



Avant-projet de norme soumis à enquête probatoire jusqu'au :
5 septembre 2003

Pr NF EN ISO 16665

Indice de classement : T 90-371

T1 Qualité de l'eau

T2 Lignes directrices pour le prélèvement quantitatif et le traitement d'échantillons de la macro-faune marine à font mou

T3

E : Water quality – Guidelines for quantitative sampling and sample processing of marine soft-bottom macro fauna

D :

Avant-projet de norme française homologuée

Remplace : (optionnel)

Correspondance (optionnel)

Analyse (optionnel)

Modifications (optionnel)



ICS

English version

Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macro fauna (ISO/DIS 16665:2003)

Qualité de l'eau - Lignes directrices pour le prélèvement quantitatif et le traitement d'échantillons de la macro-faune marine à fond mou (ISO/DIS 16665:2003)

This draft European Standard is submitted to CEN members for parallel enquiry. It has been drawn up by the Technical Committee CEN/TC 230.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Foreword

This document (prEN ISO 16665) has been prepared by Technical Committee ISO/TC 147 "Water quality" in collaboration with Technical Committee CEN/TC 230 "Water analysis", the secretariat of which is held by DIN.

This document is currently submitted to the parallel Enquiry.

Endorsement notice

The text of ISO 16665:2003 has been approved by CEN as prEN ISO 16665:2003 without any modifications.

NOTE Normative references to International Standards are listed in Annex ZA (normative).

Annex ZA (normative)

Normative references to international publications with their relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE Where an International Publication has been modified by common modifications, indicated by (mod.), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN</u>	<u>Year</u>
ISO 5667-3	1994	Water quality - Sampling - Part 3: Guidance on the preservation and handling of samples	EN ISO 5667-3	1995
ISO 5813	1983	Water quality - Determination of dissolved oxygen - Iodometric method	EN 25813	1992
ISO 5814	1990	Water quality - Determination of dissolved oxygen - Electrotechnical probe method	EN 25814	1992



DRAFT INTERNATIONAL STANDARD ISO/DIS 16665

ISO/TC 147/SC 5

Secretariat: **AFNOR**

Voting begins on:
2003-05-08

Voting terminates on:
2003-10-08

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Water quality — Guidelines for quantitative sampling and sample processing of marine soft-bottom macro fauna

Qualité de l'eau — Lignes directrices pour le prélèvement quantitatif et le traitement d'échantillons de la macrofaune marine à fond mou

ICS 13.060.10; 13.060.70

ISO/CEN PARALLEL ENQUIRY

The CEN Secretary-General has advised the ISO Secretary-General that this ISO/DIS covers a subject of interest to European standardization. **In accordance with the ISO-lead mode of collaboration as defined in the Vienna Agreement, consultation on this ISO/DIS has the same effect for CEN members as would a CEN enquiry on a draft European Standard.** Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month FDIS vote in ISO and formal vote in CEN.

In accordance with the provisions of Council Resolution 15/1993 this document is circulated in the English language only.

Conformément aux dispositions de la Résolution du Conseil 15/1993, ce document est distribué en version anglaise seulement.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du Secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

Copyright notice

This ISO document is a Draft International Standard and is copyright-protected by ISO. Except as permitted under the applicable laws of the user's country, neither this ISO draft nor any extract from it may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, photocopying, recording or otherwise, without prior written permission being secured.

Requests for permission to reproduce should be addressed to either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Reproduction may be subject to royalty payments or a licensing agreement.

Violators may be prosecuted.



Contents

Page

Foreword	vi
Introduction	vii
1 Scope.....	1
2 Normative references	1
3 Definitions.....	2
4 Quality and safety	3
4.1 Health and Safety requirements	3
4.2 Quality assurance and Quality Control.....	3
5 Strategies and objectives for soft-bottom faunal surveys	4
5.1 Sampling programme and plan	4
5.2 Positioning of sampling stations.....	5
5.2.1 Introduction	5
5.2.2 Station network (grid or area sampling)	5
5.2.3 Random or scattered sampling	5
5.2.4 Stratified sampling	5
5.2.5 Transect sampling	5
5.2.6 Single-spot (station) sampling.....	6
5.3 Reference stations	6
5.4 Types of surveys.....	6
5.4.1 Introduction	6
5.4.2 Pilot survey.....	7
5.4.3 Baseline survey/ environmental impact assessment.....	8
5.4.4 Temporal trend monitoring	9
5.5 Change in sampling programme and intercalibration	9
6 Sampling	10
6.1 Documentation and field log.....	10
6.2 Sampling and sample processing in the field.....	11
6.2.1 Sampling requirements	11
6.2.2 Defining the position of sampling stations	11
6.2.3 Choice of sampling equipment.....	12
6.2.4 Sampling procedure	12
6.2.5 Guidelines for approval/rejection of samples	13
6.2.6 Sieving of samples in the field.....	13
6.3 Sample fixation.....	14
6.4 Background environmental descriptors.....	15
6.4.1 Introduction	15
6.5 Responsibility.....	17
7 Sample processing in the laboratory.....	17
7.1 Sorting.....	17
7.1.1 Sample residue.....	18
8 Taxon determination and quantification.....	18
8.1.1 Level of identification and taxon lists.....	18
8.1.2 Quantification	18
8.1.3 Reference collection	19
8.2 Biomass	19
8.3 Data reporting.....	20
8.4 Storage and archiving	20
8.5 Analytical quality control and quality assurance	21

8.5.1	Auditing	21
8.5.2	Equipment calibration	21
8.5.3	Training	21
8.5.4	Check-lists, sample log and anomaly reporting	21
8.5.5	Sample sorting	21
8.5.6	Taxon identification	22
8.5.7	Identification literature	22
8.5.8	Reference collection	22
Annex A (informative)	Processing particularly large samples	23
Annex B (informative)	Biomass measurements	24
Annex C (informative)	Sampling devices	25
Annex D (informative)	Useful faunal checklists and selected general works	27
Bibliography		28



Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16665 was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 5.



Introduction

Analysis of macrofaunal communities in soft bottom sediments is an integral part of marine environmental assessment. The faunal composition, in terms of both the species present and their relative abundance, reflects integrated environmental conditions in the survey area over a period of time. The composition and structure of soft bottom macrofaunal communities therefore can be used to characterise environmental conditions and estimate the extent of environmental impact.

Characterisation of environmental conditions is usually based on quantitative methods, in this case by relating the numbers of species and individuals captured to a known area of sea floor. For accurate data interpretation, it is essential to add information on the geophysical/ geochemical characteristics or properties of the water masses and bottom sediments (including nutrients, oxygenation and redox state, where appropriate).

For effective data utilisation and quality assurance of the work carried out, it is essential that surveys are inter-comparable, temporally, spatially and between operators. The present standard contributes to on-going work on quality assurance of data from soft-bottom macrofaunal surveys.

The standard aims to be informative for both monitoring and research investigations (these may inter-link). The aim is to standardise the main approaches to achieve data inter-compatibility. At the same time, scope for individually tailored sampling and analytical programmes is given.

The sensitivity of the method (detection of faunal disturbance, change in taxon composition or faunal mapping) is dependent on the type of environmental influences present in the area and on the level of competence/standardisation of personnel.



Water quality — Guidelines for quantitative sampling and sample processing of marine soft-bottom macro fauna

1 Scope

This International Standard provides guidelines for quantitative collection and processing of soft-bottom macrofaunal samples in subtidal marine waters. The standard applies to all areas of the sea floor where it is possible to collect faunal samples by grab or coring device. For practical reasons, this applies to animals retained on a mesh screen of 0.5 mm or 1 mm aperture size.

The standard encompasses:

- development of the sampling programme;
- requirements for sampling equipment;
- sampling and sample treatment in the field;
- sorting and species identification;
- storage of collected and processed material.

The standard does not specifically address the following (although some elements may be applicable):

- bioassay sub-sampling;
- deep water (> 750 m) or offshore sampling;
- *in situ* faunal studies (eg. recolonisation assays);
- non-benthic organisms caught in the sampling device;
- estuarine sampling;
- intertidal sampling;
- meiofaunal sampling and analysis;
- Self Contained Underwater Breathing Apparatus (SCUBA) sampling;
- statistical design.

Accuracy of position fixing is determined by the geographical area, equipment used and survey objective.

2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of,

any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/DIS 5667-3 Water quality – Sampling - Guidance of the preservation and handling of samples

ISO 5667-12 Water quality -- Sampling -- Part 12: Guidance on sampling of bottom sediments

ISO/DIS 5667-19 Water quality – Sampling - Guidance for sediment sampling in marine areas

ISO 5813 Water quality - Determination of dissolved oxygen - Iodometric method - (= EN 25813:1993) (ISO 5813:1983)

ISO 5814. Water quality - Determination of dissolved oxygen - Electrochemical probe method - (= EN 25814:1992) (ISO 5814:1990)

3 Definitions

The following definitions apply to this international standard:

3.1
**baseline survey/
environmental impact assessment**
a survey with emphasis on characterisation and description of biotic and abiotic conditions in the survey area, and which forms the basis for future monitoring and/ or follow-up surveys

3.2
benthic
associated with the sea floor

3.3
benthic macrofauna
bottom-dwelling animals retained on a mesh screen of 0.5 mm or 1 mm aperture size

3.4
receiving water body
water body which receives an input of material, of either natural or anthropogenic origin

NOTE The term often appears in the context of anthropogenic input, for example, effluent from municipal waste-water outlets or industrial processed water.

3.5
reference station(s)
one or more sampling stations chosen to represent environmental conditions in a given area; i.e. free from direct anthropogenic influences

NOTE Reference stations should have similar depths, sediment types and hydrographic conditions as the sampling stations, if possible. These also should not be in the vicinity of any polluting discharge, although little account can be taken of diffuse pollution.

3.6
replicate samples
a series of samples taken in the same time frame, at the same sampling station, in the same manner for statistical validity and comparison. Replicate samples may include sets of sub-samples taken from a larger sample

3.7
sampling station
precise location where samples are collected.



NOTE: A sampling station is defined by its geographical position (OS National Grid Reference, latitude, longitude), depth (relative to chart datum and normalised to mean low water as given in tide tables) and any other invariant or physical conditions. The station is delineated using the given level of precision. In cases of doubt when revisiting sampling stations, emphasis should be placed on landmarks and water depth.

3.8

soft-bottom

areas of sea floor consisting of loose deposited particles including clay, mud, sand and gravel, shells and maerl, but excluding cobbles. Includes also mixed substrates with gravels, small stones and pebbles scattered on a bed of finer material.

3.9

soft-bottom fauna

animals living on or completely/partially buried in soft-bottom sediments

3.10

sublittoral

portion of the shore which is either totally immersed or only uncovered by the receding tide infrequently and then for very short period (i.e. below the littoral zone)

3.11

sub-sample

ideally representative portion removed from a sample, taken for separate analysis. See annex A (informative)

4 Quality and safety

4.1 Health and Safety requirements

All phases of benthic sampling and sample processing should adhere strictly to national and international health and safety regulations. This applies to behaviour, protective clothing and handling of equipment during sampling, safety precautions taken while handling hazardous chemicals (such as fixatives and preservatives), as well as safe sample processing and storage. In particular, many types of sediment samplers present a serious danger to personnel; all staff should be fully aware of the appropriate procedures to operate safely around each sampler.

All personnel collecting and handling samples should be given training in the appropriate health and safety procedures and, where in force, have attained certification status. Refresher training should be carried out every three years or sooner. Staff should be trained in assessing risks to personnel or equipment and follow any documented procedures.

A valid health and safety manual should be freely available in the institute or laboratory and the appropriate first-aid supplies and emergency facilities (such as eyewash station and shower) should be installed. In addition, vessels used for sampling should be certificated for safety and equipped with experienced crews and onboard machinery maintained and suited to the operating environment.

Appropriate protective clothing should be made available in the field, laboratory and sample store (such as helmets, protective boots, aprons, gloves, goggles and gas-filters). The laboratory should be equipped with point-ventilation outlets and preferably have a monitor for chemical levels in the air. Where feasible, less-hazardous alternatives to formalin should be considered, especially when dealing with small sample volumes.

Specific health and safety issues are further emphasised in the text below.

4.2 Quality assurance and Quality Control

Quality assurance and quality control measures should be incorporated during all stages of benthic sampling and sample processing programmes. These principles help to guarantee that all data produced is of a specified quality and that all parts of the work are carried out in a standardised and inter-comparable manner.

All procedures are therefore clearly described and carried out openly, such that all of the laboratory's activities can be audited (checked) internally and externally at any time.

The overall aim is to assure traceability and full documentation of samples and equipment from beginning to end (from sampling, sample transport, offloading from survey vessel, placement within and retrieval from a sample store to sample processing, reporting and final archiving).

National and/ or international accreditation should be sought if appropriate (required for most commercially-operative laboratories). Guidance from relevant accreditation bodies should be sought in developing specific in house quality systems, work procedures and protocols. It is recommended that laboratories participate in intercomparative tests or learning schemes to develop expertise and maintain the appropriate skills. This EXAMPLE ensures continued standardisation and reproducibility of results.

Recommendations on quality assurance practices are given in RUMOHR (1999)¹.

EXAMPLE Some examples of national guideline and/or audit schemes for marine benthos are given below:

Germany - (<http://www.umweltbundesamt.de/wasser/themen/q-blmp.htm>);

UK - National Marine Biological Analytical Quality Control Scheme (www.nmbaqcs.org);

Norway – accreditation scheme EN/ISO 17025 and Norwegian standard NS 9423.

A quality assurance/ quality control scheme should encompass the following:

- training and training records;
- traceability of work and samples;
- standardised practices throughout;
- calibration of sampling and sample processing equipment;
- in-house and external audit (also referred to as Analytical Quality Control schemes);
- literature updates;
- reference (voucher) collections.

Specific details on analytical quality assurance and quality control are given in section 8.5.

5 Strategies and objectives for soft-bottom faunal surveys

5.1 Sampling programme and plan

The design of the sampling programme depends on the detailed aims of the survey and the required power of the data. The programme should be developed with regard to local topographical and hydrographic conditions in the survey area, information on local contamination sources and knowledge from previous surveys (if any). The number of sampling stations, their positions and numbers of replicate samples to be taken at each sampling station should be established prior to the initiation of the survey. The design of the programme has a strong influence on the options for data treatment and statistical analyses. Prior considerations about data treatment and reporting should therefore be made. Quality Assurance procedures should be incorporated at this stage

1) Within ICES are also two relevant Steering Groups on Quality Assurance of Biological Measurements in the North-East Atlantic and Baltic sea, respectively (see <http://www.ices.dk/iceswork/workinggroups.asp>).

Guidance and considerations for sampling and statistical design may be found in Rumohr (1999).

5.2 Positioning of sampling stations

5.2.1 Introduction

Sampling stations should be located to satisfy pre-defined requirements bearing in mind the objectives of the study and the likely scale of natural variability in the biota.

For monitoring purposes, sampling stations should preferably be positioned in areas of even sandy/muddy bottom sediments. Certain bottom types where it is difficult to obtain good-quality samples, such as in sediments containing large amounts of stones, hard gravel, twigs and similar objects should be avoided. However, it may be possible for a diver to sample pockets of sediment in such areas. Alternatively, supplementary semiquantitative techniques may be used (e.g. underwater photography, video or ROV or benthic dredging). In special cases where habitats within the sampling area vary strongly, different sampling techniques may be combined, but generally the same gear should be used for all sampling in one survey.

For biodiversity studies, various bottom types should be included, as appropriate to the aims of the programme.

Sampling stations can be positioned according to one of the following strategies:

- station network (area sampling or grid);
- randomly or scattered;
- stratified;
- transect;
- single-spot (station) sampling.

5.2.2 Station network (grid or area sampling)

Sampling stations are arranged in a regular grid-like pattern. This arrangement is appropriate for overview surveys and for mapping of distribution of factors of interest, for instance zone of influence around point source discharges. The survey area should be one of topographic homogeneity, but some adjustments can be made according to local conditions, for instance in fjords and coastal waters with smaller variations in depth.

5.2.3 Random or scattered sampling

In special circumstances, sampling stations may be positioned randomly or scattered. An example of where this may be appropriate is where statistical power and sample representability has lower priority over gaining an overall impression of faunal conditions in the area at large.

5.2.4 Stratified sampling

Sampling stations are arranged within locally homogeneous subdivisions of the survey area. The subdivisions (strata) may be delineated according to depth, sediment types or other factors that vary across the survey area. Stratification is appropriate in cases where habitat variability may confound patterns of interest. Within strata stations may be placed in network, for instance for zone of influence mapping, or randomised for description of 'average' characteristics of the strata.

5.2.5 Transect sampling

Sampling stations are arranged along linear transects. One approach is to place stations along a known or anticipated gradient of a factor of interest in a sub-area of minimum habitat variability. This is applicable, for

instance, to trace effects of point-source discharges by establishing the transect in the main current direction from the source. Another, rather different approach, is to place stations across possible habitat gradients when it is not feasible (or not appropriate) to work in strata. This is often the case in intertidal studies, where transects may be established from upper to lower shore.

5.2.6 Single-spot (station) sampling

This applies when a small number of stations are placed according to individual assessment. In cases of known or suspected eutrophication or chemical contamination, sampling stations may be positioned in the deepest parts of the survey area (depressions, basins), where the earliest signs of disturbance are often seen.

5.3 Reference stations

For surveys carried out in contaminated areas, or those believed to be contaminated, one or more reference stations are chosen outwith the affected area. The reference stations should, as far as possible, be representative of conditions unaffected by effluent sources and allow assessment of natural temporal and spatial variations in the soft-bottom faunal communities. Reference stations are used in surveys where special circumstances demand direct comparison of the fauna with that beyond the disturbed or affected area, or where knowledge of the extent of natural variation is required.

Reference stations should be located in as similar conditions as possible to those at the regular sampling stations (i.e. similar depth and sediment type). Multiple reference stations are particularly important in heterogeneous areas.

Statistical considerations and the required precision of results will dictate the number of reference stations and sample replicates required (for example, some surveys demand a higher number of sample replicates at reference stations than at 'ordinary' stations).

5.4 Types of surveys

5.4.1 Introduction

Surveys may be divided into three main categories (see Table 1), according to the objectives.

Precision of results refers to the expected accuracy of the data obtained, i.e. how representative the samples are of the environmental conditions. This is a complex issue, not easily quantified, and varies greatly between different areas. Precision of results is less in heterogeneous relative to homogenous sediments or water depth across a sampling area. Therefore, to achieve the same precision, heterogeneous sediments require higher numbers of sampling stations and/or replicate samples relative to homogenous sediments. In addition, precision varies depending on whether the samples are processed quantitatively or semi-quantitatively. The required precision (and therefore the sampling and processing intensity) is determined by the individual aims of the survey.

Table 1. Overview of main categories of survey types

Survey type	Objectives	User group	Precision of results
Pilot survey	Gives a general overview of bottom and faunal conditions. Used for simple rapid assessment or to give basic information for designing more detailed sampling programmes	Regulatory authorities and consultancies. Research use as precursor to larger programme	Low
Baseline survey/ environmental impact assessment	Characterises conditions in a given area. Also maps or identifies the impact of point-source discharges (spatial extent and intensity). Faunal composition is compared with	Mostly regulatory authorities and consultancies. Research use for mapping, succession/	Medium to high, depending on individual requirements

Survey type	Objectives	User group	Precision of results
	specified assessment criteria or simply with other representative areas	recolonisation or gradient studies	
Temporal trend monitoring	Describes changes in benthic fauna over time, either for detecting change in biodiversity or as applied to environmental conditions	Mostly regulatory authorities and consultancies. Research use for environmental and biodiversity changes over time (also applied to climate monitoring)	Medium to high, depending on individual requirements

Note that the different survey types may supplement each other. For example:

- a pilot survey may provide information needed to design a sampling programme for a baseline survey/ environmental impact assessment;
- any of the surveys when repeated in the same manner and at the same time of year will provide temporal trend data.

5.4.2 Pilot survey

This is an initial assessment of faunal conditions in the bottom sediments in an area where the contamination source is not known or where there is no existing data from the area. The survey allows a coarse assessment of conditions and can provide the basis for development of a sampling programme for applied surveys as well as long-term surveillance. The requirements for equipment, sampling methodology and repeatability are usually relatively simple (see table below).

A pilot survey generally requires relatively few samples. For applied purposes, the sampling area is chosen in accumulation areas (rather than where net erosion takes place). Sampling stations may be positioned at random or in a grid. If the objective is to assess the faunal assemblages across an area at large, samples should be taken in both deep and shallow water. The sampling area should cover as much of the survey area as possible.

In addition to the quantitative faunal sampling, dredging should be carried out to collect the rare, large and more mobile taxa not adequately sampled by remote quantitative methods. Especially in regions with varying sea floor topography and open to wind and currents, a ROV (Remote Operated Vehicle) or sledge-mounted video reconnaissance is recommended to determine the extent of sediment and faunal patchiness (can occur both in areas of coarse and fine sediments). If appropriate, acoustic ground discrimination techniques may also be used to provide additional information.

Strategy and design for pilot surveys are summarised in Table 2.

Table 2 - Strategy and design for pilot surveys

Sampling devices	Usually grab or box corer, preferably supplemented by use of a benthic dredge. If appropriate, also other semi-quantitative techniques may be used (such as underwater photography, ROV, video or acoustic ground discrimination tools).
Strategy for sampling stations	No prescribed strategy. May be one or a combination of strategies outlined in 5.2.
Minimum requirements for faunal assessment	Semi-quantitative assessment of benthic fauna at all stations (at least presence and relative abundance of the major animal taxa), preferably also identification of large, abundant or otherwise prominent organisms.
Optional sampling	Samples from priority stations (as assessed by visual observations or physico chemical data obtained during sampling or other documented or anecdotal information) may be

	retained for later quantitative processing.
Field documentation required	Field log of sampling conditions and sediment description (see section 6.1.)
Reference station requirements	No fixed requirements

5.4.3 Baseline survey/ environmental impact assessment

This is a survey widely carried out for applied research or commercial surveys, generally either where a known source of impact exists or before effluent discharge is established. Such surveys may also be carried out for biodiversity research or where an area requires to be characterised biologically. The aim is to document faunal conditions and/or map the spatial extent of biological impact. Such surveys may be carried out using relatively simple methodology, but there usually are specified requirements for the methodology and procedures to be used.

Where external reference or survey data exist, these should be used to help plan the survey programme and to assess overall impact, where appropriate. See also section 5.4.2 for comments on supplementary non-quantitative sampling.

Strategy and design for baseline surveys/ environmental impact assessment are summarised in Table 3.

Table 3 - Strategy and design for baseline surveys/ environmental impact assessment

Sampling devices	Usually grab or box corer, preferably supplemented by a benthic dredge (see also section 5.4.2). If appropriate, also other semi-quantitative techniques may be used (such as underwater photography, ROV, video or acoustic ground discrimination tools).
Strategy for sampling stations	Sampling stations positioned according to aims of survey. Grid or transect sampling; stations positioned in relation to known discharge points if applicable. Stratified random sampling may also be applied according to the knowledge of distribution of impacts. Likely impact distribution may be determined by assessing the degree of impact in relation to local hydrography and bottom topography. Where there is a strong gradient, preference is always placed upon fewer replicates from more stations rather than many replicates from few stations. If intended to detect diffuse effluent or monitor environmental change, one station may be placed in the deepest part of the survey area (where unfavourable conditions often first appear). In some cases, a follow-up survey can be carried out using a fewer number of samples than the initial thorough environmental description. Where the samples are used for legislative purpose, the required precision of results (or statistical power) should be determined, and the number of replicate samples taken adjusted as appropriate. If necessary, the number of replicate samples to be used for the analyses can be determined by calculating taxon-area curves.
Minimum requirements for faunal assessment	At least one, usually three or more replicates are processed quantitatively, depending on statistical requirements. Faunal assessment may focus on individual taxa, groups of taxa or community-based assessment. For impact assessment, larger-scale effluents will demand a more extensive station network and statistical power than small-scale effluents. In many countries, large-scale domestic effluent is defined as 10 000 person equivalent units (p.e.) or more, whereas some countries operate at lower levels.
Optional sampling	Contingency replicates may be collected from priority stations (assessed as for pilot survey) to be processed later if required.
Field documentation required	Field log of sampling conditions and sediment description (see section 6.1.)
Reference station requirements	Reference station(s) should be established in cases where environmental impacts are expected. In areas of strong impact gradients, one reference station may be sufficient. Where there is much natural variation in conditions (heterogenous bottom) and/or only low to moderate impacts, two or more reference stations are recommended. If the end-points of transects are demonstrated outside the zone of impact, these may act as

	reference stations. Where standards of “pass/fail” have already been established for the area, reference stations may not be required. To assess possible overall impact in the area studied, external reference data across a wider area are recommended (can encompass new or existing data).
--	--

5.4.4 Temporal trend monitoring

This is a survey of the benthos in response to temporal changes in the chemical and/or physical conditions in the sediments to document either contamination or natural variation over time. The surveys should be carried out using fixed sampling points and time(s) of year and using standardised methodology according to an established programme. Sediments that are physically disturbed by man's activities (e.g. trawling) are generally not suitable for retrospective trend monitoring purposes.

It is particularly important that all sampling equipment and procedures are documented and any field observations and measurements recorded on an appropriate field sheets/log book. This will facilitate accurate repeat surveys according to the temporal scale on which the surveys are being undertaken.

The statistical power of the sampling for trend data should be robust and suited to the requirements of the study.

Strategy and design for temporal trend monitoring surveys are summarised in Table 4.

Table 4 - Strategy and design for temporal trend monitoring surveys

Sampling devices	Usually grab or box corer, supplemented if appropriate by semi-quantitative assessment techniques (such as benthic dredging, remote underwater photography, ROV, video or acoustic ground discrimination tools).
Strategy for sampling stations	Sampling stations positioned according to aims of survey, but positions fixed and re-sampled at regular intervals. A high level of documentation and replicability is required. Statistical power is assessed as for baseline survey/ environmental impact assessment.
Minimum requirements for faunal assessment	As for baseline survey/ environmental impact assessment.
Optional sampling	As for baseline survey/ environmental impact assessment.
Field documentation required	Field log of sampling conditions and sediment description (see section 6.1)
Reference station requirements	Reference station(s) appropriate only if monitoring effluent impact (in which case strategy as for zone of impact mapping).

Seasonal sampling may have an important influence on the results of temporal trend monitoring. Surveys should always be carried out during the same season to ensure continuity. The minimum is one sampling per survey year, but two samplings during the same year are advantageous. For monitoring surveys, sampling during summer or known recruitment periods generally is avoided, except where there is an express interest in recruitment and production.

The timing of sampling will vary geographically. In certain areas, winter sampling is not possible due to ice cover, sub-zero temperatures or other unfavourable conditions (e.g. the Arctic and Baltic Sea). In these cases, spring and/or autumn sampling are the only alternatives. Where climate is not an issue, the preference is usually for winter sampling, with additional sampling in autumn, if appropriate.

5.5 Change in sampling programme and intercalibration

The issue of reproducibility should be given due concern. If changes or modifications are to be made in a running sampling programme, care should be taken to ensure comparability of old and new data. In particular, if the sampling gear in a long-term monitoring programme is to be changed, appropriate validation of the new

techniques should be carried out. Intercalibration should be conducted when comparisons between studies carried out with different techniques are to be made.

6 Sampling

6.1 Documentation and field log

A field log should be kept for recording information pertaining to the sampling, sampling stations and the individual samples.

A minimum of the following information concerning sampling and the sampling stations should be recorded in the field log:

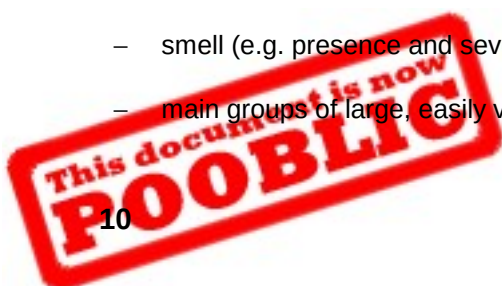
- person responsible for sampling;
- project or contract identification code;
- geographical co-ordinates for each sampling station (also for each replicate sample if required, eg. in case of boat drift during sampling. See section 6.2.2);
- track-plot of stations sampled, if required by the relevant protocols;
- water depth (m) at each sampling station and for each replicate sample, normalised to mean low water (see section 3.9);
- sampling programme for each sampling station (number of replicate samples, sampling of background parameters etc.);
- date and time for each sample and/or sampling station;
- sieve aperture sizes and number of replicates collected;
- other comments (such as rejected samples, delays and other problems experienced, together with the causes).

The following additional information is useful for any retrospective assessment of sample anomalies:

- estimated wind strength and direction;
- estimate of wave height or assessment of state of sea (eg. Beaufort Scale);

The following information should be recorded for each sample replicate (before and after sieving, as appropriate). The sample may be photographed, if wished.

- sediment volume or bite depth (measured by means of, for example, a calibrated rod or volume markers on the inside of the sampling device);
- visual sediment description (sand, silt and/or clay, giving relative proportions of each for mixed sediments);
- description of the sediment profile and thickness of surface layer, if visible;
- colour (surface and down the sediment profile);
- smell (e.g. presence and severity of H₂S);
- main groups of large, easily visible animals present;



- anthropogenic debris, rubbish, sanitary products, plastics;
- other particular characteristics, for example, presence of oil, drilling mud, fish food pellets, stones, dead shells, terrestrial material, fruit pips/seeds (as sewage indicator) etc.;
- number of sample containers used for each replicate, after sieving and fixing.

6.2 Sampling and sample processing in the field

6.2.1 Sampling requirements

Sampling may be carried out from a wide range of survey vessels, from fully equipped research or supply vessels to small inshore workboats and inflatable crafts, depending on the requirements of the survey. The use of small boats may be an advantage in shallow inshore areas or around aquaculture installations. The choice of sampling equipment should be scaled appropriately and used within the operational safety limits of the individual vessel.

All survey vessels should comply with local sea-going safety regulations and carry all required certificates and equipment. Trained crews or scientists with experience of sampling techniques, position fixing/recording and necessary seamanship should man the vessel.

The survey vessel should be appropriately and adequately equipped for bottom sampling, with sufficient deck space. The following equipment is required:

- winch or hauler with boom or crane of sufficient height and correct lifting specification to allow unhampered retrieval of the sampling device on deck;
- wire of the appropriate dimensions (depending on equipment type and safety requirements), rigged to a meter wheel or marked with depth markers;
- echo-sounder;
- Satellite navigation global positioning device (Differential Global Positioning System DGPS, reference system Universal Transverse Mercator UTM 32 or 33). Where no GPS signal can be obtained, a minimum requirement of radar, used in conjunction with admiralty charts is recommended;
- seawater hose with adjustable pressure and preferably sprinkler devices.

All equipment must be tested and certified to comply with Health and Safety regulations.

6.2.2 Defining the position of sampling stations

The position of the sampling stations should be defined unambiguously, such that they can be relocated by other operators. The system used for plotting should be stated explicitly in any report or work procedure.

Positions should be defined using geographic co-ordinates (eg latitude/longitude in decimals) with reference to the appropriate system for graticules (such as European Datum: ED-50, World Geodetic System: WGS-84), and also using the Universal Transverse Mercator UTM system, if so desired. Accuracy of sampling station positions should be defined by the aims of the survey. Track-plotting during longer sampling stations may be advantageous.

Differential Global Positioning System (DGPS) with monitor should be used in all sea areas if possible, Where the differential is not available accuracy should be assessed and a minimum of Global Positioning System (GPS) without differential receiver used. Unless in open seas, sampling stations should also be defined using the direction and distance from landmarks or fixed points of reference, in addition to geographical coordinates.



When revisiting sampling stations poorly-defined in terms of geographical coordinates, the normalised water depth, known landmarks and well as sediment features should be used as the main criteria for relocating the sampling station. DGPS should then be used to relocate for future reference.

A minimum accuracy of +/- 50 m and +/- 20 m in open waters and estuarine areas, respectively, should be attained. A greater accuracy is desirable and achievable if survey aims dictate.

Water depths are given to the nearest metre, relating to chart datum and normalised to mean low water according to tide tables.

6.2.3 Choice of sampling equipment

Remote sampling is most commonly carried out using a grab or corer. The most commonly used grabs for soft-sediments are the van Veen, Day or Smith-McIntyre grabs, but also a PONAR grab may be appropriate. Typical coring devices are the box corer (large sample volume), HAPS and Craib single corers or various multicorers based on the Craib principle, such as the Bowers & Connelly series (small sample volumes).

Grabs are widely used for routine sampling purposes, and operate best in sandy sediments, as well as fine mud with an admixture of gravel and stones. An appropriate type of corer should be used in cases where a completely undisturbed sediment surface is required (e.g. for sediment-water interface studies) or in cases where the infauna lives deeper than the penetration depth of a grab (to ensure that organisms inhabiting sediment layers deeper than 20 cm are adequately sampled). Corers are also useful where information on the vertical distribution of organisms is sought.

Grabs should be equipped with inspection ports covered with metal gauze (0.5 mm aperture size), extending over a minimum 60 % of the top surface, to reduce the bow-wave effect. Similarly, corers should be open at top and bottom during descent. The apparatus should close completely during hauling, such that the sample material is not washed out, and so that the supernatant water is kept stationary relative to the sediment surface.

The biting depth of grabs can vary with sedimentary conditions. Weights can be added to adjust according to the sedimentary conditions (25 kg - 40 kg in mud/muddy sands and up to 70 kg - 100 kg in coarser sediments). Similarly most corers can be weighted according to sampling conditions. This is usually carried out before commencing the sampling. If required by national accreditation schemes, the precise sampling area of the grab should be verified at regular intervals, particularly after prolonged use or sampling in hard-packed or silty sediments, which may distort the bite action.

A grab type with a sampling area of 0.1 m² should be used in the majority of surveys. Where a long-term investigation has been carried out using a different sampling area, it is permissible to continue its use. However, for large-scale integration, it is highly recommended that new faunal investigations use 0.1 m².

Grabs and corers with smaller sample volumes are used in certain types of surveys, and are representative where the faunal density is high and homogeneously distributed. In special cases, such as in shallow or enclosed waters, or where a vessel with the appropriate heavy rigging for benthic sampling equipment cannot be used, smaller, hand-operated grabs and coring devices may be used. Small grabs should have a minimum sampling area of 0.02 m² and top flaps to prevent loss of or disturbance to sediment (essential for most background parameters). On the other hand, coarse sediments or sampling in deep water may require the use of a larger type of grab or box corer.

A brief overview of grabs and box-corers is given in Annex C (informative). Further guidelines on choice of equipment in relation to sampling conditions and requirements is given in, Holme & McIntyre (1984), Rees et al. (1990) and Rumohr (1999).

6.2.4 Sampling procedure

The apparatus is lowered vertically towards the sea floor, at an even rate, at a speed that will avoid triggering the mechanism. Care should be taken to keep the survey vessel in position and the wire vertical during lowering. Between approximately 5 m and 10 m above the sea floor, the lowering speed is reduced or come to a complete stop in order to reduce further the bow-wave and water turbulence in front of the apparatus.

Contact with the sea floor is observed by the slack on the wire, after which the apparatus is gently raised for approximately the first 5 m. Then the apparatus should have closed, left the bottom and can be raised with maximum safe speed. The samples are inspected for approval via the top opening flaps immediately upon retrieval on deck. Sediment characteristics and background information must be recorded before sieving (see section 6.1).

Any sampling for background sediment descriptors is carried out at this point. The rest of the sample is then discarded. Only complete samples are kept for faunal analysis. Any necessary sample splitting, e.g. into vertical sedimentary layers for vertical faunal distribution analyses, may be carried out before sieving. The sample can be transferred to a barrel to await sieving, but sieving should commence as soon as possible and at least during the same day. Sampling on shallow stations (< 70 m) is recommended to be conducted during daytime, because some benthic organisms have semi pelagic activity during the night.

The apparatus is rinsed thoroughly between each sample. In areas where there is a risk of transfer of infectious agents (e.g. near aquaculture sites), the apparatus should be disinfected before moving to a new area (e.g. between cage groups). Disinfections should be carried out in accordance with the appropriate regulations. If sampling for bioassays and/or sediment chemistry in conjunction with benthic faunal sampling, the appropriate guidelines should be followed for cleaning the sampling device.

6.2.5 Guidelines for approval/rejection of samples

Samples from different sampling apparatus require different rejection criteria. To be approved, a sample from a large grab should contain the upper layer of sediment, and at least 5 litres (sand) or 10 litres (mud) of sediment. Alternatively, bite depth may be measured (5 cm for sand and 7 cm for mud). The sediment surface should be undisturbed. Samples from a smaller grab should contain the upper layer of sediment and an appropriate volume or bite depth (depending on the grab size). Samples collected by corer must include the sediment surface and be at least 7 cm - 10 cm in length. Samples where the apparatus is not closed properly and the draining supernatant water has damaged the sediment surface should be discarded, as are those where the bite is obviously uneven. Any samples discarded, together with the cause, should be noted in the field log.

If sediment characteristics make it impossible to collect approved samples, the best available samples are retained, and the circumstances noted in the field log.

6.2.6 Sieving of samples in the field

Approved samples should be sieved in the field to remove the fine sedimentary material. The sample is emptied onto a washing table, hopper, autosiever or other container where the sample material can be washed out gradually as a suspension into the sieves. National and individual requirements for mesh size vary. For most routine environmental monitoring surveys, a mesh screen of 1 mm aperture size is used as the finest sieve, but in particular cases, e.g. studies of juvenile recruitment or estuarine studies, sieves of both 0.5 mm and 1 mm aperture sizes can be used in series. In the latter case, the 1 mm and the 0.5 mm fractions should be processed separately for comparability (e.g. with other surveys using only 1 mm sieves). This separate processing should be carried out in the field, because live and fixed material behaves differently during sieving. However, as a minimum, a laboratory should be consistent in its procedure. The sieve aperture size(s) used is recorded in the field log. Sieves should be quality controlled each carrying a calibration certificate and conform to recognised quality standards.

Samples that contain large amounts of coarse material can, if appropriate, be passed through a sieve stack, usually with aperture sizes of 5 mm and 1 mm. During sieving, the sieves should be placed in a water bath deep enough to cover the mesh screen and 'puddled' to remove remaining fine material, unless using an autosiever. The use of a water bath greatly reduces damage to the organisms, relative to the water stream hitting a dry sieve surface.

The samples are washed and sieved with seawater. The pressure of the seawater hose should be kept low and direct contact of the sample material with the water stream should be avoided, to minimise damage to the animals. Especially polychaetes, amphipods and oligochaetes are very fragile. During sieving, the sieve may be agitated gently, and in the event of blocking, the mesh screen can be rinsed gently from the underside. Sieving is complete as soon as the fine material is washed out of the sample. Long sieving times should be

avoided because small animals may actively pass through the sieve. Appropriate characteristics should be noted in the field log.

Where the sediments contain a large component of firm glacio-marine clay, processing should be divided into two phases: firstly, the soft upper layer of sediment that is rich in animal life is sieved and the sieve residue is carefully transferred into a separate sample container. Thereafter, the more compact clay is given a firmer treatment during washing. If necessary, the clay may be broken up manually, in search of burrowing organisms. Should it take an unreasonably long time to dissolve the clay, clay lumps that appear not to contain animals may be put into separate sample containers and fixed for subsequent washing in the laboratory

If the sample contains animals that produce slime (for example Chaetopterus, Cerianthus, Myxine), these may be placed in separate plastic bags/ jars and fixed (see 5.3), before being placed in the container along with the rest of the sample. Large stones, shells, sticks etc., which can cause damage to the sample material during transport, are kept in separate containers or discarded if devoid of encrusting fauna.

After completion of sieving, the sample is carefully washed to the edge of the sieve and carefully flushed into appropriate sample containers (for example plastic jars or small plastic buckets) equipped with watertight lids, using a water stream applied to the underside of the sieve. It is recommended that this be carried out over a mesh screen or sieve, as a safety measure in case of accidental spillage.

The sample containers should be indelibly marked with the unique sample information externally (field name/project code, station number/code, replicate number and date). An additional label on waterproof paper containing the same information may be added internally. The sieving equipment should be washed clean between each sample to ensure that material is not transferred between samples.

Fragile animals may be carefully washed or picked out of the sample during sieving using soft forceps to prevent damage. Large objects (stones or empty shells) should be discarded if no attached fauna or shell borers are present or stored separately to prevent grinding during transfer and storage. The use of spoons and other hard tools in the transfer of material should be avoided.

Should sample material (> 5 %) be lost during processing, the entire sample should be discarded and a new sample collected.

6.3 Sample fixation

Sample fixation is the act of stopping the living function of the organism tissues. Fixative solutions are not suited for long-term storage. Preservation is the transfer of the fixed organisms to ethanol, wherein they may be stored almost indefinitely.

Samples are fixed as soon as possible after sieving, in a 10 % to 20 % by volume formalin (=approximately 37 % formaldehyde)-seawater solution (4 % to 8 % formaldehyde; 37 % - 41 % w/w HCHO) with added buffer to neutralise acidity (for example 2 g/l borax powder). A non-drip dispenser approved for formalin should be used. The pH of the formalin solution should not be below 7. Further, formalin should be handled only in well-ventilated areas and appropriate precautions taken during sample transport. Because the pH level decreases over time, additional buffer should be added as required to samples kept in storage prior to sorting. This is determined by periodic checks on pH levels in the stored samples. More buffer is added if the pH drops below 7.

In cases where the sample comprises a large volume of sediment, and where there is a high content of organic material (plant/algal remains, etc.), the formalin concentration may be increased up to 30 % (10 % formaldehyde). There should be at least the same amount of solution in the sample container as solid material. Large shells may, if deemed necessary, be opened or slightly perforated to allow the fixative to penetrate to the animal tissues. The sample container should be gently inverted to mix in the fixative, which should remain in the sample for at least 12 hours. The samples should be protected from frost during all stages of storage and transport.

The samples may be stained as required. Staining increases sorting efficiency, but can seriously reduce the value of the material for taxonomic purposes by masking certain features. The recommended stain is Rose

Bengal. Sufficient strength of colour is achieved with approximately 1 mg/ml concentrated formalin (i.e. 1 g Rose Bengal powder to 10 litres concentrated formalin). Stain can alternatively be applied in the laboratory where the sample is washed to remove formalin and immersed in stain for 20 mins. Rose Bengal should be handled according to appropriate Health and Safety procedures.

6.4 Background environmental descriptors

6.4.1 Introduction

Background environmental descriptors provide sedimentary data at the sampling stations and physical and chemical properties of the water masses in the survey area. The selected background parameters represent the most influential environmental conditions. An understanding of these is essential for correct interpretation of the faunal data, or as required as part of any set programme. Table 5 lists the main descriptors used in benthic surveys.

When using a grab or box-corer, the sediment sample for background environmental descriptors should be taken out through the inspection ports on the top of the sampling device. The surface of the sediment should be undisturbed. The sediment samples should be put into plastic jars/bags and frozen at – 20 °C for storage.

Where a high level of precision is required for the sediment analyses, or where sectioning of the sediment profile is to be carried out, a coring device should be used in preference to a grab, because the latter can distort the sediment. However most well designed grabs appropriately weighted will provide an adequate sample for the analyses as used to support faunal data.

Samples to be analysed in either the field or laboratory as environmental descriptors, should not be taken from the faunal samples but from separate/additional replicate samples. This avoids loss of material from the faunal sample. However, in heterogeneous areas, inter-sample variation should be borne in mind and it may be advantageous to take several replicates for environmental descriptions as well as for faunal analyses. In addition, the faunal biomass may be measured in the laboratory (see Annex B).

Descriptors appropriate to the aims of the survey should be agreed during the design of the survey strategy. i.e. they are not all necessary in every case. Field descriptors are very useful and the data should be recorded in the field log: these should include qualitative sediment descriptions. It may be appropriate to use video surveillance to assist in this process.

It is however customary to carry out at least quantitative laboratory measurements of sediment granulometry and a measure of Carbon or organic content. In aquaculture surveys it is usual, in addition, to measure total sulphide, redox, trace metals (Cu and Zn) and often pH. Separate samples may also be taken for contaminant analyses (e.g. trace metals) as required (see ISO/TC 147/SC10/WG11 under development). This is useful in areas where gradients of impact are suspected.

Samples for element analyses in the laboratory should be determined from the surface 0-1 cm layer of sediment. Where sediment mixing by bioturbation is an issue, element analyses may be carried out on vertically sectioned sub-samples, usually at 1 cm intervals down to 5 cm. Granulometric analyses are usually carried out on the 0-5 cm layer (especially in areas where the top layer is extremely flocculent and not representative of the sediments as a whole), but may also be vertically sectioned if appropriate to the survey aims.

Table 5. Main environmental descriptors, methods and information value.

MATRIX	Environmental Descriptor	Method	Information value	Data quality
Sediment: Field measures	General description of bottom sediments	List dominant sediment types (clay, sand, pebbles, boulders etc.). For mixed sediments estimate the relative abundance of each type.	General characterisation	Qualitative

**This document is now
PUBLIC**

MATRIX	Environmental Descriptor	Method	Information value	Data quality
	Assessment of sediment oxidation state	1. Assess sediment colour and smell. Black sediments or patches of sediment indicate anoxic conditions. Depth of anoxic layer and intensity of for example methane/H₂S smell can be scaled. 2. Standardised colour classification according to "Munsell® Soil Color Charts"; 3. Redox – electronically : standardised against reference cell 4. Interstitial DO – gas sensitive probes	General characterisation	Qualitative Semiquantitative Quantitative Quantitative
Sediment: Laboratory measures	Sediment granulometry (fractions expressed as % dry weight)	Dry sieving, laser granulometry or coultercounter, according to "Wentworth grade classification" (Silt/clay (< 63 µm), very fine sand (63 µm - 125 µm), fine sand (125 µm - 250 µm), medium sand (250 µm - 500 µm), coarse sand (500 µm - 1 mm), very coarse sand (1 mm - 2 mm), gravel (2 mm - 64 mm) and pebbles (> 64 mm). Additionally, assessment of the <16 µm sediment fraction is recommended in estuarine areas.	Indicates sediment homogeneity/heterogeneity and sorting. Important in determining faunal community composition and relationship to organic or trace metal/contaminant content. Gives useful indication of bottom current conditions.	Quantitative Method used MUST be quoted in any report as results can vary.
	Total organic carbon (TOC) of the sediment	Use of element analyser on dried sediment, excluding grains larger than 2 mm.	Gives an indication on food availability to benthic fauna (note that not all TOC is bioavailable). Can also indicate degree of organic enrichment. Should preferably be normalised for sediment grain size composition.	Quantitative
	Total organic matter (C & N)	Loss on Ignition (LOI). Sediments dried in muffle furnace.	Simple surrogate for TOC indicating degree of organic enrichment.	Quantitative
	In coastal areas also total Nitrogen (TN) and total Phosphorus (TP) if applicable	Use of element analyser on dried sediment, excluding grains larger than 2 mm	TOC: TN ratio indicates extent of terrestrial input. TN and TP useful in areas at risk of eutrophication.	Quantitative
	Sediment water content (or equivalent dry substance)	Calculated from weight loss after drying	Indicates degree of compactness of the sediment. Particularly useful where this is altered by anthropogenic impact.	Quantitative
	Interstitial water salinity (in estuaries)	Draining or squeezing	Assists in explaining species distribution in areas of high surface run off	Quantitative
	Total sulphide	Titration against iodine	Particularly useful around aquaculture installations. Relates to degree of reduction in sediments due to organic deposition and deoxygenation	Quantitative

MATRIX	Environmental Descriptor	Method	Information value	Data quality
	Trace metal or other known contaminants	Flame AAS or HF	Useful in and describing anthropogenic impacts around discharges.	Quantitative
Aquatic: field measures	Salinity /Temperature/ pH/ DO	Meter analyses calibrated against known standards	May be recorded from the bottom water or through a depth profile. These should be carried out as close as possible to the end of the stagnation period, normally in late summer/ autumn. (see ISO 5813 and ISO 5814).	Quantitative

6.5 Responsibility

The survey leader is responsible for ensuring that the correct procedures for sampling and sample treatment are followed. Deviation from the specified procedures should be recorded in the field log.

7 Sample processing in the laboratory

7.1 Sorting

A sorting log should be compiled, either as a continuation of the sample log used in the field, or a separate, but compatible document. Any general notes on the sample, such as its general appearance or any anomalies in fixation may be recorded here, together with the name of the sorter (for traceability purposes). Additional useful information for commercial institutes includes the time taken for sorting and, if deemed excessive, the reason for this.

The formalin solution should be rinsed from the sample in the laboratory in a ventilated sink or under a fume extractor, using a mesh screen with the same or smaller aperture size than that used in the field. Samples which are to be stored for more than one to two months before sorting may, to advantage, be washed and transferred in their entirety to ethanol, particularly if the material is for taxonomic investigation.

The sample material should be sorted under suitable magnification. As a general rule, all fauna should be extracted from the residue, but in cases where there is a large volume of sample material or faunal densities, it may be acceptable to sub-sample (see Annex A for a further description). The method of sub-sampling used is recorded in the sample log.

All fauna should be sorted into the main taxonomic groups, which are placed in separate sample vials with identification label. Large forms, such as large shells, starfish and sea urchins, should be kept in separate vials/jars. Tubes should not be removed from polychaete worms at this stage because of the risk of specimen damage and also because these are informative for identification (see Annex B for issues with biomass measurements). Animals attached to stones and organisms that could easily be confused with abiotic material (such as Foraminifera and Pogonophora), also are kept in separate vials. The sorted material is placed in 75 % - 80 % alcohol (IMS or ethanol) If wet weight analyses are to be carried out, this is advised before transfer to ethanol. For long-term storage, glycerol may to advantage be added to the alcohol (10 % - 20 %).

A consistent sample and vial labelling system assuring sample integrity and traceability is required. Sample information should be written (or pre-printed) on the label using alcohol-proof black ink or soft lead pencil as appropriate on waterproof paper. In case of pre-printed labels, particular care should be paid to the choice of ink type and printing process to ensure durability. The following information should be recorded on the labels:

- field name/ project code;



- sampling station number;
- replicate number;
- date of sampling,
- animal group;
- initials of sorter.

7.1.1 Sample residue

The volume and composition of the sample residue (the material remaining after extraction of benthic macrofauna) should be recorded in the sorting log (for example fruit pips/seeds, mineral sand, shell remains, wood fibres, slag). These notes may in future help to interpret any anomalies in faunal composition. Unless otherwise specified, the residue is retained until completion of control sorting and up to the limits stated within any quality procedures and/or national guidance.

8 Taxon determination and quantification

8.1.1 Level of identification and taxon lists

The fauna should be identified to the lowest (most detailed and usually “species”) taxonomic level possible, or that appropriate to the aim of the survey. The nomenclature used should be in accordance with recent editions of general faunal works and an agreed regularly updated literature checklist or relevant catalogues of benthic fauna, such as the European Register of Marine Species (ERMS; Costello & al. 2001). Updating is likely to be best done through national quality groups e.g. NMBAQC in the UK or ICES. References to useful faunal lists are given in Annex D. Where a taxon is not listed in such a catalogue, the reference to the original description should be given together with any additional identification literature used. Where a taxon has changed its name since list publication, then the new reference should be cited.

Unless otherwise specified in the survey programme outline, the following animal groups may be identified to a higher taxonomic level for routine monitoring purposes:

- Platyhelminthes;
- Nemertini;
- Nematoda (including the larger macrobenthic forms);
- Oligochaeta (unless important to the survey aims, and where good identification literature exists, in which case identification to “genus” is appropriate);
- Harpacticoid copepods;
- Chironomidae and insects in general;
- Hemicordata.

8.1.2 Quantification

In the case of fragmented specimens, body parts that can be identified unequivocally (such as the head in annelids or the mouthparts of brittle stars) are counted. Unless otherwise specified in the survey programme outline, the following animal groups are not quantified, but their presence should be noted:

- Foraminifera



- Nematoda;
- Cirripedia;
- colonial Porifera, Cnidaria and Bryozoa;
- planktonic organisms.

Taxa represented by a particularly large number of individuals may be sub-sampled before quantification (Appendix A). Where a taxon is represented by a large number of juvenile individuals (newly settled larvae), the adult and juvenile specimens should be recorded separately.

Identification of encrusting organisms on stones should be carried out in a manner appropriate to the survey aims. Where very high numbers occur (eg. Filograna or newly settled Semibalanus), these may be sub-sampled.

Particular in-house guidance is required to define the size limits or stage of maturity used to make a practical definition of juveniles in the relevant area. For example, suitable size-controlled objects or images attached to the bottom of a petri-dish may be used to help identifiers quantify juveniles and adults in a rapid and standardised manner.

Shell size measurements in (bivalve) molluscs or length-width measurements in other taxa may be carried out if appropriate to the survey aims.

8.1.3 Reference collection

(See also section 8.5). It is recommended that a reference (voucher) collection be kept of all taxa identified by the institute/laboratory. Inter-laboratory validation of the reference collection is recommended. Wherever possible, relevant taxonomic experts such as museum personnel should be asked to check specimens that are difficult to determine. Nomenclature should follow standard taxon lists (e.g. national lists, European Register of Marine Species).

The collection should contain a minimum of the following information:

- species name;
- name of identifier and supervisor, if appropriate;
- sampling location/ station code;
- date of collection;
- verification date, if any, and name of verifier;
- any nomenclatural changes (when these differ from the standard taxon list);
- depth and sediment type if possible. This is timesaving for future reference to the specimens.

The collection should be updated continually, during the course of surveys carried out, and be easily available for users. Particular attention should be paid to sealing of the vials. For particularly important specimens, the “double-vial” practice carried out by museums is recommended. The reference collection also serves as part of quality control procedures (see section 8.5).

8.2 Biomass

Biomass measurements give additional information and may be carried out as required. Wet weight analyses are preferable for routine and monitoring surveys. Analysis of dry weight and ash-free dry weight may be

carried out in certain circumstances, but is not generally recommended for faunal studies as the material is destroyed in the process. Annex B gives further information on wet weight analyses.

8.3 Data reporting

The taxon lists should reflect the complete faunal content of the samples. Pelagic organisms, colonial forms and groups, which, due to small size, are not quantitatively represented in the samples (such as Nematoda), are marked as such in the taxon lists.

The data should be recorded as a taxon by individuals by station matrix in electronic spreadsheet format or a relational database.

The following minimum information and analyses are carried out as a minimum for scientific reporting:

- complete list of taxa recorded and numbers of individuals within each taxon;
- number of taxa and number of individuals in each sample and at each sampling station;
- biomass as appropriate to the individual survey aims;
- table of the numerically dominant, i.e. most abundant taxa ("species") at each sampling station;
- derived statistics of faunal diversity as appropriate to the individual survey aims.

Techniques for data analyses and graphic presentation should be selected according to the individual survey aims. Some commonly used strategies and techniques include:

- rarefaction techniques;
- univariate analyses describing fauna at each station;
- multivariate analyses describing fauna across a set of sampling stations and often incorporating environmental variables;
- community or biocenosis characterisation (see Pérès & Picard, 1964; Bellan-Santini et al., 1994);
- reference to national and/ or international habitat or biotope classification schemes (see for example EUNIS draft habitat classification at <http://mrw.wallonie.be/dgrne/sibw/EUNIS/home.html>) .

8.4 Storage and archiving

For long-term storage, the biological material should be kept in 75 % - 80 % alcohol (IMS or ethanol), with 10 % - 20 % glycerol added, if appropriate. Further guidance on long-term storage is given in ISO/DIS 5667-3.

Processed material should be stored in facilities suited for long-term storage. The storage area should be fireproof and preferably lockable. The material should be easily accessible for periodic checks and refilling of preservative.

In principle, all material is retained for as long as is practicable. However, certain quality procedures specify a fixed storage time (up to 6 years in some cases). For particularly valuable material, an agreement should be made for permanent storage of the material, for example at an appropriate natural history museum.

All documentation for stored material should be properly archived and retained for at least as long as the samples are stored.



8.5 Analytical quality control and quality assurance

8.5.1 Auditing

External audits (checks) can take a variety of forms. A full or partial audit on a random selection of processed samples (including sample residue) by an appointed person out with the laboratory is recommended. The frequency and level of detail is determined as appropriate but is often dictated by national requirements.

Agreed standards can be applied and a pass/fail tag be applied to the data. It is especially useful if the external auditor can identify particular problems, which the laboratory can then address, thus putting in place a review system for improvement.

8.5.2 Equipment calibration

The technical quality of the equipment used should be verified at appropriate intervals. The most important of these are:

- accuracy of depth and position fixing equipment;
- grab bite area;
- sieve mesh apertures (most sieves have manufacturer certification);
- microscope maintainance (including periodic recalibration of eyepiece graticules, if used).

Any other laboratory equipment should also be within a regular checking system.

8.5.3 Training

It is essential that all participating staff are given the appropriate training and that a minimum level of competence is achieved and documented (for example by a certificate system). This includes all parts of the process, from sample collection, processing and documentation.

Staff should participate in appropriate workshops and courses wherever possible.

8.5.4 Check-lists, sample log and anomaly reporting

To ensure sample traceability (see also section 4.2), a system of check-lists for samples should be developed, with a facility for noting the progress of the sample through the various stages from sampling to data reporting. The worker associated with each stage in the process should be noted. These combined checklists and notes therefore form a detailed sample log.

This should ensure that at any time, the whereabouts and status of the sample (or its individual components) are documented and readily available for internal use as well as for external audits (checks).

A reporting system for anomalies found or operational errors should also be developed. Immediate action should be taken to reduce the risk of re-occurrence.

Such checklists and reports are normally required as part of laboratory accreditation procedures.

8.5.5 Sample sorting

A recommend minimum of 10 % of the processed samples (randomly selected) should be re-sorted to determine if the sorter has missed any animals and, if so, to what extent. The residue remaining after sorting is checked through once more by the assigned sorting coordinator, or appointed person with the relevant experience. A different person from the one who carried out the original sorting should always carry out control sorting.

If more than approximately 5 % of the taxa have been missed from the sample, all the samples in the batch should be resorted.

Where available, external audits (checks) or ring tests should be carried out for sample sorting.

8.5.6 Taxon identification

In practice, there are three levels of quality assurance and quality control for taxon identification:

- the identifications must be scientifically correct, and follow updated taxonomic knowledge and faunal nomenclature;
- the identification practices carried out must be consistent at least within a single survey, and in particular, where several identifiers are involved in processing a batch of samples;
- the quantifications must be accurate (or within specified level of accuracy in the case of very abundant taxa).

Each identifier must have a proven level of relevant taxonomic competence. Where available, identifiers should participate in national/international ring tests and other efforts towards taxonomic standardisation. It is useful for the laboratory to send to an auditor (if available) or willing expert/ external colleague a selection of identified specimens for checking. In regions where a formal taxonomic auditing scheme is established, the auditor will select the taxa required for checking.

If appropriate, entire vials of identified material can be reprocessed by an internal or external auditor to check accuracy of taxon identification and quantification.

For in-house standardisation between a team of identifiers, and/ or between individual surveys, the respective taxon lists should be checked against each other to ensure consistency in:

- taxonomic level used, especially for difficult or time-consuming taxa;
- taxonomic conventions followed;
- distinctions between juveniles and adults;
- quantification accuracy.

8.5.7 Identification literature

A list of literature used for taxonomic identification of the different faunal groups should be compiled by each institute. The list should be updated at regular intervals and should reflect recent advances in the taxonomic literature. The list should be arranged taxonomically rather than by author, to quickly identify appropriate keys.

8.5.8 Reference collection

At least one specimen, but preferably as many as practical, of each identified taxon (voucher specimens) should be placed in separate vials in the reference collection. Any identifier who is not formally associated with the institute/laboratory concerned, or who does not have access to the reference collection whilst working, should make a separate reference collection. In certain circumstances, a separate reference collection may be required for individual surveys.



Annex A (informative)

Processing particularly large samples

In general, the sample material retained on the sieves should be processed in full. Where both coarse and fine mesh screens (usually 5 mm and 1 mm) have been used, the material from the coarse sieve is sorted under low magnification (2 x - 3 x), while the finer material (from the 1 mm mesh screen) is sorted under a minimum of 3 x - 6 x magnification. In special cases where samples contain large amounts (> 2 litres) of sieve residue, such as shell-sand or plant material, the methodology for processing may be amended as appropriate.

For samples containing large amounts of sand, flotation techniques may be used, where the low-density material is separated from the rest of the sample during washing and sorted separately. The remaining material may be sub-sampled, but at least $\frac{1}{4}$ of the material should be sorted.

Samples containing large amounts of plant material may be stained (if appropriate, depending on the type of plant material present) and sorted under low-power magnification. In the case of extremely large sample volumes, these may be sub-sampled.

Where the entire sample is dominated by very high numbers of individuals of very few taxa, (for example *Capitella capitata* in enriched areas), sub-sampling can be carried out prior to sorting, using appropriate equipment or strategy.

For samples containing taxa that are represented by particularly large numbers of individuals, these taxa may be sub-sampled before quantification. A minimum of 1/10 of the material should be counted. The remaining taxa are quantified in the usual manner.

When the procedures are so amended, all taxa found in the sample should be recorded, even if the subsequent quantification is not entirely accurate. The procedures used are described and documented in detail.



Annex B **(informative)**

Biomass measurements

A discussion of wet versus dry weight analyses, together with techniques is given in Rumohr (1999). For faunal analyses where the emphasis is on community structure and species composition rather than sediment energetics, non-destructive wet weight analyses are recommended as detailed below:

All animals should be weighed before transfer to ethanol, complete with shell, tube etc. where appropriate. Wet weight measurements may be carried out at various levels of detail. The following solutions may be appropriate:

- the animals are weighed at the lowest identified taxonomic level, for each replicate sample. This is appropriate for research projects, or where information on the production of each individual species is required;
- key taxa are selected on the basis of prior knowledge of the dominant organisms. This gives some information on the production of species of ecological importance.
- the major taxonomic groups are weighed collectively after sorting. This can reveal broad trends in environmental disturbance.

There are arguments for and against removal of tubes from polychaete worms before biomass analyses. Including them may inflate the recorded weights. Completely removing all parts of the tube may cause undue damage to the specimens (depending on the expertise of the worker). Further, in some cases (e.g. mucus or calcareous tubes), the tube is entirely created by the animal, thereby using energy resources. The decision whether to include or exclude tubes, or whether to distinguish types of tubes (or even weigh them separately) should therefore be dictated by the individual survey aims and the fauna present.

The animals are weighed at room temperature after blotting with filter paper to remove residual fluid. Echinoids and the shells of large bivalves should be punctured to drain excess fluid. The animals are returned to the sample vial immediately after weighing.

Recently collected material is kept in buffered fixative for a recommended period of three months before wet-weight analysis, to stabilise the weight. Practical issues relating to survey demands may dictate earlier analysis, in which case absolute values may be unreliable, but spatial information may still be informative. The type of fixative/ preservative used should be specified.



Annex C (informative)

Sampling devices

Sampling devices should be constructed of stainless steel or other appropriate rust-free material,

Grab

The recommended types of grab are the van Veen grab, the Day grab and the Smith-McIntyre grab. The Hamon grab is also widely used in gravelly deposits. The top of the grab should be equipped with inspection ports, covered with fine mesh (0.5 mm pore aperture) netting and/or an overlying rubber, stainless steel or plastic flap. The flap is hinged and flexible, and attached such as to allow flow-through of water while the grab is being lowered to the bottom, and such that it closes while the grab is being raised, to prevent the surface sediment from being washed out of the grab or disturbed (important for background sediment samples). The weight of the grab is adjusted by assembling additional weights as required.

Hamon Grab

This is a frame-mounted grab with a lever-driven scoop action, widely used in gravelly sediments around the UK and English Channel. The sampling area is about 0.25 m² and the grab can be weighted according to sediment consistency. The Hamon grab is described in Elefteriou & Holme (1984).

Ponar Grab

The Ponar grab sampler consists of two opposing semi-circular jaws that are normally held open by a trigger mechanism. The sampler is lowered to the bottom where contact with the bottom sets off the trigger and a strong spring snaps the jaws shut trapping a sample of the bottom inside. Fine copper screen covers the top of the jaws so that the trapped material will not wash out as the sampler is retrieved.

Box-corer

Box corers are described in Elefteriou & Holme (1984). Light box-corers are the most appropriate for routine sampling purposes, but in general, these have a limited utility in sandy sediments. In special circumstances, larger box-corers with a sampling area of up to 0.25 m² (such as the Kastengreifer) may be used. These devices may be appropriate for sampling in deep water (> 750 metres). Use of these large sampling devices requires a large vessel with strong rigging, and the sampling generally is time-consuming.

Craib corer and multicorers

The Craib corer (Craib 1965) comprises a metal frame and a single cylindrical core that is pushed gently into the sediment by means of weights and a simple hydraulic mechanism. The top of the core is open during descent, almost eliminating the bow wave. After penetration, the top of the core is sealed with a rubber cork and the core raised, drawing the sample out by suction. Once the bottom of the core tube emerges from the sediment, another rubber cork swings into place such that the core tube is sealed at both ends. Multiple-tube corers have been developed using the same principle (Bowers & Connelly multi-corers, see www.oceanscientific.com). Various models are available with between 4 and 12 tubes, with a choice of two tube-lengths and diameters (64 cm or 110 cm). The smallest models are hand operated and are suitable for small boat work.

Craib-type corers function extremely well in soft muddy to sandy sediments, but are less suitable in gravelly or stony areas.

Further information is given in ISO 5667-12 annex J and Elefteriou & Holme (1984).

HAPS corer

The HAPS corer is a winch-operated cylindrical single core sampler mounted within a robust square-based frame. The core tube is pushed into the sediment by means of weights, after the device has settled on the bottom. The weights can be adjusted to compensate for sediment and weather conditions (up to 150 kg total weight). The HAPS corer is suitable for sampling in both soft and mixed/hard sediments. Commonly manufactured core tube diameters are 133 mm (stainless steel) or 140 mm (polycarbonate). The HAPS corer is sealed during ascent by a plane shovel that is pressed under the core during the onset of the hauling process.

The HAPS corer is together with other recent sampling devices depicted on the “Biological Effects Quality Assurance in Marine Monitoring (BEQUALM) website (see “Sitemap” at <http://www.asa-multimedia.de/benthos/framesets/Bequalm.htm>).

Wilson Autosiever

The Wilson Autosiever is a framework supporting the sieve containing the sediment sample. Underneath is a chamber of water within which a spinning spray head (dishwasher principle) is mounted, with the spray directed upwards. Waste sieved sediment is transported away via a pipe mounted on the underside of the water chamber.

Use of a Wilson Autosiever is a recommended option, particularly in areas where the sediment does not readily pass through the sieves. Its construction and instructions for use are given in Proudfoot et al. (1997).



Annex D (informative)

Useful faunal checklists and selected general works

Bellan-Santini, D., J.C. Lacaze & C. Poizat (1994). Les biocenoses marine et littorales de Méditerranée, synthèse menaces et perspectives. Museum Nat. d'Histoire Naturelle Paris. Collection Patrimoines Naturels. Vol 19. 246 pp.

Brattegard, T. & T. Holthe 1997. Distribution of marine, benthic macro-organisms in Norway. - Research report for DN (Directorate for Nature Management, Norway) 1997-1. ISSN 0804-1504, ISBN 82-7072-251-0.

Costello, M.J., C.S. Embrow & R. White (eds.), 2001. European Register of Marine Species. A check-list of the marine species in Europe and a bibliography of guides to their identification. *Patrimoines naturels* 50: 463p.

Gulliksen, B., R. Pallerud, T. Brattegard & J.-A. Snøli, 1999. Distribution of marine benthic macro-organisms at Svalbard (including Bear Island) and Jan Mayen. - Research report for DN (Directorate for Nature Management) 1999-4. ISSN 0804-1504, ISBN 82-7072-313-4.

Hayward, P.J. & Ryland, J.S. 1990. The marine fauna of the British Isles and north-west Europe. Volume 1. Introduction and protozoans to arthropods. Oxford: Clarendon Press. xvi+624 pp.

Hayward, P.J. & Ryland, J.S. 1990. The marine fauna of the British Isles and north-west Europe. Volume 2. Molluscs to chordates. Oxford: Clarendon Press. xvi+pp. 628-996.

Hayward, P.J. & Ryland, J.S. 1995. Handbook of the marine fauna of the British Isles and north-west Europe. Oxford: Oxford University Press. x+800 pp.

Howson, C.M. & B.E. Picton. 1997. The Species Directory of the Marine Fauna and Flora of the British Isles and surrounding seas. Pub. The Ulster Museum and The Marine Conservation Society, Belfast and Ross-on-Wye, 508pp.

Minelli, A., S. Ruffo & S. La Posta (eds) 1995. Checklist delle specie della fauna italiana. Calderini, Bologna.

National Oceanographic Data Center. 1996. NODC Taxonomic Code, Version 8 on CD-ROM. Note: This CD-ROM is no longer available as explained on the NODC website (<http://www.nodc.noaa.gov/General/CDR-detdesc/taxonomic-v8.html>). Please see the Integrated Taxonomic Information System (ITIS) web page regarding successor to NODC: <http://www.itis.usda.gov/>

North Sea Benthos Survey – ongoing project carried out within Benthic Ecology Working Group. Faunal information and taxonomic lists available at <http://www.vliz.be/vmdcdata/nsbs/index.htm>.

Sims, R.W., Freeman, P., & D.L. Hawksworth (Eds.). 1988. Key Works to the Fauna and Flora of the British Isles and North-western Europe. Fifth Edition. The Systematic Association, Special Volume No.33, 312pp.



Bibliography

- [1] Biological Effects Quality Assurance in Marine Montiroing (BEQUALM). Website <http://www.asa-multimedia.de/benthos/framesets/Bequalm.htm>.
- [2] Buchanan, J.B. 1984. Sediment analysis. In: Methods for the study of marine benthos, 2nd ed. Holme, N.A. & A.D. McIntyre (eds). Blackwell scientific publications, ISBN 0-632-00894-6
- [3] Elefteriou, A. & N.A. Holme, 1984. Macrofaunal techniques. In: Methods for the study of marine benthos. IPB Handbook 16, Blackwell Scientific publications, Oxford.
- [4] Fieler, R., M.J. Greenacre & T.H. Pearson 1994. Evaluation and development of statistical methods. Akvaplan-niva report no 750.92.347, 71 pp + Appendix.
- [5] GESAMP 1996. Monitoring of ecological effects of coastal aquaculture wastes. Rep. Stud. GESAMP 57. 45 pp.
- [6] HelCom 1999. Soft Bottom Macrozoobenthos Annex C-8 (<http://www.helcom.fi/Monas/CombineManual2/PartC/CFrame.htm>).
- [7] Holme, N.A. & A.D. McIntyre 1984. Methods for the study of marine benthos. Blackwell Scientific Publications, ISBN 0-623-00894-6.
- [8] Keegan, B.F. (ed.), 1991. Space and time series data analysis in coastal benthic ecology. An analytical exercise within the framework of the COST 647 Project on coastal benthic ecology. Commission of the European Communities, Report EUR 13978 EN.
- [9] Keegan, B.F. (ed.), 1991. COST 647: Coastal Benthic Ecology: Activity Report 1988-1991. Commission of the European Communities, Report EUR 13984 EN.
- [10] Munsell® Soil Color Charts, 1990. Munsell Color, Macbeth Division of Kollmorgen instruments corporation, 2441 North Calvert Street, Baltimore, Maryland 21218
- [11] NS 9423, 1998. Water quality – Guidelines for quantitative investigations of sublittoral soft-bottom benthic fauna in the marine environment. Norwegian General Standardizing Body (NAS), Oslo. 16 pp. (In Norwegian, English translation available from NAS)
- [12] OsParCom 1997. Eutrophication and Monitoring Guidelines: Benthos. JAMP (Joint Assessment and Monitoring Programme), Oslo and Paris Commissions.
- [13] Pearson, T.H. & R. Rosenberg 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. Ann. Rev. 16: 229-311.
- [14] Pérès & Picard 1964. Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec. Trav. Stat. mar. Endoume 31(47): 1-137.
- [15] Proudfoot, R.K., M. Elliott, M.F. Dyer, B.E. Barnett, J.H. Allen, .L. Proctor, N. Cutts, C. Nikitik, G. Turner, J. Breen, K.L. Hemmingway & T. Mackie. 1997. Proceedings of the Humber Benthic Field Methods Workshop, Hull University 1997. Collection and processing of macrobenthic samples from soft sediments; a best practice review. Environment Agency R&D Technical report E1-116, 47pp. + appendices. Peterborough, UK.
- [16] Rees, H.L. et al. (eds), 1991. Benthic communities: Use in monitoring point-source discharges. ICES Techniques in Marine Environmental Sciences, no. 16. 70 pp.

- [17] Rumohr, H., 1999. Techniques in Marine Monitoring: Soft Bottom Macrofauna: Collection, treatment, and quality assurance of samples. ICES Techniques in Marine Environmental Sciences, no. 27. 19pp (revision of no. 8).
- [18] Rees et al. 1990. Procedures for the monitoring of marine benthic communities at UK sewage sludge disposal sites. Scottish Fisheries Information Pamphlet No. 18 1990. ISSN 0309 9105.
- [19] Rees et al. 1991. Benthic communities: Use in monitoring point-source discharges. ICES TIMES no 16. Copenhagen. ISSN 0903-2606. 70 pp.
- [20] SFT 1997. Classification of environmental quality in fjords and coastal waters. Guidance document 97:03. Norwegian State Pollution Control Authority. TA-1467/1997, Oslo. 36 pp. ISBN 82-7655-367-2. In Norwegian.
- [21] SFT 1999. Environmental monitoring of Petroleum activities on the Norwegian Shelf; Guidelines. Norwegian State Pollution Control Authority (SFT) report 99:01. ISBN 82-7655-164-5; 123pp. (replaces SFT guidelines 90:01, but is still under revision).
- [22] UK National Marine Monitoring Programme 2000. The Green Book Monitoring Manual, (<http://www.marlab.ac.uk/greenbook/GREEN.htm>).

