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Generic monitoring programme for monitoring watercourses in relation to onshore wind farm developments

April 2018

GENERIC MONITORING PROGRAMME FOR MONITORING WATERCOURSES IN RELATION TO ONSHORE WIND FARM DEVELOPMENTS

Marine Scotland Science

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Appropriate site selection and design, good construction techniques and implementation of appropriate site specific mitigation measures are the primary means of avoiding and/or minimising impacts on the freshwater environment from wind farm developments. In addition, integrated monitoring programmes that include water quality, macroinvertebrate and fish population assessments can also provide important and rapid information on impacts, ensuring effective site management, mitigation and, if necessary, restoration throughout the course of a wind farm development.

The following sequence will often apply:

- **site characterisation** which is required to assess the likely significant impact of the development on fish populations as required by the Electricity Works (Environmental Impact Assessment) (Scotland) (EIA) Regulations (2017) and should be outlined in the Environmental Impact Assessment Report (EIAR). This will include a description of the watercourses which could be impacted by the developments, including an assessment of water quality parameters (see below) at high and low water flows, macroinvertebrate samples to determine the composition and abundance of individuals within the community and the fish species distribution and abundance of salmon and trout in these waterbodies. Fish species which are important for conservation and supporting fisheries will be carefully considered. Such site characterisation may include sites to which further data may be added to produce a baseline data set;
- assembling a baseline **dataset before** any construction, from which to assess potential impacts. The inclusion of appropriate control sites in the survey plan will allow the developer to separate natural and anthropogenic change and consider how the data will feed into site management;
- collection of data **during construction** and **post-construction** using a consistent methodology and set of sampling sites. Regular reporting to allow for rapid remediation of any potential impacts;
- further data may be required in the year or more prior to **decommissioning** to fully assess the likely impacts on water quality and aquatic biota at this stage of the development.

The current document describes the sampling approach that Marine Scotland Science (MSS) would recommend to:

- provide site characterisation data;
- provide a robust pre-construction baseline data set which can be used to assess whether anthropogenic changes have taken place in site condition during and after construction and assist in setting threshold levels for remedial action. Similar sampling can be adopted for decommissioning; and
- ensure data are collected to common standards. This will also facilitate its use in any meta-analyses of the effects of wind farms to assess potential effects and the circumstances under which impacts are and are not observed.
- Generic scoping guidelines (http://www.gov.scot/Topics/marine/Salmon-Trout-Coarse/

Freshwater/Research/onshoreren) have been drawn up by MSS which outlines activities, during construction, operation and decommissioning, which have the potential to impact water quality and aquatic biota. Such impacts should inform the developer as to what form of monitoring should be undertaken throughout the development.

SAMPLING DESIGN

Sampling (or treatment) sites should be identified on watercourses that have the potential to be impacted by the development (e.g. turbines, access tracks, watercourse crossings, borrow pits, substation/control room buildings). A set of comparable control sites (similar sites which are unlikely to be affected by any aspect of the development for the duration of the monitoring programme) should also be selected.

Control sites are required to distinguish impacts associated with the development from natural environmental variability. Control sites should have similar physical site characteristics, hydrochemical and fish characteristics (similar fish species, population distributions and densities) to the "treatment" sites (those potentially affected by the development). The method and sampling frequency deployed at control and treatment sites should be the same. The same survey sites should be used for water quality, macroinvertebrate and fish sampling. It is recommended that any sampling design includes multiple treatment and control sites that are approximately balanced in number and cover similar environmental variability.

The location of adjacent wind farms and other developments should be considered throughout the process of site selection.

Water quality

Frequency of sampling

To develop a reasonable baseline dataset from which to detect change it is important that sampling takes place:

- for a period of at least one year prior to construction commencing;
- during construction;
- for a period of at least one year after construction dependent on the results of monitoring during construction (i.e. are impacts still being observed); and
- with sampling taking place at intervals no greater than one month. Fortnightly sampling is encouraged in more sensitive catchments and/or time periods, e.g. areas with known acidification problems, when adverse weather conditions occur, during concrete batching.

Continuous monitoring for selected parameters e.g. flow (stream stage), turbidity and pH should also be considered, particularly in sensitive catchments.

Methodology

Collection of water samples should be undertaken by a suitably trained person, whereby a single dip water sample is collected from each sampling location and transported, under refrigerated container, for laboratory analysis by an appropriately qualified laboratory e.g. a United Kingdom Accredited Service (UKAS) accredited organisation.

Water quality parameters included are:

- turbidity (NTU) - in relation to site disturbance;
- dissolved organic carbon (DOC) (mgl^{-1} (ppm)) - in relation to site disturbance and peat deposits;
- pH, alkalinity (ALK) (μeql^{-1}), acid neutralising capacity (ANC) (μeql^{-1}) and aluminium (μgl^{-1} (ppb)) in relation to changes in hydrology, DOC export and acidification. The Cantrell approach of calculating ANC (see below) is a better predictor of salmonid fry presence than the ion balance method.
- ANC=ALK (μeql^{-1})+ 5x DOC (mgl^{-1}) when pH>5.5
- ANC=ALK (μeql^{-1})+ 4.5x DOC (mgl^{-1}) when pH<5.5
- These equations are applicable to the ALK being measured by dual endpoint titration or Gran titration. If the alkalinity has been analysed using a single endpoint titration then the following conversion equation should be used:
- ANC= ALK (μeql^{-1})+0.65 square root ALK ($ueql^{-1}$) (Henriksen (1982); Cantrell, Serkiz and Perdue (1990); Harriman and Taylor (1999));
- total oxidised nitrogen (nitrate and nitrite) (mgl^{-1} N (ppm)) and phosphate (μgl^{-1} P (ppb)) in relation to nutrient leaching;
- stream height – spot measurements of stream height can be obtained from stage boards installed at sites;
- temperature; and
- dissolved oxygen concentration (DO) (mgl^{-1}) and biological oxygen demand (BOD) (mgl^{-1}) which can be an indicator of the health of a water body, where low DO and high BOD levels indicate poor water quality. Analysis for DO may be best performed in the field, as time delays between sample collections and testing may result in an alteration in oxygen content. BOD levels are determined by calculating DO in one sample; a second sample is incubated in the dark at 20°C for 5 days and tested for the amount of DO remaining. The difference between the two samples is the calculated BOD.

Visual Inspection

Regular visual inspections of all watercourses (flow conditions, discolouration, collection of debris, fish in distress or floating), presented in a monthly report on water quality, is advised by an independent, suitably qualified Environmental Clerk of Works (ECoW) with particular emphasis placed on:

- watercourses downstream of site activities;
- at times when heavy traffic is frequenting the site;
- during and after periods of heavy or prolonged rainfall and during winter months e.g. during and after snow melt;
- during fish migration and spawning periods; and
- of watercourse crossings to ensure that the existing mitigation measures are effective in preventing any sediment reaching streams.

Data analysis

The pre-construction baseline samples should provide a robust data set from which relationships between the sampling sites and the control sites can be established under pre-development conditions. Based on the pre-construction dataset it should be possible to statistically identify unusual or un-observed catchment behaviour from which threshold levels can be identified for management action. Where no inter site relationships can be established between the sampling sites and control sites, threshold levels may be determined from hydrochemical parameters and/or turbidity values commonly observed under base and high flow conditions during the baseline period, ensuring a reasonable balance is sought between environmental protection and natural variability.

The Water Framework Directive (WFD) of the European Union requires member states to identify environmental standards to support healthy aquatic communities. Survey and monitoring water quality data can also be compared to these standards (http://www.scotland.gov.uk/Resource/0045/00457867.pdf) throughout the development period to determine a decrease in overall chemical status under the WFD.

WFD standards for pH and ANC are outlined in Table 1 and 2, where humic water is defined as the annual average concentration of DOC ≥10 mgl^{-1} and clear water where DOC < 10mgl^{-1}.

Table 1. WFD standards for annual mean pH for rivers

	Humic water	Clear water
High	5.10	6.60
Good	4.55	5.95
Moderate	4.22	5.44
Poor	4.03	4.89

Table 2. WFD standards for annual mean ANC (μeql^{-1}) (Cantrell method) for rivers

	Humic water	Clear water
High	80	80
Good	50	40
Moderate	10	15
Poor	5	-10

Labile aluminium has been identified as a reliable indicator of the suitability of water quality for salmonid fry in acid sensitive areas and an environmental threshold of 14 μgl^{-1} is proposed for protecting salmonid populations (Malcolm *et al* 2014). Therefore the measurement of this parameter is recommended in acid sensitive waters particularly where felling could exacerbate acidification issues.

AQUATIC BIOTA

Macroinvertebrates

Macroinvertebrates are a diverse group of organisms with a wide range of environmental tolerances and preferences. Consequently their community composition can be used to identify water quality changes/impacts, capturing short term perturbations that may be missed by spot hydrochemical samples of water quality. Healthy macroinvertebrate populations also indicate the potential for supporting sustainable salmonid populations, if other environmental variables are suitable.

Timing and frequency of sampling

It is recommended that baseline macroinvertebrate sampling should be carried out at least one year prior to construction at all sampling sites, including control sites, at a minimum of once a year, preferably in spring. Similar sampling should be undertaken during construction and for at least one year after construction.

Methodology

Sampling can be based on the standard semi-quantitative kick methodologies used by Scottish Environment Protection Agency (SEPA) to determine the species most commonly present in the watercourses and/or via quantitative Surber/Hess samples where densities can also be determined.

Kick sampling uses a 25 cm wide kick sample net with a 1mm mesh placed in riffle-type habitat, as these are considered productive habitats in rivers for macroinvertebrates. The substrate downstream of the net is kicked for a period of three minutes followed by a one minute examination of stones; all organisms are washed into the net.

A Surber/Hess sampler comprises a standard frame containing a sampling net which can be deployed in shallow streams to survey bottom dwelling macroinvertebrates. The frame, which covers an area of approximately 0.1m^2, and a 0.5mm mesh net, is placed firmly on a suitable riffle-type habitat in the river bed; the enclosed substrate is agitated for a fixed period of time e.g. two minutes, whereby the dislodged organisms are washed by the current into a collecting bag at the end of the sampler.

Samples from kicking and Surber/Hess are preserved separately in 70% Industrial Methylated Spirits in sealed plastic containers and can be identified to species level in the laboratory.

Accompanying physical environmental factors including stream width, depth, flow types and substrate profiles (using the Wentworth scale) should be recorded on each occasion.

Data analysis

Aquatic macroinvertebrate species can be used as biological indicators of water quality and/ or the production of biotic indices used to assess water quality. Some commonly used scores are listed below:

- the Biological Monitoring Working Party (BMWP), the sum of the group scores for the sample, or the Whalley, Hawkes, Paisley and Trigg (WHPT) metrics which replace the BMWP for WFD river basin status classification;
- taxon richness (NTAXA), the number of different macroinvertebrate taxa collected;
- the Average Score per Taxon (ASPT), the average score for the taxa assigned a score in the sample; and
- the WFD Acid Water Indicator Community (AWIC), based on the presence or absence of taxa.

Low BMWP, WHPT, NTAXA and ASPT scores indicate possible organic pollution, whilst high scores indicate good water quality. SEPA has used the following scores as a classification scheme for rivers.

Table 3. SEPA classification of rivers using BMWP and ASPT scores.

Class	Description	BMWP	ASPT
A1	Excellent	≥85	≥6.0
A2	Good	70-84	≥5.0
B	Fair	50-69	≥4.2
C	Poor	15-49	≥3.0
D	Seriously polluted	<15	<3.0

The AWIC provides an indication of the probability and likely magnitude of acidification of watercourses.

The above biotic index scores, taxon richness, invertebrate abundance and biomass can be determined from the baseline data set and used to make comparisons with similar scores calculated during construction and post-construction monitoring to detect any water quality changes.

Fish

A general description of fish habitat (e.g. substrate type, water depth, flow rates, in-stream cover) in the development area and what fish species are present should be provided to assess the potential impact of the development on fish populations and consequently inform the EIAR. This should identify actual and possible physical barriers to migratory fish movement. The main method of determining the health of salmonid populations within streams is by the use of electrofishing equipment.

Methodology

The electrofishing survey should cover all stream habitat types available for salmonid use. The location of survey sites and their upstream and downstream boundaries of the areas sampled should be fully documented so that they can be revisited in the future. Appropriate control sites are also required.

To obtain fully quantitative information on salmonid populations (which is recommended for monitoring purposes), each survey site of approximately 100 m^2, marked out using stop nets at either end, should be electrofished up to four times in a consecutive manner to allow a depletion estimate of the density of each age class of each species to be made. Standard protocols outlined by the Scottish Fisheries Co-ordination Centre (http://www.scotland.gov.uk/Topics/marine/science/sfcc/Protocols/ElectrofishingSurveys) are recommended. The numbers of each age class of each species caught should be provided. Fish length measurements and summary length data for the different age classes should also be provided. Although the length frequency may provide an indication of age structure, the collection of scales is required to verify age classes of parr (age 0+ salmonids).

Salmonid habitat surveys describing available habitats for all species and age ranges in terms of water depth, flow regime, substrate type, in-stream cover, riparian vegetation, land use etc. should be provided for selected sampling sites of watercourses within the proposed development area.

Non-salmonid fish species which may be present and caught during such surveys should also be recorded and measured. However their population densities may not be accurately assessed using the electrofishing techniques which have been designed for surveying salmon and trout populations.

Developers should ensure that all fish work complies with the Animal (Scientific Procedures) Act (1986) and Animal Health and Welfare (Scotland) Act (2006) where required.

Standard biosecurity practices should be carried out at all times to minimise the risk of transferring fish pathogens between catchments (http://www.gov.scot/Topics/marine/Fish-Shellfish/FHI/healthpractice).

Timing and frequency of sampling

Late summer/autumn is the preferred time of year for carrying out fish surveys. Annual surveys are recommended.

Fully quantitative baseline salmon and trout surveys and accompanying habitat assessments at the fish survey sites, including the control sites, should be undertaken before construction commences. Data from these surveys can be compared with data similarly collected during and after construction. Site characterisation data, collected to inform the EIAR, may contribute to the baseline data set.

Data analysis

The analysis of the data should take into account natural events such as drought, large spates and low numbers of spawning adults which can influence the abundance of juvenile fish populations. It will be important to make use of information from the control sites. Key population metrics (e.g. age structure, distribution, density, fish size, biomass for each age class) for both salmon and trout populations can be determined throughout the development period and compared with data obtained prior to construction commencing to determine any differences in the overall health of salmonid populations.

Because of the annual nature of fish survey work, the data obtained may only reveal impacts after an event; therefore routine monitoring of water quality at the fish survey sites and regular visual inspections of all watercourses should also be carried out.

ACTIONS TO TAKE AS A RESULT OF MONITORING

Any observation of a visual deterioration of water quality, fish in distress or floating or other dead fish should constitute a trigger for urgent investigation.

During construction, a monthly report on water quality should be prepared for the relevant consenting or regulatory body within one week of receipt of analytical results to consider the results of laboratory analysis completed that month. These will be compared, by the ECoW, the developer's environmental staff or by an environmental consultant appointed by the developer, to previous monthly reports, the threshold values from baseline monitoring results (i.e. has the water quality changed unexpectedly given baseline behaviour) and with WFD water quality environmental standards. If any change is observed in the water quality data collected during construction and post-construction whereby results are outside the 95% prediction limits for the baseline relationship between the control and treatment site, further examination should take place to determine if these changes are attributable to construction activities.

Any observed significant change in the macroinvertebrate population between sampling sites and control sites and/or between data collected before construction commenced with data collected during construction and post-construction, (using simple statistical comparison tests) such that:

- scores of the biotic indices differ;
- a reduction is recorded in abundance and diversity of organisms; or
- indicator species differ in occurrence and abundance

and/or ordination analysis as used by Millidine *et al* (2015)) should trigger further investigation to establish if such differences are attributable to natural processes or related to construction practices.

Should a construction related incident be identified, construction should cease until the problem is identified and isolated. SEPA should be informed and mitigation measures implemented (e.g. placement of additional silt traps, check dams, diversion of runoff or other pollution responses) to ensure that no further effects can occur. Other organisations may also be informed e.g. the local District Salmon Fishery Board and the local Planning Authority. Provision for additional water samples may be required and monitoring of the recovery after such an event should be carried out to include macroinvertebrate and fish sampling after the event and when annual monitoring takes place. The aim of the remedial actions should be to restore baseline conditions, as quickly as possible.

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