



Quality Assurance in Marine Biological Monitoring

**A report prepared for the Healthy and Biologically Diverse Seas Evidence Group
and the National Marine Biological Analytical Quality Control scheme**

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Cover Note:

The importance of quality assurance in marine biological monitoring is a priority of the UK Marine Monitoring and Assessment Strategy and is implicit in several European directives, such as the Water Framework Directive, the Marine Strategy Framework Directive and the OSPAR Joint Assessment Monitoring Programme.

Quality Assurance in marine biology is the systematic examination and evaluation of all aspects of a monitoring programme (from survey design, field methods, laboratory methods, data analysis and storage) to ensure that standards of data quality and comparability between organisations are being met. This in turn provides confidence in the evidence base for policy and decision making.

The following paper presents the principles of the current best practice Quality Assurance system which the UK's government agencies, their contractors, partners and data providers are expected to adhere to.

1 Documentation

The following types of documentation are expected for an organisation undertaking any type of marine biological monitoring:

1.1 Standard Operating Procedure

Standard Operating Procedure(s) (SOP) should be produced/adopted for all monitoring methods which an organisation is engaged in. In order to ensure that all aspects of Quality Assurance have been met for a particular monitoring method, a SOP should include:

1. A clear statement of the qualitative and quantitative goals of the monitoring programme, which demonstrates that the specified methods are fit for purpose.
2. Methodological details of all steps performed in a monitoring programme, including all monitoring methods (e.g. both field and laboratory aspects), details of equipment/instruments used and their calibration and maintenance schedule.
3. Details of the procedures related to the generation, analysis and archiving of data.
4. The quality assurance system in place.

1.2 Quality Manual

A Quality Manual details an organisation's quality assurance system/policy (i.e. all aspects of quality assurance described in this document), which allows systematic audits of a monitoring programme to ensure that all aspects of quality assurance are being met. It should also detail the frequency at which different aspects of quality assurance must be audited and the standards/limits that should be met and what remedial action is necessary if the standards/limits are not met.

2 Adherence to standardised methods

Development of and adherence to national, European or international standardised methods (where they exist) is a statutory requirement in the Water Framework and the Marine Strategy Framework Directives. The adoption of standardised methods ensures consistency between organisations and will allow for the production of data which is of an equivalent scientific quality and comparability.

Certification/accreditation can also be obtained for an organisation which follows a national, European or International standard through accreditation schemes such as Good Laboratory Practice (GLP) or United Kingdom Accreditation Service (UKAS). If no standard exists, it is also possible to become accredited in an organisation's own method.

Section 10 'Standards for Marine Monitoring' shows the current list (as of January 2010) of all British Standards (BSi), International Organization for Standardisation (ISO) standards and European Committee for Standardisation (CEN) standards which exist for marine biological monitoring.

Many of the UK government agencies protocols and standards for UK and European marine monitoring programmes are also easily accessible on the Marine Monitoring Protocols Database.

3 Adherence to data standards and guidelines

Adherence to data standards and guidelines (where they exist) on a national, European or international scale is necessary to demonstrate that the data produced from an organisation's monitoring programme is of an equivalent scientific quality and comparability at a national, European or international scale. Such data standards and guidelines include:

1. Species lists which contain current taxonomic names and synonyms (e.g. World Register of Marine Species (WoRMS), which is now endorsed by the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG)).
2. Data and metadata guidelines which define data and metadata formats to ensure data can be easily and shared in the future (e.g. Marine Environmental Data and Information Network (MEDIN) data guidelines and Mapping European Seabed Habitats (MESH) standards.

4 Calibration and maintenance of instrumentation and equipment

Instrumentation and equipment used in an organisations laboratory and field aspects of monitoring must be subject to routine calibration and maintenance to ensure against bias in results. Maintenance includes the general servicing of equipment and instruments, appropriate cleaning and careful use. Calibration is the operational checks of equipment and instrumentation at specified intervals to ensure the accuracy of data collected.

5 Voucher/Reference collection

For any biological work, a voucher/reference collection containing examples of taxa encountered should be compiled and retained for each monitoring programme. The benefits of a voucher collection are two-fold, as they provide evidence of species identification from a particular monitoring programme (e.g. if any identification queries are raised in the future), and the voucher collection can be used as a reference for future identification of taxa.

A voucher collection can consist of preserved specimens or images of specimens/habitats. Specimens/images should be fully labelled stating at least the taxon/habitat name, sample location and date, and the identifier. Ideally the details recorded (including the taxon/habitat identification) should be confirmed by a second biologist.

6 Taxonomic resources

A standard collection of taxonomic resources should be used to aid in the identification of marine biological taxa. This, along with the use of a standard species list, will ensure that the identification of taxa follow the current literature. Taxonomic resources can include:

1. A collection of up to date literature and identification/reference books.
2. A comprehensive and regularly updated reference and taxonomic key library.
3. Expert second opinion.

7 Staff competency

A minimum competency (education, training, work experience and/or other demonstrated skills) necessary for staff to undergo different types of marine monitoring work must be defined by the organisation. This competency must be checked and documented within a *Training Manual*. For less experienced staff who are undergoing training, appropriate supervision of work should be provided until the required competency in the method is achieved. It is important for an organisation to consider staff competency in order to plan for future succession to maintain a skilled work force. Consideration should be given to ensure at least two staff members are competent in each type of marine monitoring activity.

Individual competency can be improved/maintained through participation in internal or external training in all relevant aspects of marine monitoring work:

7.1 Training

Training ensures that staff are competent in specific monitoring methods, and that staff are kept up to date with the current literature and best-practice methods. Training can be done *internally within an organisation*, however participation in *external training through quality assurance, accreditation or qualification schemes* should also be done to demonstrate an organisation's competency is similar to a wider group of organisations to ensure the quality and comparability of data at a larger scale. Training can generally take the form of workshops, proficiency tests or qualifications:

7.1.1 Workshops

A workshop involves the training/teaching of new techniques or taxonomic identification to staff and the sharing of good practice. Workshops can be run internally or externally through universities, museums or marine organisations/associations.

7.1.2 Proficiency tests

A proficiency test involves a sample, of a known content, being given to a staff member to assess. The staff member is tested on their assessment of the sample, which for biological samples can include their extraction, identification and enumeration of taxa from the sample. For chemical or physical samples a staff member would be tested in the accuracy of their chemical and physical measurements from the sample.

Proficiency tests can be run through an external quality assurance scheme, where they are often referred to as Interlaboratory Comparisons or Ring Tests.

7.1.3 *Qualifications*

Qualifications (additional to tertiary qualifications) such as an Identification Qualification awarded by a professionally recognised institute can demonstrate an individual's proficiency has reached an externally recognised standard at the time of the test.

8 **Quality Control**

8.1 Internal Quality Control

Internal Quality Control (QC) is a system of routine technical checks to measure and control the quality of operational techniques and equipment and data and analysis within an organisation.

QC of operational techniques and equipment is where techniques and equipment are checked against certified reference materials, or repeat analyses are conducted and compared using a control chart (where the precision of measurements are compared against an expected standard/limit of error). QC also includes details of remedial action in cases where expected standards/limits are not met.

QC of data and analysis is where samples are re-checked and compared against the original and compared to an expected standard/limit of error/deviation from the original. This measures the repeatability of the method of analysis, and highlights factors such as inter-worker variability. QC must also include details of remedial action in cases where expected standards/limits are not met.

In general internal QC should be done within an organisation by a staff member who is different from the staff member who conducted the original sample analysis.

Recommended approaches to internal QC can be found in BSi/ISO/CEN standards such as those listed in Section 10 'Standards for Marine Monitoring'.

8.2 External Quality Control

Participation in an External Quality Control (QC) or Analytical Quality Control (AQC) scheme is mandatory for organisations involved national monitoring programs such as CSEMP and WFD. External QC involves a selection of samples from an organisation being re-analysed by an external QA scheme. The similarity of the original is compared to the QC sample and a pass or fail flag is given based on a minimum expected standard of similarity. The data from the samples under test may be qualitative, quantitative, continuous or discrete, and derived from laboratory analysis or field survey. By working to a standard set by the external QA scheme, participation in external QC will ensure comparability of data quality across multiple organisations.

The batch of samples associated with sample(s) which are subject to external QC must be retained until QC samples are deemed to have passed (or remedial action of failed samples has been completed satisfactorily). All reports and Statement of Performance certificates provided by the external QA scheme should be filed in the Quality Manual and available for inspection upon request. Samples should be

flagged as pass/fail prior to being put onto a national database, with failed samples not databased until remedial action has been taken.

In the case of the National Marine Biological Analytical Quality Control (NMBAQC) scheme's Invertebrate component, benthic infaunal samples are re-analysed and the similarity (e.g. Bray-Curtis Similarity Index (BCSI)) of the original sample and the QC sample is compared. A pass or fail flag is given to the participating organisation's sample based on a minimum acceptable similarity (e.g. >90% BCSI). The organisations are required to achieve the scheme's quality standards and complete any required remedial actions.

9 Quality Management System

An organisation should maintain an appropriate quality management system which provides an audit trail of the entire quality assurance system (as outlined in the Quality Manual). The frequency at which audits should be done will be specified in the Quality Manual. Audits ensure that any biases (e.g. inter-worker variability) are controlled so that quality outputs are maintained and confidence in the outputs can be demonstrated. Audits can take many forms, and it is likely that there will be different types of audits for an organisation and all of its marine monitoring practices. The following are the main types of audits that an organisation should complete to ensure they have a working QA system in place:

9.1 Quality Control Audit

Examination of in-house QC data, check of appropriate control limits, and corrective action is documented where QC data has breached control limits.

9.2 Vertical Audit

A random selection of data points, where each item is traced to the Method, Instrument/Equipment, Calibration and internal QC, and internal or external AQC.

9.3 Calibration Audit

Check of equipment calibration certificates, in-house maintenance and checks comply with calibration schedule and actual results documented.

9.4 Method Witnessing

Comparison of written procedure to observed procedure under real conditions. Any differences must be resolved through corrective action where needed.

9.5 Training Manual

Criteria stating the minimum competency (education, training, work experience and/or other demonstrated skills) necessary for staff to undergo different types of marine monitoring work must be defined in the Training Manual. The competency of each staff member must be signed off initially against all criteria and evidence of ongoing competency must be maintained on a regular basis.

10 Standards for Marine Biological Monitoring

10.1 Fish

BS EN 14757:2005. Water quality - Sampling of fish with multi-mesh gillnets. 30pp.

BS EN 14962:2006. Water quality - Guidance on the scope and selection of fish sampling methods. 28pp.

10.2 Phytoplankton

BS EN 15204:2006. Water quality - Guidance standard on the enumeration of phytoplankton using inverted microscopy (Utermöhl technique). 46 pp.

BS EN 15972:2009. Water quality - Guidance on quantitative and qualitative investigations of marine phytoplankton. 29 pp.

BS EN 16695. (*Draft for public comment*). Water quality. Guidance on the estimation of algal biovolume.

ASTM D4137 - 82(2012). Standard Practice for Preserving Phytoplankton Samples. 2pp.

ASTM D4148 - 82(2012). Standard Test Method for Analysis of Phytoplankton in Surface Water by the Sedgwick-Rafter Method. 4pp.

10.3 Benthic Infauna

BS EN ISO 16665:2013. Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna.

10.4 Epibiota

BS EN 16260:2012. Water quality. Visual seabed surveys using remotely operated and/or towed observation gear for collection of environmental data

EN ISO 19493:2007. Water quality - Guidance on marine biological surveys of hard-substrate communities. 32 pp.

10.5 General

BS EN ISO 5667-1:2006. Water quality - Sampling - Part 1: Guidance on the design of sampling programmes and sampling techniques. 42 pp.

BS EN ISO 5667-3: 2012. Water quality -Sampling - Part 3: Guidance on the preservation and handling of water samples.

BS EN 16493:2014. Water quality. Nomenclature requirements for the recording of biodiversity data, taxonomic checklists and keys. 16pp.

BS ISO 11352:2012. Water quality. Estimation of measurement uncertainty based on validation and quality control data.

BS EN 16164:2013. Water quality. Guidance standard for designing and selecting taxonomic keys.

13/30260857 DC. BS ISO 5667-14. (*In development*) Water quality. Sampling. Part 14. Guidance on quality assurance and quality control of environmental water sampling and handling.

BS ISO 5667-20:2008. Water quality. Sampling. Guidance on the use of sampling data for decision making. Compliance with thresholds and classification systems.

BS ISO 5667-14. (*In development*). Water quality - Sampling Part 14: Guidance on quality assurance of environmental water sampling and handling.

BS 6068-6.9:1993, ISO 5667-9:1992. Water quality. Sampling. Guidance on sampling from marine waters.

BS 6068-6.12:1996, ISO 5667-12:1995. Water quality. Sampling. Guidance on sampling of bottom sediments.

10.6 Marine Sediment

BS EN ISO 5667-19:2004. Water quality - Part 19: Guidance on sampling in marine sediments. 26 pp.

10.7 Quality Assurance and Quality Control

BS EN 14996:2006. Water quality – Guidance on assuring the quality of biological and ecological assessments in the aquatic environment. 14pp.

BS EN ISO/IEC 17025: 2005. General requirements for the competence of testing and calibration laboratories. 28pp.

BS EN ISO 19011:2011. Guidelines for quality and/or environmental management systems auditing.

BS EN 16101:2012. Water quality. Guidance standard on interlaboratory comparison studies for ecological assessment.

ICES, 2004. Biological monitoring: General guidelines for quality assurance. Ed. by H. Rees. ICES Techniques in Marine Environmental Sciences, No. 32. 44 pp.

10.8 Zooplankton

BS EN 15110:2006, BS 6068-5.41:2006. Water quality. Guidance standard for the sampling of zooplankton from standing waters.

ASTM E1200 - 87(2012). Standard Practice for Preserving Zooplankton Samples.