REPORT OF THE

ICES/OSPAR STEERING GROUP ON QUALITY ASSURANCE OF BIOLOGICAL MEASUREMENTS RELATED TO EUTROPHICATION EFFECTS

ICES Headquarters
15–18 February 2000

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

The ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements Related to Eutrophication Effects (SGQAE) held its fourth meeting at ICES Headquarters, Copenhagen, from 15–18 February 2000, with Dr Hubert Rees (UK) chairing the meeting. A list of participants attending the meeting is attached as Annex 1. The Chair opened the meeting at 10.00 hrs on 15 February.

The Terms of Reference for the 2000 meeting of the Steering Group (SGQAE) were adopted by the ICES Council as ICES C.Res. 1999/2ACME05.

The **ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements Related to Eutrophication Effects** [SGQAE] (Chair: Dr H. Rees, UK) will meet at ICES Headquarters from 15–18 February 2000 to:

a) produce a final draft of OSPAR/ICES QA guidelines for biological measures, for review by the relevant specialist groups;

b) in joint session with SGQAB, review and agree on final versions of the ICES Biological Data Reporting Format and data entry program produced by the ICES Environmental Data Centre, and the latest draft of the OSPAR/ICES QA guidelines;

c) consider QA in relation to survey objectives and design, with particular reference to the outcome of discussions in the relevant ICES Working Groups and in other fora;

d) review progress in the application of JAMP guidelines and associated QA activities, especially the outcome of workshops/intercomparison exercises, by OSPAR Contracting Parties;

e) further evaluate criteria for judging the acceptability of biological data in international monitoring programmes;

f) compile a programme of planned biological workshops/intercalibration exercises/ring tests, etc., relevant to ICES/OSPAR activity, covering the years 2000 and 2001;

g) review the outcome of activities of SGPHYT, and of other comparable efforts in compilation of species lists, with emphasis on QA aspects;

h) discuss the scientific and QA merits for inclusion of additional parameters (especially zooplankton and primary production) in monitoring the effects of eutrophication, in consultation with the relevant working groups;

i) review the outcome of an evaluation, by BEWG, of benthos standard operating procedures (SOPs) and make appropriate recommendations, including the possibility of extending the exercise to other biological measures;

j) follow up results obtained within the BEQUALM project, with the aim of producing recommendations relevant to JAMP guidelines;

k) review QA aspects of a standard method for chlorophyll *a* determination to be finalised by MCWG and WGPE.

SGQAE will report to the ACME before its June 2000 meeting and to the Marine Habitat and Oceanography Committees at the 2000 Annual Science Conference.

2 APPOINTMENT OF RAPPORTEUR

Dr Kari Nygaard was appointed rapporteur.

3 ADOPTION OF AGENDA

The agenda was adopted without amendments, and is attached as Annex 2.

4 REVIEW OF RELEVANT BIOLOGICAL STUDIES AND RELATED QA ACTIVITIES BY COUNTRY AND BY DISCIPLINE, ESPECIALLY RECENT AND PLANNED FUTURE PROGRAMMES

4.1 Belgium

The following information was communicated by Veronique Rousseau (ESA-ULB, vrousso@ulb.ac.be) who was unable to attend the meeting.

Three Belgian laboratories are responsible for monitoring biological parameters related to eutrophication effects, i.e., chlorophyll *a*, phytoplankton and macrozoobenthos as well as related environmental parameters.

4.1.1 MUMM (Management Unit of the North Sea Mathematical Model) – Brussels, Laboratory in Ostende

This laboratory is responsible for the Nutrient Monitoring Programme (OSPAR Convention) and is currently developing a holistic quality control system which includes the production of a Quality Manual. It aims to achieve national accreditation through BELTEST (beltest.be). SOPs for the different analyses currently exist.

Several informal intercalibration exercises for nutrients and chlorophyll *a* measurements have been undertaken with RIKZ (NL). Since 1994/1995, joint cruises have been organized on both Belgian and Dutch research vessels for the intercalibration of chlorophyll *a*, nutrients, temperature, salinity, suspended matter, and oxygen. These annual exercises cover all aspects of analysis, including sampling.

MUMM also participates in QUASIMEME laboratory performance studies (round 17, exercise 386, DE-6 Chlorophyll *a* in sea water and standard solutions) and will be attending the forthcoming QUASIMEME Workshop (Büsum, Germany), 11–18 May 2000.

4.1.2 ESA (formerly GMMA; Ecology of Aquatic Systems) – ULB, Brussels

This laboratory conducted an intercalibration exercise for major inorganic nutrients and chlorophyll *a* with MUMM, which took place during a common cruise on board R/V 'Belgica' in January 1999 along an offshore gradient from the Scheldt Estuary to the offshore limits of the Belgian continental shelf. It consisted of direct comparisons of sampling and laboratory analysis. Sampling was performed by two methods: a bucket (surface sample) used by ESA for monitoring *Phaeocystis* colonies in order to avoid disruption of the colonies, and Niskin bottles for deeper samples (3 m). An analysis of the results is currently in progress.

ESA participated in the intercalibration exercise as part of the EC-funded BEQUALM project: Phytoplankton Interlaboratory Ring Test, Part I. Microscopic work is currently in progress. They will participate in the follow-up workshop (V. Rousseau) to be held in Büsum (30 March–2 April 2000), where the results of this exercise will be presented and discussed.

Although SOPs are not available for phytoplankton enumeration and biomass, the methods used are regularly evaluated through internationally peer-reviewed papers.

4.1.3 DVZ (Department voor Zeevisserij; Sea Fisheries Department) – Ostende

DVZ has not performed any intercalibration to date due partly to the high diversity of taxa encountered in their macrozoobenthos samples. However, DVZ has shown interest in participating in future intercalibration exercises. They currently use SOPs.

4.2 United Kingdom

4.2.1 Eutrophication-related studies

The second phase of a nationally funded 'Joint Nutrient Study' (JONUS II) was completed in March 1999. An account of earlier work under this project was given at a previous SGQAE meeting. Possible follow-up work will include an evaluation of ecosystem-related consequences of eutrophication, including scope for development of ecological quality objectives (EcoQOs) and basic research on the effects of nutrient enrichment on plankton/benthos. Also, changes in N:P ratios in relation to the composition of phytoplankton communities will be investigated.

From April 2000, scientists at the CEFAS Laboratory, Lowestoft, will be engaged in a study entitled 'The fate and transport of UK nutrients in the southern North Sea', with special reference to the plume off the English east coast arising from efflux from the Humber/Wash and Thames rivers. An important question which the work will seek to address is: Does the plume extend to the Friesian Front or move north? The work is linked to a Dutch study entitled 'Plume and Bloom', also concerned with the transport of nutrients from UK sources to the Friesian Front, and including work on plankton and benthos.

Eutrophication-related monitoring activities under the auspices of the UK National Marine Monitoring Programme are continuing.

The Environment Agency (EA) is developing a strategy for dealing with and studying eutrophication around the England and Wales coastline; publication is awaited. Work to develop an EA Marine Procedures Manual is also continuing; this presently covers marine sampling and laboratory analytical methodology for benthos. Procedures for studying any effects of eutrophication (e.g., on micro-algae and *Enteromorpha*) are in preparation. In response to the requirements of the EC Urban Waste Water Treatment and 'Nitrates' Directives, the EA is seeking to identify candidate 'sensitive areas', on grounds of the occurrence and frequency of algal blooms, excessive benthic algal growth and other eutrophication-related measures. For these areas, management plans will be developed for remedial action to reduce nutrient inputs, and to implement a monitoring programme to evaluate progress.

A research initiative of the UK Natural Environment Research Council ('GANE': Global Nitrogen Enrichment; www.nerc.ac.uk/science/gane) aims to address the UK interest in the global issue of nitrogen enrichment. The programme covers soils, vegetation, freshwaters, coastal oceans and the atmosphere, and will address the following key questions:

1) the transformation and pathways of reactive N;
2) quantifying N fluxes at large temporal and spatial scales (from landscape to the globe); and
3) impacts on N-sensitive semi-natural ecosystems and coastal waters.

(Further details of 'GANE' were made available to SGQAE members.)

4.2.2 UK National Marine Biological Quality Control (NMBAQC) Scheme

The role of the UK NMBAQC Scheme has been reported in previous SGQAE reports. In order to brief new members of SGQAE, an overview of the Scheme was presented and recent developments were reported for the benefit of all members.

The need for good in-house quality assurance right from the survey design stage, through to sampling, sorting, identification, enumeration and data analysis, and finally, to reporting was strongly emphasised. Taxonomic excellence is redundant if the samples have been carelessly collected, poorly preserved or badly sorted.

The need for laboratories to maintain Reference collections was stressed, as this would provide a tool for future correction of data sets when misidentifications are discovered, e.g., as the result of advances in taxonomic knowledge.

The Scheme also highlights the ongoing problems associated with biomass determination of individual species. Consideration needs to be given to the provision of a standardised protocol and reporting format. It is important that the agreed format should neither destroy the specimens nor render them indistinguishable.

The NMBAQC Co-ordinating Committee is initiating a process for externally auditing the Scheme and is currently engaged in contracting an independent evaluator.

4.2.3 Marine Life Information Network

The 'Marine Life Information Network' (MarLIN) is a Plymouth-based project aimed at synthesising the large array of data on marine life around Britain and Ireland into a manageable and accessible form. It consists of three sub-programmes: 'biological recording centres and education', 'biology and sensitivity key information' and 'seabed data acquisition'. Systems are being developed for addressing the quality of data used in compilations. Further details of the scheme appear in Annex 3.

4.3 The Netherlands

4.3.1 Eutrophication-related work

The national monitoring programme covering Dutch salt and brackish waters is carried out under the auspices of the National Institute of Coastal and Marine Management (RIKZ). The programme involves the sampling of phytoplankton, zooplankton, zoobenthos, phytobenthos, birds and sea mammals. In addition to this national programme, an account of two other relevant works was presented. The outcome of the first project has recently been released in a report entitled 'Eutrophication and productivity in the North Sea' (in Dutch, with a summary in English). This report gives an overview of the effects of eutrophication between 1975 and 1995, and the effects of control measures since 1987. Compared to 1985, the phosphate concentrations in the Dutch coastal zone have decreased by approximately 60 %, while the nitrogen concentration has not decreased significantly (and is still too high). The report focuses in particular on the question concerning to what level P and N should be decreased to minimise the risk of oxygen deficiency and harmful algae, and at what level this decrease will negatively affect shellfish and fish production. Experimental work (mesocosms) is being carried out on the effects of different nutrient reduction schemes. In combination with the outcome of field studies, it is concluded that the foam-forming alga *Phaeocystis* is sensitive to decreases in both P and N. As *Phaeocystis* is regarded as a less suitable food source, no negative effect is expected on fish production. Reductions in nitrogen loading will mainly affect the growth of summer phytoplankton. A reduction of more than 50 % will affect the benthic fauna.

Secondly, there was a short presentation on the Friesian Front project that was carried out in September 1999 by RIKZ in cooperation with NIOZ (Texel). This unique and nutrient-rich area in the Dutch part of the Continental Shelf received a lot of attention in the 1970s. The Friesian Front is a well-known area because of the diatom blooms ('green curtain') and the densities of zooplankton, benthos, fish, and seabirds, which are about 2–3 times higher than at other southern locations. Results from the national benthos monitoring programme re-stimulated interest in the Friesian Front because of a dramatic decrease in benthos abundance, in particular, *Amphiura filiformis*, in the 1990s. Possible reasons include a change in sediment composition, food availability or predator pressure. At about 60 locations, the seabed and water column were sampled to measure a variety of parameters (grain size, POC, chlorophyll, elemental composition, clay composition, pollution, phytoplankton, macrofauna, megafauna, bacterioplankton, salinity, temperature, oxygen, nutrients, chitobiase activity and transparent particles). Locations near the Brown Bank formation are also included in the survey area. Presently, the data are being processed. Early results show that, in addition to a period of winter erosion, there is an erosion of the Brown Bank clay during each tidal cycle, producing a clear plume of silt and clay in the direction of the Friesian Front. The Friesian Front project has led to new projects that are planned for 2000 (e.g., 'Plume and Bloom'; see also Section 4.2, above), which will map the seasonal dynamics of the plankton communities in English coastal waters. Access to the data is possible on the internet at http://kellia.nioz.nl.

4.3.2 QA activities

Departments responsible for sampling programmes have established quality assurance procedures. In 1999 an intercomparison was carried out between Belgian and Dutch sampling ships. All the sampling as well as analyses are carried out according to internal SOPs.

Further QA-related activities are under way for the monitoring of phytoplankton in the North Sea. Analyses of nutrients, including chlorophyll, are done at the RIKZ laboratory. In summer 1999, this laboratory was accredited by STERLAB and the yearly certification has recently been prolonged to include 2000. In summer 1999, QUASIMEME organised a chlorophyll ring test in which RIKZ, who carry out the analysis, also participated. Using the HPLC method, they performed very well. The analysis of phytoplankton is contracted to a company which is also QA certified. At the moment, the Netherlands participates in the BEQUALM phytoplankton intercomparison. Within the Fifth Framework Programme of the EU, a (modified) proposal will be submitted on the QA of phytoplankton (coordination by A. Zingone, Italy; Dutch participation by P.V.M. Bot, RIKZ).

4.4 Norway

4.4.1 Monitoring

The National Coastal Monitoring Programme, operating since 1989 (described in the 1999 SGQAE report), has been extended for another five years. A ten-year summary report will be available in December 2000. Weekly updated information regarding selected harmful algae continues on the internet at http:\\www.imr.no.

4.4.2 Norwegian standard for the study of rocky habitats

A Norwegian standard for supralittoral, littoral, and sublittoral rocky habitats will be available by the end of 2000. A committee has been appointed by the Norwegian standardisation agency, representing the following organisations: DNV, NMR, UiO, IFM, NFH, NAS, NINA, NIVA, NP, SINTEF, SFT. The first draft will be finished by spring 2000. Macro-organisms included in the standard are: phytobenthos, non-mobile or slowly moving zoobenthos.

4.4.3 Guidelines—soft-bottom fauna

Akvaplan-NIVA (sabine.cochrane@akvaplan.niva.no) has been contracted to produce an ISO-standard guideline for quantitative investigations of marine soft-bottom benthic fauna in the marine environment. The guidelines will be based on existing national and international standards. The final draft will be finished by December 2000.

4.5 Germany

4.5.1 Monitoring

The German National Monitoring Programme places a strong emphasis on quality assurance of all associated activities, as previously reported to SGQAE. Further details of QA activities in relation to data management are given under Section 16, below.

4.6 Forthcoming Workshops and Ring Tests

Dr Sunhild Wilhelms provided information on forthcoming workshops/ring tests relevant to the QA of biological measures in connection with the German National Monitoring Programme (Annex 4, Table 1). SGQAE also compiled a list of other relevant activities known to participants. This is provided in Annex 4, Table 2.

5 QA ISSUES ARISING FROM DISCUSSIONS WITHIN ICES WORKING GROUPS

5.1 ICES Working Group on Phytoplankton Ecology (WGPE)

Relevant items from WGPE included a review of a draft ICES standard procedure for chlorophyll *a* determination; WGPE proposed to adopt the specified methodology noting that, if other methods were used, then these must be shown to produce comparable results. However, it was noted from the report of Lars Edler to SGQAB 2000 that developmental work relating to this manual is continuing. See also SGQAE comments under Section 12, below.

WGPE also noted the importance of a checklist of phytoplankton species for the ICES/OSPAR area for the effective input, use, and archiving of biological data in the ICES database.

5.2 ICES Benthos Ecology Working Group (BEWG)

At this meeting, Dr Rees reported on the outcome of a review of Standard Operating Procedures (SOPs) (see also Section 11, below). A request was made for further submissions, to allow specific sampling and analytical procedures to be addressed. An account of the activities of the UK National Marine Biological AQC Scheme was also presented. Dr Rumohr outlined progress within the EC BEQUALM project, and emphasised the importance of workshops for enhancing taxonomic expertise among collaborating institutes. The role of certification of individual expertise was also discussed. It was noted that the ICES database would also need to allow for frequent changes in taxonomic nomenclature in line with future research.

An updated inventory of published guidelines for benthos sampling was presented by Dr Rees (this is given in Annex 5 of the present report). Requests for comments on the SGQAE draft guidelines were sought. For its 2000 meeting, the BEWG will *inter alia* agree a final draft of the SGQAE guidelines, prepare guidelines for epibiota sampling, and discuss data banking issues (including data exchange) in relation to ICES work on a biological data reporting format.

6 ACTIVITIES OF OTHER INTERNATIONAL QA GROUPS

6.1 EC BEQUALM Project

Details of relevant activities are provided separately under Section 7, below.

6.2 Workshops on Ecological Quality Objectives for the North Sea

Reference was made to the report of a workshop on Ecological Quality Objectives for the North Sea, held in the Netherlands in September 1999, and published by the Nordic Council of Ministers (TemaNord 1999:591). The Workshop was organised by the Netherlands, Norway, the EC, ICES and the 5th North Sea Conference Secretariat. SGQAE emphasised that, in any future application of such an approach, sound data quality would be essential for the evaluation of spatial and temporal trends, especially where comparisons are made between countries. In the absence of guaranteed consistency, conclusions could be misleading and could have serious (and costly) consequences in terms of management action.

6.3 SGQAC Questionnaire on Laboratory Analytical Performance

SGQAE noted a report on the outcome of the circulation of a questionnaire by SGQAC, concerning laboratory analytical performance in the Baltic Monitoring Programme. There may be benefits to a comparable exercise covering biological QA/AQC activities in the OSPAR area, to identify *inter alia* strengths and weaknesses in current approaches, provided that the questions are well formulated, do not impose an unnecessary burden on laboratory staff, and guarantee confidentiality in reporting the outcome. SGQAE proposed to further consider the merits of such an approach at its next meeting (see Recommendations, Annex 14).

6.4 QA Manual (University of Sydney)

Dr Heye Rumohr reported on a new Quality System used in the Centre for Research on Ecological Impacts of Coastal Cities (EICC) at Sydney University in Australia. This manual was issued by Prof. A.J. Underwood and circulated to all members of the EICC, all staff engaged in projects contracted by the centre, and project leaders of external consultancies for projects contracted by the EICC, in order to give clear procedures for responsibilities in contracted projects. It covers survey design, review of designs, management issues, and control of documents. For further details, see Annex 6.

6.5 Data Management Workshops

Dr Sunhild Wilhelms informed SGQAE that, within the ICES Working Group on Marine Data Management (WGMDM), quality assurance guidelines for CTD, current meters, nutrients, and chlorophyll data are being developed as part of a wider initiative to cover all types of marine data. More information can be found on the ICES web site at http://www.ices.dk/ocean.

Mention was also made of the EEA/EIONET work groups on data management, GIS, and zoning.

6.6 SGQAB

SGQAE took note of the 1999 SGQAB report. Much of the activity at this meeting involved final revision of sections of the HELCOM COMBINE Manual. An initial review of the draft ICES Biological Data Reporting Formats was conducted jointly with SGQAE.

6.7 QUASIMEME – Chlorophyll *a*

SGQAE also took note of the generally encouraging outcome of a QUASIMEME laboratory performance study for the determination of chlorophyll *a* and phaeopigments in sea water (‘QUASIMEME Laboratory Performance Studies Round 17’. Report for Exercise 386 m DE-6 Chlorophyll *a* in Sea Water and Standard Solutions, April to June 1999).

7 REVIEW PROGRESS OF THE EC BEQUALM PROJECT

Dr Heye Rumohr gave a review of the progress of the BEQUALM project, in particular, work packages 8 and 9 (Phytoplankton communities and Chlorophyll *a*, and Benthic Community Analysis, respectively). He informed SGQAE about the second BEQUALM newsletter that was recently issued and can be downloaded from the CEFAS web page at http://www.cefas.co.uk/bequalm/bequalmnews2.pdf.

He gave a short presentation on the Second International HELCOM/BEQUALM Benthos Taxonomic Workshop in Hamburg, 7–11 February 2000. Twenty participants from European countries, nine of whom work with Baltic benthos, met at the Zoological Institute of Hamburg University to participate in taxonomic expert seminars on crustacean groups such as Amphipoda, Isopoda, Decapoda, and others. Special identification keys, literature, and other materials were available at the workshop (see Annex 7).

Samples for a BEQUALM ring test on macrobenthos have been distributed to twenty participating laboratories in Europe and the return of the data is expected within two months. Both sorting efficiency and taxonomic skills will be tested and compared in this ring test. Information about this project can be obtained from H. Rumohr (hrumohr@ifm.uni-kiel.de).

Dr Rumohr also gave a short account of forthcoming activities in the Phytoplankton Project, including a workshop planned for 30 March to 3 April 2000, to discuss the outcome of the first BEQUALM phytoplankton ring test conducted in November 1999. The workshop will be held at the FTZ Centre in Büsum (see Annex 4, Table 1, for details).

A second workshop, also at the FTZ, will evaluate different methods for determining chlorophyll *a* contents in samples. This workshop will be held in conjunction with QUASIMEME, who deal with the same problems. The workshop will be held 11–14 May 2000. Further information can be obtained from Prof. F. Colijn (colijn@ftz-west.uni-kiel.de) or Dr Recker (recker@ftz-west.uni-kiel.de). See also Annex 4, Table 1.

8 REVIEW ICES BIOLOGICAL COMMUNITY DATA REPORTING FORMAT AND DATA ENTRY PROGRAM (JOINT MEETING BETWEEN SGQAB AND SGQAE)

8.1 Draft ICES Biological Community Data Reporting Format

The ICES Environmental Data Scientist, Jørgen Nørrevang Jensen, informed the joint meeting about recent developments in the ICES database structure for biological community data measurements. The database will be an ACCESS database. The draft ICES Environmental Biological Community Data Reporting Format (http://www.ices.dk/env/) listing parameters to be included in the biological community database was presented and commented on by SGQAE participants. For the time being, the data exchange format will be ASCII–DOS files. As these are still draft formats, further comments to the list can be sent to J.N. Jensen by e-mail.

Three possibilities for data exchange in the future are planned or being considered:

1) ASCII files, which will be converted to ACCESS upon arrival.
2) Files produced by BDE **–** Biological community data entry program, which is still under development**,** for reporting institutes that have not yet developed a database for biological community data.
3) A spreadsheet data exchange format that will make it possible to report using, e.g., EXCEL or comma-separated ASCII files. This possibility is being considered by ICES.

J.N. Jensen took note of written comments submitted by Germany, Belgium, and the UK.

There was a strong demand from the participants to develop the data exchange formats to include a spreadsheet format. There was considerable frustration due to the continued delay. Some of the participants indicated that they would not be able to supply biological community data to ICES until Option 3 is available. Germany refused to use the ASCII-format data exchange for biological community data and will not submit biological community data until the database meets modern standards for data exchange with the possibility to submit data in spreadsheet form (EXCEL).

J.N. Jensen acknowledged this problem, which is partly a function of constraints imposed on ICES by earlier specifications for the database structure and partly due to manpower limitations. The difficulty with further development of Option 3 (above) should be resolved with the planned appointment of an ICES database manager, which is expected as early as November 2000. The development of Option 3 might therefore not be finalised until mid-2001. ICES will also take an initiative to arrange a workshop for data originators submitting data for OSPAR, HELCOM, or AMAP programmes in November 2000, in order to discuss practical issues relevant to data handling procedures. Further minor amendments to the data exchange specifications were passed on to J.N. Jensen.

The Finnish participant pointed out that the Contracting Parties of HELCOM and OSPAR are very disappointed about the delay in the development of the database, reporting format, data exchange and data entry program. He recommended that ICES be more flexible not only for the sake of ICES' reputation but also to meet actual data management needs.

8.2 Review of SGQAE Draft QA Guidelines

SGQAB was content with the progress so far, noting that the Guidelines have been drafted specifically to address issues relating to biological measurements under the SGQAE remit, and that elements of the final version would also be helpful for HELCOM activities, alongside the COMBINE Manual.

9 PRODUCE FINAL DRAFT OF OSPAR/ICES GUIDELINES FOR QA OF BIOLOGICAL MEASURES

Further progress was made in developing QA guidelines for biological parameters, although not to the stage of producing a final draft. An amended draft is given in Annex 8.

10 REVIEW PROGRESS IN THE PREPARATION OF TAXONOMIC LISTS, ESPECIALLY PHYTOPLANKTON (VIA ACTIVITIES OF SGPHYT)

10.1 Phytoplankton

Lars Edler, Chair of the Study Group on an ICES/IOC Checklist of Phytoplankton (SGPHYT), reported on progress to SGQAE. SGQAE noted that a questionnaire on criteria for a phytoplankton checklist is being planned. At present it is proposed that the checklist be structured according to different marine areas. The draft SGPHYT report is to be presented at the WGPE meeting in April 2000, and the complete version will be available at the ICES Annual Science Conference in September 2000.

10.2 Decapod Crustaceans

Dr Rumohr presented a list of 130 decapod species in the North Sea and the Baltic Sea, compiled by Dr Micheal Türkay from the Senckenberg Museum in Frankfurt, which provides an up-to-date and detailed listing of decapod crustaceans in the North Sea, Skagerrak, Kattegat, Belts and Sound, and in the Baltic Proper. The list includes a family key to decapod families in the area (see Annex 9).

10.3 Coding/Checklists for the Netherlands Biota

The coding of all Dutch biotaxa is done according to the IAWM (Inter Ambtelijke Werkgroep Milieukartering) code, a hierarchical 10-character code. Activities are under way for the development of a new coding system (TCN, Taxon Code Nederland) in which a non-hierarchical number is assigned to each species.

For the analysis of Dutch phytoplankton, an annotated species list is used.

10.4 Checklist/NODC Coding of UK Marine Biota

The second edition of the 'Species Directory of the Marine Fauna and Flora of the British Isles and Surrounding Seas' was published in 1997 and is a standard reference source for UK work. The species coding system is non-hierarchical; D. Moore (FRS, Aberdeen) has succeeded in applying hierarchical NODC codes (with US NODC assistance) to all species, with the exception of plants, listed in the UK directory. A CD ROM will be released as soon as permission from the publisher is obtained.

10.5 European Register of Marine Species

This project, sponsored by the EC, is nearing completion, and a comprehensive list of marine species, together with documentation of taxonomic keys and experts in the field, should be available after March 2000. Information on this project is available via the internet at http//www.erms.biol.soton.ac.uk/index.shtlm.

11 CONSIDER THE OUTCOME OF A REVIEW OF BENTHOS SOPs AND THE POSSIBLE BENEFITS OF CONDUCTING A COMPARABLE REVIEW OF SOPs COVERING OTHER BIOLOGICAL MEASURES

Dr Rees presented the results of a review of submitted SOPs for macrozoobenthos studies from various countries, conducted on behalf of the ICES BEWG. The aim was to identify examples of good practice, and to promote harmonisation in approaches to field sampling and laboratory analysis, as revealed though these documents. Although the response to a request for submission of SOPs was disappointing, the exercise was useful in identifying variability in approaches, and in allowing basic recommendations to be made concerning format and content. There would be benefits to reviewing SOPs for other biological measures, if sufficient support were forthcoming. It was important to emphasise that any material submitted would be treated in confidence, and that the source laboratories were not named, unless they specifically wished to be identified. A summary of the outcome is given in Annex 10.

As a follow-up to the above exercise, the UK National Marine Biological AQC Committee is undertaking a review of Standard Operating Procedures (covering both field sampling methodology and laboratory analysis) employed by participating laboratories. Again, the aim is to identify and report on examples of good practice and, in cases where inconsistencies are identified, to advise on means for future improvement in order to promote harmonisation in approaches between laboratories.

So far, procedures covering a wide variety of tasks, both field and laboratory-based, have been received from six of the fourteen NMBAQC participants. Many of the procedures show that individual laboratories are working to detailed procedures, some of which include measures to ensure the quality of collected data. However, differences in approaches have been identified which may have implications, particularly where more than one laboratory is contributing to a programme of study.

Finally, reference was also made to the submission of standard procedures for Belgian benthos work (submitted by Dr Rousseau).

12 REVIEW QA ASPECTS OF A STANDARD METHOD FOR CHLOROPHYLL *a* DETERMINATION

SGQAE discussed the draft for a chlorophyll *a* methodology prepared by Alain Aminot and Francisco Rey as a proposed standard procedure for the ICES area, to be published in the ICES TIMES series.

12.1 General Comments

The standard method described is no longer the most common method used in many countries. SGQAE therefore recommends that the method be circulated to major research institutes and laboratories in the HELCOM and OSPAR areas for an additional expert review before it is accepted.

12.2 Specific Concerns

One specific comment concerns item 3.2 Filtration, which states '…Carry out filtration within one hour after collection of the sample…'.

It was considered that, in practice, this will be impossible for most research institutes and laboratories to accomplish, and the following amendment was proposed:

'…within 24 hours after collection of the sample, which has been stored cold in opaque bottles'.

13 QA IN RELATION TO SURVEY OBJECTIVES AND DESIGN

There is a need to firmly establish linkage between QA of analytical work, the overall objectives of a survey, and the means by which such objectives are achieved. Since objectives may range from, say, a descriptive exploratory survey of a wide area, to detailed quantitative evaluation of trends in relation to a marginal change in nutrient status of waters, then, in principle, it may be permissible to vary the required level of accuracy and precision on the grounds of cost-effectiveness. For benthic studies, an example would be the requirement for species-level identification, as opposed to identification at a coarser level of taxonomic resolution, which has been advocated by some workers as an acceptable approach for certain types of investigation. In the case of phytoplankton studies, where the goal is to identify occurrences of potentially toxic species then, clearly, identification to this level is required.

Survey objectives may change during the course of a study, e.g., an initial descriptive survey may lead logically to the targeting of sub-areas of concern, at which more precise and accurate determinations are required, at an enhanced sampling frequency appropriate to seasonal or annual variations in the influence of concern.

Such considerations emphasise the importance of incorporating an element of *flexibility* into established monitoring programmes, allowing regular reviews of the linkage between the planning and execution of surveys on the one hand and appraisals of the analytical outcome on the other, with the option to modify survey and sampling methodologies accordingly. These aspects are further discussed in the draft QA guidelines document (Section 9), and also have an important bearing on criteria for compliance monitoring (see Section 16).

The principles involved in the quality assurance of programme design are well documented in TemaNord (1997) and a summary appears in the SGQAE draft QA guidelines document (Annex 8).

14 FUTURE ROLE OF SGQAE

The ICES Environment Adviser, Janet Pawlak, outlined the expectations of OSPAR concerning future output from SGQAE, and the required time scale.

Several practical points were raised concerning SGQAE activity. For example, SGQAE may have a significant future role in data evaluation, including agreement on criteria for evaluating the acceptability of biological data, recommendations concerning the use of appropriate community indices, and establishing relationships between biological measures and nutrient concentrations in eutrophication studies.

It was recognised that the erratic but generally low support provided by OSPAR Contracting Parties to date has placed an unreasonable burden on core participants, despite the importance of the issues dealt with for the effective conduct of harmonised monitoring programmes at the international level (see below). This may partly reflect the focus on eutrophication issues that, for political reasons, may inhibit interest from certain Member Countries. A solution might be to extend the remit of SGQAE and change the name of the group (as proposed in the 1997 SGQAE report) to the Steering Group for the Quality Assurance of Biological Measures in the Northeast Atlantic Area.

Dr Rumohr proposed the merging of SGQAE with SGQAB in view of the significant overlap on many of the important QA issues of interest and the fact that both groups have suffered from low attendances and high turnover rates. This was strongly supported by SGQAE members, for the following reasons:

a) SGQAE noted the growing reliance on measures of biological change in environmental quality assessments at all levels, including international programmes within ICES, OSPAR, and the EU. This has been stimulated not only by concerns over the *eutrophication* of marine waters, but also by the necessity to control other sources of pollution as reflected in a variety of EU directives, and developing interests in the conservation of *marine biodiversity* and *habitats*.
b) At the same time, systems for ensuring the quality of biological data have generally lagged far behind those for ensuring the quality of chemical data, with the result that severe difficulties have been experienced in syntheses of data from collaborating countries, e.g., in relation to the preparation of *Quality Status Reports* for the OSPAR maritime area.
c) Sound QA of biological measures is therefore of *fundamental and continuing importance* to the successful conduct of international assessments of environmental quality. This is the rationale for the creation of SGQAE to cover QA issues for the OSPAR area, alongside SGQAB (its earlier counterpart) which addresses HELCOM interests in the Baltic Sea.
d) In recognition of this important role, SGQAE recommends that its remit be extended to cover QA of all biological measures used in marine monitoring in the Northeast Atlantic area, and that such a task will be best served by merging its activities with those of SGQAB, to the mutual benefit of both groups (such a proposal was also considered and supported by SGQAB at its February 2000 meeting).

Further discussion on the future role of SGQAE is reflected in the Recommendations (see Annex 14).

15 CONSIDER THE MERITS OF ADDITIONAL PARAMETERS (E.G., ZOOPLANKTON AND PRIMARY PRODUCTION) IN MONITORING EUTROPHICATION EFFECTS

SGQAE felt that there was a strong case for the inclusion of zooplankton in OSPAR/ICES eutrophication-related studies because of their potential value as an interpretative aid, e.g., with respect to interactions with phytoplankton populations, and as indicators of environmental degradation. (It was noted that zooplankton studies will be included as a component of monitoring work under the EC Water Framework Directive.) However, it was recognised that there would be a need to carefully identify measures appropriate to the robust estimation of changes in populations, e.g., diversity and biomass. As a result, SGQAE recommended that expert advice on the scope for the inclusion of zooplankton studies in monitoring programmes, including consideration of appropriate sampling and analytical measures, be sought from the ICES Working Group on Zooplankton Ecology (WGZE).

SGQAE noted with satisfaction that the long-awaited Zooplankton Methodology Manual (Harris *et al*., 2000) has just been published (see Annex 11). The Manual provides an up-to-date basis for the development of further QA measures in zooplankton investigations.

SGQAE also felt that there was a strong scientific case for the inclusion of a measure of primary production in ICES/OSPAR monitoring, because of the potential sensitivity of the measure to changes in eutrophication status. SGQAE recognised that, in addition to considerations of the accuracy and precision of a selected method, critical QA aspects include the importance of matching what is known about the process being measured with the timing and spatial scale of sampling effort. Automated measures (e.g., chlorophyll fluorescence) used in towed bodies or moored buoys may satisfy issues concerning spatial and temporal scales, but probably at the expense of precision of the measure. SGQAE therefore recommends that the ICES WGPE consider the practical benefits and drawbacks of the inclusion of currently available measures in eutrophication-related monitoring studies.

16 CRITERIA FOR EVALUATING THE ACCEPTABILITY OF DATA: ‘COMPLIANCE’ MONITORING

This issue is particularly challenging with respect to the outcome of studies of plants and animals at the community level.

16.1 German Experience

Dr Wilhelms noted that the first criterion governing the acceptability of data submitted by laboratories to the German National Monitoring Database was compliance with the required data reporting formats, which are developed in the relevant National QA Working Groups. The second criterion concerned the completeness of data sets (results, methods, QA information, accompanying measurements, etc.) with regard to species records, i.e., the specification of correct Latin names for genera and species, and the listing of taxonomic keys used in identifications. (A central species list is maintained to facilitate checking.) Information is also required on whether or not laboratories are accredited and have participated in AQC exercises. As yet, there is no ‘flagging’ system as such to reflect variability in the performance of individual laboratories in such exercises and, hence, variability in data quality, but doubtful data are filtered by means of comparisons of recent data sets with previous submissions.

16.2 Dutch Experience

In the Netherlands, a significant amount of biological work for national monitoring is contracted out and, hence, systems are in place to evaluate the completeness and quality of submitted data, e.g., with respect to compliance with SOPs. Accreditation is an important criterion when selecting a laboratory. Data are submitted to the Dutch national database and have to meet the required reporting format and are checked for completeness.

16.3 Norwegian Experience

Norway does not maintain a national database—NIVA is the reference centre for environmental data. A filtering system for data quality operates through a requirement for laboratory accreditation, implying conformity with national standards, and adequate performance in periodic ring tests and other AQC exercises.

16.4 UK Experience

Case studies of the UK experience with the application of criteria for evaluating the quality of data submitted to the 'National Marine Monitoring Programme' have been outlined in earlier SGQAE reports. These include specifications for acceptable errors in species identifications, species counts, and biomass determinations.

One difficulty is the arbitrary nature of the limits set upon acceptance or rejection of data, in the absence of any direct linkage with operational survey objectives, such as the detection of a specified degree of biological degradation in response to a pollution influence or, more widely, the **significance** of detectable changes relative to, say, ecosystem function, fisheries resources or human health. Nevertheless, while efforts to improve cause-effect linkages in studies continue, it seems entirely reasonable to proceed, as at present, with a narrower QA focus on analytical competencies, based upon pragmatic judgements as to the level of achievement that can realistically be expected from the majority of participating laboratories.

Earlier limits for acceptable error set by the UK AQC scheme are presently the subject of an independent review (by I. Rees, University College of Wales, Bangor). One interesting suggestion has been to weight the outcome of ring tests for identification proficiency according to the perceived difficulties presented by individual taxa. This is a variation of an earlier attempt to weight taxa according to their perceived importance in a pollution monitoring context which, in practice, proved difficult because of a strong element of subjectivity in dealing with the large array of 'rare' species typically encountered in survey work, for which little or no knowledge exists concerning their sensitivities.

Another interesting observation concerns the effects, on a hypothetical quantitative data set, of misidentifications of rare, common or abundant species. When expressed in terms of the degree of dissimilarity from a correct outcome using the Bray-Curtis measure, failure rates (>10 % departure, as set by the AQC scheme) arising from misidentifications of a proportion of species of intermediate abundances were less than might intuitively have been expected. Transformations of the data (commonly used in analyses of benthic community data) further reduced the influence of misidentifications on failure rates. While these examples were not presented as a justification for a lowering of standards of workmanship, the observations are, nevertheless, relevant to considerations of the objectives and, hence, the costs of surveys. For example, where the primary aim of a spatially extensive sampling programme is to describe variation solely in terms of the output from multivariate analysis as a precursor to more demanding follow-up analysis at sub-areas, then the correct naming of uncommon species may be less important than the capacity simply to recognise their presence as entities.

The UK NMBAQC Scheme has demonstrated through ring tests that laboratories may have problems identifying taxa to the species level (UK NMBAQC Annual Report 1998/1999). Only 3 out of 18 participating laboratories managed to achieve 100 % accuracy in the twelfth ring test. Eight of the laboratories misidentified 4 or more of the 25 specimens supplied. A similar performance was recorded for the subsequent ring test. However, it is worthy of note that the overall performance in ring-test species identification has generally improved since the start of the scheme in 1993. Even though these ring tests may indicate an inability to discriminate taxonomic species with consistent 100 % accuracy, they are valuable in identifying problem groups (such as Cirratulidae) as well as for providing a valuable training exercise for laboratories who may not routinely encounter such a wide and diverse range of species. Revision of taxonomic keys and provision of workshops may address problematical taxa groups which have been identified by the participating laboratories. The coordinating laboratory for the Scheme is also in a position to inform laboratories that their misidentification may be due to use of an outdated key, since this information is supplied when making a ring-test submission.

SGQAE also discussed the problem of introducing species error data into national databases. In a case where identification may be suspect, then it may be appropriate to perform subsequent analyses on data transformed to a lower level of taxonomic discrimination such as genus or family. SGQAE re-affirmed the view that identification should always be made to the species level, where possible. Annex 12 presents a case where species error in a temporal trend study was rectified through transforming the data from species to family.

17 DATE/VENUE FOR NEXT SGQAE MEETING

A list of intersessional activities to be performed by SGQAE members was adopted (Annex 13). A draft list of recommendations was discussed with the ICES Environment Adviser, J. Pawlak.

SGQAE recommended that it meet at ICES Headquarters in Copenhagen from 14–17 February 2001 in order to address the items listed in Annex 14 as its Terms of Reference.

18 ANY OTHER BUSINESS

No other issues were raised.

19 CLOSING OF THE MEETING

The Chair closed the meeting at 13.00 hrs on Friday, 18 February 2000.

ANNEX 1: LIST OF PARTICIPANTS

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ANNEX 2: AGENDA

1) Opening of meeting.

2) Appointment of Rapporteur.

3) Adoption of Agenda.

4) Review of relevant biological studies and related QA activities by country and by discipline, especially recent and planned future programmes.

   (To include: progress in relevant eutrophication-related biological work and in the implementation of JAMP guidelines, and compilation of information on QA workshops/ring tests, etc., planned by Member Countries in the coming two years.)

5) QA issues arising from discussions within ICES Working Groups. (WG on Phytoplankton Ecology, Benthos Ecology WG, etc.)

6) Activities of other international QA groups.

   (Especially the ICES/HELCOM Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea (SGQAB) and the ICES/HELCOM Steering Group on Quality Assurance of Chemical Measurements in the Baltic Sea (SGQAC).)

7) Review progress with the EC BEQUALM project.

8) Review final draft of the biological data reporting format and data entry program produced by the ICES Environmental Data Centre*.

9) Produce final draft of OSPAR/ICES guidelines for QA of biological measures*.

10) Review progress in the preparation of taxonomic lists, especially phytoplankton (via activities of SGPHYT).

11) Consider the outcome of a review of benthos SOPs and the possible benefits of conducting a comparable review of SOPs covering other biological measures.

12) Review QA aspects of a standard method for chlorophyll *a* determination.

13) QA in relation to survey objectives and design.

14) Consider the future role of SGQAE.

15) Consider the merits of inclusion of additional parameters (e.g., zooplankton and primary production) in monitoring eutrophication effects.

16) Criteria for evaluating the acceptability of data: ‘compliance’ monitoring.

17) Date/venue for next SGQAE meeting.

18) Any other business.

*These items will also be discussed during a joint session with SGQAB on the afternoon of 15 February.

The Marine Life Information Network for Britain and Ireland

Information to support marine environmental management, protection and education

The Marine Life Information for Britain and Ireland *(MarLIN)* is an initiative of the Marine Biological Association of the UK (MBA) in collaboration with the major holders and users of marine data. The *MarLIN* team currently employs six full time staff, and is based at the MBA in Plymouth, under the direction of Dr Keith Hiscock. See reverse of this leaflet for further information regarding the structure of *MarLIN* and its Sub-programmes.

The Biology and Sensitivity Key Information Sub-programme is researching biology and sensitivity of priority seabed species and habitats. Key information is held in a database and used to generate Web pages. The database presently contains basic information on 95 seabed species and full sensitivity and key information on 25 species. The basic information was placed on-line in November 1999 and the full key information reviews will appear as they are peer reviewed. The Biotopes being researched are especially those relevant to managing sites under the Habitats Directive.

The Data Access Sub-programme has begun the task of linking marine life data sets. A trial is being undertaken with National Marine Monitoring Programme data, provided by the Environment Agency. The *MarLIN* Web site includes an audit of available marine life data sets. The data audit is currently being expanded to accommodate specific information searches. The *MarLIN* team would welcome any information about available marine life data. *MarLIN* is working within the National Biodiversity Network to provide access to marine life information. This Sub-programme requires further funding to complete its aims.

The Biological Recording and Education Sub-programme. *MarLIN* is currently involved in the development of Local Record Centres, the redevelopment of the Seasearch programme and is undertaking a diving based species recording project for PADI AWARE. The Sub-programme requires further funding to complete its aims.

MarLIN's benefits to industry

- Avoids the need for time consuming and costly library research by your staff or consultants.
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For further information on *MarLIN's* progress and products visit: ***www.marlin.ac.uk***

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- Centre for Environment, Fisheries and Aquaculture Science
- Countryside Council for Wales
- Department of Environment, Transport and the Regions (Water and Land Directorate)
- Department of the Environment (Northern Ireland) Environment and Heritage Service
- Department of Agriculture for Northern Ireland (Agriculture and Environment Division)
- Duchas the Heritage Service, National Parks and Wildlife, Dublin
- Environment Agency (National Data Centre for Environmental Data and Surveillance)
- English Nature
- Joint Nature Conservation Committee
- Ministry of Agriculture, Fisheries and Food
- Marine Biological Association of the United Kingdom
- National Marine Aquarium
- National Museums of Scotland
- National Museums of Wales
- Natural History Museum
- Natural Environment Research Council (Centre for Coastal Marine Science)
- Scottish Association for Marine Science
- Scottish Environment Protection Agency
- Scottish Natural Heritage
- Scottish Office (Fisheries Research Services)
- The Crown Estate (Marine Estates)
- The Wildlife Trusts
- United Kingdom Offshore Operators Association
- Ulster Museum
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For further information on *MarLIN* contact:
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Telephone: 01752 633336 E-mail: marlin@mba.ac.uk

ANNEX 4: FORTHCOMING WORKSHOPS AND RING TESTS RELEVANT TO QA ACTIVITIES

Table 1. Quality Assurance (QA) Panel of the German Marine Monitoring Programme of the North and Baltic Sea (GMMP) in the German Federal Environmental Agency (Part Biology) Plan 2000/2001 of QA Activities.

Phytoplankton				
Ring Tests				
	Year		Theme	Participants
	2000	5. Ring Test Phytoplankton	NN	GMMP Laboratories[1]
	2001	6. Ring Test Phytoplankton		
Workshops				
Taxonomic Workshops	2000	3. Taxonomic Workshop	Cyanobacteria and coccale green algae	GMMP Laboratories with international participation
Workshops on data-interpretation of Ring Tests	2000	1. Ring Test	Quantitative determination of special phytoplankton species from cultured algae	GMMP Laboratories[1]
	2000	2. Ring Test	Determination of special phytoplankton species via photos	GMMP Laboratories[1]
	2001	3. Ring Test	Determination of species and their abundance in a natural phytoplankton sample	GMMP Laboratories[1]
Macrozoobenthos				
Ring Tests				
	2000	2. Ring Test	NN	GMMP Laboratories[1]
	2001	3. Ring Test Macrozoobenthos	NN	GMMP Laboratories[1]
Workshops				
Taxonomic Workshops	2001	3. Taxonomic Workshop	NN	GMMP Laboratories[1]
Workshops on data-interpretation of Ring Tests	2000	1. Ring Test	Determination of special macrozoobenthos organisms	GMMP Laboratories

[1]If there is enough capacity, additional laboratories can take part.
NN= Topic to be further specified.

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ANNEX 4 (Continued)

Table 2. Compilation of other relevant QA activities.

Subject	**Contact point**	**Date**	**Location**
Chlorophyll *a*	QUASIMEME/EC BEQUALM David Wells The Scottish Office Marine Laboratory PO Box 101 Victoria Road Aberdeen AB9 8DB United Kingdom F Colijn: colijn@ftz-west.uni-kiel.de	11–14 May 2000	FTZ, Büsum, Germany
Introductory macrozoobenthos taxonomy	UK NMBAQC Anne Henderson SEPA West Region 5, Redwood Crescent Peel Park E Kilbride Glasgow G75 5PP United Kingdom	Deferred to Autumn 2000?	Plymouth, UK
PRIMER (New Windows version and up-date of marine analytical package)	Paul Somerfield Plymouth Marine Laboratory The Hoe Plymouth Devon United Kingdom	End March 2000	Plymouth, UK
Ecological status in relation to the EU 'Water Framework' Directive (Includes QA of water classification techniques)	Peter Holmes SEPA West Region 5, Redwood Crescent Peel Park E Kilbride Glasgow G75 5PP United Kingdom	20–22 November 2000	Edinburgh, UK
Macrozoobenthos ring test	EC BEQUALM Heye Rumohr hrumohr@ifm.uni-kiel.de	February–April 2000	EC countries
Benthos taxonomic workshop	HELCOM/BEQUALM Heye Rumohr Hrumohr@ifm.uni-kiel.de	February 2000	Hamburg, Germany
Phytoplankton species identification workshop	EC BEQUALM Prof Franciscus Colijn FTZ Busum Germany colijn@ftz-west.uni-kiel.de	30 March–3 April 2000; Autumn 2000	FTZ, Büsum, Germany
Phytoplankton species identification workshop	HELCOM Agnete Anderson-Nordstrom University of Uppsala Sweden	2000	Riga, Latvia

ANNEX 5: PUBLISHED GUIDELINES FOR BENTHOS SAMPLING

1 NATIONAL

Anon. 1998. Guidelines for quantitative investigations of sublittoral soft-bottom benthic fauna in the marine environment. Norwegian Standard, NS 9423, 1st edition, September 1998. (In Norwegian.)

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Hiscock, K. (Ed.) 1996. Marine nature conservation review: rationale and methods. Joint Nature Conservation Committee, Peterborough, England. 159 pp + appendices.

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2 INTERNATIONAL

Baker, J.M., and Wolff, W.J. (Eds.) 1987. Biological surveys of estuaries and coasts. Cambridge University Press, Cambridge. 449 pp.

George, J.D., Lythgoe, G.I., and Lythgoe, J.N. (Eds.) 1985. Underwater photography and television for scientists. Clarendon Press, Oxford. 184 pp.

Gray, J.S., McIntyre, A.D., and Stirn, J. 1992. Manual of methods in aquatic environment research. Part 11. Biological assessment of marine pollution with particular reference to benthos. FAO Fisheries Technical Paper, No. 324. FAO, Rome. 49 pp.

Green, R.H. 1979. Sampling design and statistical methods for environmental biologists. J. Wiley, New York. 257 pp.

Higgins, R.P., and Thiel, H. (Eds.) 1988. Introduction of the study of meiofauna. Smithsonian Institution Press, Washington, DC.

Holme, N.A., and McIntyre, A.D. (Eds.) 1984. Methods for the study of marine benthos. IBP Handbook No. 16 (2nd Ed.). Blackwell Scientific Publications, Oxford, England. 387 pp.

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Somerfield, P.J., and Warwick, R.M. 1996. Meiofauna in marine pollution monitoring programmes. A laboratory manual. Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research, Lowestoft. 71 pp.

ANNEX 6: MANUAL OF QUALITY SYSTEM PROCEDURES CONTENTS

MANUAL OF QUALITY SYSTEM PROCEDURES (UNIVERSITY OF SYDNEY): CONTENTS

DOCUMENT: EICC QA-1

QUALITY ASSURANCE: AS 3901-1987

FEBRUARY 1999

CENTRE FOR RESEARCH ON ECOLOGICAL IMPACTS OF COASTAL CITIES (EICC) MARINE ECOLOGY LABORATORIES, UNIVERSITY OF SYDNEY

DIRECTOR: PROFESSOR A. J. UNDERWOOD

CONTENTS

ANNEX 7: SECOND INTERNATIONAL HELCOM/BEQUALM BENTHOS TAXONOMIC WORKSHOP

Dr Heye Rumohr

1 Introduction

The HELCOM/BEQUALM Benthos Taxonomic Workshop is a follow-up meeting first initiated by the ICES/HELCOM Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea (SGQAB). After a series of SGQAB meetings, it was decided to hold taxonomic workshops on a regular basis, with alternating national and international participation. The first workshop was held in 1997 at the Zoological Museum in Copenhagen and dealt mainly with polychaeta (Phyllodocidae, Nephtidae, Nereidae, Polynoidae, Pholoidae, Cirratulidae and Ampharetidae), Porifera, Gastropoda (Hydrobia, tectibranch Opistobranchia), and Bivalvia (Cardium-complex). It is also a component of the ongoing BEQUALM Quality Assurance work (Work package 9 Macrobenthos) for biological effects techniques.

2 Terms of Reference for the 1997 Workshop

ICES C.Res.1996/3:4

An ICES/HELCOM Benthos Taxonomic Workshop [WKBT] will be held under the chairmanship of Mr J. Nørrevang Jensen, Denmark) at Roskilde, Denmark from 4–7 November 1997, including participation of experts from the Zoological Institute of the University of Copenhagen, to:

a) identify benthic invertebrate species over which there is taxonomic disagreement and find a common identification;
b) review material brought together by researchers and research assistants that has created taxonomic problems and determine ways to obtain a correct identification;
c) review the development of ‘in-house quality assurance manuals’ for benthos studies;
d) prepare the materials resulting from this Workshop as a laboratory report for publication.

The Workshop will report to the MEQC at the 1997 Annual Science Conference.

The report of the ICES/HELCOM Benthos Taxonomic Workshop was published as ICES CM 1998/ACME:8.

A Project Proposal on Quality Assurance of Macrozoobenthos - Monitoring in the Baltic Sea was reviewed by the HELCOM Environment Committee in 1998 (see HELCOM EC 9/98, 14/1 Annex 7).

3 Programme for the Workshop

The Convener, Dr Heye Rumohr, opened the HELCOM/BEQUALM Benthos Taxonomic Workshop and made a short introduction on the history of HELCOM intercalibrations and Quality Assurance workshops. He also presented an outline of the BEQUALM quality assurance programme in general and the macrobenthos work package in detail. Prof. Angelika Brandt from the host organization, the Zoological Institute and Museum of Hamburg University, welcomed the 19 participants and gave a short introduction on the Institute’s work and goals. The participants came from the UK (3), the Netherlands (1), and Germany (15). Nine of the participants work part or full time on investigations for the HELCOM Baltic Monitoring Programme. No participants came from the actual Baltic region, due partly to financial constraints. The list of participants is attached as Appendix 1[*].

3.1 Amphipoda

The first day’s programme started with an introduction to special taxonomic features of amphipods, namely the genus *Bathyporeia* and *Gammarus*, by Dr Hans-Georg Andres from the German Centre of Marine Biodiversity, the follow-up organization of the ‘Taxonomische Arbeitsgruppe der BAH’ (Taxonomic Working Group of the BAH). These two genus had been identified as especially problematic. Special emphasis was placed on the identification features of juvenile organisms. The afternoon was devoted to individual work and identification of material brought by the

[*]Note: The Appendices mentioned in this Annex are not included in this report. To receive the full report, please contact Dr H. Rumohr.

participants. A list of identification keys and literature, a preliminary key to *Bathyporeia* species, and a table of taxonomic features for *Gammarus* species can be found in Appendix 2.

3.2 Isopoda

Prof. Angelika Brandt stressed in her introduction to Isopoda the relatively poor situation with respect to identification keys and the consequent need to consult the original literature. She outlined the external morphology of Isopoda with respect to diagnostic features. Special emphasis was placed on the shape of the mandibles. She presented a rich variety of images of live isopods from various parts of the world's oceans and distributed a literature list, an identification key for the genus *Idothea* in North European waters including the West Coast of Britain, and some original descriptions of the species and a table with important distinguishing features of the different *Idothea* species. Special emphasis was made during the day on the differentiation between *I. balthica* and *I. chelipes*. The group had a guided tour of the crustacean collections of the Museum and it was stressed how important such collections are for the solution of taxonomic questions that cannot be solved with identification keys and the original literature (see Appendix 3).

3.3 Decapoda

Dr Michael Türkay from the Senckenberg Institute and Museum in Frankfurt introduced the group to the history and the worldwide distribution of research areas of the Senckenberg Institute in Frankfurt. This is one of the oldest taxonomic research institutions in Germany. J.W. von Goethe was one of the founders. It is now also the German Centre for Marine Biodiversity with experts working in various locations. He explained a comprehensive list of decapod crustacea and commented in great detail on biological features of each genus and the distribution of 130 decapod species recorded from the North Sea and the Baltic Sea, divided by area into the North Sea, Skagerrak, Kattegat, Belt Sea and Sound, and the Baltic Proper. He also produced a key to the families of North Sea and Baltic Sea Decapoda (see Appendix 4).

3.4 Oligochaeta

Prof. Olav Giere from the Zoological Institute in Hamburg gave an introduction to the world of oligochaetes, which often occur as 'Oligochaeta indet.' in the species data lists. They can, however, be determined to the species level in routine samplings. Today about 600 marine species are known and new descriptions are published regularly. In contrast to the polychaetes, the oligochaetes form a monophyletic group. Segments are counted in Roman numerals (I, II, III, ...) The Sub-Phylum Clitellata contains three families: Tubificidae, Naidae, and Enchytraeidae, all of which are hermaphroditic.

The Naidae are small, almost meiofauna-like, living epi- and hyperbenthic; they prefer brackish, tidal waters and feed on diatoms. They can also reproduce asexually by splitting. Diagnostic features are the chaetae and the sexual organs in segments V–VI. In northwestern Europe, there are three species: *Paranais littoralis*, *Amphichaeta samnio* and *Nais elinguis.*

The most abundant group are the Tubificidae, with more than 300 marine species; they feed on detritus, and can also occur as 'gutless monsters' with symbiotic heterotrophic bacteria. Diagnostic features are the chaeta and the position of the reproductive organs in segments X–XI. The most abundant species is *Tubificoides benedii* (earlier known as *Peloscolex benedeni*) with external papillae, living on sub-oxic tidal flats. Other common species are *Tubifex costatus, Clitella arenarius, Monopylephorus* spp., and *Limnodrilus hoffmeisteri* from brackish to limnic estuarine conditions.

Living in the moist upper shoreline, semi-terrestrially is the goup of Enchytraeidae. They radiated from the terrestrial system to the hydrosphere. Only the genus *Grania* is fully marine and can be found even in the deep sea. Diagnostic criteria are the straight, single-pointed, non-flexible chaetae. The internal organs are: spermatheka in the V segment, other sexual organs in the XI and XII segment. The best identification literature is the book by Ralph Brinkhurst on the Synopsis of the British fauna (out of print) and the book by Nelson-Smith *et al*. (see Appendix 5). The British participants showed very detailed material from an Oligochaeta training course run in 1994 by UNICOMARINE Ltd. (with Mike Milligan as expert). A table showing Tubificidae features from this workshop is also annexed. Ecological information can be found in Giere and Pfannkuche (1982). Special mounting techniques for identification and special information regarding Baltic oligochaetes are annexed. Staining is done with Paracarmin (see Appendix 6).

3.5 Acari

Dr Ilse Bartsch, from the German Centre for Marine Biodiversity in Hamburg, gave a short account on the group of mites (Acari) which mainly belong to the meiofauna (up to 2 mm long), who nevertheless are regularly found in macrofauna samples. Acari are present everywhere in the marine environment down to the deep sea (mostly halacarids). The halacarids are the most abundant mite group in our area. The only identification key to be used can be found in the 'Marine Fauna of the British Isles and North-West Europe' Vol. I, pp. 562–585 (see Appendix 7). Acari can be found in our area in the upper tidal zone, in the red algae belt. They are more abundant in the Baltic Sea (35 species) than in the North Sea (about 60–70 species). They should not be fixed in formalin, because it hides the internal structures. If taken from formalin-fixed samples, they should be transferred to ethanol. When stained with rose bengal, they look quite pale. Care should be taken not to have the ubiquitous house-dust mites in the samples. They have very long hairs and tend to jump into every open vessel.

3.6 Sampling Techniques

Dr Heye Rumohr gave a short summary on sampling techniques in use with emphasis on new and special methods for problematic habitats. He showed videos from previous ICES/HELCOM intercomparisons and the group agreed that recording the performance of each group is the best way to compare methods and performance within an expert group. This impression was confirmed by a demonstration of a video from the Humber Benthic Methods Workshop (1997) by Marie Pendle from the CEFAS Laboratory in Burnham-on-Crouch, UK. Dr Rumohr explained the revised version of the ICES TIMES document on the ‘Collection, treatment, and quality assurance of soft bottom macrofauna samples’ (Rumohr, 2000).

3.7 UK National Marine Biological AQC Scheme

Elaine Hamilton (SEPA, Edinburgh) gave a short introduction into the structure and the performance of the British National Marine Biological Analytical Quality Control Scheme (NMBAQC). This programme was established six years ago and runs ring tests with all laboratories engaged in UK national monitoring programmes. It also contains the external checking of laboratory reference materials and the check of one analysed macrobenthos sample by a contractor (UNICOMARINE Ltd.). The contractor is audited every five years. Communication between individual laboratories is encouraged and tests are only rated pass/fail and individually ranked. Ten percent deviation from the real value is assumed to be acceptable; the scores are based on Bray-Curtis similarity. They established a UK-wide list of experts on certain groups to solve taxonomic problems. In SEPA, 10 % of the samples are routinely double-checked. The UK participants emphasized that this period of AQC had certainly improved their professional performance, and it also has increased the standing and esteem of benthos ecology in the group of experts from the ‘exact’ (physico-chemical) sciences. For the epifauna, there only exist pilot AQC schemes including images of samples. Meiofauna is not under AQC as it is only done at PML (Plymouth) and CEFAS Burnham at a more research level.

3.8 Cnidaria

The group had the chance to see a demonstration of selected species of live cnidarians from the groups Anthozoa, Scyphozoa, Cubozoa, and Hydrozoa by Dr G. Jarms. The Zoological Institute of Hamburg has possibly the largest collection of live cnidarians in culture (60 species) which are used both for academic education and research.

4 Summary and Closing of the Workshop

The group discussed the programme and the outcome of the workshop. In general, all participants emphasized the importance of such workshops which not only offer seminars and demonstrations of relevant taxonomic material but also provide the opportunity for direct communication between experts that would not be possible otherwise. They proposed nevertheless for future workshops that potential participants being asked in advance which groups or even species are of special interest. Groups like actinians, tunicates, Syllidae, Nemertini, Pantopoda, Gastropoda, and Baltic Ponotoreia are still open for more training by experts. More sample materials to work with, more ‘play materials’ would increase the outcome of such workshops. Reference materials from the laboratories should be validated at such occasions. In the UK, workshops are arranged on a voluntary basis, consequently fees have to be paid (ranging from 300–900 Euro/week).

Members of the group emphasized the need for statistical workshops, including questions on sampling strategy and sample size and numbers. These recommendations are similar to those of the Quality Assurance workshops on Baltic benthos in the 1990s. In the UK, the last workshop of this kind was in 1993.

The group also discussed possibilities for disseminating taxonomic news and obtaining identification help through the internet and through news groups such as the ANNELIDA list. In this context, the final versions of the ETI CD-ROMs are eagerly awaited.

Finally, the Convener thanked the Zoological Institute and Museum in Hamburg for their hospitality and for hosting this meeting in Hamburg; he also thanked the local lecturers for their personal input, and the participants for their active participation. He than closed the workshop.

[Note: The Appendices mentioned in this Annex are not included in this report. To receive the full report, please contact Dr H. Rumohr.]

ANNEX 8: GENERAL GUIDELINES ON QUALITY ASSURANCE FOR BIOLOGICAL MONITORING IN THE OSPAR AREA

DRAFT (18 February 2000)

Contents

EXECUTIVE SUMMARY

1. This report was prepared by the ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements related to Eutrophication Effects, as part of its role to encourage the production of biological data of consistent quality by member states.

2. The biological measures covered are: chlorophyll *a*, phytoplankton, macrozoobenthos and macrophytobenthos, reflecting the remit of the Steering Group to address eutrophication-related studies. Tables of critical QA factors and priority QA actions for these measures are presented. However, the guidelines for developing effective QA/AQC procedures governing field and laboratory work will be found to have a more general relevance to laboratories engaged in biological studies in the marine environment.

3. QA guidelines are presented across the full range of monitoring activities, i.e., from the objective-setting and sampling design stages of field surveys, to the generation, analysis and archiving of data.

4. In the preparation of the report, every effort has been made to ensure compatibility with the recently-revised ICES/HELCOM guidelines contained in the COMBINE Manual, and there has been free exchange of drafts between the respective QA Steering Groups.

5. Where possible, illustrative examples of good practice in relation to QA of biological measures are included, to aid in practical applications of the guidelines document, and to provide an indication of the likely direction of future QA developments for biological studies.

DRAFT (17 February 2000)

GENERAL GUIDELINES ON QUALITY ASSURANCE FOR BIOLOGICAL MONITORING IN THE OSPAR AREA

1 INTRODUCTION

1.1 Need for Quality Assurance of Analytical Procedures in Marine Biological Monitoring

As a consequence of the absence—or improper application—of measures to assure the quality of biological data, information about variations in the status of natural populations both in space and time is often uncertain or misleading, and the effects of political measures to improve the quality of the marine environment cannot be adequately assessed. Therefore, the acquisition of relevant and reliable data is an essential component of any research and monitoring programme associated with marine environmental protection. To obtain such data, the whole analytical process must proceed under a well-established Quality Assurance (QA) programme.

In guiding such a development, the OSPAR Commission has formulated the following quality assurance policy:

1) Contracting Parties acknowledge that only reliable information can provide the basis for effective and economic environmental policy and management regarding the Convention area;

2) Contracting Parties acknowledge that environmental information is the product of a chain of activities, constituting programme design, execution, evaluation and reporting, and that each activity has to meet certain quality assurance requirements;

3) Contracting Parties agree that quality assurance requirements should be set for each of these activities;

4) Contracting Parties agree to make sure that suitable resources are available nationally (e.g., finances, ships, laboratories) in order to achieve this goal;

5) Contracting Parties fully commit themselves to following the guidelines adopted by JMG and the Commissions in accordance with this procedure of quality assurance.

1.2 Need for QA Guidelines Specific to Biological Measures

Background

Adherence to well-documented QA/QC procedures is an established part of the activities of most chemical analytical laboratories, often occupying up to 20 % of staff time and, in recent years, much effort has been devoted within ICES to improving interlaboratory and inter-country data quality in national/international monitoring programmes. In contrast, much less effort has traditionally been devoted to QA/QC of biological measures employed in marine monitoring. This is largely due to the subsidiary role that many such measures have played in international assessments of environmental quality (with the notable exception of Baltic monitoring activity). Recently, there has been a shift in emphasis within ICES and OSPAR towards holistic evaluations of the biological status of the marine environment in relation to man's activities. This shift, along with a quite separate development towards increased contracting out of biological analysis by resource-limited regulatory bodies to commercial consultancies (who are, as a result, under competitive pressure to deliver data of a consistent quality), has sharply highlighted the need for more effective and harmonised approaches to QA within and between member countries.

Rationale for report structure

SGQAE has developed the following guidelines with particular reference to the biological targets within its Terms of Reference, namely chlorophyll *a*, phytoplankton, macrozoobenthos and macrophytobenthos. In doing so, SGQAE has freely adapted guidelines applicable to a much larger suite of variables under investigation in the Baltic Monitoring Programme (the COMBINE Programme Part B). While the same general principles governing the development of QA programmes still apply, such adaptation was felt to be necessary as an acknowledgement of the very different organisational structures within which biological work may be conducted in OSPAR member countries. For example, at one extreme, local output may be vested in a single individual, where certification of that individual's expertise may be more appropriate than a formal system of accreditation requiring a hierarchical QA management structure for its application.

Biological studies at the community level (in this context, macrozoobenthos, phytobenthos, and phytoplankton) present particular challenges in QA, since each field-collected sample constitutes a unique *multivariate* entity, i.e., consisting of a combination of species and individuals peculiar to that sample. Of course, this is not to imply that all component species are unique in their occurrence, and some may be sufficiently widespread to be suitable for intercomparison exercises of identification proficiency among many countries. However, many species will be more localised in distribution, and competency in identification may, as a result, be more fairly tested at a regional level.

Proficiency in species identification is, of course, only one of many aspects of biological study which will determine the eventual quality of data sets. The present account covers the entire range of activities, from the initial setting of programme objectives and survey design, through to the collection of field samples, their processing in the laboratory leading to the generation of raw data and, finally, their compilation, analysis and archiving. QA actions appropriate to each of these stages can be arrived at, in order to enhance consistency both within and between laboratories.

1.3 Strategy for Practical Implementation of QA Programmes for Biological Measures

Technical specifications pertaining to the variables of interest, namely chlorophyll *a*, phytoplankton, macrozoobenthos and macrophytobenthos, can be found in the JAMP guidelines (OSPAR, 1998).

For phytoplankton/chlorophyll *a*, the priority is likely to be for international-level QA assessment, at least at the level of sampling methodology, since the same (or similar) approaches will apply throughout the OSPAR area. It is also self-evident that the habitat, i.e., the water column, is dependably present at all locations, even if variable in terms of stratification, depth and so on. This is in contrast to some benthos studies, where gross variability in the physical habitat may result in entirely different species assemblages being encountered, which require the adoption of markedly different sampling methods. Thus, not all countries will be involved in identical survey and sampling approaches. An example would be the presence or absence of a coastal rocky habitat.

Also, biogeographical factors affecting the species composition of phytoplankton, or the benthos of widely distributed habitats (such as soft bottoms) may, in practice, determine that intercomparisons of proficiency in species identification through ‘ring’ tests should be conducted at a regional rather than OSPAR-wide level. For example, biogeographical provinces across the OSPAR area range from Arctic Boreal to Lusitanean. Such natural variability in biological systems determines that a tiered approach to QA initiatives, i.e., varying from the level of the laboratory to the national or international level, would be appropriate, depending upon the measure of interest.

It is also to be expected that there will be some examples of entrenched differences in sampling approaches between countries even for comparable habitats. For example, where evidence for the greater efficiency of one sampling device over another is unconvincing, personal preferences or historical precedents will be influential. There is no intrinsic reason why this should lead to significant problems with the quality of the resulting data, provided that acceptable documentation is available to demonstrate comparability of data arising from different sampling methodology. However, standard methods conforming with up-to-date guidelines should be adopted in any new monitoring programme.

SGQAE emphasises the fundamental importance attached to agreement among participating countries on basic sampling issues such as mesh size, criteria for acceptance/rejection of samples, and consistency in timing of annual or more frequent surveys. Disparities here will nullify any benefits of sound QA, when it comes to intercomparisons of the results.

As part of this strategy, SGQAE identified a set of critical QA factors and priority QA actions for monitoring the relevant variables (chlorophyll *a*, phytoplankton, macrozoobenthos and phytobenthos). These are given in Appendix 1.

1.4 Objective

The objective of this document is to guide organisations (or individuals) towards the establishment of QA procedures, often for the first time, which will ensure that the data generated are suitable for contributing to international-level assessments of environmental quality. While some elements of any newly-incorporated QA scheme must, from the outset, be considered mandatory, past experience suggests the need for a pragmatic view of how such a scheme will initially proceed. Thus, enhancements in performance may well be step-wise, in response to the adoption of new in-house working procedures, and as lessons are learned from intercomparison exercises, workshops and so on. At this stage, a prevailing climate of encouragement will be the most helpful in facilitating such a progression.

2 THE QUALITY SYSTEM

2.1 General

'Quality system' is a term used to describe measures which ensure that a laboratory fulfils the requirements for its analytical tasks on a continuing basis. A laboratory should establish and operate a Quality System adequate for the range of activities, i.e., for the type and extent of investigations, for which it has been employed. The Quality System should refer to methodology, organization and staff, equipment, quality audit.

The Quality System must be formalized in a Quality Manual that must be maintained and up-to-date. Some comments and explanations are given in this section.

2.2 Topics of Quality Assurance

In practice, **Quality Assurance** applies to all aspects of analytical investigation, and includes the following principal elements:

- A knowledge of the purpose of the investigation is essential to establish the required data quality.
- Provision and optimization of appropriate laboratory facilities and analytical equipment.
- Selection and training of staff for the analytical task in question.
- Establishment of definitive directions for appropriate collection, preservation, storage and transport procedures to maintain the integrity of samples prior to analysis.
- Use of suitable pre-treatment procedures prior to the analysis of samples, to prevent cross-contamination and loss of the determinand in the samples.
- Validation of appropriate analytical methods to ensure that measurements are of the required quality to meet the needs of the investigations.
- Conduct of regular intralaboratory checks on the accuracy of routine measurements, by the analysis of appropriate reference materials, to assess whether the analytical methods are remaining under control, and the documentation and interpretation of the results on control charts.
- Participation in interlaboratory quality assessments (proficiency testing schemes, ring tests, training courses) to provide an independent assessment of the laboratory's capability of producing reliable measurements.
- The preparation and use of written instructions, laboratory protocols, laboratory journals, etc., so that specific analytical data can be traced to the relevant samples and vice versa.
- The management of the information in a suitable database/information sysytem.

2.3 In-house Quality Manual

Every phase of a monitoring or assessment survey, even in small laboratories, must be enforced to ensure the quality of data acquisition, collection, handling and analysis, and subsequent reporting. In-house Quality Manuals must be developed in accordance with appropriate national and international standards and followed rigorously.

The person responsible for authorization and compilation of the Quality Manual should be identified. A distribution list of the quality manual and identification of holders of controlled copies of the quality manual should be included.

The in-house quality manual should contain, as a minimum, the following items or their equivalent:

1) Scope.
2) References.
3) Definitions.
4) Statement of quality policy.
5) Organization and management.
6) Quality system audit and review.

7) A formal listing of the staff involved in the monitoring, analytical and technical work as well as quality control management with respective training, professional qualification and responsibilities within the laboratory.
8) Standard Operating Procedures (SOPs) (see below).
9) Certificates and reports.
10) Sub-contracting of calibration or testing.
11) Outside support services and supplies.
12) Handling of complaints.

2.3.1 Standard Operating Procedures (SOPs)

An SOP may be defined (as in 'Good Laboratory Practice' guidelines) as 'a documented procedure which describes how to perform tests or activities *normally not specified in detail in study plans or test guidelines*'. The italicised text helps to clarify some confusion that exists with regard to the role of an SOP. For example, in cases where international guidelines for a sampling or analytical procedure are written in sufficient detail, then these will perform the same function. However, guideline documents frequently cover large sea areas and a variety of habitats and cannot be expected to provide sufficient detail for the requirements of all local surveys. In these circumstances, an SOP bridges the gap between the activity of an individual laboratory and the wider need for harmonisation of methodology. For example, a laboratory SOP might include a description of sample-processing equipment peculiar to that laboratory (though compatible with the performance needs of external guidelines), and perhaps its local source of manufacture.

A well-written SOP will help inexperienced members of staff in a laboratory to quickly develop expertise in a sampling or analytical area which is consistent with past practice at that laboratory, while being compatible with established approaches elsewhere. For those seeking laboratory accreditation, the production of SOPs will be essential as part of a wider QA package but, even for those who are not, they provide an important means to foster good practice internally. However, SOPs are clearly not, in themselves, guarantors of data quality.

SOPs should describe all steps performed in biological measurement. They should be established to cover the following areas of activity:

- Handling and use of chemicals (i.e., fixatives, preservatives, reagents) used in marine environmental surveys;
- Handling, maintaining, and calibrating the field and laboratory equipment;
- Station selection and location, navigational accuracy;
- Collection of biological material;
- Storage of biological material including labelling, checking preservation status;
- Analytical methods of biological material;
- Distribution of biological material to external contractors/taxonomic specialists;
- Identification of biological material including taxonomic expertise of the personnel;
- Recording of biological and environmental data;
- Analysis of biological and environmental data;
- Monitoring report writing and documentation including signed protocols in all steps of analysis.

SOPs should contain a description of operational procedures. An outline structure for an SOP (modified from DIN EN 45001, Chapter 5.4.3) is as follows:

a) scope of procedure used;
b) description of the study target;
c) variable to be determined;
d) equipment necessary, reference material (e.g., voucher specimens), taxonomic literature used;
e) specification of working conditions required for effective sampling;
f) description of procedure/method with respect to the following aspects:
    i) sampling and sample treatment, labelling, handling, transport and storage of samples, preparation for laboratory analysis,
    ii) instrument control and calibration,
    iii) recording of data,

iv) safety aspects;

g) criteria to adopt or reject results/measurements;

h) data to be recorded and methods for their analysis;

i) assessment of uncertainty of measurements.

In considering ‘best practice’, it is recommended that SOPs should:

- be structured logically by heading and sub-heading to cover the full sequence of activities in field sampling and laboratory analysis;
- carry an issue number, date, and the name(s) of the individual(s) responsible for its drafting and updating. This anticipates a likely requirement for changes to SOPs in response to new equipment, guidelines and so on;
- document in-house AQC procedures;
- account for the specific practices of the individual laboratory. At the same time, SOPs must of course reflect agreed guidelines applicable at national or international level;
- be filed as paper copies in an accessible place, as well as being available on computer;
- be freely available to all interested parties (especially funding agencies);
- contain explicit instructions for the tracking of samples from the point of collection to the point of archiving of analysed material.

SOPs may usefully contain:

- diagrams depicting gear, especially where local modifications to equipment are made;
- a summary flow-chart as an accompaniment to a lengthy SOP, as an *aide memoire* for field and laboratory bench operators;
- a full listing of taxonomic keys used for laboratory identification, and other useful reference works relating to procedures;
- details of local suppliers, manufacturers, etc., where relevant.

SOPs should not:

- contain vague generalisations;
- contain excessive detail: a sensible balance needs to be achieved which takes into account the basic level of training and common sense that a new operator will possess;
- cover too many activities: for example, it is logical to have separate SOPs for field and laboratory procedures. Different types of field activity such as intertidal core sampling and ship-board sampling are also sensibly treated separately.

2.4 Organisation, Management, and Staff

2.4.1 Organisation

The Quality System should provide general information on the identity and legal status of the laboratory and should include a statement of the technical role of the laboratory (e.g., employed in marine environmental monitoring).

The information must include general lines of responsibility within the laboratory (including the relationship between management, technical operations, quality control and support services, and any parent or sister organisations). In the case of smaller units, the organisational tasks must be allotted to fewer personnel or even one individual.

2.4.2 Management

Clear job descriptions, qualifications, training, and experience are necessary for all persons concerned with QA and QC.

Job descriptions should include a brief summary of function, the pathways of reporting key tasks that the jobholder performs in the laboratory, and limits of authority and responsibility.

2.4.3 Staff

Minimum levels of qualification and experience necessary for engagement of staff and their assignment to respective duties must be defined. Members of staff authorised to use particular items of equipment should be identified and the institution should ensure that all staff receive training adequate to the competent performance of the relevant methods and operation of equipment. A record should be maintained which provides evidence that individual members of staff have been adequately trained and that their competence to carry out specific methods, identifications or techniques has been assessed. Managers should be aware that a change of experienced and well-trained staff might jeopardise the continuation of quality.

In the case of small units employing few staff or even single individuals responsible for the generation of data, a scheme for the certification of individual expertise (e.g., in aspects of species identification) may be a valid alternative to formal accreditation involving a hierarchy of quality managers, which may not be practicable.

2.5 Equipment

As part of its quality system, a laboratory is required to operate a programme for the necessary maintenance and calibration of equipment used in the field and in the laboratory to ensure against bias of results.

General service equipment should be maintained by appropriate cleaning and operational checks where necessary. Calibrations will be necessary where the equipment can significantly affect the analytical result.

Performance checks and service should be carried out at specific intervals on microscopes, balances and other instruments. The frequency of such performance checks will be determined by experience and based on the need, type and previous performance of the equipment.

2.6 Documentation

All biological data produced by a laboratory should be completely documented (‘meta-information’) and should be traceable back to its origin. The necessary documentation should contain a description of sampling equipment and procedures, reference to SOPs for sampling, sample handling and analytical procedures involved, and the names of persons responsible for Quality Control. In general, one signed protocol should accompany a sample through all steps of processing.

3 QA OF SAMPLING DESIGN

The following account is an edited version of text relating to this issue published by the Nordic Council of Ministers (ref.).

3.1 Quality Objectives

This section describes the planning process, which is the most critical process in the production of environmental information. The basis for all further work is the information requirements, to be described in detail by the users and decision-makers. In order to design a tailor-made environmental monitoring system, the <u>key</u> issue is the final use of data and the final utilisation of the information obtained. The objectives of the planned programme shall be clearly and precisely formulated by the user and shall be put in writing.

The user should also formulate the requirements as qualitatively and quantitatively as possible. Precise sets of qualitative targets are essential in optimising sampling, analysis and data-handling programmes. If data are to be treated statistically, the number of samples, sampling frequency, sampling locations, and other quantitative aspects are of great importance. A statistician experienced in these types of problems should be consulted.

Available resources and monitoring costs influence the programme design. Clear specification of objectives in relation to costs will ensure that only necessary and relevant data are collected. A consideration should also be made of the possible risk of incorrect decisions based on insufficient data acquisition as a result of financial constraints.

Information requirements in relation to available resources are the basic elements in the further planning process. The result of this planning process shall be documented in the quality objectives plan.

Periodic evaluation of the information requirements should be based on monitoring results and changes in the requirements of the users. Stability and continuity are of great importance in the monitoring process that has an ongoing and iterative character. All changes shall be documented and validated before being implemented.

3.2 Specification of Information Needs

Many different approaches indicating different information needs can be identified in the design of monitoring programmes. There are mainly two broad categories:

- compliance monitoring or the emission-based approach, including sampling and analysis according to national regulations;
- ambient monitoring or the environmental quality approach, including sampling and analysis in order to establish baseline levels or trends, set from the original/desirable state of the environment.

These different approaches are interrelated and complement each other in many ways.

Define in detail the information needs:

- which questions are to be answered;
- which levels of overall reliability are to be attained;
- what are the intended uses of data/results.

The proper level of quality assurance can only be performed when the requirements of the information needed are made explicit.

In monitoring trends in the conditions of the environment, extreme care shall be exercised that observed trends are not influenced or biased by changing methodology, change of laboratory, differences in sample stability, or time and frequency of sampling.

Reuse of monitoring information should always be kept in mind. In case of new and unforeseen environmental questions, thoroughly documented and accessible information may be re-evaluated in the far future, tackling quite new problems and thus the reuse of data should be facilitated as far as possible.

The information needs, as the basis for further work, shall be:

- detailed, specified and put in writing in order to avoid ambiguity;
- subject to review for conformity to legal, scientific, technical and quality expectations;
- approved by top management and included in the quality management plan.

3.3 Strategy and Determinands

After defining the information needs, a strategy for monitoring must be defined. This involves decisions about what information is to be produced by the monitoring system, in order to translate the information needs to data collecting activities. What determinands are to be measured, physical, chemical, biological, microbiological, hydrological, etc., and which levels of quality are required.

The monitoring strategy shall define what is to be determined and in which media, as well as its required quality. The strategy should also include information on the final use of data, including data analysis, compilations, statistical calculations and evaluations.

In designing the monitoring strategy, the selection of determinands is of greatest importance. To obtain the most reliable and complete picture of the state of the environment, an integrated monitoring approach should be recommended, which means coordinating both chemical and biological measurements in order to assess ecosystem quality as a whole.

Spatial monitoring or mapping means coverage of chosen variables within geographically defined areas. It can be made on one occasion or be recurrent mapping. Remote sensing, the use of aerial photographs or satellite images are important tools in early discovery, surveillance and identification of objects to be further studied in field surveys by ground stations. The development of new satellite sensors means that remote sensing may be an alternative to ground stations in the near future.

Model calculations may be seen as an alternative to sampling programmes and/or remote sensing. Models are based on the assumption that a variable will continue to react as previously, depending on changes in one or more other control variables. Models are used for calculating loads and concentrations and for making prognoses. But there are difficulties in making predictions in the state of the environment and models are always simplifications of reality. All models used in monitoring should be clearly described, documented and validated. The quality of models depends mainly on the quality of entity and the correctness of the basic assumptions. Defined action for continuous follow-up and corrections of the model should be included in the quality control plan. Modelling and environmental indicators are further discussed in (ref.).

3.4 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements derived from the DQO-process, which is a systematic planning tool based on a method that identifies and defines the type, quality and quantity of data needed to satisfy a specified use. The DQO-process provides a logical and quantitative framework for finding an appropriate balance between the time and resources that will be used to collect data and the quality of the data needed to make the decision. The quality level may be defined according to the tolerable total measurement uncertainty in different sets of data in order to achieve an acceptable level of confidence in final decisions. The DQO-process stresses the cooperation between the end users of the data and the scientific staff planning the monitoring programme.

The DQO-process was originally developed by the U.S. Environmental Protection Agency. The U.S. EPA has recently changed the three stages mentioned above to a more manageable ‘seven steps of the DQO-process’. The seven steps are:

1) state the problem;
2) identify the decision;
3) identify inputs to the decision;
4) define the study boundaries;
5) develop a decision rule;
6) specify limits on decision errors;
7) optimize the design;

and are fully discussed in the EPA Quality System Series documents. These seven steps of the DQO-process may profitably be applied to all projects where the intention is to collect environmental data and to make a specified decision. The seven-step DQO-process provides a method for establishing decision performance requirements by considering the consequences of decision errors. A statistical sampling design satisfying the DQO can be generated. The introduction of the data quality objectives process in the planning of monitoring programmes is of vital importance. In other cases a similar process is called *the graded approach*, basing the level of quality on the intended use of the data and the degree of confidence needed in the quality of the results. Quality assurance means to test, define and document the quality level needed and to maintain this quality level in all subsequent steps.

3.5 Sampling Design

The previous parts of this section emphasise the importance of precisely defining the objectives of the monitoring programme. The monitoring strategy considers what is to be measured, e.g., the selection of determinands. The data quality objectives process tries to find the proper balance between time, costs, resources, and the desired quality of the results. The sampling design concentrates on where and when: it specifies which determinands are to be measured at which location, at which time and frequency. In sampling design emphasis may be put on statistics. But it should also be borne in mind that the programme designers must have insight into the temporal and spatial variability and other relevant phenomena of the system studied.

In a representative sample, all relevant determinands have the same values as in the system at the point and time of collection. A sampling programme or a set of samples is said to be valid if it gives an adequately accurate representation of temporal and spatial variability of ‘environmental quality’ for the duration of the monitoring programme.

It must be noted that most factors are interrelated and in part exchangeable. In some cases, there may be a choice between many locations and low frequency of sampling or few locations and frequent sampling.

Relevant factors in sampling design

- Sampling location (system homogeneity, number of sampling locations, accessibility and safety precautions);
- Sampling time and frequency (system homogeneity over time, random and cyclic variations);
- Estimated nature and magnitude of total variations;
- Duration of sampling period—discrete or composite samples;
- Methods to change sampling frequency and number of sampling points (systems with a high degree of homogeneity and stability may allow reduction in sampling frequency and locations and vice versa);
- Economic and practical considerations;
- Quality control.

After a complete sampling cycle, all results are to be evaluated and tested to meet the pre-set quality targets.

Expert assessment of the final results may identify weak points and inconsistencies that can be corrected to increase the quality of the programmes.

3.6 Specification of Sampling Procedures

Sampling is the starting point in the collection of information and a cornerstone in the monitoring process. Mistakes in sampling may invalidate the whole process and normally it is not possible to correct errors made in sampling. Environmental monitoring means mostly sampling in time, which can never be reproduced. Sampling procedures include sample collection, preservation, transport and storage of samples. All decisions relating to sample strategy and sampling operations shall be thoroughly documented.

4 QA FOR FIELD WORK

4.1 Sea-going Procedures

The QA of sea-going procedures covers methods, instruments and equipment including their description, SOPs, applicability, limitations, calibration, and maintenance. Safety is also a critical consideration and will be an essential part of any QA programme.

The personnel are an additional important factor for the collection of data with high quality. QA covers the fields of responsibility and authority as well as education, experience, and all aspects of special training.

The description of the measuring site (station, area, transect, etc.) covers not only the unequivocal (geographical) identification of the site, but also the description of the physical environment (depth, sediment, etc.) as well as of the hydrographical and meteorological settings (temperature, salinity, currents, wind direction and speed, cloud cover, etc.). It is an indispensable need to have a comprehensive signed field log that covers all aspects and steps of the sampling process including personnel, instruments and equipment, and recording activity including deviations and deficiencies. A time log preferably using a calibrated time is of use especially when the results have to be combined.

The securing of results from instruments and data loggers is an indispensable and delicate step in QA that can be safeguarded by keeping parallel hard copies of results.

The securing of samples and material is another important field for QA, where especially a persistent and clear (internal and external) labelling is of importance. Parallel documentation by photo and video can increase reliability.

There is a need for predetermined solutions in case of deviations, malfunctions and deficiencies and in cases of illness of personnel that makes them incapable of fulfilling their tasks.

Further criteria for changes of methods must be set up, including calibration, parallel measuring and other comparative measures. The recording and documentation of these results are very important.

The whole sea-going process (that ends when the samples, materials and documents are handed over to the analytical laboratory) must be accompanied by **quality control activities** such as:

- simultaneous records with different observers;
- parallel measurements with different instruments;
- test comparisons (intercomparisons);
- field blank samples (chlorophyll *a*);
- measuring reference materials;
- securing the stability of measuring instruments under changing ambient conditions (temperature, humidity);
- observing interferences with other instruments or installations on the ship (this includes the need for a stable voltage supply).

4.2 Coastal and Land-based Procedures

Many of the above considerations apply equally to surveys employing divers, and activities directly accessible from land, especially evaluations of intertidal habitats. Approaches to the QA of the main activities under this category are outlined below.

4.2.1 Intertidal soft sediment surveys

(Text to be prepared on QA/AQC principles)

4.2.2 Intertidal rocky surveys

(Text to be prepared on QA/AQC principles)

4.2.3 Surveys of shallow coastal soft and hard substrata by means of diving

A European standard for scientific diving is being developed within the EU. Specifications concerning diver certification, including critical safety issues, are generally regulated at a national level. Certification should be a mandatory requirement for all those engaged in scientific diving activity.

Reporting

Standard procedures must be established for the reporting of scientific surveys by divers, examples of which may be found in …(Norway), …(United Kingdom), …(other). A typical specification will include:

- persons and institution
- project identification
- coordinates
- date and time (start - end)
- type of substrate
- angle of gradient
- wave exposure (very sheltered …. very exposed)
- registration conditions (sun, wind, visibility)
- locality type (e.g., estuary, fjord, coast)
- reference to other sampling activity (e.g., hydrography, hydrochemistry)
- size of the locality (littoral surveys, description including drawings, photos, etc.).

5 QUALITY ASSESSMENT FOR LABORATORY ANALYSIS AND DATA HANDLING

The objective of a quality assurance programme is to reduce analytical errors to required limits and to assure that the results have a high probability of being of acceptable quality.

5.1 Routine Quality Control at the Laboratory Analytical Level

Having developed an analytical system suitable for producing analytical results of the required accuracy, it is of extreme importance to establish a continuous control over the system and to show that all causes of errors remain the same in routine analyses (i.e., that the results are meaningful). In other words, continuous quantitative experimental evidence must be provided in order to demonstrate that the stated performance characteristics of the method chosen remain constant.

For marine environmental monitoring programmes, it is essential that the data provided by the laboratories involved are comparable. Therefore, activities such as participation in external quality assessment schemes, ring tests, and taxonomic workshops and the use of external specialists by the laboratories concerned should be considered indispensable.

While the use of a validated analytical method and routine quality control (see above) will ensure accurate results within a laboratory, participation in an external quality assessment or proficiency testing scheme provides an independent and continuous means of detecting and guarding against undiscovered sources of errors and acting as a demonstration that the analytical quality control of the laboratory is effective.

Generally, proficiency testing, ring tests, etc., are useful to obtain information about the comparability of results, and ensure that each of the participating laboratories achieves an acceptable level of analytical accuracy. Most ring tests and proficiency testing schemes are based on the distribution of samples or identical sub-samples (test materials) from a uniform bulk material to the participating laboratories. The test material must be homogeneous and stable for the duration of the testing period. Amounts of the material should be submitted that are sufficient for the respective determinations.

The samples are analysed by the different laboratories independently of one another, each under repeatable conditions. Participants are free to select the validated method of their choice. It is important that the test material is not treated in any way different from the treatment of samples ordinarily analysed in the laboratory. In this way, the performance established by the proficiency testing results will reflect the actual performance of the laboratory.

Analytical results obtained in the respective laboratories are returned to the organiser where the data are collated, analysed statistically, and reports issued to the participants. In cases where laboratories are formally accredited, external quality audits are carried out in order to ensure that the laboratory's policies and procedures, as formulated in the Quality Manual, are being followed. All data are computerised and back-up files can be mailed to the institute server or the forms containing data could be faxed to the institute to assure a paper copy.

The trend towards applications of internationally consistent AQC criteria to biological studies, especially of pelagic and benthic communities, is a relatively recent development. In practice, this determines that available procedures, a number of which are still subject to development or refinement, may fall some way short of the ideal. In Appendices 3–6, examples of best practice covering both field sampling and laboratory analysis are provided for the biological variables of interest, including imaging methods, as a supplement to the information on critical QA factors and priority QA actions identified in Appendix 1.

5.2 Routine Quality Control at the Data Handling Stage

5.2.1 Data management

For adequate management of the data obtained (especially when different laboratories are involved), an information management system is essential. The database should allow the storage/management of the full set of information related to the data (information on QA, methods, etc.). A proper reporting format or data entry system should allow the submission of the required information in order to describe fully, and if necessary to trace back, the data/samples.

Data checks performed by the (national) data manager should only be set up on a quality controlled data set. Therefore, the information on the QA procedures and results have to accompany the data or, better, have to be regarded as part of the data submission (see below).

A central data management system should guarantee safe archiving (regular back-ups, multiple storage, etc.) and access to the data.

Check routines performed by the data management system should look for:

- format compliance;
- completeness of data/information;
- compliance with the programme and guidelines;
- deviations from previous sampling/analysis procedures;
- plausibility (e.g., sampling position on land? Values within plausible ranges? ⇒ screening for outliners, etc.).

Quick-look visualisation of the data/information (track plots, charts) should be provided by the data centre, as well as meta information on the submission of data, the state of validation, submission to the ICES/OSPAR database, etc. Communication between the data centre and the data originators should be part of the work. Regular intercomparisons between the (national) data centre and ICES should be performed.

The qualifications of the data managers and programmers are of importance for the reasonable management of the data. A scientific background of the data manager is highly recommended, as well as training of both data managers and programmers in order to meet up-to-date standards.

5.2.2 National accreditation

It may be considered appropriate for member states to adopt a National Accreditation Scheme (NAS) for the purpose of assigning annual competence to laboratories engaged in the production of data of national/international importance. Through such a scheme, which may be overseen by a nationally appointed group of experts, national data are screened and ‘flagged’ appropriately (e.g., acceptable, unacceptable, acceptable under certain conditions) prior to inclusion in a national database. These flags are assigned after a strict assessment of data against standards of performance, e.g., in relation to interlaboratory calibrations and external analytical quality control checks by an approved expert laboratory. It is envisaged that such national schemes would come under scrutiny by the relevant ICES/OSPAR/HELCOM Steering Groups, in order to ensure consistency of approaches and comparability of all data entering the ICES Marine Environmental Database.

6 DEFINITIONS

Accuracy. Difference between the expected or true value and the actual value obtained. Generally accuracy represents the sum of random error and systematic error or bias.

Analytical method/process. The set of written instructions completely defining the procedure to be adopted by the analyst in order to obtain the required analytical result (Wilson, 1970).

An **analytical system** comprises all components involved in producing results from the analysis of samples, i.e., the sampling technique, the ‘method’, the analyst, the laboratory facilities, the instrumental equipment, the nature (matrix, origin) of the sample, and the calibration procedure used.

Benthos. Animals and plants associated with the seabed.

Calibration is the set of operations which establishes, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system, or values represented by a material measure, and the corresponding known values.

External quality assessment. See Section 5.

Intercalibration. Comparative sampling, laboratory analysis, and evaluation with the aim of detecting systematic differences that have to be overcome.

Intercomparison. Comparative sampling, laboratory analysis, and evaluation with the aim of detecting systematic differences.

Macrozoobenthos. Benthic fauna retained on a 1 mm screen.

Matrix. The totality of all components of a material, including its chemical, physical and biological properties.

Performance characteristics of an analytical method used under given experimental conditions are a set of quantitative and experimentally determined values for parameters of fundamental importance in assessing the suitability of the method for any given purpose (Wilson, 1970).

Phytobenthos. Benthic flora.

Phytoplankton. 'Chlorophyll-containing', autotrophic, drifting organisms (mainly algae) in aquatic systems.

Primary production. Formation of organic material by photosynthesis by phytoplankton.

Precision. Closeness between parallel analyses.

Proficiency testing is the determination of the laboratory calibration or testing performance by means of interlaboratory comparisons.

Quality. Characteristic features and properties of an analytical method/analytical system in relation to their suitability to fulfill specific requirements.

Quality Assurance. Quality Assurance (QA) is the total management scheme required to ensure the consistent delivery of quality controlled information fit for a defined purpose. The QA must take into account as many steps of the analytical chain as possible in order to determine the contribution of each step to the total variation. The two principal components of QA are quality control and quality assessment.

Quality Control. The procedures which maintain the measurements within an acceptable level of accuracy and precision.

Quality Assessment. The procedures which provide documented evidence that the quality control is being achieved.

Quality audits are carried out in order to ensure that the laboratory's policies and procedures, as formulated in the Quality Manual, are being followed.

Quality Manual is a document stating the quality policy and describing the quality system of an organization.

Quality policy. Overall quality objectives of a research unit and laboratory.

Quality system is a term used to describe measures which ensure that a laboratory fulfills the requirements for its analytical tasks on a continuing basis.

Quality Manager. Person responsible for QA (even in small laboratories).

Ring test. Interlaboratory test with either preserved samples, identical samples or artificial samples to compare the laboratory performance.

SOPs. Standard operating procedures. Detailed (cookbook-like) descriptions of analytical procedures in standardised format.

Technical Manager. The post-holder who has overall responsibility for the technical operation of the laboratory and for ensuring that the Quality System requirements are met.

Sample tracking. The ability to trace results or data back to their origin.

Voucher specimens. Specimens from routine collections put under museum curatorship to make later taxonomic checks possible.

Zoobenthos. Benthic fauna.

Zooplankton. Animal-like, heterotrophic organisms drifting in aquatic systems.

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APPENDIX 1

CRITICAL QA FACTORS AND PRIORITY QA ACTIONS FOR MONITORING CHLOROPHYLL *a*, PHYTOPLANKTON, MACROZOOBENTHOS, AND MACROPHYTOBENTHOS

Table 1. Chlorophyll *a*

Steps	**Method diversity**	**Critical QA factors**	**Priority QA actions**
Sampling procedures	3–4 methods according to JAMP Guidelines - pump/hose - bottle sampler - *in situ* fluorescence different QA procedure for chlorophyll *a* extracts	Variability in accuracy among methods (effectiveness of methods in coping with patchiness).	intercomparisons (workshops) on sampling method performance: hose vs. bottle sampler vs. *in situ* fluorescence
Sample analysis	2 (3) principles recommended - spectrophotometer - fluorometer (-HPLC as clean-up option)	Accuracy and precision.	Certified reference material International calibration Calibration of *in situ* measurements (if *in situ* fluorometers are used, they should be calibrated with filtered water samples)
Data treatment	Low variety of statistical methods		Reporting of data should be followed by control charts

Footnote. Supplementary variables essential for interpretation of chlorophyll results include: suspended particulate matter, particulate nitrogen and phosphorus, particulate organic carbon, temperature, salinity, and light penetration.

Table 2. Phytoplankton

Steps	**Method diversity**	**Critical QA factors**	**Priority QA actions**
Sampling procedures	High (4) - water bottles - hose - pumps - nets	Large variability in accuracy between methods especially among nets.	Intercomparison of methods
Treatment and storage of samples	High (4–6) - different fixatives - living samples	Algae may be impossible to identify as a result of group-specific fixation damage.	Intercomparison of fixative effects
Concentration of samples	High (4) - sedimentation - centrifugation - filtration - no concentration	Large variability in accuracy between methods (species dependent).	Intercomparison of methods
Sample analysis	Use of light microscope offers different techniques such as: - brightfield - darkfield - phase-contrast - epifluorescence Species identification	Magnification. Quality of optics (resolution). Taxonomic expertise. Change of species names (Synonyms).	Intercomparison exercises Control of optical quality Training and intercomparison exercises Ring tests Common check list including synonyms
Biomass transformation	Two main methods: - cell measurements - use of standard volumes	Large variability in size for the same species.	Use of standard geometric cell shapes Establish lists of standard volumes
Data treatment	Use of 'control charts' with relevant information accompanying the data.	Simplicity and uniformity of control charts.	Develop and maintain control charts

Footnote. Supplementary variables essential for interpretation of phytoplankton results include: particulate and total organic carbon, particulate organic nitrogen, temperature, salinity, and light penetration.

Table 3. Macrophytobenthos: hard bottom

Steps	Method diversity	Critical QA factors	Priority QA actions
Sampling procedure	High. At least 3 different method principles recommended: - aerial surveillance, - shoreline and diving transects and frames, - photography or video.	Frame and transect work: representativity (accuracy) of stations. Taxonomic competence of field observers. Operation of photographic and video equipment. Photo/video resolution.	Guidelines on assessment of representativity of stations Taxonomic intercomparison workshops Preparation of regional check lists of taxa Internal assessment of observer precision (repeated registrations) Training courses Instrument intercalibration exercises
Sample analysis	Low for each of the above sampling procedures	Taxonomic competence. Precision in quantification of abundances from photo and video images.	Taxonomic intercomparison workshops Preparation of regional check lists of taxa Intercalibration workshop on image analysis procedures
Data treatment	Low in OSPAR recommendations	None.	None

Footnote. Supplementary variables essential for interpretation of macrophytobenthos results include: substrate type, slope and bearing, presence of loose sediment, degree of wave exposure, tidal range, Secchi disk depth, and salinity.

Table 4. Macrozoobenthos: hard bottom

Steps	**Method diversity**	**Critical QA factors**	**Priority QA actions**
Sampling procedure	High. At least 3 different method principles recommended:	Frame and transect work: representativity (accuracy) of stations.	Guidelines on assessment of representativity of stations
	- aerial surveillance, - shoreline and diving transects and frames, - photography or video.	Taxonomic competence of field observers.	Taxonomic intercomparison workshops Preparation of regional check lists of taxa Internal assessment of observer precision (repeated registrations)
		Operation of photographic and video equipment.	Training courses
		Photo/video resolution.	Instrument intercalibration exercises
Sample analysis	Low for each sampling procedure	Taxonomic skill.	Taxonomic intercomparison workshops Standardized taxonomic lists
	High diversity in quantification of abundance (abundance scales)	Precision of quantification of abundances from photo and video images.	Intercalibration workshops - image analysis procedures - abundance estimates
Data treatment	Variable principles with respect to inclusion/exclusion of species in community description	Criteria for inclusion of epigrowth and colonial organisms.	Standard approaches to pooling/exclusions of species
		Consensus on how to treat abundance of colony-forming species.	More specific guidelines Recommendations for best practice
		Inconsistency in handling uncertain identifications.	
	Numerous methods (and software packages) for univariate and multivariate analysis	'Rounding' errors with different computer packages.	Intercomparisons of analytical output from a standard data set
		Mistakes in data compilation.	Standardized taxonomic lists

Footnote. Supplementary variables essential for interpretation of hard-bottom fauna results include: substrate type, slope and bearing, presence of loose sediment, degree of wave exposure, tidal range, dominating macroalgal cover, and salinity.

Table 5. Macrozoobenthos: soft bottom

Steps	Method diversity	Critical QA factors	Priority QA actions
Sampling procedure	Sample collection: Low: 2 main categories – grabbing and coring. A wide variety of sampler designs are available within these categories Field processing: Low: the aim is invariably to extract fauna from sediments, and to preserve the material. Approaches to processing can vary substantially in the details	Variability in sediment and faunal sampling efficiency according to sampler design and handling. Mesh design (round vs. square, plastic vs. metal), sieving procedures, especially hose pressure.	Intercomparisons of sampling devices in the field Agreement on minimum acceptable sample volumes and sample quality Intercomparisons of methods for field sample processing Recommendations on 'best practice'
Sample analysis	Low: manual counting, identifying and weighing of species. Variability is encountered in: 1) means to extract fauna from residual sediment; 2) use of magnification during sorting; 3) access to up-to-date taxonomic keys; 4) biomass determinations	Extraction and sorting efficiency. Proficiency of species identification. Precision/accuracy of biomass estimates (method-determined).	Independent (in-house or external) checks on sorting and identification efficiency Workshops on species identification Access to up-to-date taxonomic keys Standardized taxonomic lists Ring tests (identification, counting, biomass) Compilation of biomass conversion factors
Data treatment	High: numerous methods (and software packages) for univariate and multivariate analysis	Inconsistency in handling of uncertain identifications. 'Rounding' errors with different computer packages. Mistakes in data compilation.	Standard approaches to pooling/exclusions of species Intercomparisons of analytical output from a standard data set

Footnote 1. Supplementary variables essential to the interpretation of soft-bottom benthos data include: particle size analyses of sediment sub-samples; measurements of redox potential; concentrations of specified contaminants, e.g., heavy metals; organic matter content; chlorophyll *a*. QA procedures should already be established for many of these variables. However, for those not presently covered, advice is needed on the appropriate ICES/OSPAR groups to deal with them.

Footnote 2. Epifauna are sampled by a variety of means across both coarse and soft bottoms. QA procedures must also be developed for this group. A wide variety of sampling methods is currently employed (e.g., underwater photography, dredges/sledges, trawls) and, in most cases, the results are strongly method-dependent.

APPENDIX 2

QUALITY AUDIT

Areas of particular importance to a chemistry laboratory (drafted by the WELAC/EURACHEM Working Group, 1992) but in most parts valid also for biology.

1 STAFF

- Staff are properly trained and up-to-date training records are being maintained.
- Tests are only carried out by authorised analysts.
- The performance of staff carrying out analyses is observed.

2 EQUIPMENT

- The equipment in use is suited to its purpose.
- Major instruments are correctly maintained and records of this maintenance are kept.
- Equipment, e.g., balances, thermometers, glassware, time pieces, pipettes, etc., is calibrated, and the appropriate calibration certificates demonstrating traceability to national or international standards are available.
- Calibrated equipment is appropriately labelled or otherwise identified.
- Instrument calibration procedures are documented and records of calibrations are satisfactorily maintained.
- Appropriate instructions for use of equipment are available.
- Instrument performance checks show that performance is within specifications.

3 METHODS AND PROCEDURES

- In-house methods are fully documented and appropriately validated.
- Alterations to methods are appropriately authorized.
- The most up-to-date version of the method is available to the analyst.
- Analyses are following the methods specified.

4 STANDARDS AND CERTIFIED REFERENCE MATERIALS

- The standards actually required for the tests are held.
- The standards are certified or are the ‘best’ available.
- The preparation of working standards is documented.
- Standards and reference materials are properly labelled and correctly stored.
- New batches of standards are compared against old batches before use.
- The correct grade of materials is being used in the tests.
- Where reference materials are certified, copies of the certificate are available for inspection.

5 QUALITY CONTROL

- There is an appropriate degree of calibration for each test.
- Where control charts are used, performance has been maintained within acceptable criteria.
- QC check samples are being tested by the defined procedures, at the required frequency, and there is an up-to-date record of the results and actions taken where results have exceeded action limits.
- Results from the random re-analysis of samples show an acceptable measure of agreement with results from the original analyses.
- Where appropriate, performance in proficiency testing schemes and/or interlaboratory comparisons is satisfactory and has not highlighted any problems or potential problems. Where performance has been unsatisfactory, corrective action has been taken.

6 SAMPLE MANAGEMENT

- There is an effective documented system for receiving samples, identifying samples against requests for analysis, and showing progress of analysis and fate of sample.
- Samples are properly labelled and stored.

7 RECORDS

- Notebooks/worksheets include the date of test, analyst, analyte, sample details, test observations, all rough calculations, any relevant instrument traces, and relevant calibration data.
- Notebooks/worksheets are completed in ink, mistakes are crossed out and not erased, and the records are signed by the analysts.
- Where a mistake is corrected, the alteration is signed by the person making the correction.
- The laboratory’s procedures for checking data transfers and calculations are being complied with.
- Vertical audits on random samples have not highlighted any problems (i.e., checks made on a sample, examining all procedures associated with its testing from receipt through to the issue of a report).
- Proof-reading of the final data report has been made.

REFERENCE

EURACHEM/WELAC (Cooperation for Analytical Chemistry in Europe/Western European Legal Metrology Cooperation). 1992. Information Sheet No. 1 (Draft): Guidance on the Interpretation of the EN 45000 series of Standards and ISO Guide 25. 27 pp.

APPENDIX 3

GOOD PRACTICE IN THE SAMPLING AND ANALYSIS OF PHYTOPLANKTON AND CHLOROPHYLL *a*

Sampling

- Be sure the sampling personnel is well informed about sample location, type of sample and sampling method;
- Avoid contamination with sediment;
- Register date, time and any other co-variable such as water temperature, salinity and extinction;
- Keep the samples in the dark;
- Fixed (phytoplankton) samples: fixate immediately, avoid big air bubbles, do not shake the bottle;
- Non-fixed (living) samples for qualitative analysis: keep the samples in the dark and at a temperature of 4 ± 2 °C. Deliver the samples within 48 hours.

Phytoplankton analysis

- Take a sub-sample in case there is a need to count a non-concentrated sample;
- Make use of a determination protocol and fill in completely;
- Create and maintain an annotated species list that contains the Latin name, synonym, historic information, morphologic description, measures and determination literature;
- Enumeration should be based on at least 10 cells for a common species in a 5-ml sample. Rare species have counts less than 10 per litre;
- Control chart.

Chlorophyll analysis (HPLC method)

- Validate the HPLC system (linearity, reproducibility, etc.). Validation is done at least once a year and when the system changes (new lamp, detector, etc.) and is logged;
- Reference sample. The amount of reference sample should be enough for two months or 40 days;
- Control chart. Chlorophyll *a* content of the reference sample is registered on a control chart;
- Performance criteria of HPLC analysis:
  - a) Column pressure is allowed to vary within a certain range. Double check the peak shapes;
  - b) Background signal detector should be stable at a certain level;
  - c) Retention time standard components chlorophyll *a*/*b* and phaeophytine *a*/*b*: check the location of the peaks, take action when there is a deviation of more than 10%;
  - d) Response factor standard components should not deviate more then 10% (compared with the last day).

APPENDIX 4

Good practice in the sampling and analysis of macrozoobenthos

Text to be added.

APPENDIX 5

Good practice in the sampling and analysis of macrophytobenthos

Text to be added.

APPENDIX 6

GOOD PRACTICE IN THE USE OF IMAGING TECHNIQUES

1. General comments

No binding procedures have so far been identified for QA/QC measures for imaging methods. Retrieval methods can be grouped as follows:

a) sea-going and land-based activities;

b) satellite and airborne imagery;

c) evaluation and processing of images, videos and sidescan records;

d) storage and retrieval of image documents.

(Important considerations in relation to diver-based retrieval include: parallel checks among several divers; photo and video documentation; double recording of profiles/transects; need for specific scientific diver training and certification; strict safety rules.)

2. 'Best practice' guidelines

a) **Sea-going and land-based procedures** should follow well-documented SOPs. In addition, a precise time log (i.e., TBC or data input on screen) is a prerequisite for proper evaluation and identification of photographic and video images. Marks on videos and photographs, and in the written log, can help in identifying and tracing back the image documents. One should note, however, that for certain purposes high-quality pictures are needed for publication without the on-screen information.

All technical details of cameras, films, tapes, camera settings, angles, distances, lightings, and parallel measurements must be recorded in writing.

Films, tapes and sonar records must be labelled and stored safely (in waterproof conditions).

Underwater pressure housings should be equipped with hydrophilic drying agents (silica-gel pellets in sacks) to provide proper functioning of cameras.

Greatest care should be given to O-ring sealings to avoid floating of pressure housings.

All safety instructions for diving, safety on board ships, and underwater electricity should be followed strictly.

b) **For satellite and airborne images,** the same rules apply in principle as for other imaging methods.

c) **Images and recordings** should be evaluated following well-documented and repeatable methods conforming to standards of the highest objectivity.

All steps involved in the processing of the original image (e.g., colour enhancement) must be documented and stated in documents and figure legends.

d) Images and videos should be **stored** in suitable labelled magazines, to make later retrieval possible by other individuals.

Back-ups must be stored in other buildings as video copies, CD-ROMs of photograph collections or stored on PC drives. Future storage media may include DVD drives.

Large collections of images should be stored in image data banks in digital form, to avoid misidentifications and losses of images. The use of key words is strongly recommended, providing information about the subject, platform, format, position depth, remarks, etc.

Attention should be given to the possibility that video tapes may lose their magnetic information after > 15 years as well as CD-ROMs after > 10 years; thus, back-ups are advised every 5 years.

This also applies to old film and photographic material that is of documentary and historical value.

ANNEX 9

Crustacea Decapoda
of the North Sea and the Baltic Sea

Handout for the Second International HELCOM/BEQUALM Benthos Taxonomic Workshop

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Introduction and scope

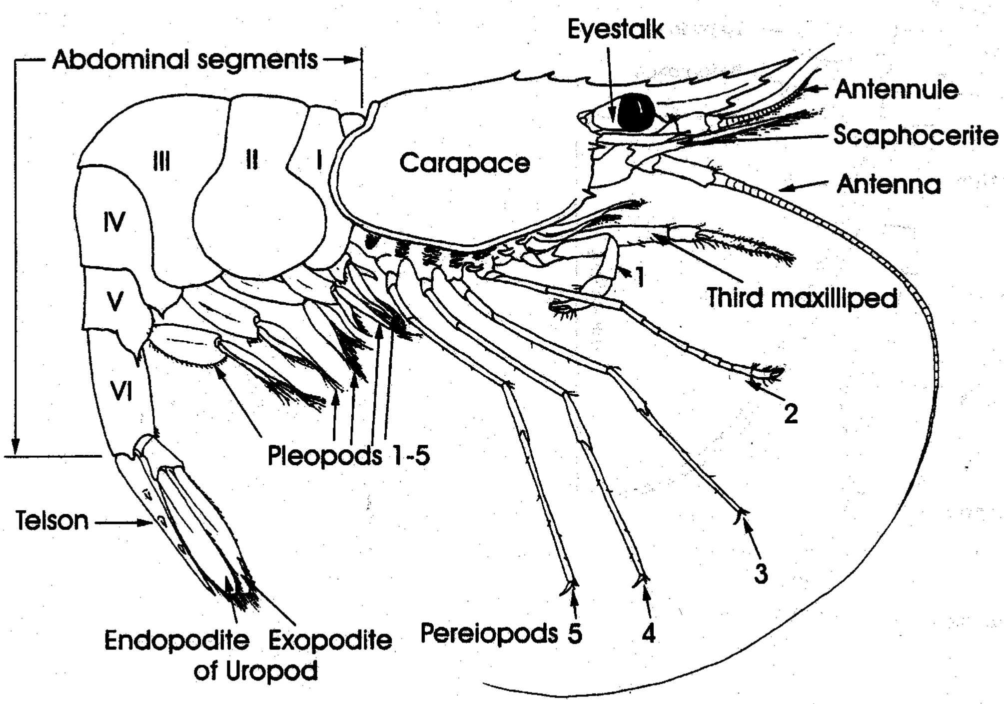
The present document has been prepared in order to have a basis for decapod identifications and some of the basic information. It contains a terminological part, a list of the species of the area dealt with and a key to the decapod families. Full keys to the genera and species are in preparation but were not ready by the time of the workshop. These handouts are not a publication and are meant for personal use only. This is especially because figures have been taken and adapted from literature, which would have to be redrawn or produced newly for an official copyrighted publication. Participants should not spread the figures freely outside their laboratories.

The area dealt with is the North Sea delimited in the usual way (Straits of Dover, Pentland Firth, Shetlands and from there towards the east along 61°N) and the whole Baltic. Distributional data have been broken down very roughly (North Sea, Skagerrak, Kattegat, Baltic Sea). A few species only known from the Straits of Dover and the immediate northern vicinity of 61°N at the Norwegian coast have been included in the keys, but not in the species list.

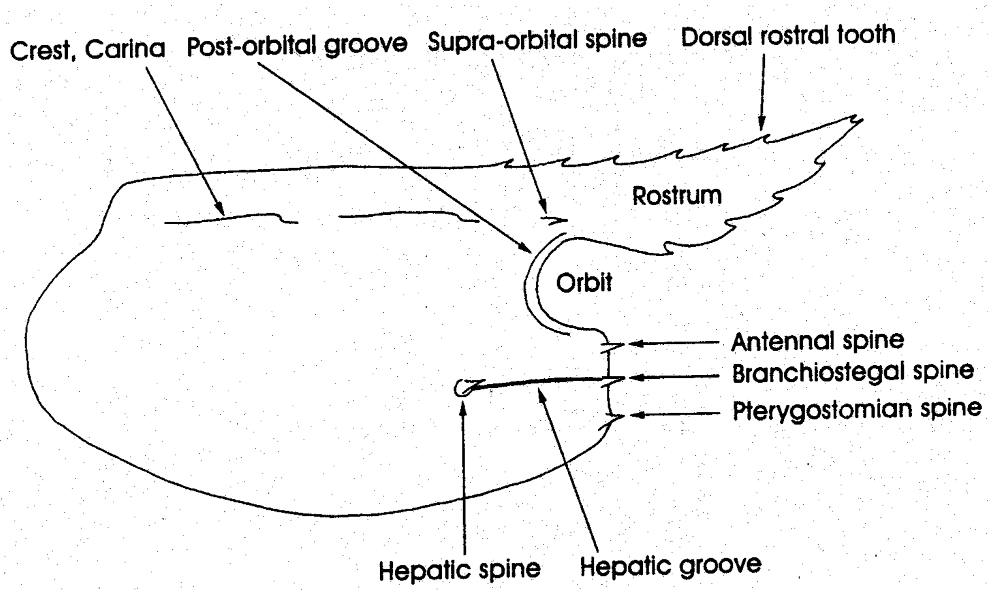
There is some good literature for the identification of decapods within the area, but no key covering the whole of it. British keys usually include the British west coast and Ireland, but not Scandinavian species. Some Scandinavian ones lack more western species. The present key aims at covering the whole area and giving hints for the recognition of extralimital groups and species if they show up. This can of course only be done to a certain extent. Ballast water tanks of ships are known to carry also decapods from very far away areas which cannot be identified with regional keys as it is unforeseeable what species will show up in future.

T e r m i n o l o g y

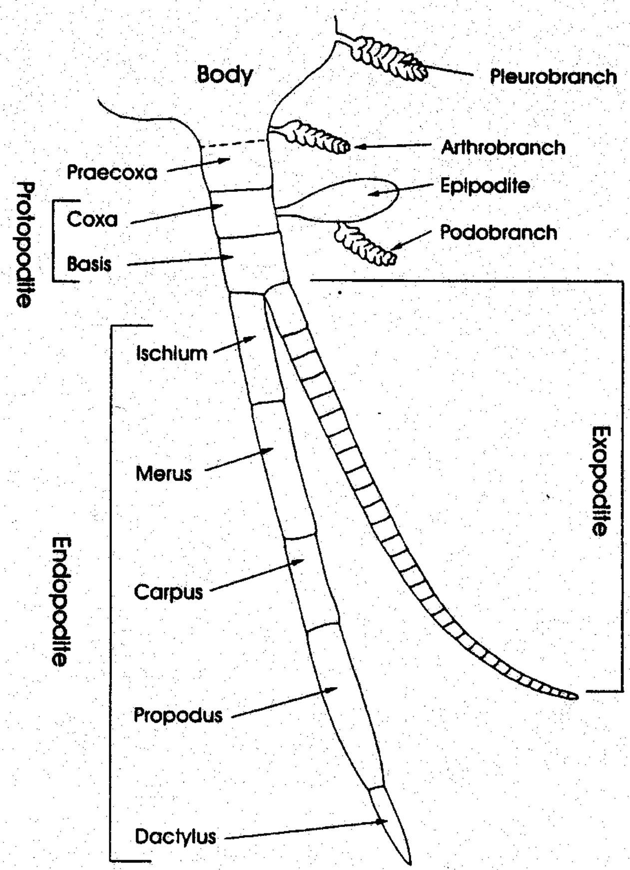
The decapod body shows a characteristic segmentation, which does not change very much, even in such different groups as shrimps, lobsters and crabs. The only changes occur in the proportions of the body parts. Therefore the segmentation here is presented on the basis of a shrimp.



In shrimps the carapace has a typical dentition and armature, which can be seen in the following figure. Note that not all spines and crests must be present in any shrimp.

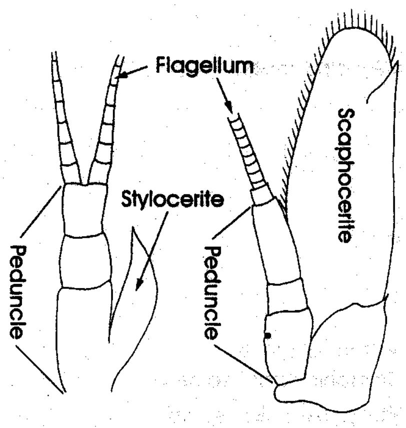


The limbs have a common construction plan and segmentation, which is modified according to the position on the body and the function connected with that.

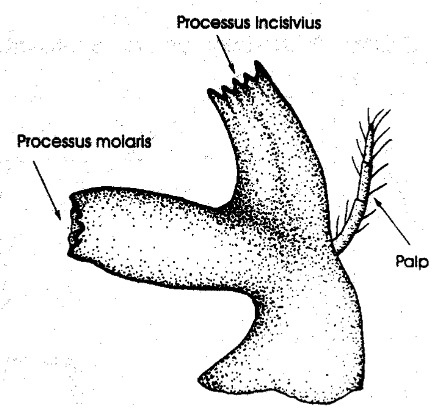


Schematic presentation of a generalised decapod leg.

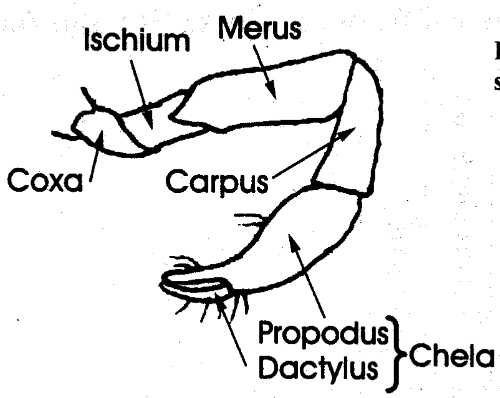
Some of the different appendages have a specific shape and terminology, which may be seen in the following figures. Only appendages with relevance for identification are depicted.



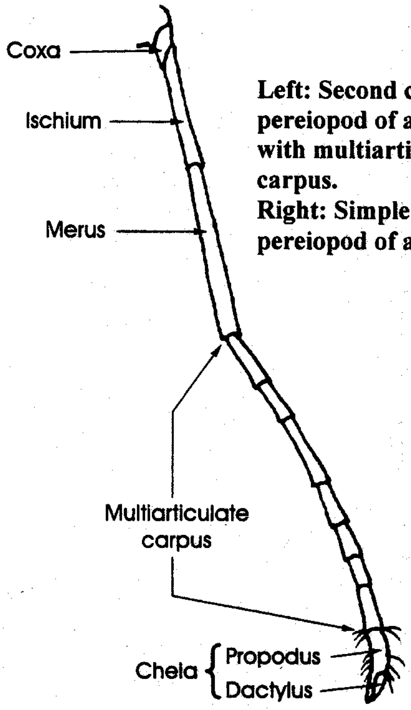
Proximal parts of Antennula (left) and Antenna (right)



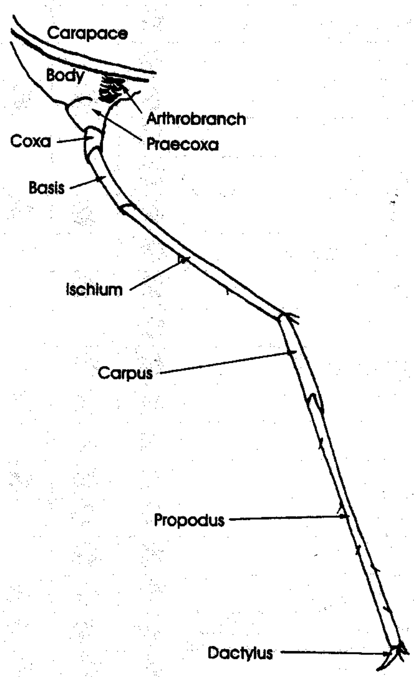
Mandible of a shrimp. In crabs the Processus molaris is missing

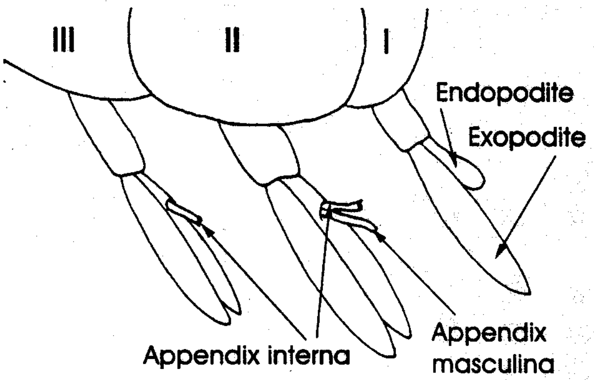


First pereiopod of a shrimp. Not all shrimps have chelate first pereiopods



Left: Second chelate pereiopod of a shrimp with multiarticulate carpus.
Right: Simple posterior pereiopod of a shrimp.





First three abdominal segments of a male shrimp, showing the pleopods and sexual organs. Though present in most shrimps, the Appendix masculina can be missing in others (e. g. crangonids)

Distribution of Decapod Species Recorded from the North Sea and the Baltic Sea

	North Sea	Skagerrak	Kattegat	Belts and Sound	Baltic Sea
Sergestes arcticus	●				
Pasiphaea multidentata	●	●			
Pasiphaea sivado	●	●			
Pasiphaea tarda	●	●			
Palaemon adsperus	●	●	●	●	●
Palaemon elegans	●	●	●	●	●
Palaemon longirostris	●				
Palaemon serratus	●			?	
Palaemonetes varians	●	●	●	●	●
Alpheus glaber	●				
Alpheus macrocheles	●				
Athanas nitescens	●	●	●	●	●
Bythocaris simplicirostris	●				
Caridion gordoni	●	●			
Caridion steveni	●				
Cryptocheles pygmaea	●	●			
Eualus gaimardii	●	●	●	●	●
Eualus occultus	●	●			
Eualus pusiolus	●	●	●	●	
Hippolyte varians	●	●			
Lebbeus polaris	●	●			
Spirontocaris lilljeborgii	●	●	●	●	●
Spirontocaris spinus	●	●	●	●	
Thoralus cranchii	●	●	●		
Processa canaliculata	●				
Processa edulis crassipes	●				
Processa modica modica	●				
Processa nouveli holthuisi	●	●			
Dichelopandalus bonnieri	●	●			
Pandalina brevirostris	●	●	●	●	
Pandalina profunda	●	●			
Pandalus borealis borealis	●	●	●		
Pandalus montagui	●	●	●	●	●
Pandalus propinquus	●	●			
Crangon allmanni	●	●	●	●	
Crangon crangon	●	●	●	●	●
Philocheras bispinosus	●	●	●	●	
Philocheras echinulatus	●	●			
Philocheras fasciatus	●				
Philocheras sculptus	●				

	North Sea	Skagerrak	Kattegat	Belts and Sound	Baltic Sea
Philocheras trispinosus	●				
Pontophilus norvegicus	●	●			
Pontophilus spinosus	●	●	●		
Sabinea sarsii	●	●	●		
Homarus gammarus	●	●	●		
Nephrops norvegicus	●	●	●	●	
Palinurus elephas	●				
Axius stirhynchus	●				
Calocarides coronatus	●	●			
Calocaris macandreae	●	●	●		
Callianassa subterranea	●	●	●		
Callianassa tyrrhena	●				
Upogebia deltaura	●	●	●		
Upogebia stellata	●	●	●		
Galathea dispersa	●				
Galathea intermedia intermedia	●	●	●		
Galathea nexa	●	●			
Galathea squamifera	●	●	●		
Galathea strigosa	●	●	●		
Munida rugosa	●	●			
Munida sarsi	●	●			
Munida tenuimana	●	●			
Munidopsis serricornis	●	●			
Pisidia longicornis	●	●	●		
Porcellana platycheles	●				
Diogenes pugilator	●				
Anapagurus chiroacanthus	●	●	●		
Anapagurus hydmanni	●				
Anapagurus laevis	●	●	●	●	
Pagurus alatus	●				
Pagurus bernhardus	●	●	●	●	●
Pagurus carneus	**L**				
Pagurus cuanensis	●	●	●		
Pagurus prideaux	●	●			
Pagurus pubescens	●	●	●		
Lithodes maja	●	●	●	●	
Dromia personata	●				
Paromola cuvieri	●				
Eurynome aspera	●	●	●		
Eurynome spinosa	●	●			
Achaeus cranchii	●	●			
Hyas araneus	●	●	●	●	●

	North Sea	Skagerrak	Kattegat	Belts and Sound	Baltic Sea
Hyas coarctatus coarctatus	●	●	●	●	
Inachus dorsettensis	●	●	●	●	
Inachus leptochirus	●				
Inachus phalangium	●	●	●		
Macropodia linaresi	●				
Macropodia parva	●	●			
Macropodia rostrata	●	●	●	●	●
Macropodia tenuirostris	●				
Maja brachydactyla	●				
Pisa armata	●				
Pisa tetraodon	●				
Ebalia cranchii	●	●	●		
Ebalia granulosa	●				
Ebalia nux	●				
Ebalia tuberosa	●	●	●		
Ebalia tumefacta	●	●	●		
Corystes cassivelaunus	●	●	●		
Thia scutellata	●	●			
Atelecyclus rotundatus	●	●			
Cancer bellianus	●				
Cancer pagurus	●	●	●	●	
Pirimela denticulata	●	●	●		
Geryon trispinosus	●	●	●		
Callinectes sapidus	●			●	
Carcinus maenas	●	●	●	●	●
Liocarcinus corrugatus	●				
Liocarcinus depurator	●	●	●	●	
Liocarcinus holsatus	●	●	●	●	
Liocarcinus marmoreus	●				
Liocarcinus navigator	●	●	●	●	
Liocarcinus pusillus	●	●	●	●	
Liocarcinus vernalis	●				
Macropipus tuberculatus	●				
Necora puber	●				
Polybius henslowii	●	●			
Portumnus latipes	●				
Monodaeus couchii	●				
Xantho pilipes	●	●	●		
Rhithropanopeus harrisii	●			●	●
Pilumnus hirtellus	●				
Pilumnus spinifer		●			
Goneplax rhomboides	●				

	North Sea	Skagerrak	Kattegat	Belts and Sound	Baltic Sea
Nepinnotheres pinnotheres	●	●			
Pinnotheres pisum	●	●	●		
Eriocheir sinensis	●	●	●	●	●
Hemigrapsus penicillatus	●				
Pachygrapsus transversus				●	
Planes minutus	●				
Species numbers	**130**	**83**	**53**	**31**	**14**

K e y t o t h e f a m i l i e s o f N o r t h S e a a n d B a l t i c S e a D e c a p o d a

This key is a regional one. It may prove quite useful in neighbouring areas (British Channel, North Atlantic), but as more genera occur there the diagnostic limits may prove unreliable. Its usage outside the area is therefore not encouraged. In spite of this the key has been enriched by remarks to make sure that such taxa from neighbouring areas can be recognized as exotic. In this case expert advice should be sought.

1) Abdomen well developed, not folded below and against Cephalothorax nor with sunken sterno-abdominal cavity, sometimes not segmented (hermit crabs) or asymmetrically calcified (lithodids). First pleopods of males either absent, largely reduced or forming a copulatory organ in which both sides of the body form a common single funnel. Uropods with the exception of lithodids always well developed though sometimes folded below telson......2

. Abdomen largely reduced, always with regularly arranged segments, folded against the Cephalothorax which ventrally forms a sterno-abdominal cavity. First pleopods of males always forming individiual copulatory organs on both sides of body. Uropods very rarely present and in these cases of simple scale shape, without endo- and exopodites (true crabs, Brachyura) 22

2) Body weakly calcified. Stylocerite of antennules well developed. Rostrum either small and spine-shaped or laterally compressed and with teeth on dorsal and/or ventral side (shrimps)...3

. Body strongly or (rarely) weakly calcified. Stylocerite of antennules absent. Rostrum either broadly rounded or elongate, in all cases dorso-ventrally compressed, teeth, if present, on the lateral sides of rostrum (Reptantia)......13

3) Pleurae of second abdominal somite overlapping at most those of third, never those of first or no overlapping at all. Second and third pairs of pereiopods with chelae (Penaeidea) 4

. Pleurae of second abdominal somite overlapping those of first and third. At most first two pairs of pereiopods with chelae, no chelae on third pereiopods (Caridea) 5

4) First pair of pereiopods without chelae, second and third with microscopic chelae, fourth and fifth reduced but present [pelagic shrimps] .... Sergestidae

. Either all three pairs of pereiopods with well developed chelae or last two pairs of pereiopods absent altogether (in this case the eyes are remarkably long and subequal to the ‘neck’ of the cephalothorax in front of the appendages)
Exotic species seek expert opinion

5) Rostrum a single short spine with simple or bifid tip...6

. Rostrum a more or less long blade bearing dorsal and/or ventral spines 9

[The Glyphocrangonidae are an extralimital family close to the crangonids which occur in the northern Atlantic deep sea. They will not key out with any of the families, as they have a long spiniform rostrum, but a subchelate first pereiopod. They are easily recognized by the fact that besides these two features the dactylus of the subchela is prehensile (i.e., works against the longitudinal upper border of the propodus) and the carpus of the second pereiopod is multiarticulate.]

6) First pair of pereiopods subchelate .... Crangonidae

. First pair of pereiopods chelate or simple 7

7) Carapace overreaching and (at least partly) covering eyes .... Alpheidae

. Eyestalks in total freely visible 8

8) Fingers of first two pairs of chelae long and slender, their cutting edges pectinate (= comb-shaped) [pelagic shrimps]...Pasiphaeidae

. Cutting edges of fingers not pectinate [benthic or benthopelagic shrimps] ....Processidae

9) At least first four pair of pereiopods with exopodites, chelae on first two pairs of pereiopods subequal in shape, though chelipeds may be of different length [to date not known in the North or Baltic seas] 10

. No exopodites on walking legs 11

10) Last three pairs of walking legs enormousely long, exceeding by far length of cephalothorax, fifth pereiopod without exopodite [deep sea, to date not known from the area, *Nematocarcinus exilis* has been recorded off the south coast of Iceland and could show up in the Skagerrak] ....Nematocarcinidae

. Last three pairs of walking legs not exceedingly long, at most subequal to cephalothorax length, all pereiopods with exopodites [bathypelacic, to date not known from the North Sea and Baltic, but *Hymenodora glacialis* has been recorded from off the west coast of Norway and could show up in Skagerrak].............................Oplophoridae

11) First pair of pereiopods with microscopically small chelae or chelae altogether absent. Carpus of second pairs of pereiopods multiarticulate... Pandalidae

. First pair of pereiopods with large and well discernible though sometimes small chelae. Carpus of second pair of periopods various..12

12) Carpus of second pair of pereiopods simple, not subdivided.. Palaemonidae

. Carpus of second pair of pereiopods subdivided (2 articles or more)...Hippolytidae

13) At least three pairs of functional walking legs behind large first chelipeds. Abdomen more ore less calcified, segmentation evident, though sometimes asymmetric (in this case body crab shaped, abdomen totally folded against cephalothorax and not visible dorsally) 14

. Two pairs of functional walking legs behind chelipeds, last two pairs of pereiopods largely reduced and used only for grooming. Abdomen uncalcified, no visible segmentation, pleopods, if present, assymetrical from second pair on. Living in gastropod shells from which they may be separated in trawl samples [Hermit crabs].......................21

14) First three pairs of pereiopods with chelae [if fourth pereiopod also bears chelae, your specimens belong to an extralimital family, the Polychelidae, the closest species of which is known to occur of the Outer Hebrides. In this case seek expert advice]...Nephropidae

. Third pereiopods not chelate, simple 15

15) Carapace covered with numerous spines of different sizes, anterior edge of carapace with two supraorbital horns, rostral spine in the middle between them minute...Palinuridae

. Carapace sometimes bears spines, but not totally covered with them, no supraocular horns 16

16) Last pair of pereiopods subequal in size to fourth and not dramatically smaller than the other pereiopods 17

. Last pair of pereiopods much smaller than preceeding ones, usually folded into the branchial chamber and then not visible from top 19

17) Linea thalassinica absent.. Axiidae and Calocarididae

. Linea thalassinica present on carapace 18

18) Rostrum minute; eyestalks flattened mesially; first pereiopods chelate and unequal, second pereiopods chelate ....Callianassidae

. Rostrum broadly triangular; eyestalks cylindrical; first pereipods chelate or subchelate, subequal, second pereiopods simple .... Upogebiidae

19) Abdomen with regular segmentation, uropods present 20

. Abdomen not with regular segmentation, three pairs of calcified larger plates at both sides and a membranous field with a large number of small plates between the larger ones; body crab-shaped....................................... Lithodidae

20) Body lobster-shaped; rostrum prominent, either triangular or spine-shaped; first two segments of abdomen fully visible in dorsal view ....Galatheidae

[The Chirostylidae, an extralimital family of which one species is known from Icelandic waters will key out with the galatheids. They can be easily distinguished from galatheids by the fact that they have a scaphocerite, missing in galatheids and that their telson has only one transversal suture in contrast to multiple ones in galatheids. For a positive identification of galatheids these characters should be checked.]

. Body crab-shaped; rostrum broadly rounded, hardly overreaching internal orbital lobes; only first segment of abdomen partly visible in dorsal view.. Porcellanidae

21) Coxae of third maxillipeds standing close together; left cheliped much larger than right one .... Diogenidae

. Coxae of third maxillipeds largely separated by a broad sternal plate; right cheliped larger than left..........Paguridae

[The Parapaguridae, an extralimital family of which one species occurs in deep waters off Iceland an the Faroe Islands will key out with the pagurids. They are easily distinguished from these last ones by the fact that the males of parapagurids have the first two pairs of pleopods transferred to pairy sexual organs and by their females having only one genital opening on the coxa of the left third pereiopod; in contrast the pagurids have no paired appendages at the anterior part of the abdomen and their females have genital openings on the coxae of both third pereiopods.]

22) Last pair of pereiopods articulating dorsally, used for carrying objects above the body; genital openings on coxae; females with external spermatheca furrows 23

. Last pair of legs normal; female genital openings sternal; females without external spermathecae 24

[A related family of primitive crabs, the Cymonomidae, has been recorded from the North Atlantic deep sea, but not from the area treated in this key. They will key out with Dromiidae/Homolidae because of the small and dorsally situated last pair of pereiopods. They will, however, not be identifiable with either of these families. They are distinguished from the dromiids by the lack of large anterolateral teeth and by their cylindrical carapace. From the homolids they differ by their uniformely thick eyestalks while the former ones have proximally slender and distally enlarged eyestalks.]

23) Eyes can be retracted into well formed orbits; anterolateral borders of subcircular carapace with four anterolateral teeth behind external corner of orbit ....Dromiidae

. Eyes cannot be retracted, orbits broadly open; anterolateral borders of subcylindrical carapace with a large number od small spines and spinules ....Homolidae

24) Antennae longer than carapace, mesially concave, forming together a rigid tube; carapace about twice as long as broad .... Corystidae

. Antennae clearly shorter than carapace which may maximally be more than 1.5 times as long as broad, but is usually broader than long..25

25) Buccal frame triangular, merus of external maxillipeds tapering .... Leucosiidae

. Buccal frame quadrangular, merus of external maxillipeds square...26

26) Carapace of subtriangular shape, narrowed frontally, front betwenn the eyes forming a paired or simple rostrum ....Majidae

. Carapace quadrangular or oval, not triangular, front between the eyes broadly rounded 27

27) Fifth pereiopods with flattened dactylus, usually forming a swimming paddle... Portunidae

. Fifth pereiopods with dactylus subcircular in cross section..28

28) Eyestalks about one third of maximum carapace width..Goneplacidae

. Eyestalks considerably less than one third maximum carapace width...29

29) Carapace circular, pea-shaped, without any lobes or dentation on anterolateral borders; adult females weakly calcified, males and first stage females calcified; commensal with bivalves and ascidians....................Pinnotheridae

. Carapace subcircular, subsquare, oval or hexagonal, lobes or dentation always present on anterolateral borders, sometimes weak indentations between broad and low lobes, in this case the anterolateral borders have a dense setation; free living 30

30) Carpus of third maxilliped articulating at inner dorsal margin of merus 31

. Carpus of third maxilliped articulating at middle dorsal margin of merus .... Grapsidae

31) Carapace heart-shaped, anterolateral lobes very low, hardly discernible between the dense setation; fingers of chelipeds without black colour .... Thiidae

. Carapace subcircular, suboval or hexagonal, anterolateral lobes or teeth well discernible; fingers of chelipeds may have black colour 32

32) Carapace subcircular, anterolateral borders setose and with 9-11 acute teeth including the exorbital one; fingers of chelipeds black in distal half...Atelecyclidae

. Carapace oval or subhexagonal, anterolateral borders either with 9 truncate, sometimes spinulous lobes or maximally 5 teeth; fingers of chelipeds various...33

33) Carapace broadly oval, considerably broader than long, anterolateral borders with 9 truncate smooth or spinulous lobes including the exorbital ones...Cancridae

. Carapace suboval or hexagonal, not considerably broader than long, anterolateral borders with maximally 5 teeth including the exorbital one..34

34) Front with a median lobe and a pair of submedians.. Pirimelidae

. Front without a median lobe, submedians either acute or low and separated by a median notch or front undivided35

35). Front with a pair of dentiform to acute submedian lobes;
fifth pereiopod longer than major cheliped.. Geryonidae

. Front with a pair of rounded or obsolete submedian lobes 36

36) Anterolateral borders with three teeth behind exorbital corner.. Panopeidae

. Anterolateral borders with four teeth behind exorbital corner 37

37) Anterolateral teeth acute, tips spiniform; carapace and chelipeds pilose; male with all abdominal segments free ....Pilumnidae

. Anterolateral teeth triangular, rounded to subacute, tips not spiniform; carapace and chelipeds with very few bristles; segments III-V of male abdomen fused.. Xanthidae

ANNEX 10: REVIEW OF STANDARD OPERATING PROCEDURES FOR THE SAMPLING AND ANALYSIS OF THE BENTHIC MACROFAUNA

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1 SUMMARY

The response to a request from the ICES Benthos Ecology Working Group (BEWG) for submission of Standard Operating Procedures (SOPs) for review was limited. In part, this appeared to reflect differences between countries regarding approaches to ensuring consistent performance within and between laboratories. Thus, for environmental assessment work in Norway, a single national standard is the chosen route and, similarly, published guidelines by the Dutch Tidal Waters Department are sufficiently detailed to function effectively as Standard Operating Procedures suitable for any individual laboratory engaged in surveys around the Dutch coast. In the United Kingdom and Germany, unpublished submissions from a number of laboratories revealed variation in the format for documenting procedures, and in the level of detail provided, although most appeared to conform with the general requirements of national or international guidelines.

Despite the limited response, it was possible to identify examples of good practice, and these are documented, together with suggestions for future improvements. There is scope for further exchange and review of Standard Operating Procedures as a means to promote harmonisation between laboratories and countries. Laboratories who do not currently document activities by means of SOPs are strongly encouraged to do so.

2 DEFINITION AND FUNCTION OF A STANDARD OPERATING PROCEDURE

An SOP may be defined (as in ‘Good Laboratory Practice’ guidelines) as ‘a documented procedure which describes how to perform tests or activities *normally not specified in detail in study plans or test guidelines*’. The italicised text helps to clarify some confusion that exists with regard to the role of an SOP. For example, in cases where international guidelines for a sampling or analytical procedure are written in sufficient detail, then these will perform the same function. However, guideline documents for benthic studies frequently cover large sea areas and a variety of habitats (e.g., Rumohr, 2000) and cannot be expected to provide sufficient detail for the requirements of all local surveys. In these circumstances, an SOP bridges the gap between the activity of an individual laboratory and the wider need for harmonisation of methodology. For example, a laboratory SOP might include a description of sample-processing equipment peculiar to that laboratory (though compatible with the performance needs of external guidelines), and perhaps its local source of manufacture.

A well-written SOP will help inexperienced members of staff in a laboratory to quickly develop expertise in a sampling or analytical area which is consistent with past practice at that laboratory, while being compatible with established approaches elsewhere. For those seeking laboratory accreditation, the production of SOPs will be essential as part of a wider QA package but, even for those who are not, they provide an important means to foster good practice internally. However, SOPs are clearly not, in themselves, guarantors of data quality.

3 REVIEW OF SUBMISSIONS

Published procedures

A Norwegian contribution (Anon., 1998) represents one of a number of National Standards in the water quality area, and covers field survey design to meet various objectives, as well as field sampling procedures and laboratory analysis. The guidelines are intended to ensure strict standardisation in approaches among Norwegian laboratories and the level of detail provided is such that the document acts, in effect, as a national SOP. It is structured as follows: scope, references to other standards, definitions, purpose and strategy for investigation of soft-bottom fauna (sampling programme, types of investigation, choice of sampling stations, reference stations), sampling (vessel requirements, position fixing, types of sampler, sampling procedures, criteria for acceptance of samples, sieving, preservation, supporting parameters, documentation, responsibilities of personnel), processing of samples and identification of species (sorting, identification, biomass, data processing and analysis), storage and archiving. Annexes cover processing of large samples, measurement of wet weight biomass and samplers.

As with the Norwegian standard, a series of documents published by the Dutch Tidal Waters Department (Essink, 1989a, 1989b, 1991; Leewis, undated-a, undated-b) represent national standards and, because of the level of detail, fulfil the function of SOPs covering the various regions and habitats along the Dutch coast. Each document carries a named author and version number. They are typically structured as follows: introduction, field of application, terms and definitions, principle of the method, reagents and auxiliary materials, apparatus, sampling (locations, dates of sampling, procedures for grab/core sampling, environmental variables, preservation), analysis of benthic fauna samples (preparation, identification and enumeration, biomass determination), calculation of density and biomass, measurement of shell length and weight of bivalves, sediment analysis.

Unpublished procedures

Of those submitted, one provided a short summary of field and laboratory procedures, including a novel system for separating animals from sediments at sea, methodology for biomass determination, and an outline of QA approaches, including the routine recording of individuals responsible for sample processing and the training of new staff through internal taxonomic workshops. A further submission documented laboratory analytical procedures, accompanied by a brief description of each activity, under the following headings: sieving, sorting, staining, identification, AQC, sample tracking, taxonomic verification/quality control, data entry, taxonomic referrals and museum links.

One SOP contained much descriptive detail under the following headings: field sampling, laboratory analysis (sample storage and archiving of information, initial sample processing, sorting, identification and enumeration, biomass determination, archiving of identified samples), data processing, analysis and archiving. Diagrams showing equipment used in the collection and processing of samples at sea were appended.

The final two submissions were similar in structure, and contained a level of detail comparable with the above Norwegian and Dutch standards, which reflected the requirements of a formal laboratory accreditation scheme. Each SOP carried the issue number, date and name of the person responsible for its production. For an SOP covering grab sampling for benthic invertebrates in marine and estuarine sediments, the topics covered were as follows: principle (of methods), sampling vessels, equipment (grab, supporting stand, hopper, sieves, sample containers, etc.), reagents, personnel (minimum level of experience required), procedures (including pre-survey checks of equipment, preparation of sampling equipment, deployment and recovery, collection of samples, sample sieving, sample retention and preservation, safety considerations), and references. The SOP was accompanied by several figures depicting sampling procedures at sea.

For identification and enumeration of the benthos, the SOP structure from the above laboratory was as follows: principle (of methods), reagents (sample fixative, stains, preservative, etc.), equipment, procedures: sample handling, staining, fixation/preservation, elutriation, fractionation, sorting, identification, taxonomy, enumeration, specimen retention, AQC, specimen preparation techniques, calculation and presentation of results, and taxonomic references.

4 CONCLUSIONS

The review revealed much variety in the structure of documented procedures, and in the amount of detail provided. However, most fulfilled the basic requirements of an SOP; there were no gross inconsistencies in methodological approaches and all followed a logical sequence in their layout. Further submissions are encouraged, as these would provide the basis for a more critical evaluation of interlaboratory consistency in specific aspects of field sampling and laboratory analysis.

In considering ‘best practice’ arising from this review, it is recommended that SOPs should:

a) be structured logically by heading and sub-heading to cover the full sequence of activities in field sampling and laboratory analysis;
b) carry an issue number, date and name(s) of the individual(s) responsible for its drafting and updating. This anticipates a likely requirement for changes to SOPs in response to new equipment, guidelines and so on;
c) document in-house AQC procedures;
d) account for the specific practices of the individual laboratory. At the same time, SOPs must of course reflect agreed guidelines applicable at national or international level;
e) be filed as paper copies in an accessible place, as well as being available on computer;
f) be freely available to all interested parties (especially funding agencies);
g) contain explicit instructions for the tracking of samples from the point of collection to the point of archiving of analysed material.

SOPs may usefully contain:

a) diagrams depicting gear, especially where local modifications to equipment are made;
b) a summary flow-chart as an accompaniment to a lengthy SOP, as an *aide memoire* for field and laboratory bench operators;
c) a full listing of taxonomic keys used for laboratory identification, and other useful reference works relating to procedures;
d) details of local suppliers, manufacturers, etc., where relevant.

SOPs should not:

a) contain vague generalisations;
b) contain excessive detail: a sensible balance needs to be achieved which takes into account the basic level of training and common sense that a new operator will possess;
c) cover too many activities: for example, it is logical to have separate SOPs for field and laboratory procedures. Different types of field activity such as intertidal core sampling and ship-board sampling are also sensibly treated separately.

5 ACKNOWLEDGEMENTS

The following individuals kindly provided information used in this review: Torgeir Bakke (Norway), Karel Essink (Netherlands), Ingrid Kröncke (Germany), Keith Cooper, Nigel Grist, Elaine Hamilton, Geoff Turner (United Kingdom).

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ANNEX 11: ZOOPLANKTON METHODOLOGY MANUAL

Much of the work of ICES is carried out by the many Working Groups, and the reports of the activities of the Working Groups provide a major input to the Annual Science Conference each year. On occasion Working Groups produce other scientific outputs, and a recent example is the 684-page, '*ICES Zooplankton Methodology Manual*', which has just been published by Academic Press, as a result of the work of the Working Group on Zooplankton Ecology, over a number of years.

ICES established a Study Group on Zooplankton Production in 1992 chaired by Hein Rune Skjoldal, of the Institute of Marine Research, Bergen, Norway. The Study Group was given as terms of reference to:

a) review existing methods for measuring biomass and production processes;

b) make proposals for improvement and standardisation of methods, and prepare a methodological manual;

c) consider the need for laboratory and seagoing workshops to intercalibrate experimental methods and evaluate new technology.

Zooplankton are the diverse, delicate and often very beautiful, assemblage of animals that drift the waters of the world's oceans. These microscopic organisms play a key role in the pelagic food web by controlling phytoplankton production and shaping pelagic ecosystems. In addition, because of their critical role as a food source for larval and juvenile fish, the dynamics of zooplankton populations, their reproductive cycles, growth, reproduction and survival rates are all important factors influencing recruitment to fish stocks. It is this latter role which has made zooplankton ecology of particular interest to ICES.

The Study Group has met eight times, in March 1992 in Bergen; in March 1993 in Las Palmas; in March 1994 in Plymouth; in June 1995 in Woods Hole; in March 1996 in Bergen; in March 1997 in Kiel, May 1998 in Santander, and May 1999 in Reykjavik. In 1997 Roger Harris of the Plymouth Marine Laboratory, United Kingdom, assumed the chairmanship. The group will hold the 2000 meeting in May in Hawaii.

The Study Group decided at the first meeting to produce a Zooplankton Methodology Manual, recognising the need for improvements and standardisation in methods for studying this important and challenging group of organisms. To assist in the review of methods and to provide input to the issue of standardisation and improvement of methods, three special workshops were convened. The first was a sea-going workshop onboard RV 'Johan Hjort' and RV 'A.V. Humboldt' on zooplankton sampling methods (June 1993). The two others were laboratory workshops at the University of Bergen on production methods using the copepods *Acartia tonsa* (October 1993) and *Calanus finmarchicus* (April 1994). A fourth workshop was arranged by US GLOBEC in Hawaii using marine copepods (April 1994). Results from these workshops have been incorporated by the Study Group in producing this Manual.

ICES changed the status of the Study Group to a Working Group on Zooplankton Ecology (WGZE) in 1994. The Working Group took over the task of completing work on the Manual.

The scope of the Zooplankton Methodology Manual is to provide an *updated review* of basic methodology used in studies of zooplankton including recommendations on improvements, harmonisation and *standardisation* of methods. The chapters aim to maintain a balance between being introductory and comprehensive. They provide an overview of methods that are useful, for example, to graduate students who are starting in a new field. They emphasise the sources of error and the strengths and weaknesses of methods for various purposes and tasks. It has not been possible, however, to go into great detail for all methods, and reference to recent reviews and detailed descriptions of methods is used where possible and appropriate.

Each chapter begins with a review of methods, which in most cases is accompanied by recommendations regarding choice and conduct of methods. These reviews consider the background and history of the methodology, the basic principles, sources of variability, equipment and procedures, comparative evaluation of alternative methods, general recommendations, and extensive literature references. Where possible, detailed descriptions of standard protocols are included. The aim is to give practical instructions on *how* to carry out particular measurements and procedures. Equipment, procedures, data analysis and interpretation are described, where possible. These protocols either define standard methods, or give examples of little-known methods. If many methods are used, or many instruments, guidance is given on the most highly recommended, or the most often used, or likely to be used. In some cases, it proved difficult to propose an agreed standard protocol. It is, however, possible to provide guidelines that reduce the variability in methods and contribute towards harmonisation and standardisation.

The various chapters of the Manual have been reviewed by the ICES WGZE, and in addition peer reviewers from outside this group have evaluated each chapter independently. Grateful thanks are due to these reviewers for their valuable contribution to the overall project.

Each chapter is authored by an expert, or group of experts, selected from both members of the WGZE and other international specialists. The writing has been organised and coordinated by the main author assisted by co-authors.

While striving to be a comprehensive treatment of modern methods in zooplankton ecology, it is inevitable that some topics have not been covered. In particular it was the original intention to include chapters on methods for investigating zooplankton behaviour, and for studying population dynamics. The former chapter was never commissioned, while the latter, although originally written as part of the ICES Manual project, was ultimately published as a separate scientific article: Aksnes *et al*., 1997. '*Estimation techniques used in studies of copepod population dynamics – a review of underlying assumptions*'. *Sarsia*, 82: 279–298. This may still be referred to as being complementary to the work. The original concept of the Zooplankton Methodology Manual included a related CD-ROM to include data, graphics and video images, particularly relating to sampling methods, and deriving from the sea-going workshop. This is not included with the Manual, however, the WGZE are still considering the preparation and distribution of such a CD-ROM.

The ICES WGZE has been encouraging and coordinating zooplankton monitoring activities in the ICES area, and this Manual should contribute to these activities. Similarly, the development of major international initiatives with a particular focus on zooplankton, particularly the IGBP/SCOR/IOC co-sponsored Global Ocean Ecosystem Dynamics (GLOBEC) project, and the Living Marine Resources module of the Global Ocean Observing System (GOOS-LMR) make the publication of this Manual particularly timely. While not formally adopted by either programme, the ICES Zooplankton Methodology Manual will contribute significantly to the standardisation of methodology that both GLOBEC and GOOS-LMR strongly endorse. The 2000 meeting of the WGZE in Hawaii, with guests from the PICES zooplankton community, is a further step in the process of zooplankton methods standardisation between ocean basins.

The preparation of the Zooplankton Methodology Manual has by definition been a team effort. The members of the WGZE and the Editors have led in this, over the years of development. It is a great pleasure to acknowledge the enthusiasm, dedication and patience of all the authors and co-authors during this process, and the help of the staff of Academic Press during the editing and production of the Manual.

Roger Harris
Plymouth
March 2000

ICES ZOOPLANKTON METHODOLOGY MANUAL

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Chapter 1: Introduction
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Chapter 2: Sampling and experimental design
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Chapter 3: Collecting zooplankton
D. Sameoto, P. Wiebe, J. Runge, L. Postel, J. Dunn, C. Miller, S. Coombs

Chapter 4: Biomass and abundance
L. Postel, H. Fock, W. Hagen

Chapter 5: Sampling, preservation, enumeration and biomass of marine protozooplankton
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Chapter 6: Acoustical methods
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Chapter 7: Optical methods
K.G. Foote

Chapter 8: Feeding
U. Båmstedt, D.J. Gifford, X. Irigoien, A. Atkinson, M. Roman

Chapter 9: The measurement of growth and reproductive rates
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Chapter 10: Metabolism
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Chapter 11: Methods for population genetic analysis of zooplankton
A. Bucklin

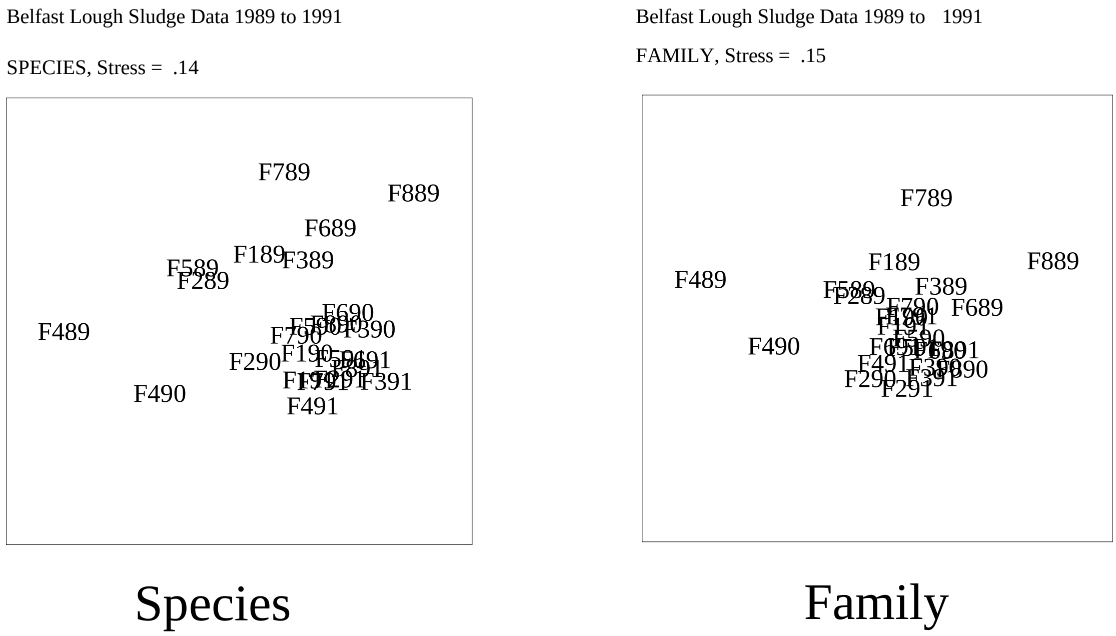
Chapter 12: Modelling zooplankton dynamics
F. Carlotti, J. Giske, F. Werner

ANNEX 12: TEMPORAL TRENDS AT A SEWAGE SLUDGE DISPOSAL SITE: INFLUENCE OF ERRORS AT THE LEVEL OF SPECIES IDENTIFICATION

Benthic monitoring at 8 sites adjacent to a sewage sludge disposal site was conducted during 1989 to 1991. Three replicates were taken at each site, sieved on a 0.5 mm sieve and identified to species level. The sites are very diverse and the combined macrofauna species list for the three years extends to almost 600 species. Three different laboratories conducted sample analysis. It was not perceived that the sites were subject to any gross temporal change as indicated by supporting sediment chemistry and particle size analysis data.

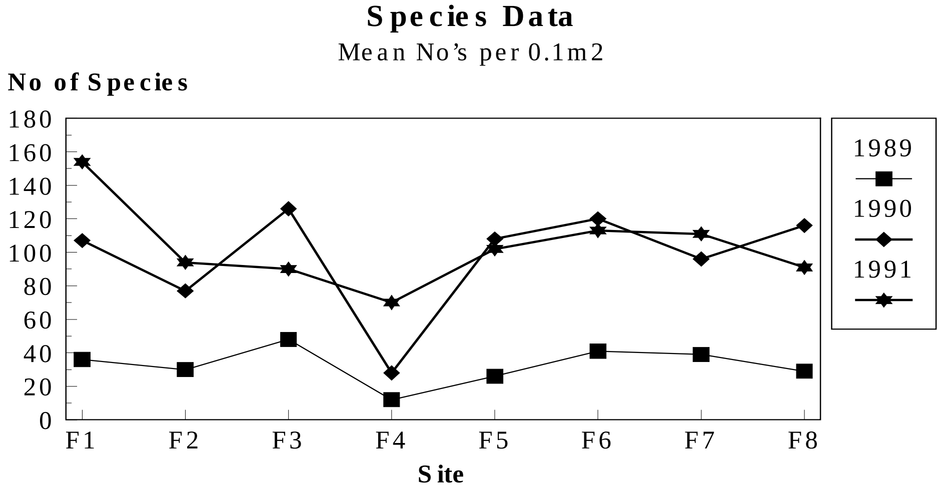
Multivariate analysis of the species data indicates a very strong temporal gradient (Figure 1).

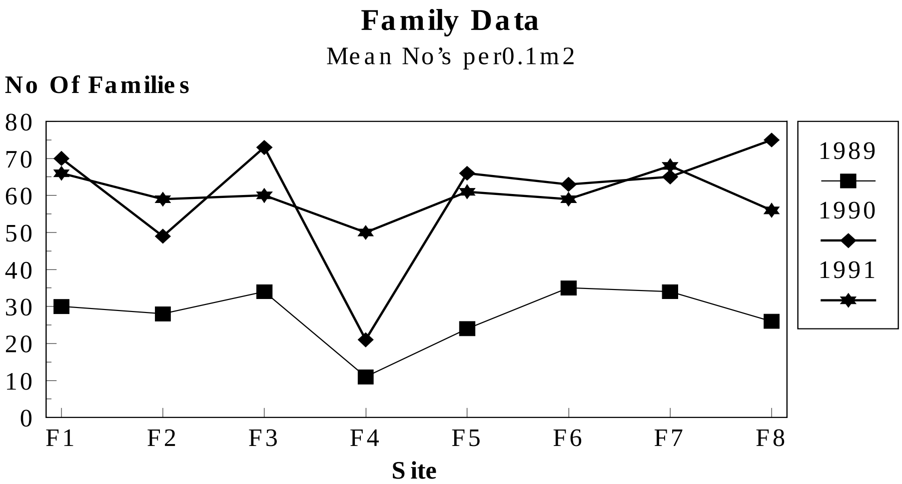
Figure 1. Multivariate analysis.



Reducing the data set to family level pulled 1990 and 1991 closer, leaving 1989 isolated. Site F4 is a sandy site quite distinct from the other sites, which are generally muddier and consequently richer. The original split of the years could be explained by the fact that most of the species (approximately 450 out of 600) are represented by single-species families. Hence misidentification of species would cause increased dissimilarity. When the 1990 and 1991 Reference Collections were re-examined and corrections to the data sets implemented, the resulting ordination was very similar to the above family ordination. The cause for the isolation of 1989 data can be explained by poor sorting by inexperienced staff with no counter checking by competent staff (Figure 2).

Figure 2. Variation in numbers of species and families per site.





The overall conclusion is that the most damage caused to this temporal trend data set occurred at a very early stage of the process during an event that is generally considered a simple process. Proper training and implementation of QA procedures would have reduced such an occurrence.

ANNEX 13: ACTION LIST

1) Dr Rees to write to Professor Underwood to acknowledge inclusion of information on Australian QA activities in the SGQAE 2000 report, and to inform him of ICES/OSPAR work.

2) Dr Rees to contact Sabine Cochrane (consultant for ISO, Akvaplan-NIVA, Norway) regarding SGQAE activities.

3) All members to further review and augment the draft SGQAE QA guidelines intersessionally, with a view to producing a final draft in 2001.

4) Dr Latuhihin to provide information on Dutch experience with QA of intertidal sampling activity.

5) Dr Rees to write to the chairs of WGPE, WGZE, and BEWG requesting consideration of the latest draft of the SGQAE QA guidelines and, in the first two cases, of the scientific and operational merits for inclusion of primary production measures and zooplankton studies in the JAMP.

6) Dr Rees to communicate comments on a proposed ICES standard method for chlorophyll *a* determination to the Chair of WGPE.

7) Dr Breen to report on progress with the application of pass/fail criteria to benthos data submitted to the UK National Marine Monitoring Programme.

8) Dr Wilhelms to report on data management and quality control initiatives in Germany.

9) Dr Rumohr to report on progress with the EC BEQUALM project.

10) Janet Pawlak to forward the latest draft of the proposed ICES standard method for chlorophyll *a* determination to Professor F. Colijn, for consideration prior to the QUASIMEME/BEQUALM workshop to be held in Büsum, Germany in May 2000.

ANNEX 14: RECOMMENDATIONS

1. Recommendations concerning a SGQAE meeting in 2001

The ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements Related to Eutrophication Effects (SGQAE) (Chair: Dr H. Rees, UK) recommends that it meet at ICES Headquarters from 14–17 February 2001 to:

a) finalise a draft of OSPAR/ICES guidelines for QA of biological measures;
b) review progress in the application of JAMP guidelines and associated QA activities, especially the outcome of workshops/intercomparison exercises, within OSPAR Member Countries;
c) further evaluate criteria for judging the acceptability of biological data in international monitoring programmes, at the field sampling, laboratory analysis and data entry stages;
d) compile a programme of planned biological workshops/intercalibration exercises/ring tests, etc., relevant to ICES/OSPAR activities, covering the years 2001 and 2002;
e) review the outcome of activities of SGPHYT, and of other comparable efforts in compilation of species lists, with emphasis on QA aspects;
f) follow up results obtained with the EC BEQUALM project, with the aim of producing recommendations relevant to JAMP guidelines;
g) consider the merit of circulation of a questionnaire to laboratories in the OSPAR area concerning QA activities in relation to biological measures and, as appropriate, to draft a set of specific questions;
h) request that WGPE and WGZE consider the scientific and operational merits of inclusion of, respectively, primary production measures and zooplankton studies in JAMP eutrophication monitoring programmes;
i) meet jointly with SGQAB, with a view to a merger of the two groups.

Justifications

a) This will meet the needs of laboratories seeking guidance in evolving new schemes for QA of biological data. SGQAE places the highest priority on achievement of this objective, in line with OSPAR requirements.

b) A review of national activities greatly assists in evaluating progress in the development and implementation of QA schemes within OSPAR Member Countries.

c) Progress in this area is essential, if biological monitoring data derived from collaborative programmes are to contribute effectively to management actions to protect the marine environment.

d) This is intended to be a helpful reference source for Member Countries/individual laboratories who wish to participate or organise their own activities. It is also a means for SGQAE to identify gaps in coverage and to recommend appropriate action.

e) This arises from an earlier ICES request, and is considered to be an important goal related to improvements in QA of biological data.

f) The BEQUALM project includes a phytoplankton and benthos component and progress will therefore be highly relevant to SGQAE interests.

g) This should have the benefit of greatly extending information on the present status of QA/AQC activities within OSPAR laboratories, and allow more specific targeting of areas for future improvement.

h) This is in response to a SGQAE appraisal of the scope for inclusion of additional measures for evaluation of eutrophication-induced changes in the OSPAR area.

i) Problems of low attendance rates and turnover of representatives apply to both groups and reduce their effectiveness, despite the critical importance of sound QA for the success of international monitoring and management initiatives aimed at protecting the marine environment. At the same time, it is clear from joint discussion that there is significant overlap between SGQAE and SGQAB with respect to the major QA issues of concern, and a merger of the two groups would seem a logical outcome, to the benefit of all contracting parties.

2. Recommendations to ICES

a) That ICES urgently addresses the need to up-date the data entry system for the Biological Database, allowing input using spreadsheet formats;

b) that ICES defer publication of the proposed standard method for chlorophyll *a* determination, pending wider review of the content, and taking into account the comments from SGQAE.