BEQUALM NATIONAL MARINE BIOLOGICAL ANALYTICAL QUALITY CONTROL SCHEME

Particle Size Component Report

Scheme Operation – Year 19 – 2012/2013

Authors: **Adam Procter**

Reviewed by: Ruth Barnich

Approved by: Richard Arnold

Contact: Adam Procter
adam.procter@unicomarine.com

thomson unicomarine

Date of Issue: 30th August 2013

PARTICLE SIZE ANALYSIS COMPONENT REPORT FROM THE CONTRACTOR

SCHEME OPERATION – YEAR 19 – 2012/13

Scheme Year 19 Exercise Reports (hyperlinked in this report)

Particle Size Results - PS44

Particle Size Results - PS45

Particle Size Results - PS46

Particle Size Results - PS47

1. Introduction

The National Marine Biological Analytical Quality Control (NMBAQC) Scheme addresses three main areas relating to benthic biological data collection:

- The processing of macrobenthic samples.
- The identification of macrofauna.
- The determination of physical parameters of sediments.

The nineteenth year of the Scheme (2012/13) followed the format of the eighteenth year. A series of exercises involved the distribution of test materials to participating laboratories and the centralised examination of returned data and samples.

In the Year 19 NMBAQC Scheme eleven laboratories participated in the particle size analysis exercises PS44, PS45, PS46 and PS47; four were government laboratories and seven were private consultancies. Five of the participants were responsible for CSEMP (Clean Seas Environment Monitoring Programme) sample analysis. To reduce potential errors and simplify administration, LabCodes were assigned in a single series for all laboratories participating in the benthic invertebrates, fish and particle size components of the NMBAQC Scheme (due to Thomson Unicomarine administering these three components).

As in previous years, some laboratories elected to be involved in limited aspects of the Scheme. CSEMP laboratories were required to participate in all relevant components of the Scheme, although this was not strictly enforced.

1.1 Summary of Performance

This report presents the findings of the Particle Size Analysis components for the nineteenth year of operation of the National Marine Biological Analytical Quality Control (NMBAQC) Scheme. This component consisted of one module with four exercises:

- Analysis of four sediment samples (PS44, PS45, PS46 and PS47) for physical description.

The analytical procedures of this module were the same as for the eighteenth year of the Scheme. The results for the four exercises are presented and discussed. Comments are provided on the performance for each of the participating laboratories in each of the exercises.

In previous years the Particle Size exercises (PS) ‘Pass/ fail’ criteria were based upon z-scores from the major derived statistics with an acceptable range of ±2 standard deviations (see Description of the Scheme Standards for the Particle Size Analysis Component). The annual report for Scheme Year 16 deemed the use of z-scores inappropriate for such a low number of data returns where two erroneous results can significantly alter the ‘Pass/ fail’ criteria.

The z-score method also assumes that the majority of respondents are correct and raised genuine concerns regarding technique and method bias. Following this, the 'Pass/ fail' criteria are currently under review and alternative flagging criteria are being trialled. Therefore, Scheme Year 19 continues the use of z-scores calculated for each half-phi interval, and multivariate analysis using Euclidean distance matrices (dendrograms and non-metric MDS plots) trialled in Scheme Year 17 and Year 18 respectively.

The variation within the ten replicate results produced for TUM in-house analysis (using the NMBAQC PSA SOP) was minimal for each of the four exercises; this is partly attributable to the use of only Malvern laser instruments and some standardised protocols, i.e. no use of chemical dispersants or hydrogen-peroxide pre-treatment. In most cases there was reasonably good agreement between participant laboratories for all four PS exercises. All four particle size exercises of Scheme year 19 received eleven data returns; exercise 1 (PS44; Sandy Mud), exercise 2 (PS45; Sand), exercise 3 (PS46; Artificial Gravel) and exercise 4 (PS47; Gravelly Sand).

Comments are provided on the individual performance of the participating laboratories in each of the above components. A summary of their performance with respect to standards determined for the CSEMP is presented.

1.1.1.1 Statement of Performance

Each participating laboratory received a 'Statement of Performance', which included a summary of results for each of the Schemes modules and details the resulting flags where appropriate. These statements were first circulated with the 1998/1999 annual report, for the purpose of providing proof of Scheme participation and for ease of comparing year on year progress.

2. Summary of PSA Component

2.1 Introduction

The Particle Size Analysis (PS) module is described in more detail below. A brief outline of the information to be obtained from the module is given, together with a description of the preparation of the necessary materials and brief details of the processing instructions given to each of the participating laboratories.

2.1.1 Logistics

The labelling and distribution procedures employed previously have been maintained and specific details can be found in the Scheme's annual reports for 1994/95 and 1995/96 (Unicomarine, 1995 & 1996).

2.1.2 Data returns

Return of data to Thomson Unicomarine Ltd. followed the same process as in previous years. Spreadsheet based forms (tailored to the receiving laboratory) were distributed for each circulation via email. All returned data have been converted to Excel 2003 format for storage and analysis. In this Scheme year data returns were prompt for most exercises, with reminders being distributed shortly before each exercise deadline.

2.1.3 Confidentiality

To preserve the confidentiality of participating laboratories, each are identified by a four-digit Laboratory Code. In September 2012 each participant was given a confidential, randomly assigned Scheme year nineteen LabCode. Codes are prefixed with the Scheme year to reduce the possibility of obsolete codes being used inadvertently by laboratories, e.g. Laboratory number four in Scheme year nineteen will be recorded as LB1904.

In this report all references to Laboratory Codes are the post-August 2012 codes (Scheme year nineteen). To reduce potential errors and simplify administration, LabCodes were assigned in a single series for all laboratories participating in the benthic invertebrate, fish and particle size components of the NMBAQC Scheme (due to Thomson Unicomarine administering these three components).

2.2 Particle Size Analysis (PS) Module

2.2.1 Description

This module examined the percentage of sediment found in each half-phi interval from the particle size analysis of replicate sediment samples. Four samples of sediment; two fine (PS44 and PS45), one coarse (PS46) and one mixed (PS47) were distributed in 2012/13. The sets of PS44 and PS45 replicate samples were derived from natural marine sediments; PS46 replicates were artificially prepared from commercial aggregate materials; PS47 replicates were prepared from a combination of artificial and natural sediments; they were prepared as described below. In each case a random subsample of the prepared replicates were divided for laser diffraction analysis to ensure sample replicate consistency. For PS44 - 47, the replicates were analysed using a Malvern Mastersizer 2000 to produce benchmark data.

2.2.1.1 Preparation of the Samples

The first two PS circulations were sediments collected from natural marine environments (Harwich for PS44, Milford Haven for PS45); the third (PS46) was artificially created from commercially acquired materials; the final circulation (PS47) was artificially created from natural sediments (from offshore in the southern North Sea) and commercially acquired materials. Natural material for PS44 and PS45 was returned to the laboratory and coarse sieved (1 mm) to remove gravel, shell and large faunal content.

A minimum of 30 litres of visually similar sediment was collected. Following sieving, the sediment for PS circulation was well mixed in a large tray and allowed to settle for a week. The sediment was sub-sampled by coring in pairs. One core of a pair was stored as the ‘A’ component, the other as the ‘B’. To ensure sufficient weight for analysis, and to further reduce variation between distributed PS samples, this process was repeated three times for each sample replicate, i.e. each distributed sample was a composite of three cores.

The artificial PS46 replicates were produced by combining known quantities of commercially acquired material. For the PS47 replicates, known quantities of commercially acquired material were added to known quantities of sand from the southern North Sea.

The numbering of the replicate samples was random. All of the odd-numbered 'B' components (a total of 10) were analysed in-house to assess the degree of inter-sample variation and produce benchmark data. All of these replicates were analysed using a Malvern Mastersizer 2000 laser. The 'A' components were assigned to participating laboratories randomly and distributed according to the Scheme timetable.

2.2.1.2 Analysis required

The participating laboratories were required to conduct particle size analysis on the samples following the NMBAQC's best practice guidance for particle size analysis to support biological data (Mason, 2011), either in-house or using a subcontractor. A written description of the sediment characteristics was to be recorded (pre-processing and post-processing using the Folk Triangle) as well as the %< 63µm and an indication of any peroxide treatment or chemical dispersant used. Also requested was a breakdown of the particle size distribution of the sediment, to be expressed as a weight or percentage of sediment in half-phi (ϕ) intervals. Optional data on the mean, median, sorting and skewness from the GRADISTAT program could also be provided. Approximately nine weeks were allowed for the analysis of each PS sample (PS44, PS45, PS46 and PS47).

2.2.2 Results

2.2.2.1 General comments

Eleven laboratories subscribed to the PSA module for Scheme Year 19 (2012/2013).

Scheme Year 19 continues with the workbook method introduced in Year 18; this workbook auto-filled the "Final Merged Data" tab based on what laboratories provided for the sieve and laser data. The aim of this was to achieve more consistency in the way results were presented. Most participating laboratories now provide data in the requested format, though some variations remain. As previously reported, it should be remembered that the results presented may be from a more limited number of analytical laboratories than is immediately apparent since this component of the Scheme is often sub-contracted by participants to one of a limited number of specialist laboratories. For each of the four exercises all of the eleven participating laboratories returned data. Detailed results for each exercise have been reported to the participating laboratories (PS44, PS45, PS46 and PS47); additional comments are added below.

2.2.2.2 Analysis of sample replicates (benchmark data)

Replicate samples of the sediment used for the four PS distributions were analysed where required using a Malvern Mastersizer 2000 with Hydro-G Dispersion unit (no blue laser) to examine replicate variability and establish benchmark data. Replicates have been examined by both laser and sieve / pipette methods in earlier Scheme years; however as the majority of laboratories are conducting analyses by laser diffraction the testing of replicates is now undertaken using laser instruments only. Scheme Year 19 replicates follow the analysis method of year 18 where all samples were analysed by Thomson Unicomarine Ltd.

Sample PS44 comprised of Sandy Mud sediment (average of 55.89% <63µm, mean phi of 4.59), the Malvern Mastersizer 2000 showed good agreement between replicate samples. Two replicates (PS44_60/63) had a slightly higher percentage of silt and lower percentage of sand compared to the other replicates. Results for the individual replicates are provided in Table 1 and are displayed in Figure 1 (PS44 Report).

Sample PS45 comprised a Sand sediment (average of 0.00% <63µm, mean phi of 1.70). The Malvern Mastersizer 2000 showed no real discernable variation between replicate samples. Results for the individual replicates are provided in Table 1 and are displayed in Figure 1 (PS45 Report).

Sample PS46 comprised of an Artificial Gravel sediment (average of 0.02% <63µm, mean phi of -2.99). The replicates were analysed by dry sieving and laser analysis. However, not enough <1mm sediment was present for three representative replicate laser subsamples. Therefore, the average laser analysis data was derived from a single replicate. The replicates show good agreement between each other. Results for the individual replicates are provided in Table 1 and are displayed in Figure 1 (PS46 Report).

Sample PS47 comprised of Gravelly Sand sediment (average of 0.00% <63µm, mean phi of -0.14). Replicates showed good agreement between each other. Replicate PS47_65 recorded sediment at the -4 phi interval (mean -0.022). Results for the individual replicates are provided in Table 1 and are displayed in Figure 1 (PS47 Report).

2.2.2.3 Results from participating laboratories

Where they were provided, summary statistics for the four PS circulations are presented in Table 1 in each individual exercise report (see PS44 Report, PS45 Report, PS46 Report and PS47 Report). After resolution of the differences in data format, the size distribution curves for each of the sediment samples were plotted and are presented in Figures 2 in each individual exercise report. Included in each of these figures, for comparison, are the mean distribution curves for the replicate samples as obtained by Thomson Unicomarine Ltd (PS44, PS45, PS46 and PS47), using Malvern Mastersizer 2000, where required.

Table 2 in each exercise report (see PS44 Report, PS45 Report, PS46 Report, PS47 Report) shows a summary of the z-scores calculated for each half phi interval. Intervals left blank or marked “not analysed” were entered as zero to calculate the z-scores. Each individual exercise report also provides a bar-chart of each lab’s z-scores. Figures 5 and 6 in PS44 and PS45, and Figures 4 and 5 in PS46 and PS47 show the results of the cluster analysis. For each exercise ten out of the eleven participating laboratories stated that they were following the NMBAQC’s methods. One laboratory (LB1908) stated that they were using alternate methods.

2.2.2.4 Forty-fourth distribution – PS44

There was generally good agreement for PS44 between the results from the analysis of replicates and those from the majority of participating laboratories (see Figure 2). One lab (LB1955) did not report any data values until phi interval 2.5, leading to a displacement of the cumulative percentage curve by 2 phi at the beginning. LB1904 did not record phi intervals >8.00 leading to a sharp increase near the end of the curve. All of the participants used the laser diffraction technique to analyse the sample. Table 1 shows the variation in data received from the participating laboratories. The derived statistic for %silt for those laboratories following alternate methods ranged from 48.15% to 75.24%, excluding data from the replicate analyses produced by Thomson Unicomarine Ltd (Malvern Mastersizer 2000). Laboratory LB1908 provided two sub-sets, following alternate methods recording a %silt of 57.96% and 57.62% respectively.

2.2.2.5 Forty-fifth distribution – PS45

There was good agreement for PS45 between the results from the analysis of replicates and those from the participating laboratories (see Figure 2). Only one laboratory (LB1910) recorded phi intervals <0.00. Of the laboratories following the NMBAQC methods, one out of the eleven laboratories (LB1909) used sieve and laser diffraction, LB1910 reported using sieve only, and the remaining laboratories used laser diffraction only. The one laboratory following alternate methods (LB1908A/B) used laser diffraction and sieves. Table 1 shows the variation in data received from the participating laboratories. The derived statistic for laboratories following the NMBAQC methods for %silt ranged from 0.00% to 0.70%, excluding data from the replicate analyses produced by Thomson Unicomarine Ltd (Malvern Mastersizer 2000). The laboratory (LB1908A/B) following an alternate method recorded %silt of 0.21% and 0.31% respectively.

2.2.2.6 Forty-sixth – PS46

There was generally good agreement between the results from the analysis of replicates and those from the participating laboratories (see Figure 2). Two labs show displaced distribution curves (LB1903 and LB1904). LB1903 recorded material at phi interval -6; and LB1904 did not start recording results until phi interval -3.5. Five out of the ten laboratories following the NMBAQC methodology (LB1904, LB1909, LB1910, LB1917 and LB1958) used dry sieving only to analyse the sample. The remaining five laboratories (LB1901, LB1903, LB1905, LB1921, LB1955) attempted laser diffraction as well as dry sieving but found there was insufficient sediment to do more than one run through the laser. The one participating laboratory using alternate methods (LB1908) used laser diffraction and sieves. Table 1 shows the variation in data received from the participating laboratories where data was submitted.

The derived statistic for %silt was 0% for four of the five laboratories (LB1904, LB1909, LB1917 and LB1958) using dry sieving only. The %silt for the five laboratories (LB1901, LB1903, LB1905, LB1921 and LB1955) who attempted laser diffraction was 0.01%, 0.02%, 0.10%, 0.09% and 0.01% respectively.

2.2.2.7 Forty-seventh distribution – PS47

There was generally good agreement between the results from the analysis of replicates and those from the participating laboratories (see Figure 2). Ten out of the eleven laboratories (LB1901, LB1903, LB1904, LB1905, LB1908, LB1909, LB1917, LB1921, LB1955 and LB1958) used sieve and laser

analysis to analyse the sample; one lab (LB1910) used dry sieving only. The remaining laboratory (LB1904) did not start recording results until phi interval -3.5. Table 1 shows the variation in data received from the participating laboratories where data was submitted. For nine of the ten participating laboratories (LB1901, LB1903, LB1904, LB1905, LB1909, LB1917, LB1921, LB1955 and LB1958) using the NMBAQC method, the derived statistic for the %silt was 0.00%, excluding data from the replicate analyses produced by Thomson Unicomarine (Malvern Mastersizer 2000). The one participating laboratory using alternate methods (LB1908) recorded a %silt of 0.53%.

2.2.3 Discussion

The samples distributed as PS44 appeared, from an analysis of replicates (Figure 1), to be good replicates with little variance. Results from participating laboratories (Figure 2) showed a general similarity in distribution curves. Cluster analysis using Euclidean distance showed that two laboratories (LB1904 and LB1955) clustered away from the majority of laboratories. The main discrepancy in LB1904's data was characterised by the sharp rise in the cumulative percentage curve between 7.5 and 8 phi and that of LB1904 did not record phi intervals >8 phi.

LB1955 did not report any data values until phi interval 2.5, leading to a displacement of the cumulative percentage curve by 2 phi. The lab also recorded a greater percentage of silt (75.24%) compared to other laboratories (average silt component of other laboratories was 55.39%).

The samples distributed as PS45 appeared from an analysis of replicates (Figure 1) to be good replicates with very little variance. Results from participating laboratories were generally consistent with one another (Figure 2). Cluster analysis shows that three laboratories (LB1904, LB1910 and 1908A/B) were discernable from the other laboratories below the ten percent significance interval. LB1904's cumulative percentage curve is displaced by half a phi. LB1908 used alternate methods to the NMBAQC scheme standard. The cumulative percentage curve shows that they recorded slightly lower percentages between 1.0 and 3.0 phi. LB1910 recorded lower percentages between 1.0 and 1.5 phi.

The samples distributed as PS46 appeared from an analysis of replicates (Figure 1) to be good replicates with very little variance. Results from participating laboratories were generally consistent with one another (Figure 2). Cluster analysis using euclidean distance shows that one laboratory (LB1904) is dissimilar to all other participant results. LB1904 did not start recording data until phi interval -3.5. This is shown on the cumulative percentage curve by a displacement of one phi, causing a sharp rise between -3.5 and -3 phi. Following feedback, this anomalous result has been attributed to LB1904 not possessing sieve mesh sizes larger than -3.5 phi.

The samples distributed as PS47 appeared from an analysis of replicates (Figure 1) to be generally good replicates with some variance. As with PS46, LB1904 did not start recording data until phi interval -3.5. This is shown on the cumulative percentage curve by a displacement of one phi, causing a sharp increase between -3.5 and -3 phi. Following feedback, this anomalous result has been attributed to LB1904 not possessing sieve mesh sizes larger than -3.5 phi. Cluster group B comprises of two laboratories (LB1908 and LB1910). Both laboratories recorded a small percentage of silt (0.53% and 0.04% respectively) compared to other laboratories.

This is also shown by both laboratories recording results above phi 4.0 (LB1910) and 4.5 (LB1908) respectively. This accounts for the deviation of z-scores for LB1908 from phi 4.0 - 12. The differences shown by LB1908 could also be attributed by adhering to a slightly different methodology than the NMBAQC Scheme standard. Cluster group C is formed of a single laboratory (LB1917). This could be attributed to LB1917 recording a higher percentage of particles between phi 0.00 and 1.00 than all other laboratories. Cluster group D is formed of a single laboratory (LB1903). The cumulative percentage curve in figure 2 shows that LB1903 has a comparatively higher percentage increase (between 0.5 and 2.5). Finally, cluster groups E (LB1905), F (LB1909, LB1921 and LB1958) and G (LB1901, LB1955, and the TUM AVERAGE) have cumulative percentage curves that look very similar to one another. Cluster group E recorded a slightly lower percentage of particles between phi -3.5 and -3 compared to other laboratories (omitting LB1904).

Participating laboratories were asked to provide the sediment description using the Folk triangle post analysis. Data were provided by all eleven participating laboratories for PS44, PS45, PS46 and PS47. Two laboratories (LB1921 and LB1958) failed to provide the post analysis description for PS44. For PS44, seven laboratories (LB1905, LB1908A/B, LB1909, LB1910, LB1917 and LB1955) had post-analysis sediment descriptions of Sandy Mud; two laboratories (LB1903 and LB1904) had a post-analysis description of Muddy Sand; and one laboratory (LB1901) of Sandy Silt. For PS45, all participating laboratories recorded the post-analysis sediment description as Sand. All post-analysis sediment descriptions for PS46 were Gravel. For PS47, seven laboratories (LB1901, LB1903, LB1904, LB1905, LB1909, LB1910 and LB1958) recorded the post-analysis sediment description as Gravelly Sand; and four laboratories (LB1908, LB1917, LB1921 and LB1955) described the sediment as Sandy gravel.

It is essential that analytical methods, including pre-treatment, are stated when reporting or attempting to compare results. The situation is further complicated by the fact that the difference between the techniques and the effects of the pre-treatment also varies with the nature of the sediment sample. As demonstrated in these and previous PS exercises, possible variations in equipment and methods can result in variable data. In order to eliminate as much variation as possible the NMBAQC's Best Practice Guide was devised for use in Scheme Year 17. Although most laboratories used the methods detailed in this document, a few laboratories still used in-house methodologies. All laboratories involved in CSEMP sample analysis used the NMBAQC PSA SOP for supporting biological data.

The workbook format introduced in Scheme Year 18 is continued in Scheme Year 19, the aim of this is to standardise the way in which laboratories provide data. Over the four exercises most laboratories completed the forms correctly. However, only a few reported the total percentage volume in the "PS_Final Merged Data" tab. Other laboratories reported raw sieve weights in this tab rather than re-proportioning the raw sieve weights with laser percentage laser volumes. This could be attributed to the Phi (explicit) description being shown as "volume/weight" rather than total percentage volume. This field has been updated for NMBAQC Scheme Year 20.

The main issue with the workbook trialled in Scheme Year 18 was with the laser replicates section, where sediment ≥1mm was being passed through laser diffraction. If following the NMBAQC methodology, laser subsamples should be passed through a 1mm sieve before laser diffraction. Although this has not occurred in Scheme Year 19, it remains noteworthy if standardisation of submitted results is to be maintained.

2.2.4 Application of NMBAQC Scheme Standards

One of the key roles of the Particle Size Analysis component of the NMBAQC Scheme is to assess the reliability of data collected as part of the Clean Seas Environment Monitoring Programme (CSEMP; formerly UK NMMP). With this aim performance target standards were defined for certain Scheme modules and applied in Scheme year three (1996/97). These standards were the subject of a review in 2001 (Unicomarine, 2001) and were altered in Scheme year eight; each performance standard is described in detail in the Description of the Scheme Standards for the Particle Size Analysis Component document. In previous years laboratories meeting or exceeding the required standard for a given exercise would be considered to have performed satisfactorily for that particular exercise. A flag indicating a 'Pass' or 'Fail' would be assigned to each laboratory for each of the exercises concerned. As the Pass/fail criteria are under review for the PS exercises in Scheme Year 19, a 'Pass' or 'Fail' flag will not be assigned to each lab for these particular exercises.

2.2.4.1 Laboratory Performance

Z-scores and cluster dendrogram figures are presented in each of the PS exercise reports; however these are only for illustration purposes. The investigations into new pass/fail standards are still underway. Pass/fail criteria will be introduced when sufficient data are collected using the new analysis guidance method.

3. Conclusions and Recommendations

A number of observations may be made from the results of the exercises described above. The following is a summary of the major points of importance.

1. Laboratories should endeavour to report their PS results in the requested format, *e.g.* at half phi intervals. This would enable the direct comparison of data from all participants and simplify the creation of cumulative curve figures. The workbook designed for use in Scheme Year 18 to enable laboratories to provide data in a comparable format has been modified slightly for Year 19 to resolve any issues that have arisen. Participants should review their data prior to submission; zeros should only appear in submitted data where no material was present; dashes, '-', should appear where analysis has not been conducted.

2. Laboratories involved in CSEMP data submission should endeavour to return data on **ALL** necessary components of the Scheme in the format requested. This will be required to allow the setting of performance "flags". Non-return of data will result in assignment of a "Fail" flag. For CSEMP laboratories this deemed "Fail" for no submitted data is to be perceived as far worse than a participatory "Fail" flag.

3. Particle size exercises (PS) over the years have shown differences in the results obtained by different techniques (laser and sieve / pipette), in-house methods (*e.g.* pre-treatment) and also differences between equipment (*e.g.* Malvern Mastersizer 2000, Mastersizer X and Coulter LS230 lasers). PS data indicates that the variance between laser and sieve results is further emphasised by certain sediments characteristics. The overall range of these variances needs to be determined if combining data sets derived from differing methods. The NMBAQC's Best Practice Guide has been developed for use in Scheme Year 17; this has helped to reduce the amount of variation between methods. It is essential that particle size data are presented with a clear description of the method of analysis and equipment used.

4. An improved learning structure to the Scheme through detailed individual exercise reports has been successfully implemented and was continued in this Scheme year. For the PS exercises, detailed results have been forwarded to each participating laboratory as soon possible after the exercise deadlines as practicable. Participants that submit significantly incorrect data are contacted immediately to ensure that in-house checks can be implemented to ensure future quality assurance. The PS44, PS45, PS46 and PS47 reports included the data submission sheets received from all participants as an appendix; Participants are encouraged to review their exercise reports and provide feedback concerning content and format wherever appropriate.

5. The current NMBAQC Scheme standards for PSA are under review. The alternative use of z-scores for each phi-interval, trialled in Scheme Year 17 appears inappropriate for such a low number of data returns where two erroneous results can significantly alter the pass/fail criteria. For example, this can occur if laboratories do not have the representative sieves to analyse the whole range of sediment fractions. The z-score method also assumes that the majority of respondents are correct and raised genuine concerns regarding technique and method bias. Scheme Year 19 (2012/13) follows Year 18 in that z-score analysis was run alongside cluster analysis using Euclidean distance matrices.

4. References

Finbow, L.A. and Hall, D.J., 2011. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS41. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps41, 38pp, December 2011.

Finbow, L.A. and Hall, D.J., 2011. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS40. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps40, 38pp, December 2011.

Finbow, L.A. and Hall, D.J., 2012. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS43. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps43, 25pp, June 2012.

Finbow, L.A. and Hall, D.J., 2012. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS42. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps42, 26pp, June 2012.

Finbow, L.A., Procter, A, Hussey, S, and Arnold, R., 2012. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS45. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps45, 28pp, December 2012.

Finbow, L.A., Procter, A, Hussey, S, and Arnold, R., 2012. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS44. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps44, 26pp, December 2012.

Folk, R.L., 1974. Petrology of Sedimentary Rocks. Hemphill Publishing Co. Texas

Hall, D.J., 2010. National Marine Biological Analytical Quality Control Scheme. Description of Scheme Standards for the Particle Size Analysis Component from Scheme Year 8 (2001/02) to Year 16 (2009/10). Report to the NMBAQC Scheme participants. Unicomarine report NMBAQCpsa_stds, February 2010.

Mason, C., 2011. NMBAQC's Best Practice Guidance. Particle Size Analysis (PSA) for Supporting Biological Analysis. National Marine Biological AQC Coordinating Committee, 72pp, December 2011.

Procter, A., and Hussey, S., 2013. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS47. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps47, 29pp, May 2013.

Procter, A., and Hussey, S., 2013. National Marine Biological Analytical Quality Control Scheme. Particle Size Results: PS46. Report to the NMBAQC Scheme participants. Thomson Unicomarine Report NMBAQCps46, 28pp, May 2013.

Unicomarine., 1995. National Marine Biological Quality Control Scheme. Annual Report (Year one). Report to the NMBAQC Committee and Scheme participants. September 1995.

Unicomarine., 1996. National Marine Biological Quality Control Scheme. Annual Report (Year two). Report to the NMBAQC Committee and Scheme participants. September 1996.