

## ANNEX F. SEABED MONITORING AND ASSESSMENT

ANNEX F. SEABED MONITORING AND ASSESSMENT.....	1
F.1 INTRODUCTION.....	2
F.2 CAR LICENCE APPLICATION SURVEY REQUIREMENTS .....	2
F.2.1 Benthic surveys .....	3
F.2.2 Visual surveys.....	3
F.3 LICENSED SELF-MONITORING REQUIREMENTS .....	11
F.4 SURVEY STRATEGIES.....	11
<b>F.4.1 Baseline Survey, Benthic - Standard</b> .....	12
<b>F.4.2 Baseline Survey, Benthic - Extended</b> .....	12
<b>F.4.3 Baseline Survey, Visual - Standard</b> .....	12
<b>F.4.4 Baseline Survey, Visual - Site Specific</b> .....	12
<b>F.4.5 Monitoring Survey, Visual</b> .....	12
<b>F.4.6 Monitoring Survey, Benthic - Standard</b> .....	13
<b>F.4.7 Monitoring Survey, Benthic - Extended</b> .....	13
<b>F.4.8 Monitoring Survey, Benthic - Site Specific</b> .....	13
F.5 SEPA AUDIT MONITORING .....	13
F.6 ASSESSING MONITORING RESULTS .....	14
F.7 DETAILS OF METHODS.....	14
F.8 SUGGESTED READING.....	14

## F.1 INTRODUCTION

The environmental effects of marine cage fish farming are generally most prevalent within close proximity to the cage groups. These impacts, predominantly on the benthos, may be long lived at sites in quiescent waters or, at more dynamic sites, relatively short lived. Consequently, much of the research activity into these impacts has concentrated on the immediate local environment. Monitoring strategies to assess the 'health' of the benthos surrounding proposed and existing fish farms have been designed to examine this risk to the local environment.

Although there is considerable effort and research into the detailed biology and chemistry of changes within the sediment, various easily measured parameters may be used to determine degree and extent of risk. These are based on well-documented consequences of organic impacts from fish farms and other discharges. SEPA considers that the most appropriate method for assessing the benthic impacts of marine cage farms is to examine a number of parameters, which describe the biological and physico-chemical status of the seabed. Additionally, the use of underwater video and still photographs may provide information on the extent of gross impacts, the location of previous cage positions or effects on hard substrate. However, its value is limited when attempting to determine the extent of impact beneath the sediment surface.

The requirements of CAR application and licence monitoring surveys depend on:

- licensed peak biomass of the farm site,
- hydrographic conditions,
- natural heritage interests and other environmental concerns,
- use of chemotherapeutants and medicines, and
- site management and history.

A combination of self-monitoring (data provided by the discharger) and audit monitoring (data gathered by SEPA) will be applied to the industry.

## F.2 CAR LICENCE APPLICATION SURVEY REQUIREMENTS

To assist in the full decision-making process for applications in respect of new farms, and to increase biomass at existing farms, SEPA must be in possession of recent relevant site data, which is used to inform the licensing process.

The choice of strategy is flexible and the frequency and intensity of surveys may be increased or decreased in proportion with the environmental risk. This approach should also take account of local issues that might affect the degree of risk to the site, such as site dynamics, low current speeds, nutrient stress, history of algal blooms, poor site management and presence of natural heritage features, both statutory and non-statutory.

When an application is received for a new cage site, SEPA requires sufficient information to enable categorisation/assessment of the benthic environment. This information is used to:

- assess the existing benthic conditions and allow comparisons with background conditions,
- permit future comparison of benthic conditions after farming has commenced, and

- assist with the process of determining the appropriate maximum biomass for the site.

Where a licence has been issued, self-monitoring data will be used:

- to determine whether sufficient sediment re-worker species are present to support an increase in biomass or use of medicines,
- to determine the quantity of in-feed sea lice medicines residues in the sediment, if licensed, and
- to build up a site history in order to make properly informed decisions for future CAR applications.

Data submitted may be from a survey carried out as part of the application for a CAR licence, or as a monitoring condition within an existing licence for the site. These data will be obtained from one of the 8 strategies listed in Section F.4.

The survey should have been carried out not more than 24 months prior to the application. If the applicant wishes to include a survey that is out with this period, then Marine Science should be contacted to discuss the appropriateness of the survey.

In addition, where a site is located in an area of natural heritage interest, e.g. SAC, SPA, MCA, then SEPA reserves the right to seek additional data over and above that given in the routine strategies. The Marine Science team should be contacted to discuss suitable additional monitoring requirements.

Surveys are of two types: benthic and visual. Where possible SEPA requires a benthic survey as a minimum – unless the substrate is unsuitable and a visual survey may be used. In addition to the benthic survey, it may be necessary (according to the Visual Survey Decision Tree below) to also conduct a visual survey to assess habitats and species of conservation importance.

#### F.2.1 Benthic surveys

The use of benthic surveys to provide data on benthic infauna and chemistry is a long established technique used by SEPA and other regulatory agencies. The health of the sediment can be readily established and the degree of impact from the fish cages can be quantified. As with all ecosystems there will be variation in faunal composition between locations depending on many factors such as depth, exposure, current speed etc. This natural variation necessitates the use of reference samples taken from similar depths and conditions in the locality of the test samples.

The collection of benthic surveys and the subsequent analyses of the samples for biological and chemical components is a mature science and the data submitted as part of fish farm surveys are acceptable for other legislative drivers such as Water Framework Directive (WFD) classification.

#### F.2.2 Visual surveys

##### **Introduction**

Visual surveys of the seabed, using video or photographic techniques, collect information on the communities living on the seabed (habitats and species). In the context of this protocol the surveys are to be gathered in proximity to new or expanding aquaculture developments such that expected impacts from the site can be evaluated in relation to any conservation objectives that may be present.

The survey information can be used as part of the supporting application for CAR licences and will also be suitable to meet data requirements for application for Planning Consent and EIA.

Survey information is also required as a condition of a CAR licence if it is deemed that the best means of assessing the sea bed survey is by visual survey.

The requirements and protocols detailed below are the result of detailed discussions by SNH and SEPA. The main drivers for this joined-up system are:

- To ensure that the legal requirements incumbent upon SNH and SEPA as Competent Marine Authorities (CMA) under conservation legislation are met,
- To make the requirements and survey techniques apparent and transparent to operators so that any survey necessary can be carried out prior to any subsequent licensing application, and
- So that operators can conduct one survey in knowledge that it will satisfy the requirements of both SNH and SEPA. This is important to minimise duplication, delays in applications and also in costs to the operators.

### **Legislative Drivers**

There are two principal legislative drivers that require SEPA and SNH to collect sea bed information that describes conservation features.

#### 1. Habitats and Birds Directives.

The 'Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora' was adopted in 1992 and is commonly known as the Habitats Directive. It complements and amends the 1979 'Council Directive 79/409/EEC on the conservation of wild birds', commonly known as the Birds Directive.

The Birds Directive protects all wild birds, their nests, eggs and habitats within the European Community. It gives EU member states the power and responsibility to classify Special Protection Areas (SPAs) to protect birds which are rare or vulnerable in Europe as well as all migratory birds which are regular visitors.

The Habitats Directive builds on the Birds Directive by protecting natural habitats and other species of wild plants and animals. Together with the Birds Directive, it underpins a European network of protected areas known as Natura 2000. This network includes SPAs classified under the Birds Directive and the set of international nature conservation areas introduced by the Habitats Directive, Special Areas of Conservation (SACs).

#### 2. Nature Conservation (Scotland) Act 2004

This Act applies to Scotland only and places a duty on every public body to further the conservation of biodiversity consistent with the proper exercise of their functions. The Act places duties on public bodies in relation to: the conservation of biodiversity (see <http://www.ukbap.org.uk/NewPriorityList.aspx>), increases protection for Sites of Special Scientific Interest (SSSI), amends legislation on Nature Conservation Orders, provides for Land Management Orders for SSSIs and associated land, and strengthens wildlife enforcement legislation.

### Scope of Visual Survey

The scope of the visual survey protocols satisfies the requirements of the Habitats and Birds Directive and also those of the Nature Conservation Act (Scotland) 2004. The level of information required will be proportional to the size of the farm, its Allowable Zone of Effects (AZE) and its likely impact on the surrounding benthic environment.

Visual surveys will be required when applications are for:

- new sites,
- for sites subject to expansion within Marine Natura 2000 sites (SAC, SPA, or MCA);subject to threshold rules (see below),
- for sites subject to significant expansion in areas with no statutory conservation designations but where there may be presence of priority UKBAP species or habitats);subject to threshold rules (see below), and
- where the information on the sea bed around the cage group is insufficient to make a conservation assessment, e.g. where no previous video surveys have been undertaken, where existing video survey data is >6yrs old.

Scenarios where visual surveys are not necessary:

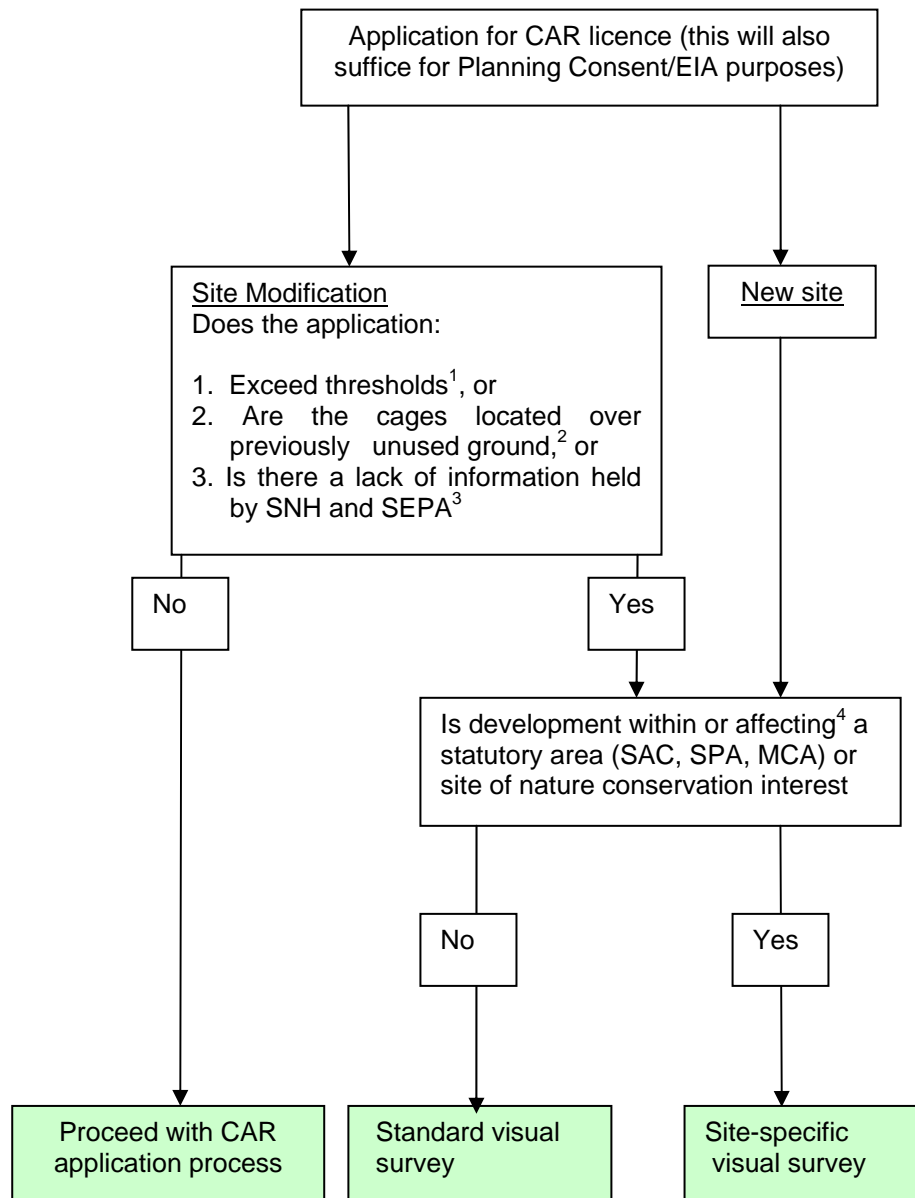
- minor expansions, and
- areas where existing information shows there are no habitats or species of special interest.

Note that the information required covers survey requirements for applications for CAR licences and should be sufficient to submit as part of applications for Planning Consents and EIA.

When considering an application for a new site or to modify an existing site an operator must be aware of any requirement to conduct a visual survey and to submit the results to the relevant CMA or Planning Authority.

In order to decide if a visual survey is required it is important to use the Decision Tree along with the sea bed thresholds and rules, which are given below.

## Decision Tree



<sup>1</sup> See below for threshold information

<sup>2</sup> If the cages are to be relocated significantly and will lie on previously unused ground i.e. not within old AZE boundary

<sup>3</sup> Applicants are advised to check this with SEPA and SNH

<sup>4</sup> For guidance on proximity please discuss with SEPA and SNH

## Thresholds

### New Site

Typically the CMAs will know little of the detail of the characteristics of the sea bed at a new site. Habitat and species mapping in the marine environment is sporadic and tends to be in locations of known conservation interest and where statutory obligations apply. In order to satisfy the CMAs that the location of a new site will not be over or adjacent to any conservation features, an underwater visual survey will be required. This will take the form of either a Standard Baseline Visual Survey or a Site Specific Baseline Visual Survey if the site is to be located in or will affect an SAC, SPA or MCA

### Site Modification

Operators apply to modify existing sites for a variety of reasons including:

- to increase biomass,
- add specific chemicals to the licence,
- change species, change cage type and configuration, or
- to change from the 25m fixed AZE to a site-specific AZE.

For sites in operation, SEPA will be in possession of environmental survey data that have been collected for a variety of reasons:

- baseline information,
- operator self-monitoring as a condition of the CAR licence, and
- from SEPA's own audit monitoring.

This information will often be sufficient to identify any features of conservation interest under and around the cage group out to at least the edge of the AZE and typically to at least 25m beyond this. The area of seabed for which this information is known can be simply calculated from the CAR licence and original application information.

Following an application to modify the layout of the site there will be a new area of sea bed that the modification proposes to cover, by the cages, their moorings grid and by the deposition of carbon from waste feed and faeces, i.e. the AZE. Whilst small additions to sea bed area will not be of any concern to the CMAs as the existing data should be sufficient to give confidence that sea bed type will be broadly similar; there is a distance at which the confidence in this data decreases such that additional data is required. To determine the threshold that will trigger a request for further information, SEPA and SNH collated information relating to AZE and cages areas and lengths of the longest AZE transect, before and after site modifications. This allowed realistic thresholds to be determined on the basis of real situations and data. The analysis produced a series of rules and threshold values based upon two typical scenarios, the first based on increased area and the second upon length of transect.

#### Scenario 1 AZE Area.

If the new AZE is in a location that is subject to low current speeds and its shape is reasonably uniform around the cages then the extension of area over new sea bed will be significantly smaller than in a site where the current is uni-directional. If there is information on the sea bed then a new visual survey will not be required, unless the area threshold is breached. The threshold area is the area of sea bed covered by the modified cages and AZE, minus the area of sea bed of the existing cages and AZE. This threshold is currently determined by the CMAs as 40,000m<sup>2</sup>

#### Scenario 2 AZE Length.

If the new AZE is significantly skewed in one direction and the longest length of AZE is greater than 200m then a survey will be required even if the area threshold is not exceeded.

In light of future knowledge or changes to legislation the area and length thresholds may be altered.

Taking the two scenarios above into account a series of three rules have been developed:

1. Is the threshold area greater than 40,000m<sup>2</sup>? If so then the appropriate visual survey is required.
2. Is the longest transect on the modified AZE >200m, irrespective of area threshold? If yes then the appropriate visual survey is required.
3. Is the longest transect on the modified AZE <60m, irrespective of area threshold? If yes then a visual survey is not required.

These rules are designed to accommodate the majority of circumstances. It is recognised that they will not fit all modification scenarios and if difficulty is experienced then the operator should contact SEPA or SNH for guidance.

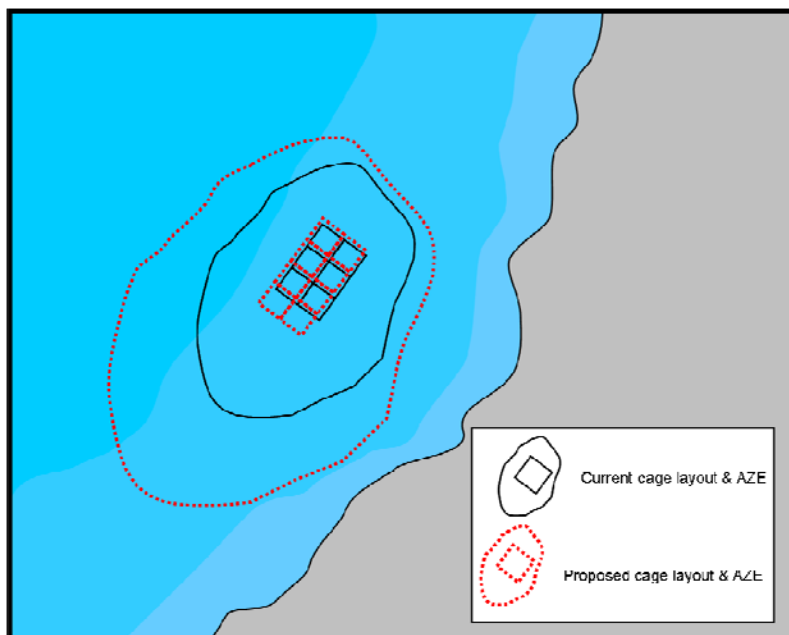
Other rules and thresholds were considered and rejected as they were too complex, too simplistic or did not cover the majority of the scenarios. The advantages of using area threshold and length rules are that:

- they automatically take into account the shape and area of sea bed that is to be used by the modified site and associated AZE footprint, and
- the threshold should not be invoked at small sites or at sites where the proposals do not significantly modify the area of the AZE.



## Worked example

The graphic below illustrates the scenario of a site increasing its biomass with accompanying increase in AZE area.



Area of existing cage group, 8363m<sup>2</sup>  
Area of existing AZE around cages, 27762 m<sup>2</sup>  
Total area of sea bed occupied by existing site, 36125 m<sup>2</sup>

Area of proposed cages group, 9530m<sup>2</sup>  
Area of proposed AZE, 72354m<sup>2</sup>  
Total area of sea bed to be occupied by proposed modification, 81884 m<sup>2</sup>

Subtract proposed modified area from existing area,  
81884m<sup>2</sup> - 36125m<sup>2</sup> = **45759 m<sup>2</sup>**

This is above the threshold of 40,000m<sup>2</sup> so a survey would be required subject to the AZE length rules above.

## Survey design

Depending upon the exact visual techniques used it is possible to collect images over a large area of seabed in a relatively short period of time, supplementing the more detailed but limited spatial coverage infaunal (grab) records already required from sedimentary areas. Visual surveys can also replace grab sampling techniques in areas of hard substrate. The wider application of these techniques will significantly improve our understanding of benthic communities present and implications for the natural heritage in accordance with SEPA/SNH biodiversity duties.

Video surveys should provide information on the key species and habitats, their abundance and frequency, and substrate type. Where habitats/species of interest are observed, the visual sampling programme should be modified to determine the extent of such features.

Note that SEPA and SNH reserve the right to request more detailed information and further work if required. This may be particularly but not exclusively relevant to sites in areas of recognised conservation or environmental sensitivity, e.g. SAC, SPA, MCA. The information asked for by SEPA and SNH may be subject to change and requirements should be checked prior to any fieldwork and laboratory analyses.

### **Submission of video and format of report**

The video or photographic survey and accompanying text shall be reported in the Visual Monitoring template. The details of this system can be found in Attachment XII. These are spreadsheet-based templates and the preferred format for submission to SEPA shall be CD or DVD. If the operator has difficulties in completing this survey template then they should contact SEPA to seek advice. It is not recommended that operators submit paper records as an alternative without prior discussion.

The completed survey shall be submitted, in duplicate, to the local SEPA Environmental Protection and Improvement team, clearly stating the licence reference number and site name. The survey should be accompanied by a completed Survey Cover Sheet printed from the survey data template.

Visual surveys (video or photographic) shall be submitted to SEPA within 12 weeks of survey. If difficulty in achieving this is experienced, then the local SEPA team must be notified as soon as possible.

### **Evaluation of the visual submission**

On receipt of the visual survey SEPA Marine Ecology staff will log the completed visual survey file into its database and then it will be evaluated by SEPA Science staff. When making an evaluation of the survey, biotope codes will be assigned where possible ([www.jncc.gov.uk](http://www.jncc.gov.uk)), and the evaluation will be entered into the SEPA fish farm database. This evaluation will be copied to the SNH local office that is making comment upon the CAR application (or Planning/EIA application).

### **Auditing and Quality Control**

SEPA may require (at any time) evidence of quality assurance and control on any procedures or processes being undertaken by the responsible person, or their agents, or require independent audit of any resulting data.

SEPA Marine Science staff are subject to routine quality control of their work and subscribe to the external proficiency tests – the National Marine Biology AQC (NMBAQC) scheme. These are listed below.

### **NMBAQC components**

Epibiota ring-test – JNCC and the NMBAQC collaborated to devise an epibiota photographic identification test delivered via the internet. This test aims to develop quality assurance procedures to ensure that epibiota identification data recorded for statutory monitoring programmes are of a uniform high standard the NMBAQC collaborated to devise an epibiota photographic identification test delivered via the internet. This test aims to develop quality assurance procedures to ensure that epibiota identification data recorded for statutory monitoring programmes are of a uniform high standard.

Video and Stills QA – Remote photography/video is increasingly being used in survey and monitoring work as a means of investigating the benthic environment. Thus far QA work has been carried out on the methods to produce protocols for undertaking the surveys themselves and ensuring the best results from use of video and stills. However, less work has gone into the QA of the interpretation of the images produced. While some ad hoc QA has taken place there are as yet no recognised

standards for this process. The focus of this work is to be on the assessment of footage itself rather than in fieldwork methodologies, the intention being that SEPA will develop QA of image "samples" in the same way that is currently undertaken for the QA of traditional biological samples.

### **Video Ring Test**

SEPA is subscribing to a trial video ring test distribution from NMBAQC scheme. If successful this will be extended.

### **SEPA Methods and Forms**

The following methods and forms will be used as part of the evaluation process.

NQF/MAR/021 Underwater video record

NQF/MAR/021b Underwater visual transect – internal AQC record

NQF/MAR/036 Video survey recording form

NWM/MAR/048 Evaluation of visual survey

NWM/MAR/044 General guidance for use of the underwater camera

## **F.3 LICENSED SELF-MONITORING REQUIREMENTS**

The CAR licence will contain monitoring requirements in the Annex to Schedule 3. The choice of survey that may be used is listed in Section F.4

## **F.4 SURVEY STRATEGIES**

The monitoring strategies for the surveys are presented below. The survey protocol for each one is provided in detail for SEPA staff in the templates section of QWeb.

On completion of these surveys, the data, once received by the local EPI team, are forwarded to the Marine Science section for assessment.

8 categories of survey apply:

F.4.1 Baseline Survey, Benthic - Standard

F.4.2 Baseline Survey, Benthic - Extended

F.4.3 Baseline Survey, Visual - Standard

F.4.4 Baseline Survey, Visual - Site-Specific

F.4.5 Monitoring Survey, Visual

F.4.6 Monitoring Survey, Benthic - Standard

F.4.7 Monitoring Survey, Benthic - Extended

F.4.8 Monitoring Survey, Benthic - Site Specific

The recommended tonnage thresholds given below are merely for guidance and a pragmatic approach should be taken to deciding which survey type is most applicable, e.g. if an application is received for 995T, it is treated as >1000T.

#### **F.4.1 Baseline Survey, Benthic - Standard**

This survey type should be conducted at proposed new sites where the maximum biomass applied for is <1000T, and where more detailed data are not required (e.g. for sites in or affecting SAC or SPA and MCA sites).

For CAR application purposes, this survey is required once only in this form and should be accompanied by collection and submission of appropriate hydrographic data for the site (see Attachment VIII).

#### **F.4.2 Baseline Survey, Benthic - Extended**

This survey type should be conducted at proposed new sites where the maximum biomass applied for is >1000T.

- It should also be undertaken at sites of lower maximum biomass where more detailed data are required, For any sites where more detailed data are required, e.g. in or near areas containing statutory natural heritage designations (such as SAC, SPA or MCA sites), where there may be UKBAP interests, where the Nature Conservation Act (Scotland) 2004 may apply, or where there are other local environmental. See SEPA Natural Heritage Handbook Section 3.3 and Regulation and Monitoring of Marine Cage Fish Farming in Scotland - a procedures manual, Section C.

For CAR application purposes, this survey is required once only in this form and should be accompanied by collection and submission of appropriate hydrographic data for the site (see Attachment VIII).

#### **F.4.3 Baseline Survey, Visual - Standard**

This survey should be conducted at:

- proposed new sites that are not located in or near to areas with statutory natural heritage designations (such as SAC, SPA and MCA sites), and
- modifications to sites according to the threshold criteria given in Section F.2.2

#### **F.4.4 Baseline Survey, Visual - Site Specific**

This survey should be conducted at:

- proposed new sites and modifications to existing sites that are located in areas within or near to statutory natural heritage designations (such as SAC, SPA and MCA sites), according to the threshold criteria given in Section F.2.2

#### **F.4.5 Monitoring Survey, Visual**

A visual seabed survey may provide sufficient information to describe the benthic environment under the following circumstances:

- for existing smaller sites (<500T), with a history of minimal impact,
- for any sites over hard substrates, and
- for any sites where more detailed visual data are required, e.g. in or affecting statutory natural heritage designations (such as SAC, SPA and MCA sites), where there may be UKBAP interests, where the Nature Conservation Act (Scotland) 2004 may apply, or where there are other local environmental concerns. See SEPA Natural Heritage Handbook Section 3.3 and Regulation and Monitoring of Marine Cage Fish Farming in Scotland - a procedures manual, Section C.

#### **F.4.6 Monitoring Survey, Benthic - Standard**

This survey should be conducted at existing sites where the licensed maximum biomass is <1000T, and where more detailed data are not required. It should not be used at sites licensed using the AutoDEPOMOD model for setting biomass and determining the edge of the AZE. In such instances, the site specific monitoring survey set out in F.4.8 should be used. The data from this survey may also be used in support of an application where the proposed maximum biomass is <1000T.

#### **F.4.7 Monitoring Survey, Benthic - Extended**

This survey should be conducted at existing sites where the licensed maximum biomass is >1000T. The data from this survey may also be used in support of an application where the proposed maximum biomass is >1000T. It should not be used at sites licensed using the AutoDEPOMOD model for setting biomass and determining the edge of the AZE. In such instances, the site specific monitoring survey set out in F.4.8 should be used.

It should also be undertaken at sites of lower maximum biomass where more detailed data are required:

- for any sites where more detailed data are required, e.g. in or affecting statutory natural heritage designations (such as SAC, SPA and MCA sites), where there may be UKBAP interests, where the Nature Conservation Act (Scotland) 2004 may apply, or where there are other local environmental concerns. See SEPA Natural Heritage Handbook Section 3.3 and Regulation and Monitoring of Marine Cage Fish Farming in Scotland - a procedures manual, Section C, and
- where there is considered to be sufficient environmental pressure (site history, management issues, low flushing rates, Dissolved Oxygen issues, etc.).

#### **F.4.8 Monitoring Survey, Benthic - Site Specific**

This survey should be conducted at existing sites which are licensed under the modeled biomass/AZE system.

The data from this survey may also be used in support of an application to increase the proposed maximum biomass.

### **F.5 SEPA AUDIT MONITORING**

SEPA benthic audit monitoring will be undertaken as a rolling programme, targeting priority areas or areas considered more at risk either due to farm size or local hydrography or natural heritage issues. SEPA audit monitoring includes additional parameters to those sought for self-monitoring.

SEPA audit monitoring includes: underwater camera, benthic faunal community assessment, sediment chemistry (redox, sulphide levels, copper and zinc levels and analysis for the full suite of medicines), particle size analysis, visual assessment of sediment structure, presence of feed pellets and *Beggiatoa* growth. Samples are collected near the cages, at the edge of the allowable zone of effect (AZE) and at reference sites.

SEPA carries out monitoring of seabed sediments to assess any unlicensed use and impacts of chemical therapeutants on the receiving environment and to validate the mathematical predictions of DEPOMOD. Residues samples are collected at selected sites and analysed for cypermethrin, azamethiphos, teflubenzuron, emamectin benzoate and deltamethrin and any other compounds thought necessary, e.g. ivermectin.

## F.6 ASSESSING MONITORING RESULTS

The data resulting from the above sampling and analysis programmes are assessed with reference to the quality standards given in Annex A of the Fish Farm Procedures Manual.

## F.7 DETAILS OF METHODS

Information on the methods to be used is presented within the monitoring protocols available on the SEPA website.

## F.8 SUGGESTED READING

Some suggested reading is given below and links to relevant websites are located in the SEPA website, aquaculture pages.

**Allen, S.F., Grimshaw, H.M., Parkinson, J.A. & Quimby, C.** (1974) *Chemical Analysis of Ecological Material*, 1st edn. Blackwell Scientific Publications, Oxford, UK

**Buchanan, J.B.**, 1984. Sediment Analysis. In *Methods for the Study of Marine Benthos. 2<sup>nd</sup> Edition*. Ed N A Holme & A D McIntyre. IBP Handbook No 16. Blackwell Scientific.

**Carr, M R** 1996. PRIMER Users Manual. Plymouth Marine Laboratory.

**Moss, D., Furse, M.T., Wright, J.F., and Armitage P.D.** 1987. The Prediction of Macro-invertebrate fauna of unpolluted running sites in Great Britain using Environmental Data. *Freshwater Biology* 17. 41-52.

**Pearson, T H and Rosenberg, R** 1978. Macrobenthic Succession in Relation to Organic Enrichment and Pollution of the Marine Environment. *Oceanography and Marine Biology Annual Review*. 16, 229-311.

**Pielou, EC** (1975) *Ecological Diversity*. Pub Wiley, New York. 165pp.

**Rees, H. L, Moore, D.C, Pearson, T.H, Elliot, M, Service, M, Pomfret, J and Johnson, D** 1990. *Procedures for the Monitoring of Marine Benthic Communities at UK Sewage Sludge Disposal Sites*. Dept of Agriculture and Fisheries for Scotland. Scottish Fisheries Information Pamphlet No 18. 79pp.

**Shilabeer, N.** 1992. The Use of a Mathematical Model to Compare Particle Size Data Derived by Dry Sieving and Laser Analysis. *Estuarine and Coastal Shelf Science*. 35, 105-111.

**Siegel S and Castellán N J.** 1988. *Nonparametric Statistics for Behavioral Sciences*. 2nd Edition. Pub McGraw-Hill International.

**Warwick, R M and Clarke K R** 1991. A Comparison of Some Methods for Analysing Changes in Benthic Community Structure. *J Mar biol Ass UK*. 71, 225-244.

**Word, J Q** (1978) The Infaunal Trophic Index. *Coastal Water Research Project Annual Report*. Southern California Coastal Water Research Project, El Segundo, CA 19-39.

**WRC** 1992. (Codling & Ashley) Development of a Biotic Index for the Assessment of Pollution Status of Marine Benthic Communities. SNIFFER report by WRc, Report No NR 3102/1.