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Analytical Quality Control Scheme
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Ring Test Bulletin – OMC RT01

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RING TEST DETAILS

Ring Test - OMC 01

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*multiple data entries per lab submitted

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1 Introduction

There has been a quality control over the submission of biological data for a number of years. This is now extending through all biological elements including macroalgae. Quality control ensures the consistency of data reported for environmental management purposes and has been primarily driven, within the sphere of marine plants, by international analytical standards due to the Water Framework Directive. The QC scheme aims to facilitate improvements in biological assessment whilst maintaining the standard of marine biological data. The scheme is able to ensure consistency between laboratories and field staff with improved confidence in ecological quality status.

The National Marine Biological Analytical Quality Control (NMBAQC) Scheme addresses two main areas relating to macroalgae and angiosperm data collection:

- The estimation of % cover
- The comparison of methodologies

This is the first year in which % cover estimations of macroalgae have been included as an element of the NMBAQC scheme and included a single exercise which was split into three smaller modules based on methodology. Test material was distributed to participating laboratories from which data forms were completed and returned.

Fourteen laboratories completed the macroalgae and angiosperm component of the NMBAQC scheme including a total of 33 participants. Thirteen of the participating laboratories were government and only one was a private consultancy.

Laboratories were able to complete all three % cover methodologies or whichever procedure was most appropriate for their laboratory, however, they were encouraged to complete all three variations of the exercise.

Currently this scheme does not provide a means of qualifying performance levels. It offers a means of assessing personal and laboratory performance from which continued training requirements may be identified or from which improvements in current field and laboratory procedures may be addressed. Certain targets have been applied to the assessment of the results based on Z-scores allowing “Pass” or “Fail” flags to be assigned accordingly; however, these have no weighting and merely act to identify those results which were considered significantly different based on comparisons between laboratories. These flags have no current bearing on the acceptability of data from such participating laboratories.

1.1 Summary of Performance.

This report presents the findings of the macroalgae component for the first year of operation within the National Marine Biological Analytical Quality Control (NMBAQC) Scheme. This component consisted of a single exercise which was subsequently split into three alternative means of assessment which could be considered as separate modules from which laboratories could complete one or more module.

The results for each of the methods within the one exercise are presented and discussed with comments provided on the overall participant performance and methods used.

2 Summary of Macroalgae Component

2.1 Introduction

There was one exercise for the assessment of % cover of macroalgae which took the form of three separate method options. This exercise is described in full below to include details of distribution and logistics, procedures for estimation of % cover, completion of test result forms and full analysis and comparison of final submitted results.

2.2 Logistics

The test material was distributed on CD to each laboratory. Each disc contained the three tests, description of methods and data submission forms. Participants were given a month to complete the test and return the results. There were no restrictions on the number of participants per laboratory.

Email has been the primary means of communication for all participating laboratories subsequent to the initial postal distribution of test material.

2.3 Methods

The percent cover estimation test consisted of a set of 20 photographs. These quadrat photos were taken by various staff of the Environment Agency and provided for the purpose of this exercise. No calibration of the photographs was conducted at the time of collection; therefore final areas of algal coverage were determined for quality assurance subsequent to field analysis.

The set of 20 photographs were adapted to produce three tests that utilised different methods of % cover estimation.

1. **Test A** was an open quadrat, this method allowed the analyst to estimate the percent cover in a 0.25m^2 quadrat without visual obstruction or assistance from gridlines. A general estimation is conducted looking solely at the total area within the quadrat that is clearly covered by opportunist macroalgae.

2. **Test B** consisted of a 9 x 9 crosshair quadrat. This method splits the quadrat into 100 squares. The crosshair referred to the point at which the lines cross and within a 9 x 9 grid amounts to a total of 81 crosshairs. The method of cover estimation was achieved by recording the presence or absence of algae under each of the crosshair points. Where alga was present under the crosshair this was recorded as 1 and absence was recorded as 0. The number of cross hairs with algae present was divided by 81, and then multiplied by 100 to give a percentage.

3. **Test C** method split the 0.25m^2 quadrat into 25 squares with each square representing 4% of the total quadrat. The percent cover was estimated by counting the number of squares, to the nearest half square, that were covered by macroalgae. Completely covered squares were counted as one each. Between 50% and 100% cover in individual squares was estimated to the nearest quarter and these portions were summed. Where only a small portion (i.e. <50%) of the square was covered these small portions were added until they equated to at least a half square. For quadrats with sparse macroalgae cover (i.e. always < 50% cover per square) the participants accumulated the small portions of

algal coverage (totalling to the nearest half square). The number of squares was divided by 25 and then multiplied by 100 to give a percentage.

2.4 Analysis and Data Submissions

Each participant had the option of completing the test which most represented their own procedures but all participants were encouraged to complete all three tests to enable a comparison of methodologies and levels of accuracy achieved within each.

For each test the participant had to estimate the % cover of opportunist algal species including *Ulva* sp., *Chaetomorpha* sp., *Porphyra* sp., *Ectocarpus* sp. and *Pilayella* sp and excluded any additional species that were present within the quadrat but were not considered opportunist algae. The assessment included a large degree of variation in % cover to represent the full range experienced within the field.

Spreadsheet based forms were distributed with the test material to standardise the format in which the results were submitted. These results will be retained and stored appropriately.

2.5 Confidentiality

To preserve the confidentiality of participating laboratories, each participant is allocated a four digit laboratory code from which they can identify their results. These codes are randomly assigned. The initial letters (MA) refer to the scheme this is followed by the scheme year which refers to the year in which the NMBAQC scheme original commenced, the final two digits represent the laboratory. For those laboratories where multiple submission were provided the four digit code is followed by a letter allocated to each participant of that laboratory. For example, participant c from laboratory twelve in scheme year seventeen will be recorded as MA1712c.

2.4 GIS analysis

A GIS analysis programme was used to achieve a precise measurement of % cover which could be compared with the traditional means of assessment. The photographs were entered into the GIS program and areas of opportunist algal growth were manually highlighted by marking the perimeter of the areas of growth. These areas of opportunist cover were pre-determined by eye from digital photographs as would be achieved by the participants and as a result are no more accurate in terms of defining the affected area. The entire quadrat, and the area highlighted as macroalgal opportunist cover, were spatially analysed and a subsequent percent cover was calculated from the areas. These percentages were used as a comparison against the skilled eye estimations as submitted by the participants.

2.5 Results

The results have been analysed using a number of different approaches to compare the results between participants, between the three different methods of estimation and to compare against GIS calculated % cover estimations. A summary of these results can be found at the end of the report.

2.5.1 Test A (Open Quadrat)

Table 1. Results for % cover estimations received from participating laboratories for test A.

Lab Code		MA1712b	MA1712c	MA1712a	MA1712d	MA1709	MA1706	MA1708	MA1702b	MA1702c	MA1702d	MA1702a	MA1702f	MA1702e	MA1714	MA1707a	MA1707b	MA1705a	MA1703a	MA1703b	MA1703c
GIS results																					
Test A	Algal coverage %																				
Quadrat 1	54.96	98	98	98	98	99	52	99	99	99	98	99	97	99	100	98	95	60	98	98	95
Quadrat 2	69.22	90	65	70	100	70	65	100	73	75	75	65	100	65	60	75	65	60	85	80	75
Quadrat 3	24.45	60	30	25	99	25	20	100	40	40	40	30	100	35	25	30	25	25	50	45	55
Quadrat 4	29.12	30	23	20	20	15	20	12	20	20	20	15	22	15	15	20	20	15	25	20	15
Quadrat 5	48.41	45	45	45	45	45	45	40	50	50	50	32	48	40	40	45	35	40	40	40	45
Quadrat 6	59.71	60	56	55	60	65	55	50	60	60	60	55	53	50	60	60	50	55	60	50	50
Quadrat 7	96.59	90	94	95	90	97	90	92	90	95	95	95	90	90	90	93	85	90	90	90	90
Quadrat 8	41.20	40	45	40	35	33	25	32	40	35	35	40	45	40	40	42	35	30	40	35	40
Quadrat 9	17.03	16	26	25	20	15	10	11	22	15	15	15	22	15	15	12	15	15	20	15	15
Quadrat 10	82.41	88	77	80	75	74	80	85	80	85	85	78	80	75	95	80	75	65	80	80	80
Quadrat 11	36.89	30	34	45	40	40	25	33	35	40	40	40	30	35	25	33	30	30	35	35	27
Quadrat 12	53.42	60	65	50	75	65	40	58	65	55	55	62	53	55	60	50	40	40	60	50	50
Quadrat 13	41.98	50	55	40	50	43	30	29	30	40	40	45	37	40	40	30	35	25	35	35	30
Quadrat 14	38.84	30	32	30	30	38	25	35	35	35	37	37	32	35	30	40	30	30	40	40	40
Quadrat 15	58.71	60	50	50	50	55	50	50	45	50	55	55	52	55	50	50	55	50	50	55	50
Quadrat 16	63.50	75	70	65	75	65	65	48	40	55	60	65	53	50	60	65	55	45	60	65	60
Quadrat 17	57.60	70	74	65	75	55	35	50	47	50	47	60	47	50	70	60	60	45	60	50	60
Quadrat 18	70.26	80	69	80	65	70	45	55	80	75	75	65	62	60	80	55	55	45	80	75	80
Quadrat 19	96.16	95	96	95	80	95	90	80	95	90	90	92	90	75	99	95	80	95	95	95	92
Quadrat 20	22.33	20	30	30	25	25	15	15	23	20	20	20	29	20	20	20	20	20	30	25	20

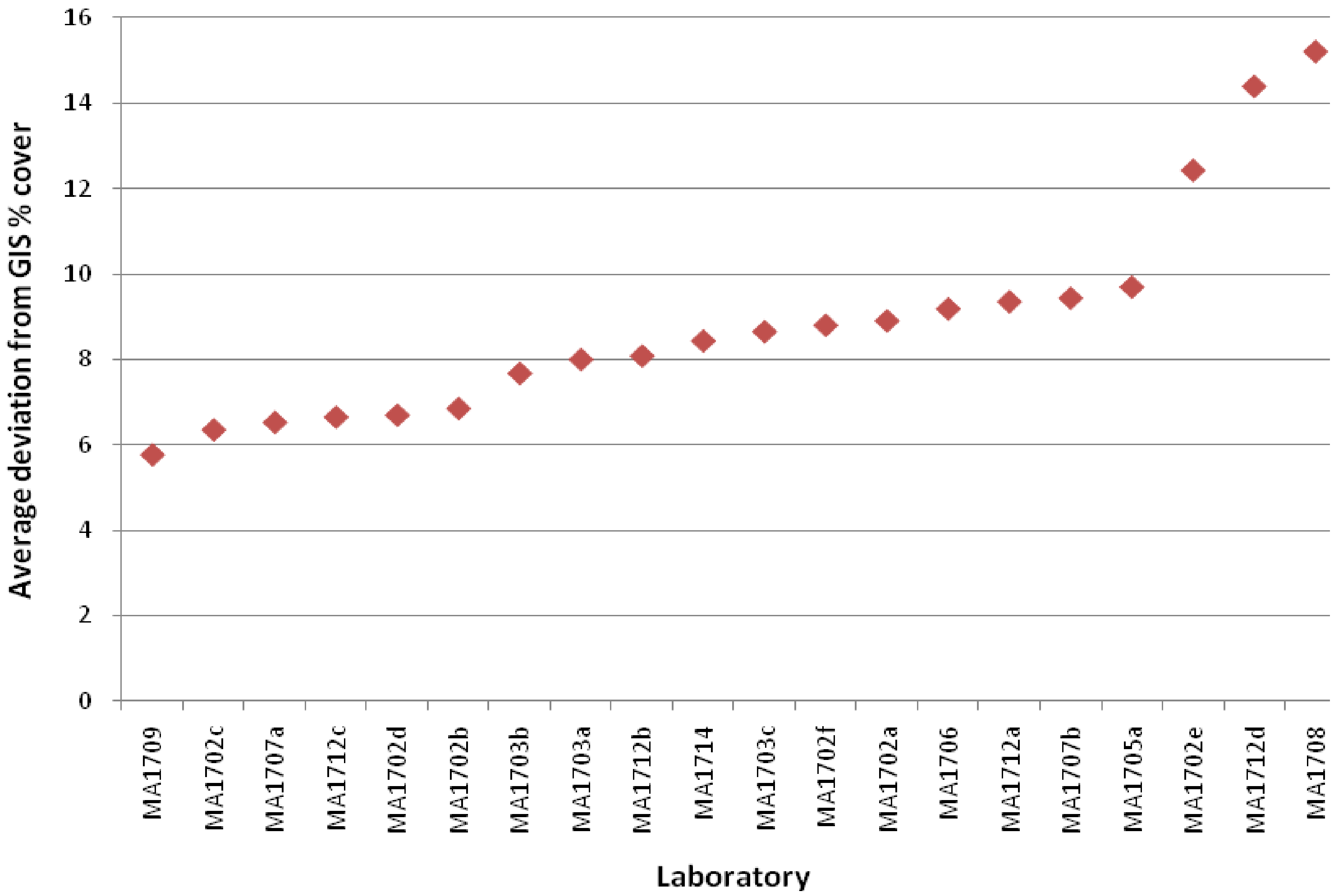


Figure 1. Difference in % cover between submitted results and GIS results, displayed as the average difference across all quadrats in test A for each participant.

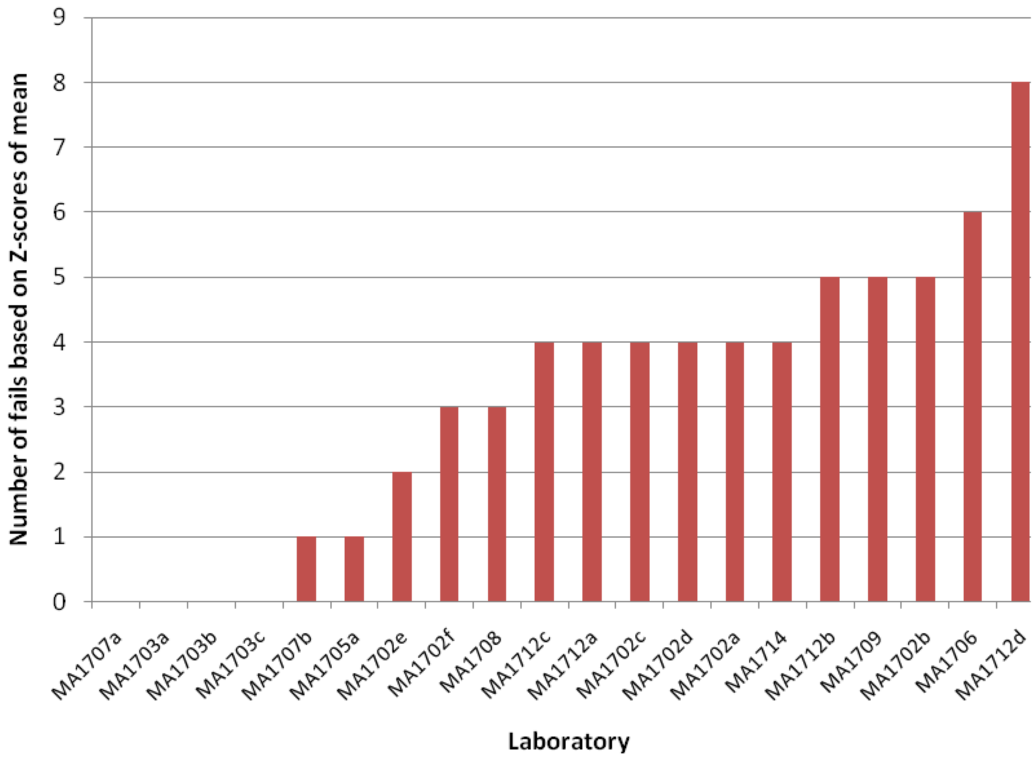


Figure 2. Number of quadrat fails per participant based on z-scores derived from mean % cover estimates for test A.

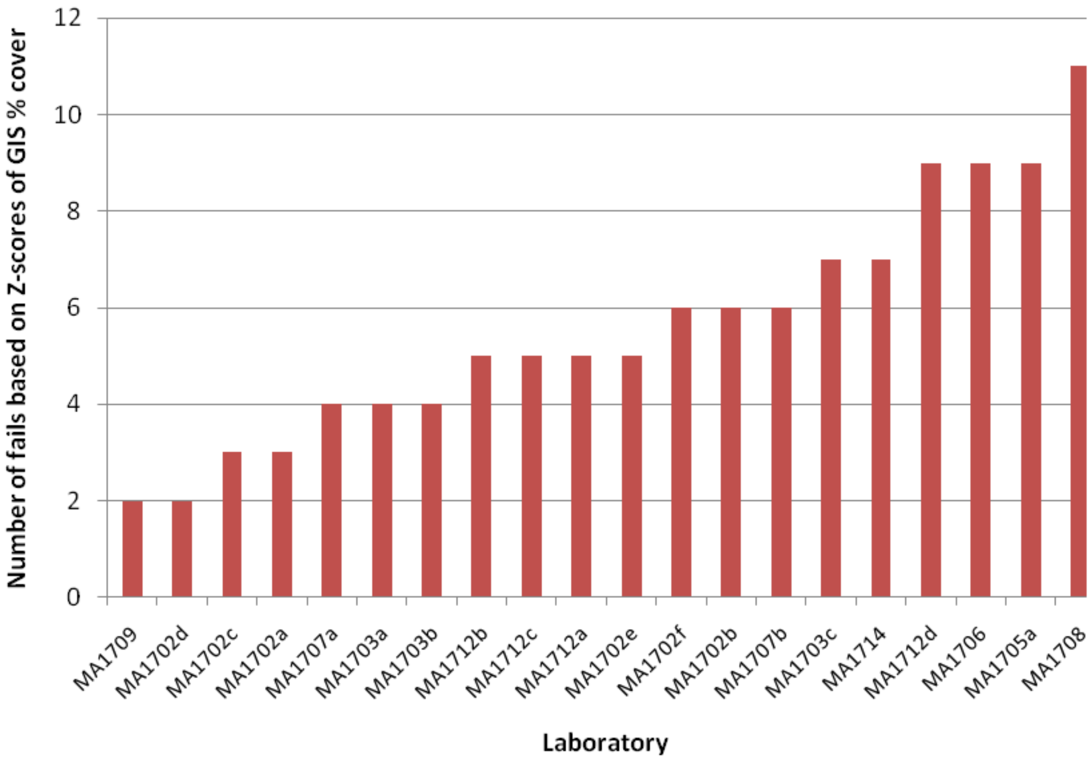


Figure 3. Number of quadrat fails per participant based on z-scores derived from % cover as calculated in GIS for test A.

2.5.2 Test B (9 x 9 Gridded Quadrat)

Table 2. Results for % cover estimations received from participating laboratories for test B.

Lab Code		MA1712a	MA1712b	MA1712c	MA1712d	MA1709	MA1701	MA1717a	MA1717b	MA1706	MA1711a	MA1711b	MA1711c	MA1711d	MA1702a	MA1702b	MA1702c	MA1702d	MA1702e	MA1702f	MA1714	MA1707a	MA1710	MA1705a	MA1705b	MA1703a	MA1703b	MA1703c
Test B	GIS results Algal coverage %																											
Quadrat 1	54.96	80	99	99	99	99	98	99	99	49	96	59	96	95	99	99	99	99	99	99	99	98	99	56	99	99	99	99
Quadrat 2	24.45	32	25	28	100	26	52	25	37	27	37	26	35	35	38	35	37	40	100	48	33	27	37	74	100	64	67	60
Quadrat 3	29.12	25	24	20	28	20	44	33	23	27	32	32	35	30	38	33	33	27	33	35	31	20	30	43	28	36	35	37
Quadrat 4	48.41	44	49	47	59	51	59	60	56	49	53	54	60	53	58	54	58	53	56	59	59	47	57	32	52	59	58	59
Quadrat 5	41.98	48	37	38	63	47	62	67	59	48	56	56	62	52	70	60	58	55	58	54	62	41	52	57	54	63	60	62
Quadrat 6	41.20	34	41	37	43	41	42	41	41	37	43	42	40	42	42	41	41	41	41	42	42	37	42	69	41	44	43	43
Quadrat 7	96.59	80	93	94	99	96	97	99	96	91	95	96	98	93	100	98	98	96	95	94	98	94	96	94	96	98	98	93
Quadrat 8	53.42	63	73	52	78	69	80	83	75	51	65	62	67	72	74	72	73	62	80	69	68	59	72	41	75	77	80	72
Quadrat 9	82.41	76	95	91	95	89	91	91	95	80	89	93	94	84	91	93	94	92	93	88	95	88	83	20	90	91	94	96
Quadrat 10	57.60	50	65	76	54	48	65	78	65	51	54	56	52	75	57	56	51	52	59	57	83	66	51	90	78	63	68	62
Quadrat 11	36.89	38	35	34	47	40	51	51	42	36	43	37	42	47	48	41	38	39	47	43	44	31	37	41	47	48	49	42
Quadrat 12	96.16	79	97	97	94	91	95	94	83	89	88	89	90	90	95	93	93	97	93	84	99	90	85	67	94	95	91	93
Quadrat 13	17.03	15	18	17	30	17	20	25	16	14	17	16	19	25	21	20	19	17	26	21	21	17	16	51	19	25	26	22
Quadrat 14	59.71	59	60	56	72	69	70	70	75	54	67	65	64	65	73	70	70	66	73	68	75	56	69	62	72	70	70	70
Quadrat 15	63.50	57	61	58	72	72	80	75	74	58	69	78	80	68	75	70	70	57	77	19	90	74	60	63	81	77	83	75
Quadrat 16	69.22	65	69	60	100	72	88	78	80	69	75	77	99	70	77	75	80	79	100	73	85	71	72	74	100	100	96	100
Quadrat 17	70.26	65	85	88	70	70	74	73	79	62	72	74	80	72	77	78	78	63	77	61	81	64	59	51	73	83	80	75
Quadrat 18	22.33	30	23	21	28	25	28	30	27	25	31	27	27	28	30	27	27	26	38	25	72	24	23	72	28	35	37	31
Quadrat 19	38.84	48	44	40	53	41	59	43	43	40	48	41	53	49	46	44	41	47	51	43	46	36	38	90	42	57	68	48
Quadrat 20	58.71	58	53	54	62	59	74	59	62	63	59	59	64	62	63	62	61	58	65	56	69	59	57	32	56	68	67	59

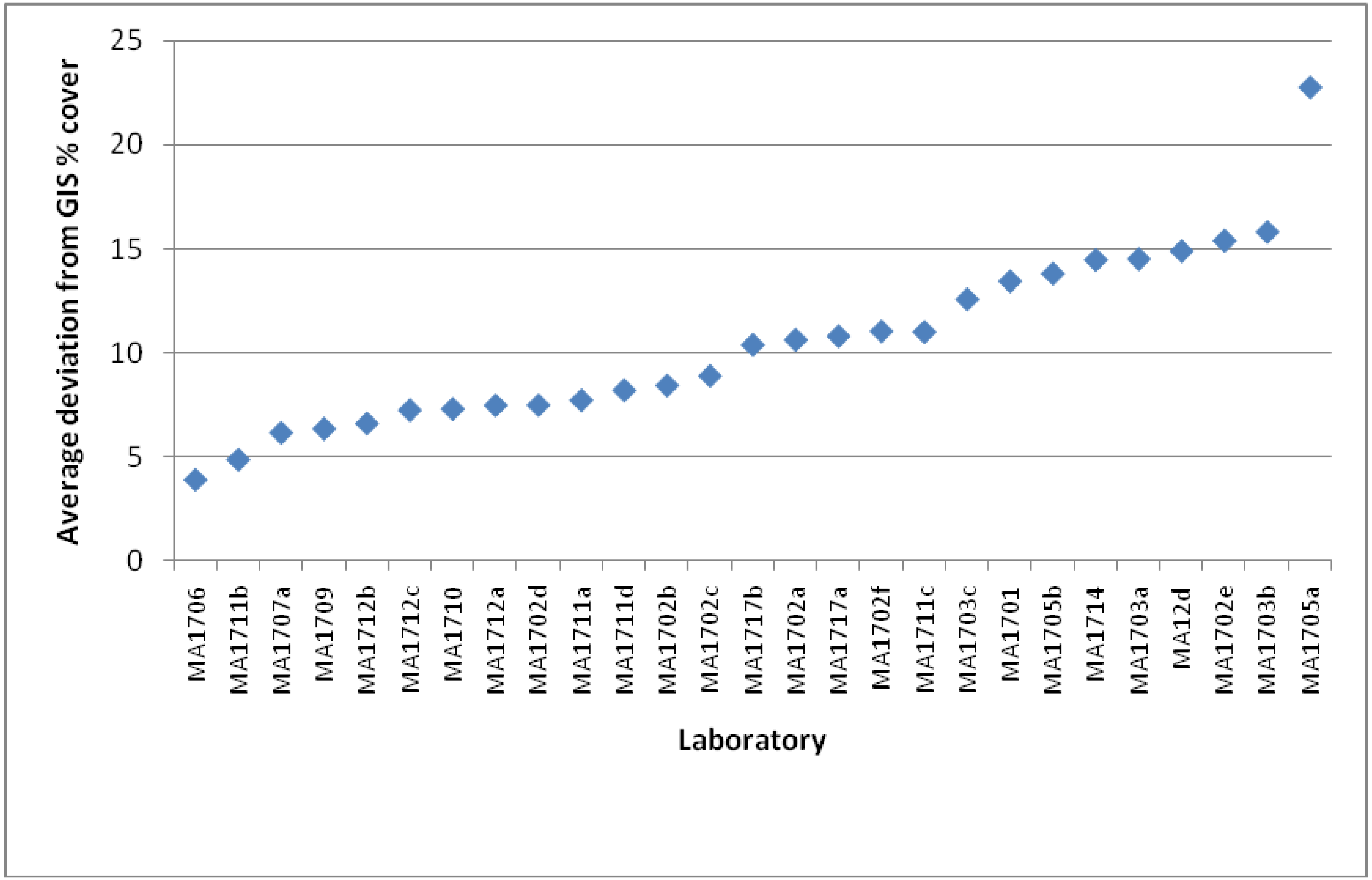


Figure 4. Difference in % cover between submitted results and GIS results, displayed as the average difference across all quadrats in test B for each participant.

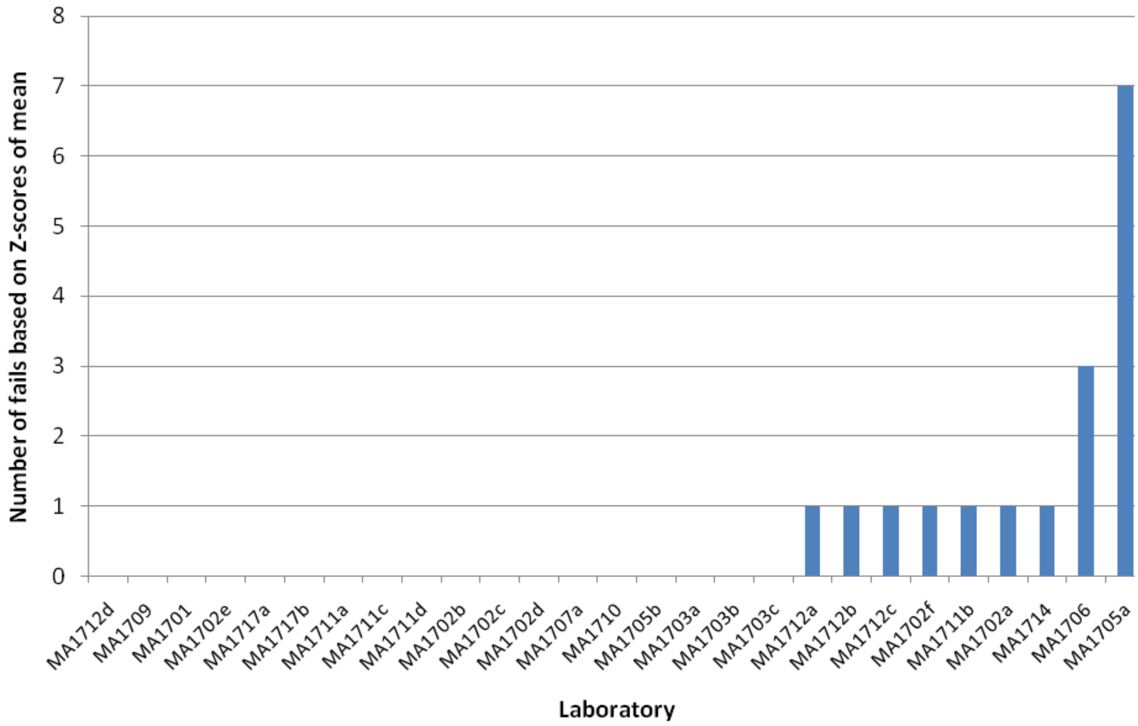


Figure 5. Number of quadrat fails per participant based on z-scores derived from mean % cover estimates for test B.

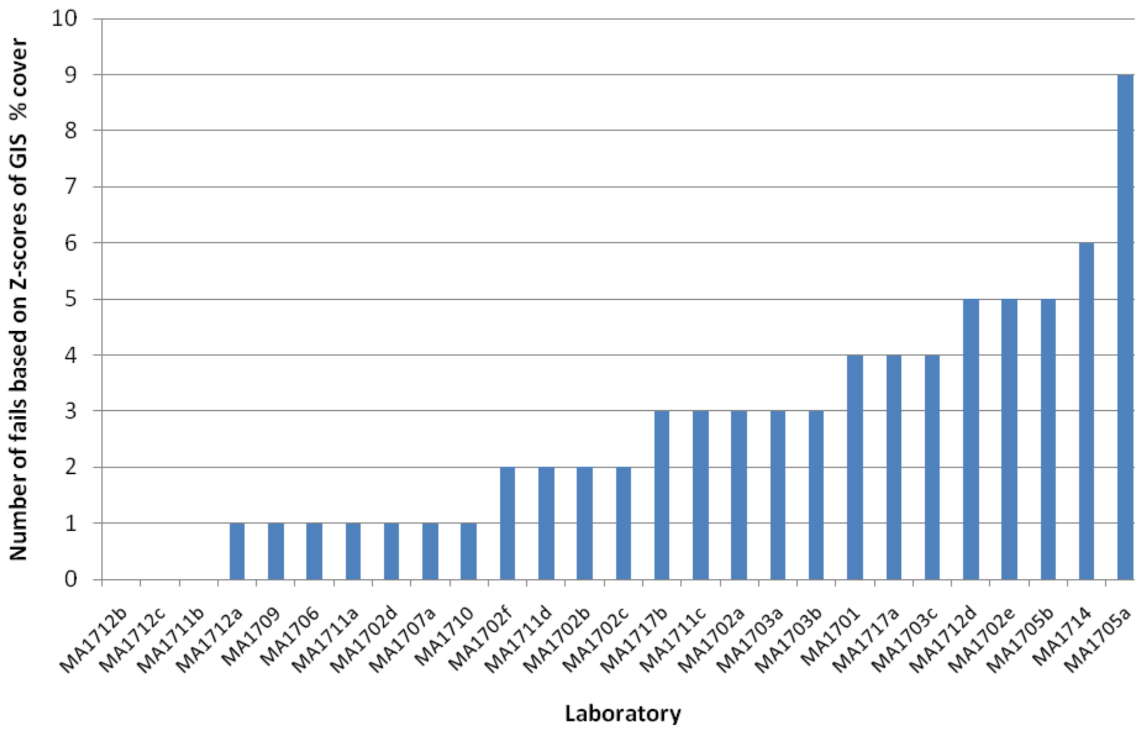


Figure 6. Number of quadrat fails per participant based on z-scores derived from % cover as calculated in GIS for test B.

2.5.3 Test C (4 x 4 Gridded Quadrat)

Table 3. Results for % cover estimations received from participating laboratories for test C.

Lab Codes		MA1712a	MA1712b	MA1712c	MA1712d	MA1718	MA1706	MA1702e	MA1714	MA1707a	MA1707b	MA1707c	MA1707d	MA1707e	MA1710	MA1705a	MA1703b	MA1703c
	GIS results																	
Test C	Algal coverage %																	
Quadrat 1	63.50	55	64	60	58	68	36	64	80	48	55	50	65	50	60	48	67	58
Quadrat 2	24.45	32	28	25	100	51	21	100	35	28	26	25	25	20	32	62	75	38
Quadrat 3	69.22	70	68	70	100	31	62	100	70	68	70	70	55	60	70	20	89	68
Quadrat 4	29.12	26	20	22	23	58	22	22	20	16	18	20	16	18	22	16	31	28
Quadrat 5	48.41	52	56	44	50	63	40	48	60	44	42	40	50	38	50	44	49	46
Quadrat 6	59.71	68	64	58	60	42	49	54	70	52	49	50	50	55	62	44	63	56
Quadrat 7	41.20	39	44	42	40	98	36	36	40	42	40	38	40	35	44	90	44	30
Quadrat 8	17.03	17	16	10	18	78	10	20	20	16	15	13	16	12	16	34	20	20
Quadrat 9	96.59	96	92	94	96	94	84	94	95	96	88	88	96	90	96	10	97	90
Quadrat 10	36.89	38	40	40	36	64	26	38	45	32	32	31	25	25	36	66	41	34
Quadrat 11	54.96	99	98	99	99	53	50	99	100	98	98	99	99	95	98	24	99	98
Quadrat 12	53.42	68	56	56	69	86	36	56	70	48	50	60	50	40	56	38	76	54
Quadrat 13	41.98	56	40	44	50	21	22	42	40	24	30	36	35	25	40	24	48	44
Quadrat 14	38.84	45	38	41	49	70	32	38	40	36	34	37	37	30	40	32	50	40
Quadrat 15	70.26	70	76	84	67	77	42	54	70	64	58	59	60	45	56	48	56	52
Quadrat 16	96.16	88	90	96	91	84	86	88	99	92	84	87	90	75	96	40	93	74
Quadrat 17	82.41	89	92	88	91	64	72	74	90	72	82	80	82	65	84	38	89	78
Quadrat 18	58.71	56	60	58	59	36	43	54	75	60	55	52	55	45	52	44	65	58
Quadrat 19	57.60	59	72	66	59	64	45	54	75	68	65	55	50	50	54	88	59	52
Quadrat 20	22.33	33	28	24	26	67	15	30	25	24	18	22	16	18	28	22	35	26

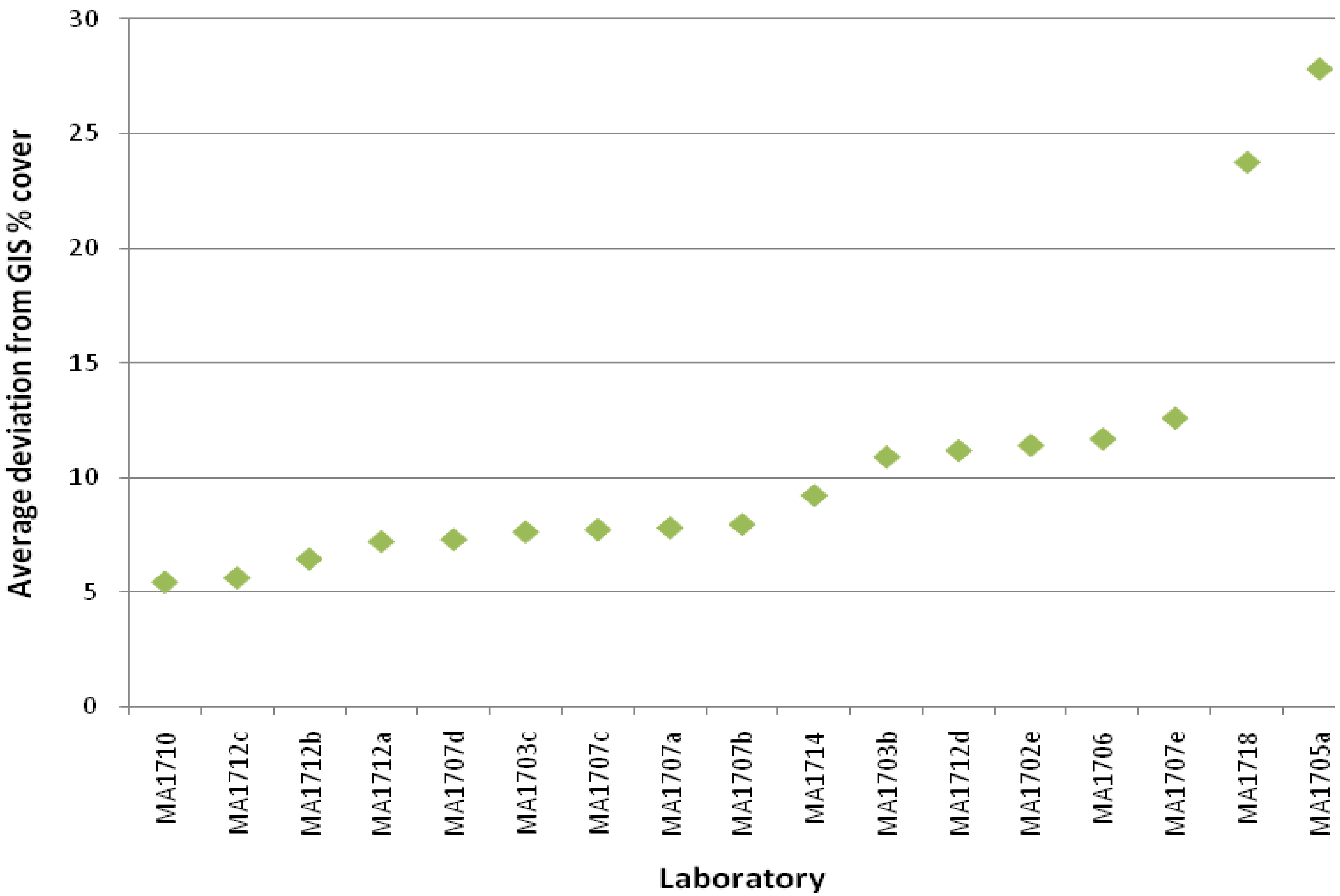


Figure 7. Difference in % cover between submitted results and GIS results, displayed as the average difference across all quadrats in test C for each participant.

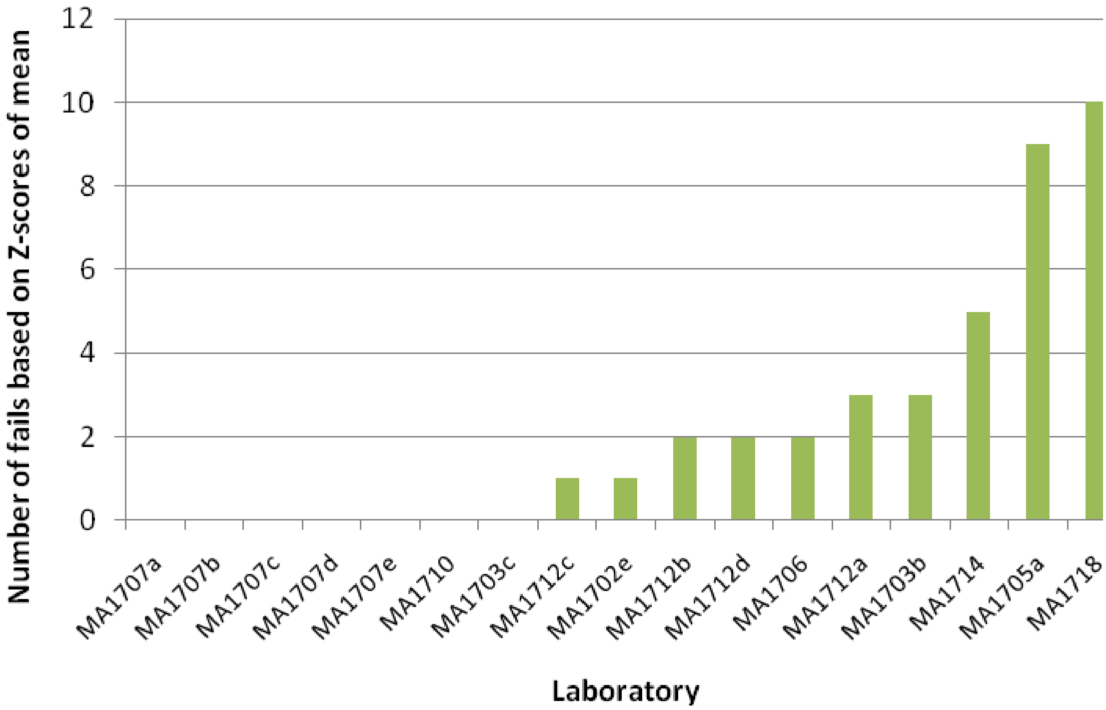


Figure 8. Number of quadrat fails per participant based on z-scores derived from mean % cover estimates for test C.

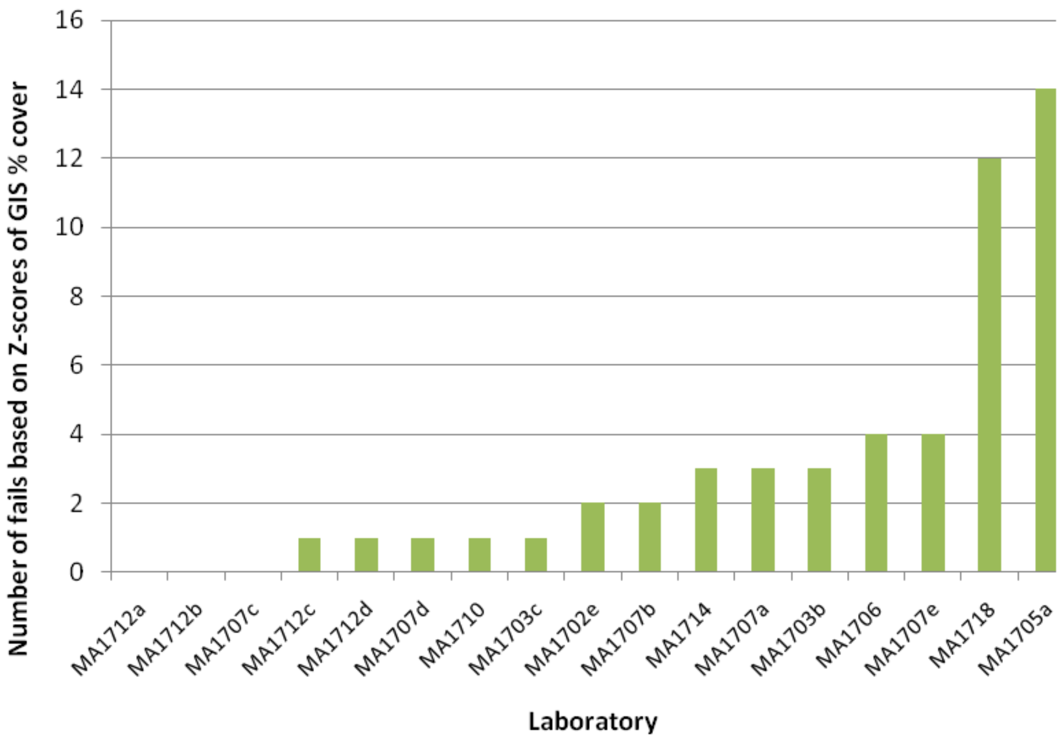


Figure 9. Number of quadrat fails per participant based on z-scores derived from % cover as calculated in GIS for test C.

2.5.4 Results Summary and Comparison

For each of the tests the results were presented as raw data. The raw data allowed results to be compared between participants and against the GIS results using the Z-scores (see below for description) which were displayed as the number of failures. These comparisons were further used to calculate deviation from the GIS results.

Z-scores indicate how much each value deviates from the mean. It uses the following formula:

$$Z = \frac{x - \mu}{\delta}$$

x is a raw score to be standardized;

μ is the mean of the population;

σ is the standard deviation of the population.

Z-scores were calculated using the mean % cover and the GIS % cover. A Z-score value of greater than +/- 2.0 was considered to be outside an acceptable limit of deviation from the mean. This value was used assign a 'Fail' or 'Pass' flag on the data.

2.5.4.1 Test A Results

Test A consisted of 20 participants with varying levels of deviation from the GIS calculation and varying deviations from the population mean. Most participants showed an average deviation from GIS % cover ranging between 6% and 10%.

Ninety percent of participants failed at least one quadrat estimation although there was a higher pass rate using Z-scores calculated from the population mean rather than the GIS % cover. The greatest average number of 'Fails' were produced using method A. This method may be considered as the most subjective.

2.5.4.2 Test B Results

Test B had the greatest number of participants with 27. This test resulted in a 98% of participants deviating significantly from the GIS results however the deviation from population mean was much lower (33%) showing a much greater consistency in the results.

The test B method provides a less subjective means of estimating % cover which has resulted in more consistent results between participants. However, the large degree of deviation from the GIS % cover results indicates a larger degree of error between manual % cover estimations and GIS calculated % covers.

2.5.4.3 Test C Results

A total of 17 participants opted to complete Test C using the 25 square method. The results verified that as with the other two test methods there was a higher degree of deviation when comparing results against the GIS % cover as opposed to population mean.

There were more ‘Fails’ compared with test B but fewer than test C with 71% failure. The reduced number of participants suggests this is the least favoured method of % cover estimation.

3 Conclusions and Recommendations

The % cover of opportunist algae in a ¼ m^2 quadrat is usually estimated based on a skilled eye observation using either an open quadrat or gridded quadrat with +/- 5% agreement. It is highly unlikely that this method of % cover estimation is 100% accurate due to the subjectivity of individuals. OMC RT01 has used the population mean and a GIS method to calculate a more precise % cover for comparison with individual participants’ records. There are difficulties in obtaining 100% accuracy for % cover of opportunist algae, however using the GIS method provides a lesser degree of subjectivity than skilled eye estimation. Once the exact area of cover has been identified the GIS programme calculated the areas, reducing subjectivity. During this first round of the macroalgae scheme photographs were not ground truthed against actual presence of alga within the field. Therefore we cannot claim at present that these comparisons against GIS are better than comparisons with the mean. In subsequent rounds each quadrat photograph will be calibrated to ensure there is no confusion between benthic diatoms and opportunist algae. Each photograph will be accurately ground truthed and the GIS method will be calibrated to show the high degree of precision within this method.

Z-scores were used to establish a level of acceptance for results submitted by participants. The results show a high level of consistency between participants when comparing with the population mean. There were a greater number of Z-scores failures when comparing the GIS % cover and the population mean of the quadrats. This was consistent across all three tests. The degree of deviation from the GIS % cover value depended significantly upon the quadrat. Some quadrats were more problematic than others (Figure 10) and this was evident in the range of % covers and could be partly attributed to the cover of microphytobenthos or more patchy coverage of opportunist algae which is much harder to accurately estimate without appropriate ground truthing.

Test A showed the least deviation from the GIS % cover and the lowest average range of values for each quadrat (Tables 4 & 5). However, this test also produced the greatest number of failures with most participants obtaining at least one failure; this is likely to result from the lowered standard deviation when calculating Z-scores. The mean for each quadrat was consistently underestimated for test A and over estimated for test B with reference to GIS results. There is evidently a high degree of error between tests as well as between participants and this has prompted the need for a specific workshop where methods may be discussed and possibly % cover estimations compared in the field.

The GIS analysis is still under development and aims to incorporate ground truthing, to pick up subtleties of variations in cover within the defined affected area, and calibration of GIS for future rounds of Ring Tests. At this time participants may want to use the Z-scores derived from comparisons with the mean if they are required for internal quality reports.

If anyone has further thoughts on this, or disagrees with any of the interpretation, please pass forward your comments. This ring test is very much in its developmental stage but hopes to be continually refined.

During this first cycle of the macroalgae scheme there were slow and missing returns from some laboratories which have lead to some delays in processing and subsequent reporting and feedback of results. In subsequent years reminders will be distributed prior to the completion deadline for the exercise.

A number of result spreadsheet forms were not completed, omitting necessary information this further caused delays in processing the results.

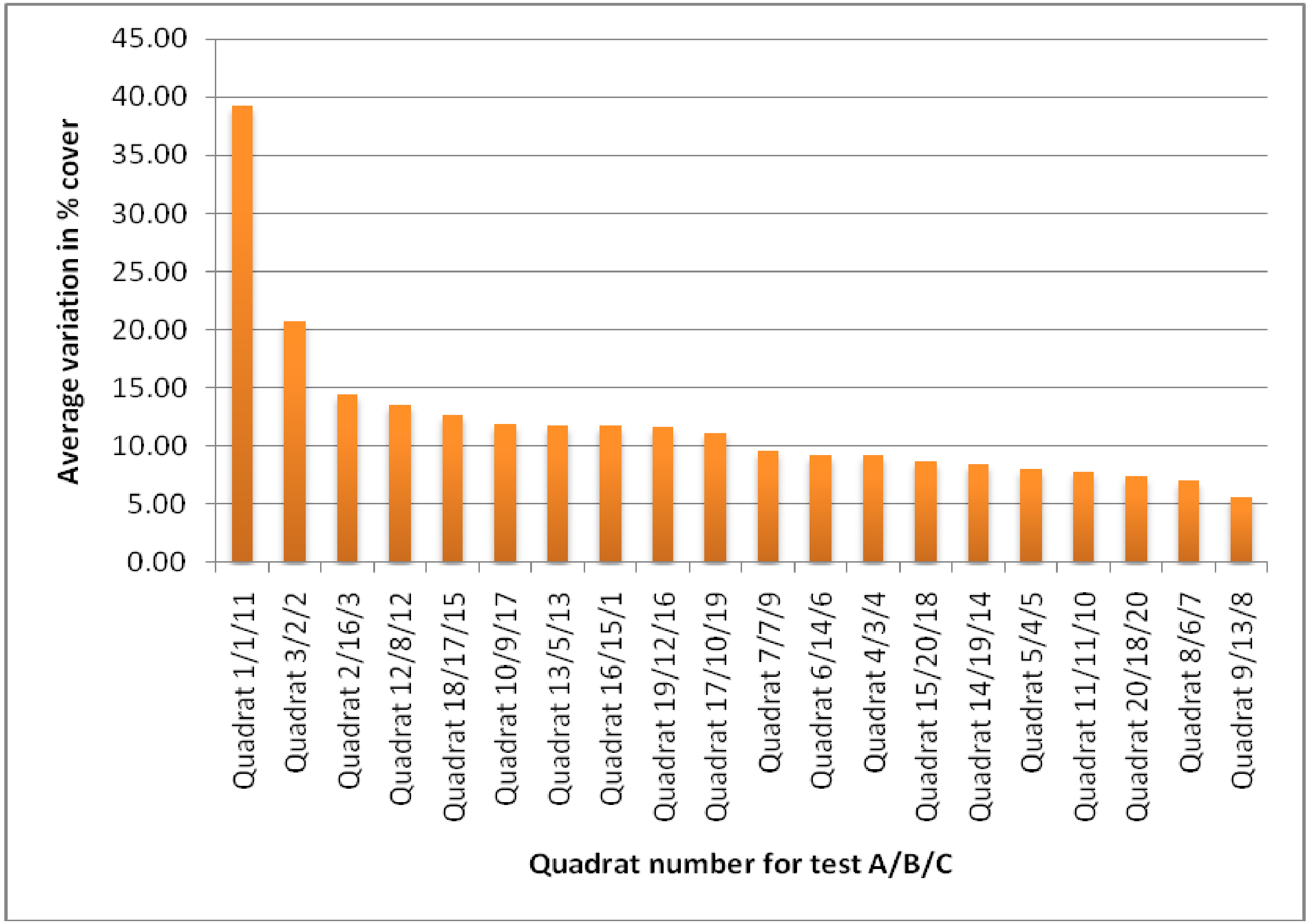
Table 4. Summary of results from tests A, B and C including minimum values recorded, maximum, mean and range per quadrat across all participants

	Results from Test A					Results from Test B						Results from Test C					
GIS algal coverage %	Test A	Min	Max	Mean	Range		Test A	Min	Max	Mean	Range		Test A	Min	Max	Mean	Range
54.96	Quadrat 1	52	100	93.85	48	54.96	Quadrat 1	49.4	99	92.9	49.6	54.96	Quadrat 11	24	100	88.5	76
69.22	Quadrat 2	60	100	75.65	40	69.22	Quadrat 16	60	100	80.9	40.0	69.22	Quadrat 3	20	100	67.1	80
24.45	Quadrat 3	20	100	44.95	80	24.45	Quadrat 2	24.7	100	46.1	75.3	24.45	Quadrat 2	20	100	42.5	80
29.12	Quadrat 4	12	30	19.1	18	29.12	Quadrat 3	20	44	30.8	24.0	29.12	Quadrat 4	16	58	23.4	42
48.41	Quadrat 5	32	50	43.25	18	48.41	Quadrat 4	32	60	53.9	28.5	48.41	Quadrat 5	38	63	48.0	25
59.71	Quadrat 6	50	65	56.2	15	59.71	Quadrat 14	54.3	75	67.1	21.0	59.71	Quadrat 6	42	70	55.6	28
96.59	Quadrat 7	85	97	91.55	12	96.59	Quadrat 7	80	100	95.3	20.0	96.59	Quadrat 9	10	97	88.0	87
41.20	Quadrat 8	25	45	37.35	20	41.20	Quadrat 6	34	69	41.9	35.0	41.20	Quadrat 7	30	97.5	45.7	67.5
17.03	Quadrat 9	10	26	16.7	16	17.03	Quadrat 13	13.6	51	21.1	37.4	17.03	Quadrat 8	10	77.8	20.6	67.8
82.41	Quadrat 10	65	95	79.85	30	82.41	Quadrat 9	20	96	87.8	76.3	82.41	Quadrat 17	38	92	78.2	54
36.89	Quadrat 11	25	45	34.1	20	36.89	Quadrat 11	31	51	42.2	20.0	36.89	Quadrat 10	25	66	38.2	41
53.42	Quadrat 12	40	75	55.4	35	53.42	Quadrat 8	41	83	69.0	41.7	53.42	Quadrat 12	36	86.4	57.0	50.4
41.98	Quadrat 13	25	55	37.95	30	41.98	Quadrat 5	37	70	55.6	33.0	41.98	Quadrat 13	21	56	36.5	35
38.84	Quadrat 14	25	40	34.05	15	38.84	Quadrat 19	36	90	48.1	54.0	38.84	Quadrat 14	30	70.4	40.6	40.4
58.71	Quadrat 15	45	60	51.85	15	58.71	Quadrat 20	32	74	60.0	42.0	58.71	Quadrat 18	35.8	75	54.5	39.2
63.50	Quadrat 16	40	75	59.8	35	63.50	Quadrat 15	18.5	90	69.4	71.6	63.50	Quadrat 1	36	80	58.0	44
57.60	Quadrat 17	35	75	56.5	40	57.60	Quadrat 10	48.1	90	62.2	41.9	57.60	Quadrat 19	45	88	60.9	43
70.26	Quadrat 18	45	80	67.55	35	70.26	Quadrat 17	51	88	72.7	37.0	70.26	Quadrat 15	42	84	61.0	42
96.16	Quadrat 19	75	99	90.7	24	96.16	Quadrat 12	67	99	90.5	31.8	96.16	Quadrat 16	40	99	85.5	59
22.33	Quadrat 20	15	30	22.35	15	22.33	Quadrat 18	21	72	31.3	51.0	22.33	Quadrat 20	15	66.7	26.9	51.7
	average range				28.05		average range				41.56		average range				51.42105

Table 5. Comparison of estimated results from tests A, B and C with GIS % cover results. The value represents the average deviation from GIS % cover value for each participant.

Lab Code	Test A	Test B	Test C
MA1712a	9.36	7.45	7.22
MA1712b	8.09	6.58	6.45
MA1712c	6.67	7.22	5.63
MA1712d	14.38	14.87	11.18
MA1718			23.75
MA1709	5.78	6.32	
MA1701		13.43	
MA1717a		10.78	
MA1717b		10.36	
MA1706	9.19	3.87	11.69
MA1708	15.19	7.70	
MA1711a		7.69	
MA1711b		4.83	
MA1711		10.99	
MA1711d		8.17	
MA1702a	8.91	10.61	
MA1702b	6.87	8.41	
MA1702c	6.37	8.87	
MA1702d	6.71	7.46	
MA1702e	12.42	15.38	11.41
MA1702f	8.81	11.02	
MA1714	8.44	14.45	9.23
MA1707a	6.54	6.13	7.81
MA1707b	9.44		7.97
MA1707c			7.73
MA1707d			7.31
MA1707e			12.59
MA1710		7.28	5.44
MA1705a	9.70	22.76	27.82
MA1705b		13.79	
MA1703a	8.01	14.50	
MA1703b	7.68	15.80	10.90
MA1703c	8.66	12.56	7.64
	8.34	13.26	10.58

Figure 10. Comparison of deviation in GIS % cover and estimated % cover between quadrats highlighting those problematic quadrats.

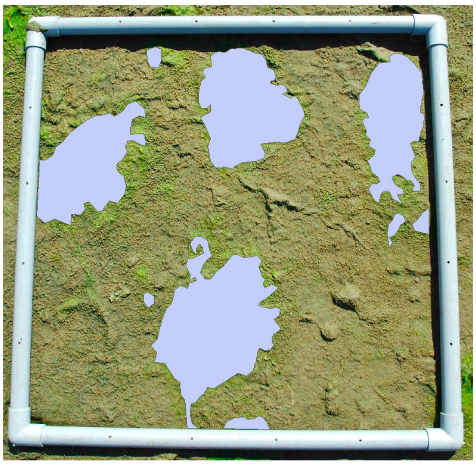


4 GIS Image Results

Areas of algal coverage as calculated using GIS. Summary results for each quadrat include the total number of failures across all three tests as calculated using Z-scores based on both the mean % cover across all participants and the actual % cover as determined by GIS. Quadrat numbers are given for all three tests as A/B/C.

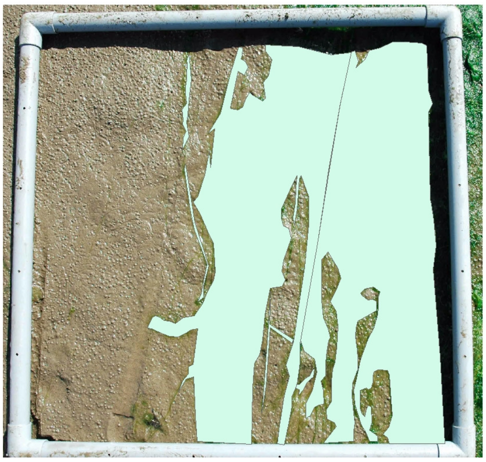
Quadrat: **1/1/11**
Actual % cover: **54.96**
No. of fails from Z-score of mean: **6**
No. of fails from Z-score of actual % cover: **41**
Average deviation: **39.27**

Quadrat: **2/16/3**
Actual % cover: **69.22**
No. of fails from Z-score of mean: **4**
No. of fails from Z-score of actual % cover: **12**
Average deviation: **14.43**

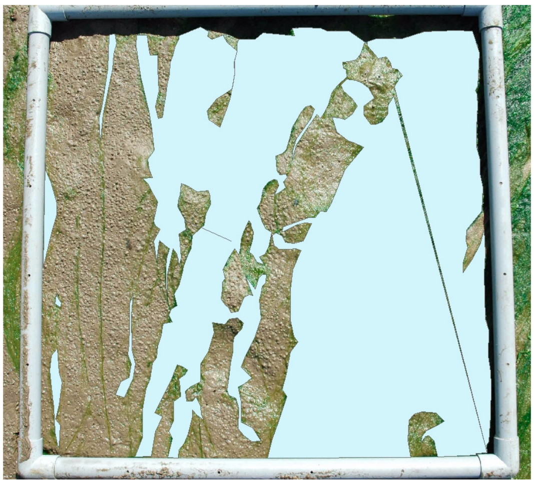


Quadrat: **3/2/2**
Actual % cover: **24.45**
No. of fails from Z-score of mean: **6**
No. of fails from Z-score of actual % cover: **12**
Average deviation: **20.72**

Quadrat: **4/3/4**
Actual % cover: **29.12**
No. of fails from Z-score of mean: **2**
No. of fails from Z-score of actual % cover: **23**
Average deviation: **9.19**

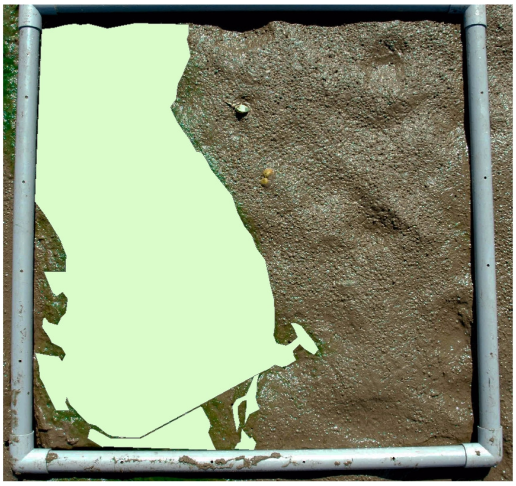


Quadrat: **5/4/5**
Actual % cover: **48.41**
No. of fails from Z-score of mean: **8**
No. of fails from Z-score of actual % cover: **11**
Average deviation: **8.08**

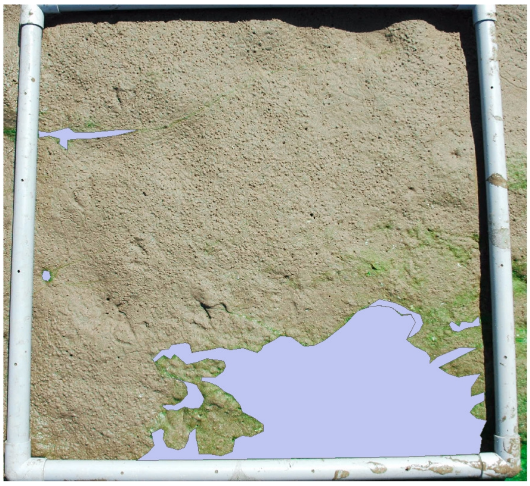


Quadrat: **6/14/6**
Actual % cover: **59.71**
No. of fails from Z-score of mean: **4**
No. of fails from Z-score of actual % cover: **8**
Average deviation: **9.17**

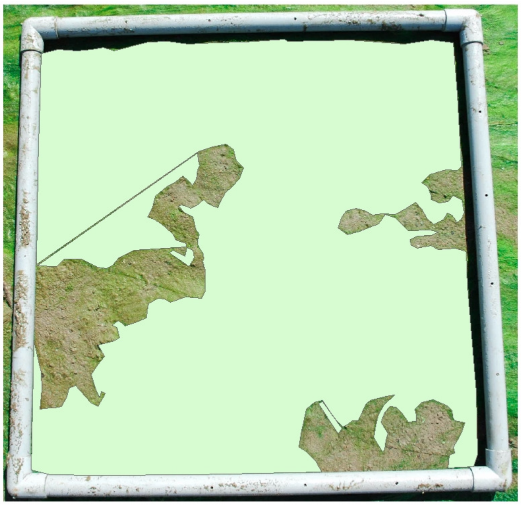
Quadrat: **7/7/9**
Actual % cover: **96.59**
No. of fails from Z-score of mean: **9**
No. of fails from Z-score of actual % cover: **17**
Average deviation: **9.57**



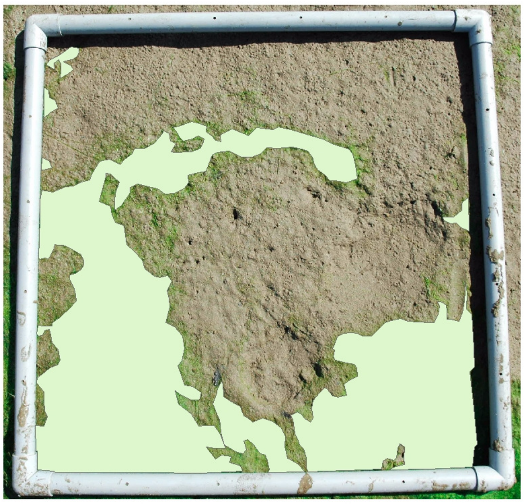
Quadrat: **8/6/7**
Actual % cover: **41.20**
No. of fails from Z-score of mean: **4**
No. of fails from Z-score of actual % cover: **6**
Average deviation: **7.06**



Quadrat: **9/13/8**
Actual % cover: **17.03**
No. of fails from Z-score of mean: **8**
No. of fails from Z-score of actual % cover: **7**
Average deviation: **5.65**

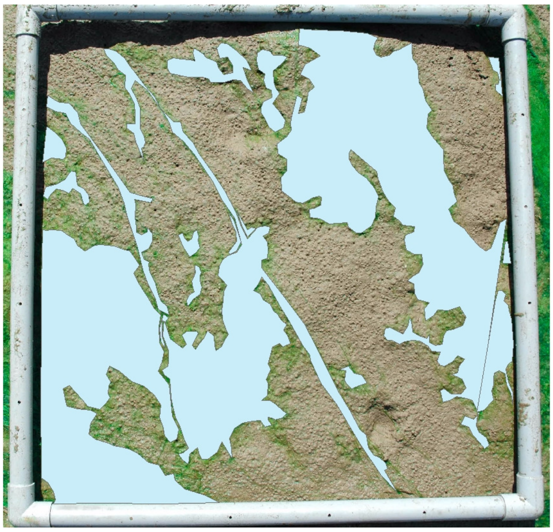


Quadrat: **10/9/17**
Actual % cover: **82.41**
No. of fails from Z-score of mean: **3**
No. of fails from Z-score of actual % cover: **4**
Average deviation: **11.90**

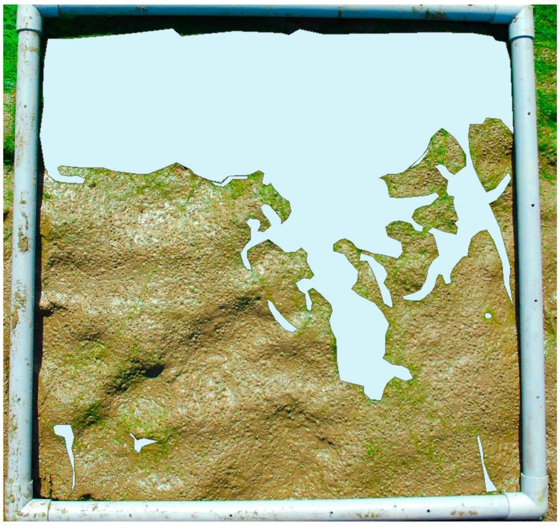


Quadrat: **11/11/10**
Actual % cover: **36.89**
No. of fails from Z-score of mean: **10**
No. of fails from Z-score of actual % cover: **12**
Average deviation: **7.77**

Quadrat: **12/8/12**
Actual % cover: **53.42**
No. of fails from Z-score of mean: **6**
No. of fails from Z-score of actual % cover: **3**
Average deviation: **13.54**



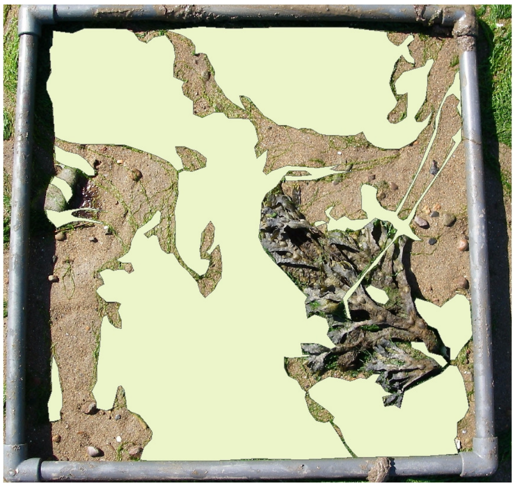
Quadrat: **13/5/13**
Actual % cover: **41.98**
No. of fails from Z-score of mean: **13**
No. of fails from Z-score of actual % cover: **24**
Average deviation: **11.78**



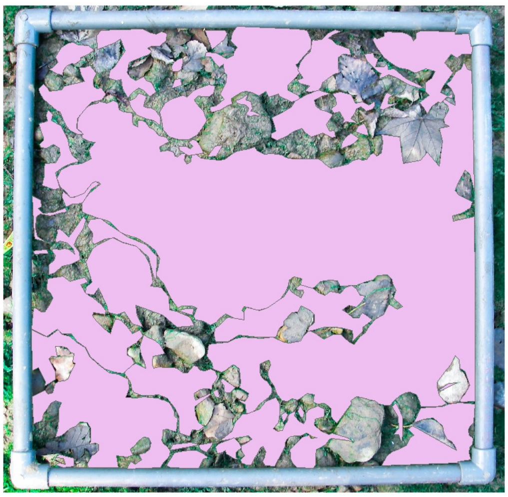
Quadrat: **14/19/14**
Actual % cover: **38.84**
No. of fails from Z-score of mean: **4**
No. of fails from Z-score of actual % cover: **3**
Average deviation: **8.37**

Quadrat: **15/20/18**
Actual % cover: **58.71**
No. of fails from Z-score of mean: **5**
No. of fails from Z-score of actual % cover: **19**
Average deviation: **8.72**

Quadrat: **16/15/1**
Actual % cover: **63.50**
No. of fails from Z-score of mean: **6**
No. of fails from Z-score of actual % cover: **11**
Average deviation: **11.75**

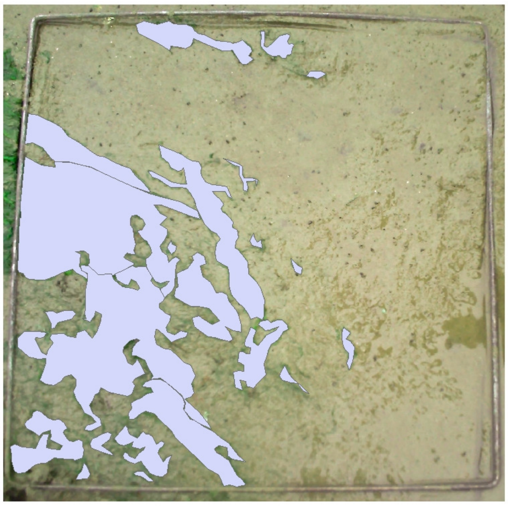


Quadrat: **17/10/19**
Actual % cover: **57.60**
No. of fails from Z-score of mean: **6**
No. of fails from Z-score of actual % cover: **6**
Average deviation: **11.08**



Quadrat: **18/17/15**
Actual % cover: **70.26**
No. of fails from Z-score of mean: **6**
No. of fails from Z-score of actual % cover: **9**
Average deviation: **12.67**

Quadrat: **19/12/16**
Actual % cover: **96.16**
No. of fails from Z-score of mean: **5**
No. of fails from Z-score of actual % cover: **6**
Average deviation: **11.69**



Quadrat: **20/18/20**
Actual % cover: **22.33**
No. of fails from Z-score of mean: **3**
No. of fails from Z-score of actual % cover: **4**
Average deviation: **7.43**