Department of
Agriculture, Fisheries and Food
An Roinn
Talmhaíochta, Iascaigh agus Bia

Monitoring Protocol No. 1

for

Offshore Finfish Farms - Benthic Monitoring

(subject to revision from time to time)

Revised December, 2008

1. Monitoring Regime Required

All finfish farms shall carry out an annual benthic survey in accordance with the protocol set out below. The benthic monitoring requirements at a fish farm are dependent on the level of biomass held at the site and the local hydrography. **Table 1** below sets out the level of benthic monitoring required based on tonnage produced and mean current speeds at the fish farm

Table 1. Matrix of production tonnage vs. current speed to determine level of benthic monitoring required.

	Mean Current Speed (cm/sec)		
Tonnage (MT)	**<5**	**5 - 10**	**>10**
0 - 499	Level I	Level I	Level I
500 - 999	Level II	Level I	Level I
>1000	Level II	Level II	Level I

The current speed is a mean value calculated from maximum current measurements over spring and neap tidal cycles at the surface and near the bottom. The tonnage refers to the maximum biomass predicted for each site. An annual survey must be carried out at each site (production and smolt) operated by a company. All sites will be subject to one of the two levels of survey.

Level I: Video/photographic and visual observations (see Section 6) and recordings shall be made at the following stations:

- **At a minimum of 2 sites directly beneath the cages**
- **At the edges of the cages**
- **Two transects at right angles to each other. Along each transect sampling stations at +/- 10m, +/- 20m, +/- 50m and + 100m from the cages (see Figure 1)**
- **At a control site (see criteria in Section 4 below)**

In addition to the above, the following samples / measurements shall be taken at the same stations as above. These will be used to calculate sediment quality parameters.

- **A minimum of one Redox potential readings shall be made at each sampling station (Section 7).**
- **A single sediment sample for Organic Carbon measurement (Section 8).**

Level II: In addition to the above three replicates grab samples shall be captured at each of the sample stations. The exact locations of sampling points should be agreed in advance with the Department of Agriculture Fisheries and Food (DAFF). The identification and abundance of macro-faunal invertebrates shall be estimated and tabulated. Identification of fauna to the level of species will be required.

2. Timing of surveys

An annual environmental survey will have to be conducted for each finfish culture site so that an assessment can be made of the impact of the farming operations on the seabed. The annual survey shall be carried out on behalf of the farmers by any consultant from a pool of approved consultants.

The survey shall be carried out during peak biomass periods or at least within 30 days after the end of harvesting of a year class. However, it is appreciated that all sites requiring surveys at the farm most likely will be carried out in one visit therefore, the timing of the surveys should by dictated by grower sites (with greater biomass) with concurrent surveys at smolt or harvest sites. A similar timing schedule applies to each of the three survey types.

3. Consultant Selection

A consultant, at the expense of the licensee, will undertake these surveys. The Marine Institute, on behalf of the Department Agriculture Fisheries and Food, will set up an approved list of consultants to carry out these environmental surveys. The Marine Institute will periodically advertise for consultants to be assessed for inclusion in the list. The consultants must demonstrate that they have the necessary skills base and technical capability available to them to carry out such surveys. Sites may be subject to random independent verification by the DAFF.

4. Transect selection

As already outlined in Section 1, the sites should be chosen such that sampling the benthos at any one location should provide a comprehensive overview of the general benthic conditions of the site. This will provide a useful management tool for the farmer and a comprehensive overview of conditions for the managers. Through each array of cages, two transects (perpendicular to each other) shall be run with each incorporating sites, directly beneath the cages, at the edge of the cages, and 10m, 20m, 50m and 100m in the direction of the prevailing current or seaward direction from the cages and at 10m, 20m, 50m in the opposite direction (see Figure 1). In the case of single cages set apart from each other (as experienced in more exposed locations) a pair of transects shall be run through one of the cages (involved in the production cycle). This will be taken to be representative of the others.

In addition, a **control** station must be situated at least 500m away from the cage sites and show similar benthic and hydrographic characteristics as the farm location. If a suitable control site cannot be located (for whatever reason) a location within 500m will be acceptable, the selection of the control site will be at the discretion of the consultants carrying out the surveys. Reasons for locating a control location within 500m could be, *inter alia*, embayment too small, heterogeneous environment or different depths. Justification for the control site selection must be detailed in the survey report.

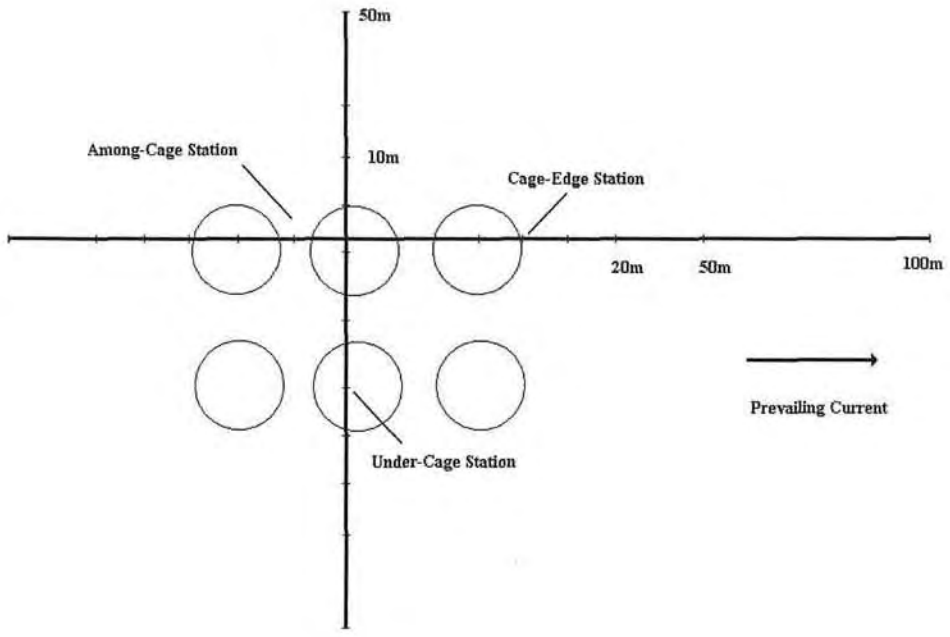

Figure 1. Example of sampling transects through a cage system at a site. Not drawn to scale.

5. Position Fixing

The start and end-point of any transect shall be logged using a Differential Geographic Positioning System (DGPS) with an accuracy of +/- 5m. The coordinates of the control location and cages relevant to the survey must also be recorded. This information must be stated in the report and retained.

Control sites and transect sampling stations must be marked by tags which shall be clearly visible in photographic or video images. Each tag shall reflect the appropriate sampling location at the designated sampling sites e.g. +/-10, +/-20, +/-50, +100m and control locations points.

6. Video and Photographic Surveys

Video

The video shall be in VHS or digital format, in colour and viewable on standard video players (incl. PCs). The following details shall appear at the start of each video:

- Name of site and bay
- Name of fish farm company
- Date of survey
- Number and biomass of fish on site
- Direction of transect and the starting station

The illumination of the video shall be sufficient for features on the seabed to be easily discerned, including *Beggiatoa* sp. patches, differentiate between food and faecal material and identify faunal features, e.g. tube openings.

Photographs

These shall be taken at each station with the number on the tag clearly visible. The photographs shall show at least $1m^2$ of seabed and be in focus. Photographs shall be in colour and printed to at least 100mm X 150mm size or of sufficient resolution to discern features on

the seabed, including *inter alia*, *Beggiatoa* sp. patches, differentiate between food and faecal material and identify faunal features, e.g. tube openings.

Reports

The video or photographic survey shall be accompanied by a written report of each sampling transect and a location map showing the transects in relation to the cages. The report shall include the following information:

- Name of licensed fish farm operator
- Name of site
- Type of survey carried out
- Date of survey
- Stocking date and/or harvest date for each cage
- Maximum biomass on site (tonnes or fish no. and mean weight)
- Maximum biomass in each cage
- Mean current speed at site
- Other site descriptors (depth, degree of exposure, etc..)
- Length of fallowing period (if applicable)
- Direction of transect and location of control station (D-GPS coordinates)
- Description of each sampling station shall include,
- Presence of bacterial mats and uneaten food pellets
- Presence of litter derived from farming activity e.g. feed bags
- Presence of gas bubbles or anoxic areas
- Animals visible or evidence of presence (e.g. tubes)
- Macroalgae visible
- Sediment colour and texture among other things
- Redox Potential results
- Organic Carbon results
- Biological results (Level II only).
- Interpretation of the findings
- Recommended mitigation measures, if necessary
- Any technical difficulties encountered.

7. Redox Potential

Redox potential shall be measured at the time of collection of the sediment sample. Profiles shall be measured in at least three (3) replicate samples within a 5m radius of each other. The redox potential shall be measured at depths of 0 cm (sediment surface) to 5cm depth, at 1cm intervals. A platinum electrode shall be used with a double-junction reference electrode, linked to a portable ph/Eh meter. The platinum electrode shall be calibrated using Zobell's solution (potential +430 mV) and the measurements made in mV when the meter readings are stable.

Sediment Profile Imagery (SPI) can also be used to measure the depth of the redox discontinuity layer. In this case, replicate images (3) shall be taken at each station within a 5m radius of each other.

8. Total Organic Carbon

At each sampling location, one sub-sample (50ml) of sediment shall be collected from the sample surface (0-2cm). The sample is stored in an airtight container and deep frozen, or frozen then freeze dried, for later analysis. Total organic carbon can be measured by combustion, wet oxidation or using an elemental analyser (the method used must be

specified) and quality assurance details provided. The method of organic carbon determination should be decided in consultation with the Marine Institute prior to sampling.

9. Biological Samples

Biological samples shall be collected using grabs or cores. Samples shall be sieved using a 1mm-mesh sieve. The residue shall be placed in clearly labelled containers and preserved using buffered formalin or some other suitable fixative solution and stained. Specimens shall be identified to species level.

The number of species and abundance at each station shall be reported. Where appropriate, diversity indices shall be calculated and multivariate analysis shall be carried out on the faunal data.

The goal of this requirement is to provide a detailed database of biological information in the vicinity of the cages, which can be used to monitoring the health of the system and the long-term influence of the cages on the benthic environment.

10. Submission of Report

The completed benthic monitoring reports must be submitted to the Coastal Zone Management Division of the Department of Agriculture Fisheries and Food by registered post no later than the end of November in any given year. This will allow for a process of assessment and decisions to be taken on proposals for increased production in subsequent years. Allowances will be made for varying production cycles and the influence of adverse weather on the survey process.

In addition all raw data must be retained by the consultants and be available on request for detailed examination by agents for the Department of Agriculture Fisheries and Food or its agents.

11. Random Verification of the Environmental Reports

The Marine Institute, on behalf of the Department of Agriculture, Fisheries and Food, will undertake an independent environmental audit of a proportion of the submitted reports every year. Sites to be selected for verification of environmental audits will be chosen at random. The selection criteria and timing of verification surveys will be undertaken at the beginning of each year and reported to the selected farms as soon as a decision is made.

12. Guideline Impact Criteria

The Allowable Zone of Effect (AZE) will be determined on a site-by-site basis and will take into consideration the direction and strength of the residual flow and any modelling information available for the site in question. The exact extent of the AZE will be determined by consultation between the producer, the Department of Agriculture Fisheries and Food and the Marine Institute.

In terms of impact criteria the sampling stations beneath or among the cages shall not have excessive mounding of food on the bottom, outgassing and extensive anoxic conditions throughout. At the sampling points from beneath the cage site to the boundary of the AZE along the transect, the Actions Levels highlighted below will apply. Beyond the AZE, to the end of the transects (100m or 50m), the Action levels for this zone will apply. **Table 2** sets out the basket of parameters, which will be used generally to define the acceptable levels of impact on the sediments for a Level I survey. The conditions at the control station must also be reported. These data will provide context against which the action levels should be calculated, e.g. high organic carbon values at the control site may explain higher levels observed inside the impact zone.

Table 2: Sediment quality criteria applied to Level I benthic surveys (subject to revision from time to time).

Criteria	Action Levels within AZE*	Action Levels outside AZE* to edge of sampling point
Visual observation	Accumulated feed pellets	Feed pellets present
Bacterial Mat	Extensive mats present (>50% cover)	Patches present
Redox	Values lower than -150mV (as a depth average profile) or Values Lower than -125 mV (in surface sediments 0-3 cm)	Control values
Organic Carbon	100% above control value (averaged within zone)	Control + 25% (averaged within zone)

* AZE - Allowable Zone of Effect

The Action levels for the biological samples (Level II) will be based primarily on the conditions at the control location. The models described by Pearson Rosenberg (1978)[1] and further developed by Borja et al. (2003)[2] and Muixia et al. (2005)[3] will inform the action levels at each the zones of assessment.

13. Remedial Action

In the event of the report indicating a breach of the required parameters of benthic impaction, the following actions will be required:

Within 30 days from the submission of the original Environmental Report the licensee shall submit to the Coastal Zone Management Division of the Department of Agriculture Fisheries and Food a **Benthic Amelioration Plan** with the aim of achieving an acceptable benthic standard in the licensed area as soon as possible. A subsequent survey of the impacted area will determine if the amelioration plan has been successful. The plan may include, *inter alia*, the following actions:

(i) In any event the licensee shall put in place in each cage a feed waste control plan (if such a plan is not already in place) and shall arrange for a reduction in the documented volumes of fish feed into the licensed area in question. If the benthic conditions in the impacted zone do not show signs of recovery, a further reduction in feed inputs will be required (and perhaps in subsequent years) until a follow-up environmental report indicates that an acceptable benthic condition has been achieved.

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[1] Pearson, T., Rosenberg, R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. Ann. Rev. 16, 229–311.

[2] Borja, A, Muxika, I., Franco, J., 2003. The application of a Marine Biotic Index to different impact sources affecting soft-bottom benthic communities along European coasts. Marine Pollution Bulletin 46, 835–845.

[3] Muxikaa, I., A. Borja, W. Bonne. 2005. The suitability of the marine biotic index (AMBI) to new impact sources along European coasts. Ecological Indicators 5: 19-31

(ii) If the site area and characteristics permit and a reduction in fish feed in the licensed area in question or other measures would be insufficient to achieve an acceptable benthic standard, the plan much provide for movement of all production cages within the licensed area coupled with as 5% reduction in production tonnage over the next cycle in comparison with the output from the previous growing cycle. Where production cages have been moved, the impacted area from the reported site must continue to be monitored annually until a subsequent environmental report indicates that an acceptable benthic condition has been achieved.

The licensee shall be obliged to furnish audited information (i.e. certified by a chartered accountant), in relation to production and feed input in each of the years in question for the licensed area concerned.

The details of the Benthic Amelioration Plan shall be agreed between the licensee and the Department of Agriculture Fisheries and Food.

Notwithstanding the foregoing, the Department reserves the right to prescribe specific remedial action in any particular case in the light of the relevant benthic monitoring report. In the event of the emergence of new proven techniques in feed formulation, waste management or other relevant developments to allow for an immediate recovery of the impaction zone, the Department may allow the licensee to maintain or increase production, in a particular year, in the licensed area where the permitted parameters of benthic impaction had been breached in the preceding year.