed (and if applicable, existing) operational practices. The information should be described in summary tables for the most relevant information.
3. Statement of objectives and aims of the marine modelling study, clearly explaining the situations being modelled and the objectives of the modelling study.
4. Description and justification of the modelling approaches taken, to demonstrate that the model(s) used are suitable for addressing the objectives.
5. Technical description of model(s) build process, including any identified strengths, weaknesses or limitations. Explanations of key modelling assumptions and decisions (e.g. boundaries, resolution, dimensions, forcing data, modelled constituents)
6. A description of data used in any modelling exercises, including input data (e.g. flow, bathymetry, feed, medicines) and data used for calibration and/or validation. Any sampling surveys undertaken to fulfil these data requirements should be described, including data collection and measurement techniques as well as expected errors and relevant quality assurance.
7. A description of what a realistic bath treatment is and model this for bath medicines.
8. A presentation of the modelled proposed scenarios including a description of predicted impacts in relation to environmental standards or other perceived risks.
9. Any model *calibration* exercises should be described in detail, including reference to the observational datasets used in comparison with model outputs, the model components used to tune the model behaviour and the basis for identifying optimal model setup.
10. Any model *validation* exercises should be described in detail, including reference to the observational datasets used in comparison with model outputs, and the outcomes in terms of demonstrated model accuracy.
11. The results of any sensitivity analyses performed with respect to forcing conditions, discharge scenarios or other key modelling choices

12. A discussion of the modelling outcomes based around the proposed farm operation (i.e. for benthic, in-feed and/or bath chemical discharges) contextualised in terms of any limitations or uncertainties that can be identified regarding the modelling approach, the validation performance and/or the representation of the suite of scenarios presented.
13. An itemized description of submitted information, including raw and processed data files and all modelling files, to ensure that there is a clear account of the modelling exercise for auditing by SEPA.

A statement of quality assurance, to demonstrate that the model has been subject to an evaluation procedure establishing its suitability for the relevant tasks.

8.2 Marine Modelling Data Reporting

Marine modelling data files supplied to SEPA should take account of the following points:

1. Bathymetry data, csv file: bathymetry.xyz
2. Boundary data (sea level data and tidal constituents to force the boundary or temperature and salinity boundary data, if applicable)
3. Wind data, raw and processed (for meteorological forcing)
4. Drogue/ drifter calibration data (if applicable)
5. Dye data, raw and processed (if applicable)
6. Temperature, salinity and depth (CTD) data for water column conditions and initial conditions, raw and processed
7. Current meter data for calibration/ validation, raw and processed

8.3 Reporting of Simplified Bath Treatment Modelling

If marine modelling has not been used to model bath medicines, (see section 5.1), please produce a report describing the simplified approach in the style of the marine modelling report. Supply the relevant report and electronic files as outlined in section 1.4.

9 Conclusion of Modelling

Purpose:

To bring together all data and modelling and reach a conclusion on the risks posed by the proposal.

9.1 Modelling Summary Report

SEPA Modelling will consider all modelling information supplied and produce a final response which will describe our view of the suitability of the work for use in the permitting process and any risks arising from the model output.

10 References

- [1] *Regulatory Modelling Guidance For The Aquaculture Sector - Version 1.0. Published On SEPA Website; June 2019..*

Appendix A: Folder Structure for Supplying Material to SEPA

Folder structure:

- Application
- Mail
- Modelling
 - Bath (if applicable)
 - Depomod
 - Marine
- ProcessedHG
- RawData
- SupportingInformation

Folders & Content:

1. Application:
Application Forms, cover letter, planning and site plan
2. Mail:
Any mail/ email correspondence
3. Modelling:
 - a. Bath: Bath modelling files (if applicable)
 - b. Depomod: Depomod modelling files
 - i. Bathymetry
 - ii. Pens
 - iii. Flowmetry
 - iv. Inputs
 - v. Models
 - vi. Results
 - c. Marine: Modelling files (flow & particle tracking), calibration, validation data, flow data, model results, bathymetry data, wind data, boundary forcing data, maps with bathymetry, pen & current meter locations and map of model grid
4. Processed Data:
Hydrographic data sheets for the separate depths in excel spreadsheets, separate sheets for each deployment and additionally the full stitched together time series as well. Processed CTD data or any other submitted data that has been corrected, modelling_metadata_template_v2.xlsx
5. Raw Data: raw current meter data from current meter instruments, raw CTD data, dye data, drogoue/ drifter data, bathymetry, depth sounding data
6. Supporting Information: Method Statement, Modelling Data Collection Report, NewDepomod Modelling Report, Marine Modelling Report (or Bath Modelling Report).

Appendix B: Suggested Modelling Data Collection Report Structure and Content

There follows a skeleton list of sections that should be included in the site survey report:

- 1) Site Description
 - a. National and waterbody scale contextual maps of site
 - b. Existing and/or proposed infrastructure
- 2) Scope of report
 - a. Required data
 - b. Existing data
 - c. Third party data
 - d. Survey data
- 3) Methods
 - a. Survey/sampling, instrument deployment
 - b. Data processing
 - c. Data repair
 - d. Harmonic analysis
 - e. Data combination
- 4) Site Infrastructure
 - a. Map showing pen layout and moorings
 - b. Table describing individual pen dimensions, shape and location (current and new, if licence variation)
 - c. Description and reasoning of changes from existing to proposed layout
- 5) Bathymetry
 - a. Description of curation of bathymetry data, conversions, interpolations etc
 - b. Plot of spot depth or survey track locations
 - c. Plot of generated, interpolated bathymetry
- 6) Flow Data
 - a. Map showing locations of deployment(s)
 - b. Description of individual deployments including appraisal of deployment, details of any data repair, tidal analysis, datum conversions, summary statistics, time series plots, scatter plots, frequency plots
 - c. Description of composite flow dataset curation, summary statistics, etc.
 - d. Discussion of main overall features of flow dataset and representability in the context of modelling
- 7) CTD Data
 - a. Map showing locations of CTD measurements
 - b. Description of individual deployments including appraisal of deployment, details of any data cleansing
 - c. Plots with temperature vs depth and salinity vs depth
 - d. Discussion if water column conditions might affect mixing within the water column(e.g. stratification/ well mixed water column)
- 8) Drifter/ Drogue data (if applicable)
 - a. Map showing locations drogues/ drifters
 - b. Description of individual deployments including appraisal of deployment
 - c. Description of data analysis and use of drogue/ drifter data

- 9) Dye data (if applicable)
 - a. Photos showing dye patch
 - b. Description of deployment including appraisal of deployment
 - c. Calculations of dispersion coefficient to be used in the model
 - d. Description of data analysis and use of dye data
- 10) Water level
 - a. Map showing deployment location(s) (if different from above)
 - b. Description of main features of data set(s)
- 11) Equipment list, specifications and set-up parameters
- 12) Survey log sheets
- 13) Calibration reports
- 14) List of data files of all data used included with filenames and description (raw, processed, repaired, etc.)

To be included in the Modelling Data Collection Report:

1. Description and specification of devices used, including serial number
2. Description of deployment process and devices setup
3. Deployment locations (in OS all-numeric grid references)
4. Deployment start and end times
5. Sampling interval and number of records for each instrument and deployment
6. Deployment water depth for current meter
7. Description of any deployment integrity checks

Plots of Hydrographic/ Dispersion Data:

For each separate deployment, the following plots should be presented:

- Map(s) showing the position of each deployment relative to the coastline, bathymetric features and farm infrastructure
- Plots showing screenshots of raw ADCP, CTD data in instrument's data processing tool
- Temperature and salinity vs. depth (CTD) plots
- Drogue/ drifter time series plots, maps of drogue/ drifter track locations, plots of distance from launch position vs time
- Photos of dye patch
- Contour plot of dye concentrations at a given location
- log Area patch vs log time to calculate dispersion

- Dye concentration vs. distance from centre

Time series plots:

For each processed time series in each depth the following plots should be presented:

- Time-series plots of heading, pitch, and roll, for acoustic profiling instruments
- Separate time series plots of flow speed and direction & comparison with harmonic reproduction of speed and direction (use Admiralty's Total Tide or UTide)
- Scatter plot of east and north flow vector components
- Time series plot of water level/pressure

Appendix C: Suggested NewDepomod Report Structure and Content

Executive Summary

1 Introduction

1.1 Site Details

2 Model Input Details

2.1 Hydrographic Data and Marine Modelling

2.2 Run Details

2.2.1. Calibration/ Validation (if applicable)

3 Modelling Results

3.1 Biomass Results

3.1.1 Full Modelled Flow

3.1.2. Calibration/Validation

3.1.3 Transect and Sampling Stations

3.2 In-feed Treatments (SLICE)

3.2.1 Full Modelled Flow

3.2.2 Transects and Monitoring Stations

4 Results and Conclusions

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Appendix D: Suggested Marine Modelling Report Structure and Content

Executive Summary

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2 Objectives of the Modelling Study

3 Marine Model Description And Configuration

3.1 Model Description

3.2. Configuration and Boundary Forcing

3.3. Calibration and Validation

4 Marine Modelling Results

4.1 Calibration, Time Period 1

4.2 Validation, Time Period 2

4.2.1 Sea Surface Height

4.2.2 Velocity Time Series

4.3 Modelled Flow Fields

4.4 Particle Tracking

4.4.1 Particle Tracking Benthic

4.4.2 Particle Tracking In-feed Chemicals

4.4.3 Particle Tracking Bath Chemicals

4.5 Preparing Velocity Data for NewDepomod (if applicable)

5 NewDepomod Modelling (when using flow fields from Marine Model)

5.1 Initial Testing

5.2 Calibration and Validation Simulations

5.3 Model Inputs and Flow Fields

5.3.1 Wind Forcing

5.3.2 Flow Fields, Time Period 3

5.3.3 Flow Fields, Time Period 4

5.3.4 Waste Feed and Faecal Solids

5.4 Calibration and Validation Results

5.4.1 Slice ("EMBZ")

5.4.2 Benthic Footprint ("NONE"), Time Period 3

5.4.3 Benthic Footprint ("NONE"), Time Period 4

References