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Preface

The Global Ocean Observing System (GOOS) has recently established the Essential Ocean Variables (EOVs) for biogeochemistry which are promoted as fundamental measurements needed to address the current scientific and societal ocean related issues; inorganic nutrients are defined as an EOV. Observation of the natural variability and trends of nutrients and inorganic carbon in the world's oceans continues to be important topics of oceanographic research. Therefore is consistency and traceability of nutrient data in the world's oceans fundamental properties, particularly for studies of global climate change. Although the oceanographic community has continued to improve the quality of nutrient data from the world's oceans, the knowledge about the variability of nutrient concentrations in seawater is hampered by the presence biases and imprecision in the measurements of nutrients.

Measurements of the inorganic nutrients silicate, nitrate, nitrite and phosphate are the perhaps most commonly measured biogeochemical variables in the global ocean, second only to oxygen. Over the decades the analytical methods has developed and refined, and today mostly these measurements are performed on auto-analyzers. Since there are issues with preserving samples for shore-based measurements nutrients are preferable measured on-board the research vessel, although this is not always possible so that a significant fraction of the global ocean nutrient data are based on measurements of preserved samples, leading to biases. More disturbing is the fact that measurements of identical samples on seemingly identical analytical instruments and methods frequently yield different results. Often the reasons for these biases are difficult to identify by a single investigator.

By performing regular inter-calibration exercises laboratories can be made aware of biases in their measurements which make it possible to scrutinize the analytical procedures in order to eliminate the reason(s) for biases. This inter-calibration exercise is last one in a row of such exercises, and it will not be the last one. Recently the community of nutrient analysts has come together and formed the SCOR supported working group COMPONUT that has been leading this exercise with the aim at improving the consistency of nutrient measurements in the ocean. This goal is further

supported by the International Ocean Carbon Coordination Project (IOCCP) that, although historically focused on ocean carbon, realize that consistent nutrient data is key to understand changes in ocean biogeochemistry in the Anthropocene. We hope that the results of this inter-calibration exercise will be one step toward increased consistency in ocean nutrient data.

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Abstract

The objective of this inter-laboratory calibration exercise is to evaluate and improve comparability of global nutrients data in the world ocean. IOCCP and JAMSTEC co-organized an inter-laboratory calibration exercise of nutrients in seawater using four lots of recently certified RM produced by KANSO and three CRMs provided by National Metrology Institute of Japan which are certified in March 2014. 71 laboratories in 28 countries had replied to the call for participants. Results were returned from 59 laboratories. Korean Institute of Ocean Science and Technology, KIOST, also offered to provide their recently developed RMs to this I/C exercise. The Royal Netherlands Institute for Sea Research, NIOZ, also offers to provide silicate stock solution to contribute to the overall assessment of results regarding with this I/C exercise.

Mean, median and standard deviation were calculated, robust mean and standard deviation were also calculated. Successive t-tests at the 95% confidence level were applied to the results before estimating the consensus mean, consensus median, and consensus standard deviation. Z-scores were also calculated to evaluate the performance of laboratories as in the previous inter-comparison studies.

The ranked concentration plots for a particular nutrient would be proportional and roughly parallel to each other for samples with different nutrient concentrations if each laboratory appropriately compensated for the non-linearity of the calibration curves. However there are non-proportional results from some laboratories for all of the determinants as well as observed in the previous I/C studies. These results indicate that non-linearity of the calibration curves for nutrient analysis is one of significant sources of less comparability of nutrients data. This implies that we need to use a set of CRM of which nutrients concentrations can cover whole range of measurements of nutrients concentration to keep comparability of whole range of nutrients concentration in the world ocean. It is clear that present comparability among the participants in 2015 I/C exercise is quite similar with previously obtained comparability in 2012 I/C study and previous I/C studies. Consensus standard deviations of all determinands are one order of magnitude large rather than homogeneity of the CRMs distributed and consensus standard deviations are about double of reported precision of measurements of the laboratories. Therefore these I/C results show that use of CRM will be able to greatly improve comparability of nutrient data among the laboratories in the world.

There are good signal in the results that although consensus standard deviations are relatively large, consensus median/mean of each samples showed good agreement with certified values of the samples within consensus SDs. This implies that majority of the participating laboratories have good capability to measure nutrients concentration in seawater and using CRM will increase more on the comparability and could be their results to be SI traceable quickly.

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1. Introduction

The objective of this inter-laboratory calibration exercise is to evaluate and improve comparability of global nutrients data in the world ocean.

In 2003, 2006, 2008 and 2012, inter-laboratory comparison studies of Reference Material of Nutrients in Seawater, RMNS, were conducted by M. Aoyama at Meteorological Research Institute, Japan and collaborators (Aoyama, 2006, Aoyama et al., 2007, 2008, 2012 in preparation). Firstly, nutrient concentrations of the distributed samples were set to cover the concentration range of nutrients in the Pacific Ocean, which has the highest nutrient concentrations among the open oceans of the world. Second, the distributed samples were prepared in a natural seawater matrix in a single bottle so that four determinands (nitrate, nitrite, phosphate, and silicate) could be simultaneously analyzed.

Results obtained in several previous inter-laboratory comparison studies indicated that variability in in-house standards of the participating laboratories and handling of non-linearity of the instruments of the participating laboratories are the primary sources of inter-laboratory discrepancy. Therefore it is obvious that the use of a certified reference material for nutrients in seawater, CRMs, and the common use of the methodology of nutrients measurements are essential to improve and establish global comparability and traceability of nutrient data in the world ocean.

In 2014, the SCOR WG 147 “Towards comparability of global oceanic nutrient data (COMPONUT)”, co-chaired by Michio Aoyama (Japan) and Malcolm Woodward (UK), started to establish mechanisms to ensure comparability of oceanic nutrient data. It will assess the homogeneity and stability of currently available reference materials (RMs) for nutrients. Standardized data-handling procedures will be developed, with common data vocabularies and formats, across producers and users, linking national and international data archives. The group will also promote the wider global use of RMs by convening workshops to actively encourage their use and to provide training in analytical protocols and best practices, particularly targeted towards developing countries. One of the important tasks of this working group is to continue regular global inter-comparison studies, following on from the previous exercises in 2003, 2006, 2008 and 2012.

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2. Preparation and samples

In 2014, IOCCP and JAMSTEC co-organized an inter-laboratory calibration exercise of nutrients in seawater collaborating with the SCOR WG #147. A list of candidate of participants was prepared based on the laboratories which participated previous inter-laboratory calibration exercise and some candidates were newly added by the information of the SCOR WG147 members and IOCCP SSG members. Finally the invitation letter (Appendix IV) was sent to 92 laboratories.

In this inter-laboratory calibration exercise we use four lots of recently certified RM produced by KANSO, former RMNS produced by KANSO which already shows excellent homogeneity of 0.2 % and the concentrations of nitrate, phosphate and silicate did not change more than 1.0 % during 6.4 years and by the criterion of the ISO Guide 35:2006 there were no instability of the RMs nutrients concentration (Aoyama et al., 2012), and three CRMs provided by National Metrology Institute of Japan which are certified in March 2014.

Certified values of seven CRMs as samples of this inter-laboratory calibration exercise are shown in Table 1.

Korean Institute of Ocean Science and Technology, KIOST, also offered to provide their recently developed RMs to this I/C exercise. The Royal Netherlands Institute for Sea Research, NIOZ, also offers to provide silicate stock solution to contribute to the overall assessment of results regarding with this I/C exercise.

Therefore a set of four samples of CRMs was distributed to all 71 participating laboratories around the globe (28 countries) in charge of free, and some combination of three lots of NMIJ CRM were distributed to 21 laboratories who agree to pay for them. Korean RMs were also distributed to 24 voluntary laboratories who agreed to analyses them. NIOZ stock solutions were sent to selected laboratories who are working on deep water samples and agree to analyses this silicate stock solution.

Table1. Certified values of four lots of CRM provided by KANSO, RM-BY, -BU, Ca and BV and three lots of CRM provided by NMIJ, CRM 7601-a, 7602-a and 7603-a, respectively.

	sample	RM-BY	RM-BU	RM-CA	RM-BV
Nitrate	Certificate Value (μmol kg^{-1})	**0.024***	**3.937**	**19.66**	**35.36**
	Expanded Uncertainty (μmol kg^{-1})	**0.019**	**0.051**	**0.15**	**0.35**
Nitrite	Certificate Value (μmol kg^{-1})	**0.019***	**0.072**	**0.063**	**0.047**
	Expanded Uncertainty (μmol kg^{-1})	**0.0085**	**0.0059**	**0.01**	**0.0073**
Silicate	Certificate Value (μmol kg^{-1})	**1.763**	**20.92**	**36.58**	**102.2**
	Expanded Uncertainty (μmol kg^{-1})	**0.063**	**0.49**	**0.22**	**1.1**
Phosphate	Certificate Value (μmol kg^{-1})	**0.039***	**0.345**	**1.407**	**2.498**
	Expanded Uncertainty (μmol kg^{-1})	**0.01**	**0.0085**	**0.014**	**0.023**
reference		(1)	(2)	(3)	(4)
Certified Date		18th June 2015	18th June 2015	18th June 2015	18th June 2015
(1)	http://www.kanso.co.jp/eng/pdf/identification_by.pdf				
(2)	http://www.kanso.co.jp/eng/pdf/identification_bu.pdf				
(3)	http://www.kanso.co.jp/eng/pdf/identification_ca.pdf				
(4)	http://www.kanso.co.jp/eng/pdf/identification_bv.pdf				
*The value are below quantifiable detection limit (QDL).					

Table1. Certified values of four lots of CRM provided by KANSO, RM-BY, -BU, Ca and BV and three lots of CRM provided by NMIJ, CRM 7601-a, 7602-a and 7603-a, respectively (continue).

	sample	CRM 7601-a	CRM 7602-a	CRM 7603-a	
Nitrate	Certificate Value ($mg\ kg^{-1}$)	**0.0009± 0.0005****	**0.948**	**2.757**	
	Expanded Uncertainty ($mg\ kg^{-1}$)		**0.03**	**0.036**	
Nitrite	Certificate Value ($mg\ kg^{-1}$)	**0.0022± 0.0002****	**0.02**	**0.0012± 0.0003****	
	Expanded Uncertainty ($mg\ kg^{-1}$)		**0.002**		
Silicate	Certificate Value ($mg\ kg^{-1}$)	**0.0036**	**0.838**	**4.132**	
	Expanded Uncertainty ($mg\ kg^{-1}$)	**0.0005**	**0.018**	**0.061**	
Phosphate	Certificate Value ($mg\ kg^{-1}$)	**0.0036± 0.0005****	**0.114± 0.0005****	**0.292**	
	Expanded Uncertainty ($mg\ kg^{-1}$)			**0.005**	
reference		(5)	(6)	(7)	
Certified Date		26th Mar. 2014	26th Mar. 2014	26th Mar. 2014	
(5)	https://www.nmij.jp/english/service/C/crm/61/7601a_en.pdf				
(6)	https://www.nmij.jp/english/service/C/crm/61/7602a_en.pdf				
(7)	https://www.nmij.jp/english/service/C/crm/61/7603a_en.pdf				

**Each value following the ± in the column of the information values is the expanded uncertainty determined with the coverage factor of 2, and defines an interval estimated to have a level of confidence of approximately 95 %.

3. Participants and response

71 laboratories in 28 countries had replied to the call for participants. The participating laboratories are listed Table A1 in Appendix I and are cross-referenced by laboratory number to the laboratories participating in the previous I/C studies in Table A2.

Results were returned from 59 laboratories. Table 2 summarizes the data responses from participants and numbers of statistically treated to calculate values presented in this report. All reported information from participants was summarized as reported in Table A3. However only numerical values were statistically treated while if reported ones were as less than certain value (eg. < 0.10) , below detection limit or ND these were not statistically treated such as an arithmetic mean calculation in this report.

Table 2. Summary of responses from participants.

Sample #	Number of results		Sample #	Number of results	
	Received	Statistically treated		Received	Statistically treated
	Nitrate+Nitrite			Nitrite	
RM-BY	57	51	RM-BY	48	42
RM-BU	57	57	RM-BU	49	47
RM-CA	58	58	RM-CA	49	46
RM-BV	57	57	RM-BV	49	45
CRM 7601-a	19	18	CRM 7601-a	16	13
CRM 7602-a	21	21	CRM 7602-a	18	18
CRM 7603-a	19	19	CRM 7603-a	16	14
	Nitrate			Phosphate	
RM-BY	43	37	RM-BY	57	51
RM-BU	43	43	RM-BU	58	58
RM-CA	43	43	RM-CA	58	58
RM-BV	43	43	RM-BV	58	58
CRM 7601-a	13	12	CRM 7601-a	18	17
CRM 7602-a	14	14	CRM 7602-a	21	21
CRM 7603-a	13	13	CRM 7603-a	19	19

Table 2. Summary of responses from participants (continue).

Sample #	Number of results		Sample #	Number of results	
	Received	Statistically treated		Received	Statistically treated
	Silicate			Dissolved organic phosphate(DOP)	
RM-BY	58	57	RM-BY	8	7
RM-BU	58	58	RM-BU	8	8
RM-CA	57	57	RM-CA	8	7
RM-BV	58	58	RM-BV	8	8
CRM 7601-a	18	18	CRM 7601-a	6	6
CRM 7602-a	19	19	CRM 7602-a	6	6
CRM 7603-a	18	18	CRM 7603-a	6	6
	Ammonia			Dissolved organic nitrogen(DON)	
RM-BY	29	28	RM-BY	8	8
RM-BU	30	30	RM-BU	8	8
RM-CA	30	30	RM-CA	8	8
RM-BV	30	30	RM-BV	8	8
CRM 7601-a	8	8	CRM 7601-a	6	6
CRM 7602-a	10	10	CRM 7602-a	6	6
CRM 7603-a	9	9	CRM 7603-a	6	6
				Dissolved organic carbon(DOC)	
			RM-BY	1	1
			RM-BU	1	1
			RM-CA	1	1
			RM-BV	1	1
			CRM 7601-a	0	0
			CRM 7602-a	0	0
			CRM 7603-a	0	0

4. Statistical treatment

4.1 Raw mean, median, and standard deviation

Mean, median and standard deviation were calculated using reported values except reported as below detection limit, less than xx etc. Results are shown in Table 3.

4.2 Robust statistics

Robust statistics is a convenient modern way of summarizing results when we suspect that they include a small proportion of outliers. Most estimates of central tendency (e.g., the arithmetic mean, in this report raw mean in Table 3) and dispersion (e.g ., standard deviation, in this report Raw SD in Table 3) depend for their interpretation on an implicit assumption that the data comprise a random sample from a normal distribution. But it is actually that analytical data we treated in this report may depart from that model. They are often heavy tailed (contain a higher or lower than expected proportion of results far from the mean) and may contain outliers as we can see ranked plots as shown in Figure 1-1 to 5-2. Robust mean (H15 mean) and standard deviation (H15 Sd) were calculated based on the AMC method (AMC, 2001). Results are shown in Table 3.

4.3 Consensus mean, median, and standard deviation

Successive t-tests at the 95% confidence level were applied to the results before estimating the consensus mean, consensus median, and consensus standard deviation as in the previous inter-comparison studies (Aminot and Kirkwood, 1995; Aoyama, 2006; 2008). Tests were applied until a stable mean was reached, and stable means were obtained at the 5th to 9th test for sets of results. This means that data within estimated consensus mean +- 3 times of consensus standard deviation were remained and the consensus mean, consensus median, and consensus standard deviation were obtained..

4.4 Calculation of Z-scores

Z-scores were used to evaluate the performance of laboratories as in the previous inter-comparison studies (Aminot and Kirkwood, 1995; Aoyama, 2006; 2008).

The *Z*-score for each analysis is defined as

$$Z_{par} = \mathrm{ABS}((C_{par} - C_{consensus})/P_{par}) \qquad (1)$$

Where *Z*par is the *Z*-score for an analysis; C_{par} is the concentration of an RMNS sample measured by a laboratory for the parameter of interest (nitrate, phosphate, or silicate); $C_{consensus}$ is the consensus sample concentration for the parameter of interest, described in section 4.1; and P_{par} is the standard deviation at the sample concentration for the parameter of interest.

The *Z*-score for all determinants, nitrate+nitrite, nitrate, nitrite, phosphate and silicate, were calculated and shown in tables 6-1 – 6-5. We calculate combined Z-scores for phosphate and nitrate+nitrite to look at performance to estimate an important biogeochemical parameter, N/P ratio, and shown in table 6-6. We also calculated combined Z-scores for phosphate, nitrate+nitrite, and silicate and shown in table 6-7 to look at overall performance of nutrients measurements of each laboratory.

Table 3. Raw and robust statistics for nutrient concentrations calculated using all reported values.

Nutrient	Sample #	n	Raw Mean μmol kg^{-1}	Raw Median μmol kg^{-1}	Raw SD μmol kg^{-1}	Robust mean μmol kg^{-1}	Robust SD μmol kg^{-1}
Nitrate+Nitrite	RM-BY	51	0.16	0.06	0.39	0.07	0.05
	RM-BU	57	3.87	3.96	0.62	3.95	0.20
	RM-CA	58	19.41	19.53	1.20	19.48	0.66
	RM-BV	57	34.48	35.10	2.71	35.03	1.22
	CRM 7601-a	18	0.19	0.07	0.53	0.07	0.03
	CRM 7602-a	21	15.84	15.88	0.76	15.92	0.51
	CRM 7603-a	19	44.08	44.38	2.01	44.35	1.29
Nitrate	RM-BY	37	0.12	0.04	0.39	0.05	0.05
	RM-BU	43	3.75	3.89	0.72	3.85	0.29
	RM-CA	43	19.33	19.43	1.13	19.43	0.71
	RM-BV	43	34.45	35.07	2.94	35.04	1.36
	CRM 7601-a	12	0.04	0.04	0.02	0.04	0.02
	CRM 7602-a	14	15.60	15.62	0.44	15.60	0.49
	CRM 7603-a	13	44.66	44.55	1.01	44.65	0.80
Nitrite	RM-BY	42	0.03	0.02	0.03	0.02	0.02
	RM-BU	47	0.09	0.08	0.08	0.08	0.02
	RM-CA	46	0.08	0.06	0.06	0.07	0.02
	RM-BV	45	0.06	0.05	0.05	0.05	0.02
	CRM 7601-a	13	0.04	0.03	0.03	0.03	0.02
	CRM 7602-a	18	0.39	0.40	0.03	0.39	0.03
	CRM 7603-a	14	0.03	0.03	0.02	0.03	0.01

Table 3. Raw and robust statistics for nutrient concentrations calculated using all reported values(continue).

Nutrient	Sample #	n	Raw Mean	Raw Median	Raw SD	Robust mean	Robust SD
			μmol kg^{-1}	μmol kg^{-1}	μmol kg^{-1}	μmol kg^{-1}	μmol kg^{-1}
Phosphate	RM-BY	51	0.05	0.04	0.04	0.04	0.02
	RM-BU	58	0.37	0.35	0.10	0.35	0.03
	RM-CA	58	1.42	1.42	0.14	1.42	0.06
	RM-BV	58	2.52	2.50	0.28	2.51	0.08
	CRM 7601-a	17	0.05	0.05	0.01	0.04	0.01
	CRM 7602-a	21	1.11	1.12	0.07	1.12	0.05
	CRM 7603-a	19	3.13	3.13	0.11	3.12	0.11
Silicate	RM-BY	57	1.66	1.72	0.55	1.67	0.28
	RM-BU	58	20.04	20.52	2.16	20.45	0.92
	RM-CA	57	35.47	36.02	3.48	36.05	1.06
	RM-BV	58	99.87	101.14	7.95	100.79	4.25
	CRM 7601-a	18	1.07	1.25	0.44	1.14	0.30
	CRM 7602-a	19	28.78	29.49	1.81	28.90	1.78
	CRM 7603-a	18	137.14	142.55	13.68	139.79	8.25

Robust (H15) means and standard deviations were calculated using Huber's method with 1.5 as the multiplier in the Winsorisation process (AMC, 2001).

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5. Results

Results from the participants which included into a database were 58 of those laboratories as of July 2015. In this report, summary of 4 CRMs by KANSO and 3 CRMs by NMIJ are presented in the main text and summary of 4 KIOST RMs are shown in appendix V.

5.1 Ranked scatter-plots of the results

Figures 1 to 5 are ranked scatter-plots for nitrate+nitrite, nitrate, nitrite, phosphate and silicate, respectively. For nitrate+nitrite, nitrate, phosphate, and silicate, the laboratory results were sorted in order of the concentrations reported for CRM-BV or CRM-7603a, which had the highest nitrate, phosphate, and silicate concentrations of the samples sent to the participants. For nitrite, laboratory results were sorted in order of the reported concentrations in CRM-BU or CRM-7602a, which had the highest nitrite concentration of all the samples. Error bars are included in Figures 1-1 to 5-2 where this information was included with the reported results.

Cross reference tables to find lab number correspond to order of ranked results are shown in Tables A8-1 to A8-10 in Appendix III for Figures 1-1 to 5-2.

In each of Figures 1-1 to 5-2, the ranked concentration plots for a particular nutrient would be proportional and roughly parallel to each other for samples with different nutrient concentrations if each laboratory appropriately compensated for the non-linearity of the calibration curves. However, as evident in Figures, there are non-proportional results from some laboratories for all of the determinants as well as observed in the previous I/C studies.

These results indicate that non-linearity of the calibration curves for nutrient analysis is one of significant sources of less comparability of nutrients data. This implies that we need to use a set of CRM of which nutrients concentrations can cover whole range of measurements of nutrients concentration to keep comparability of whole range of nutrients concentration in the world ocean. .

In Figures 1-1 to 5-2, certified values or reference values by the provider of CRMs with uncertainty are presented when they are available.

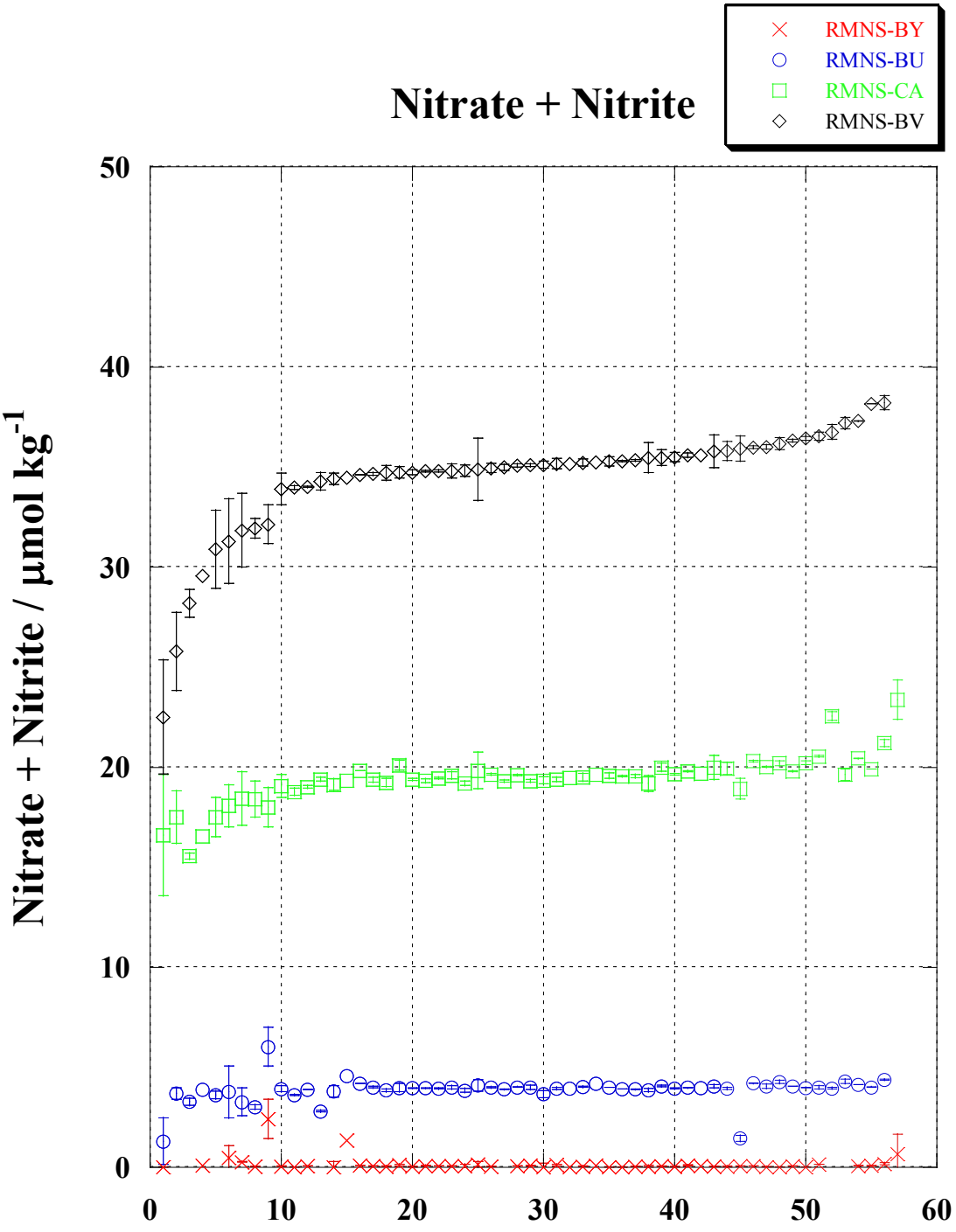

Figure 1-1. Nitrate+Nitrite results for KANSO CRMs. Laboratories are ranked in order of concentrations reported for RM-BV.

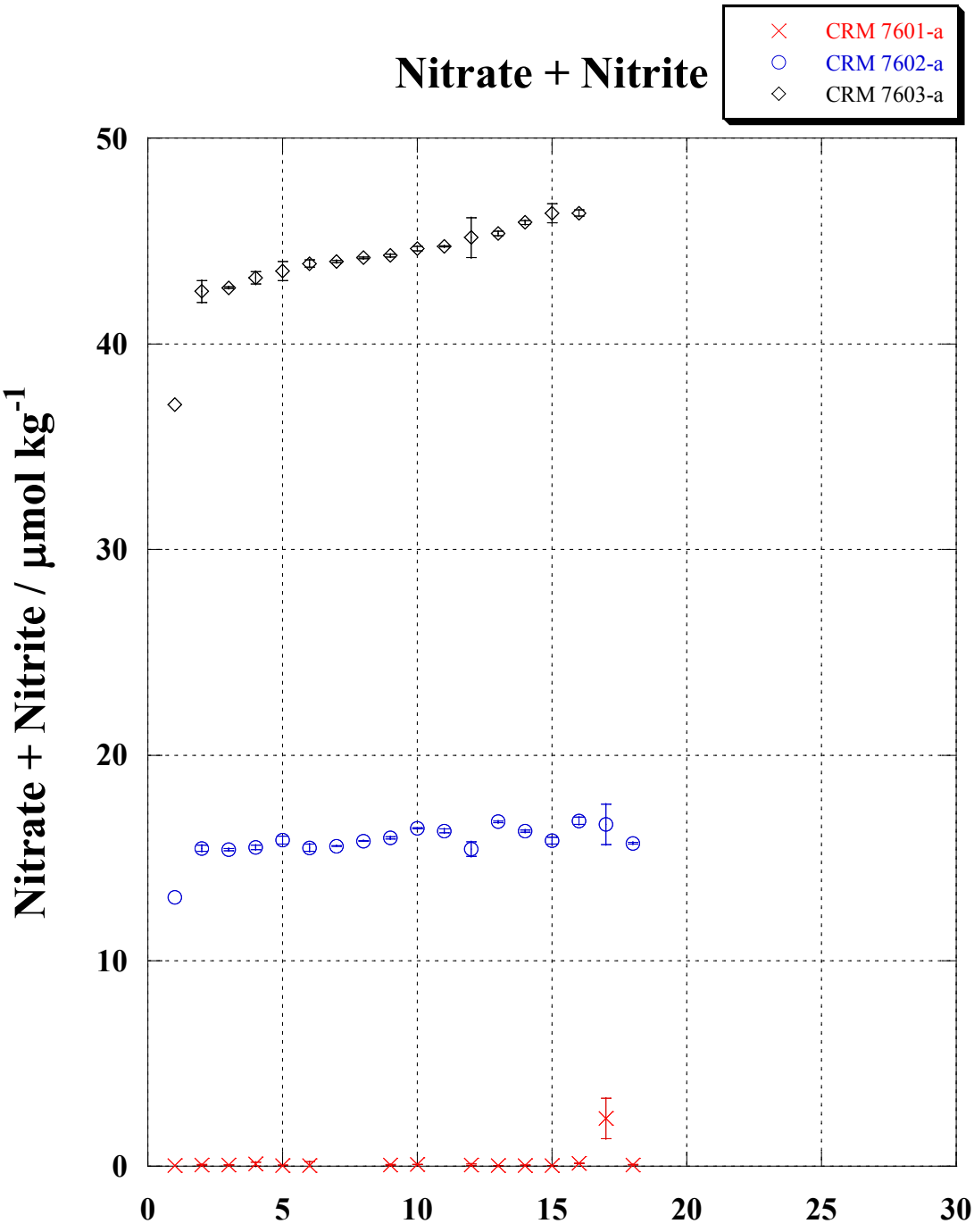

Figure 1-2. Nitrate+Nitrite results for NMIJ CRMs. Laboratories are ranked in order of concentrations reported for CRM 7603-a.

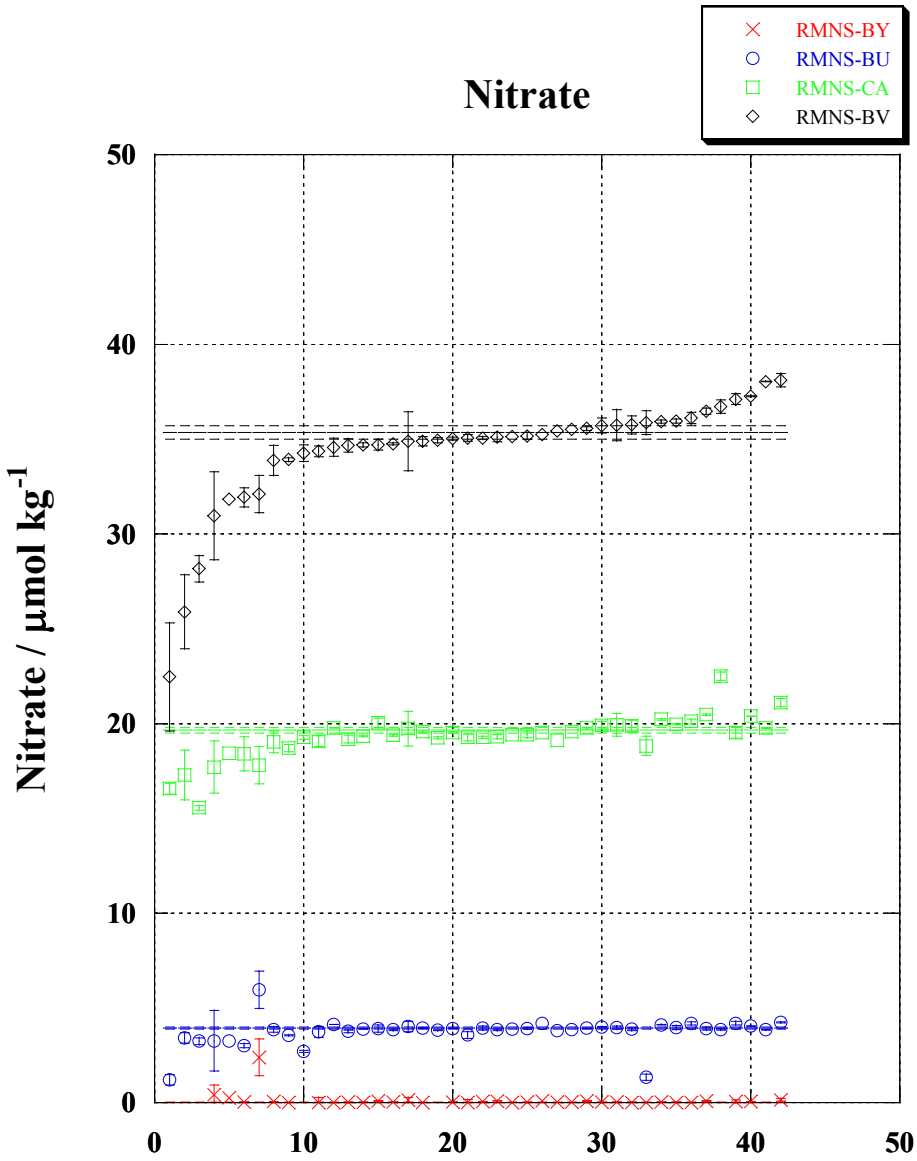

Figure 2-1. Nitrate results for KANSO CRMs. Laboratories are ranked in order of concentrations reported for RM-BV.

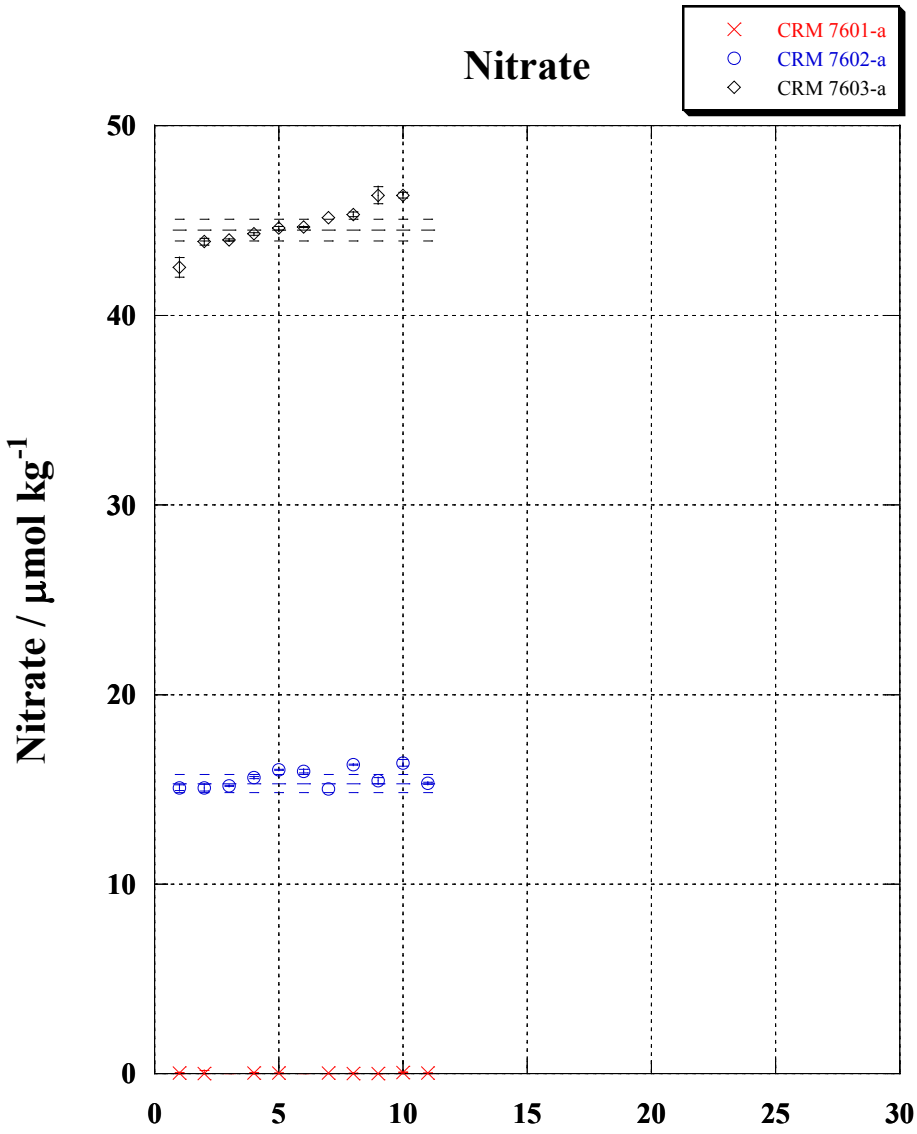

Figure 2-2. Nitrate results for NMIJ CRMs. Laboratories are ranked in order of concentrations reported for CRM 7603-a.

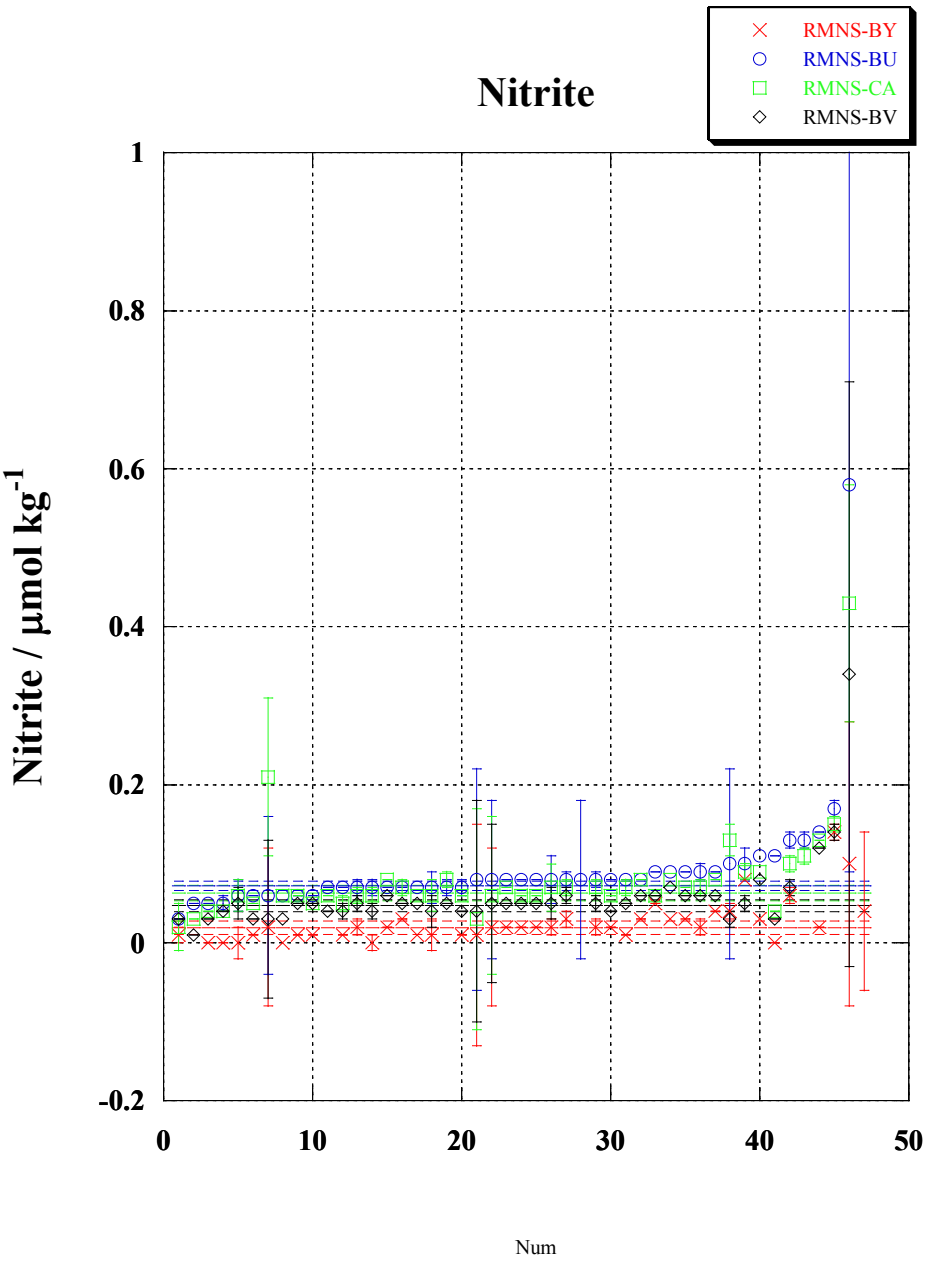

Figure 3-1. Nitrite results for KANSO CRMs. Laboratories are ranked in order of concentrations reported for RM-BU.

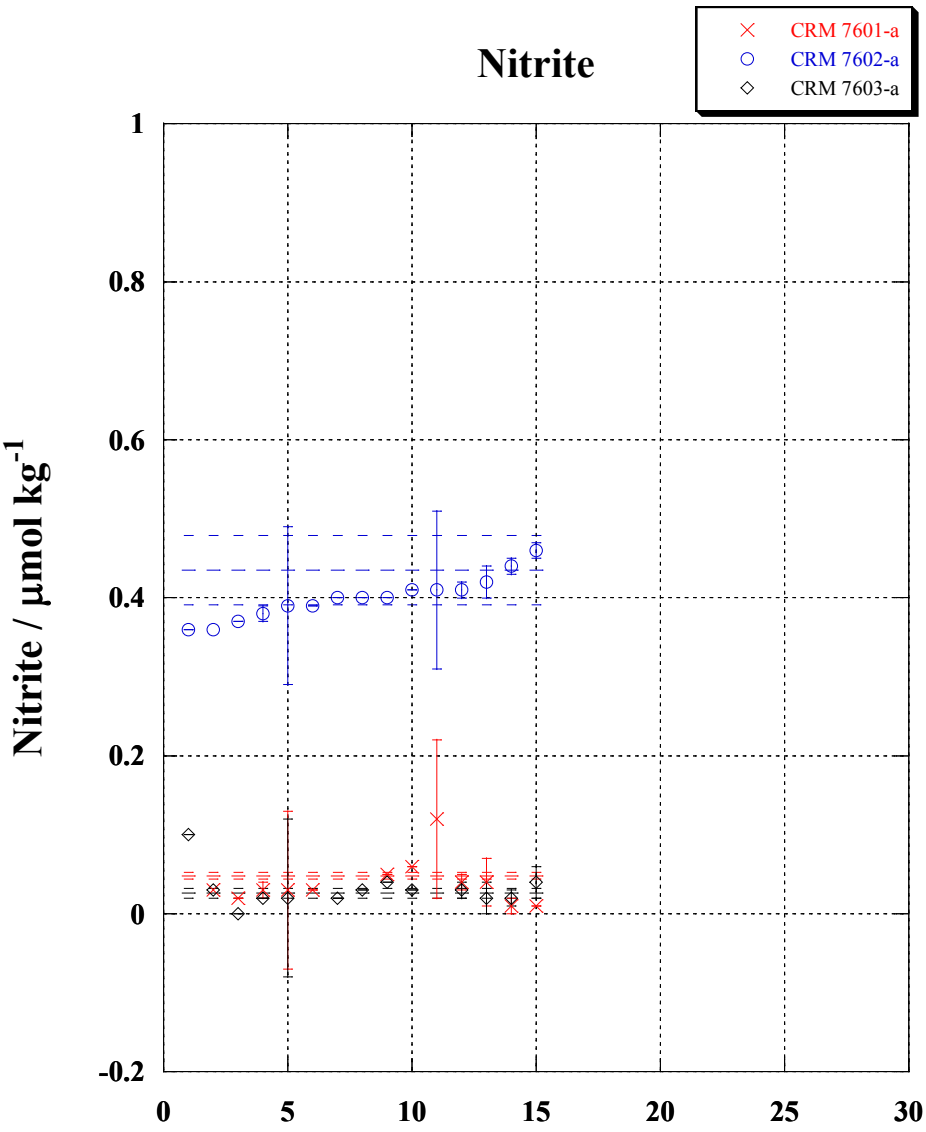

Figure 3-2. Nitrite results for NMIJ CRMs. Laboratories are ranked in order of concentrations reported for CRM 7602-a.

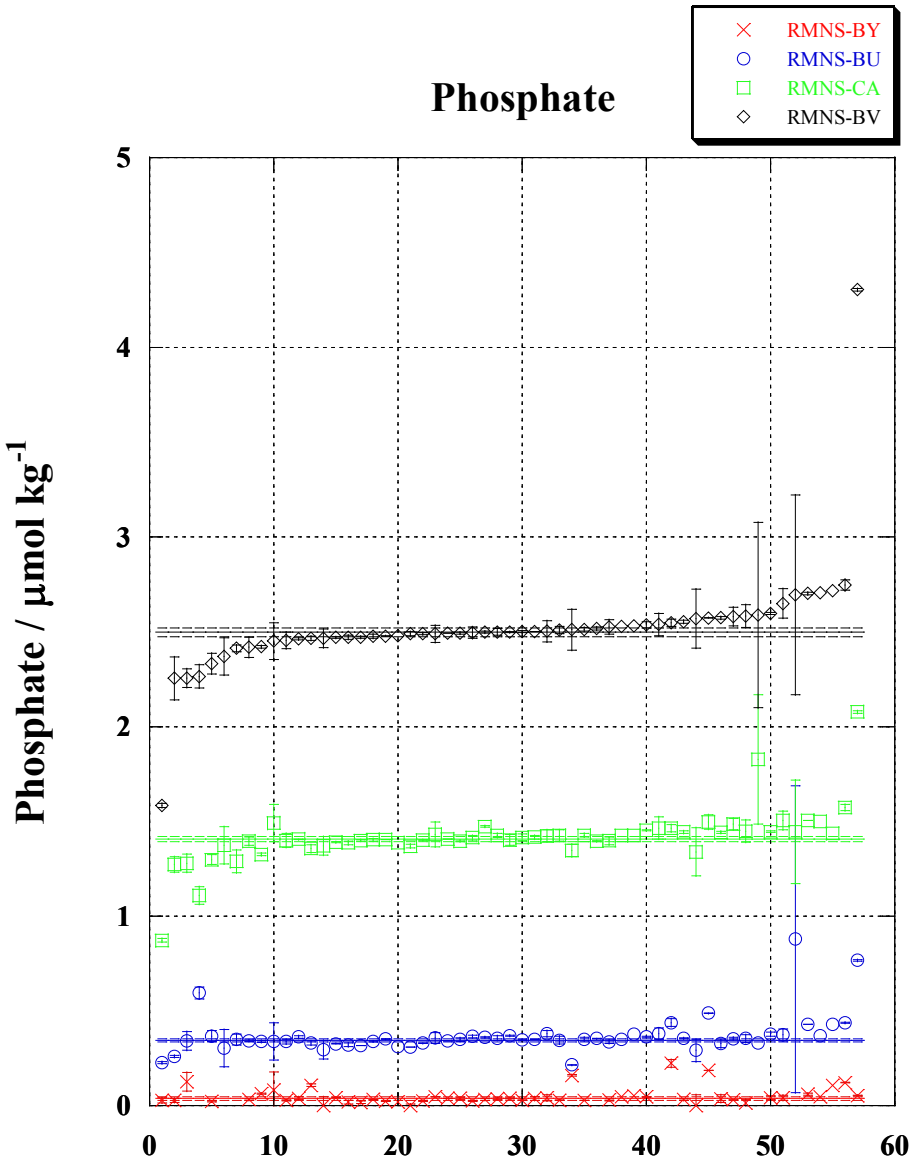

Figure 4-1. Phosphate results for KANSO CRMs. Laboratories are ranked in order of concentrations reported for RM-BV.

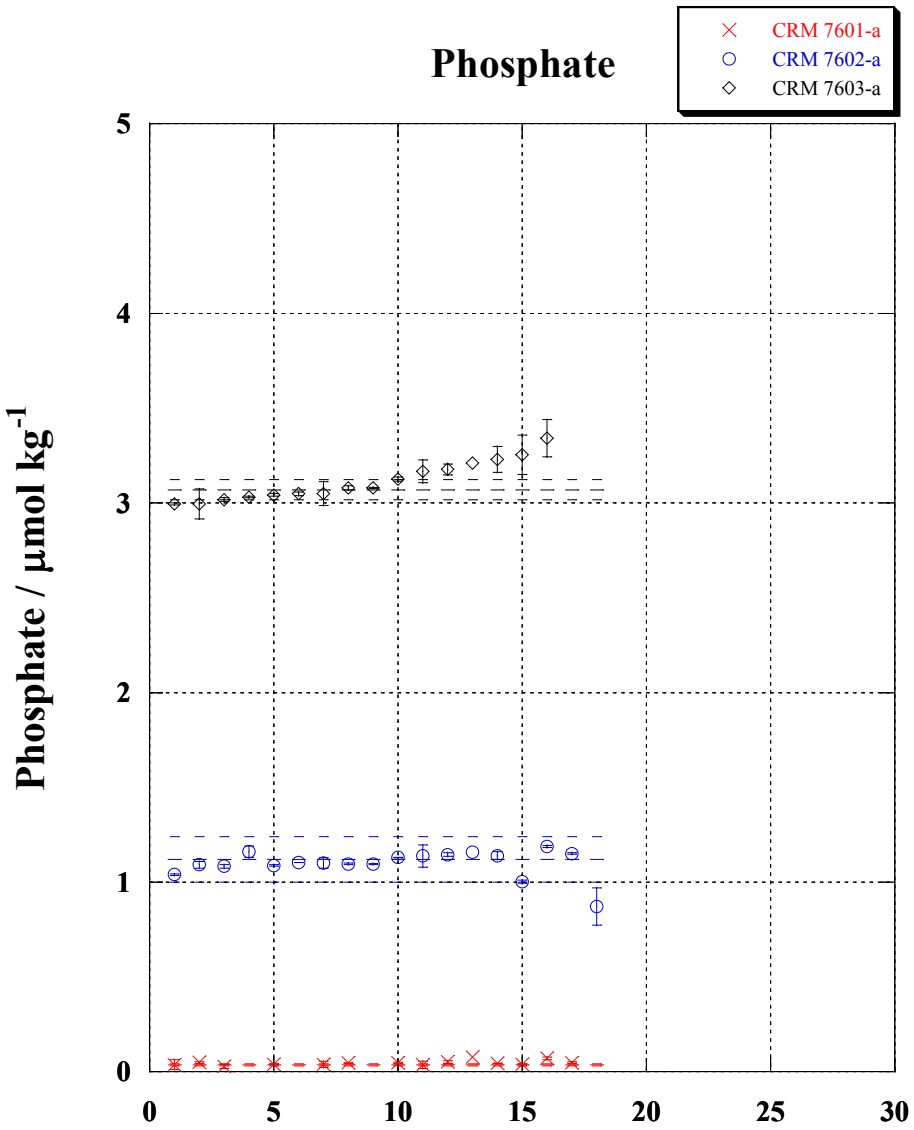

Figure 4-2. Phosphate results for NMIJ CRMs. Laboratories are ranked in order of concentrations reported for CRM 7603-a.

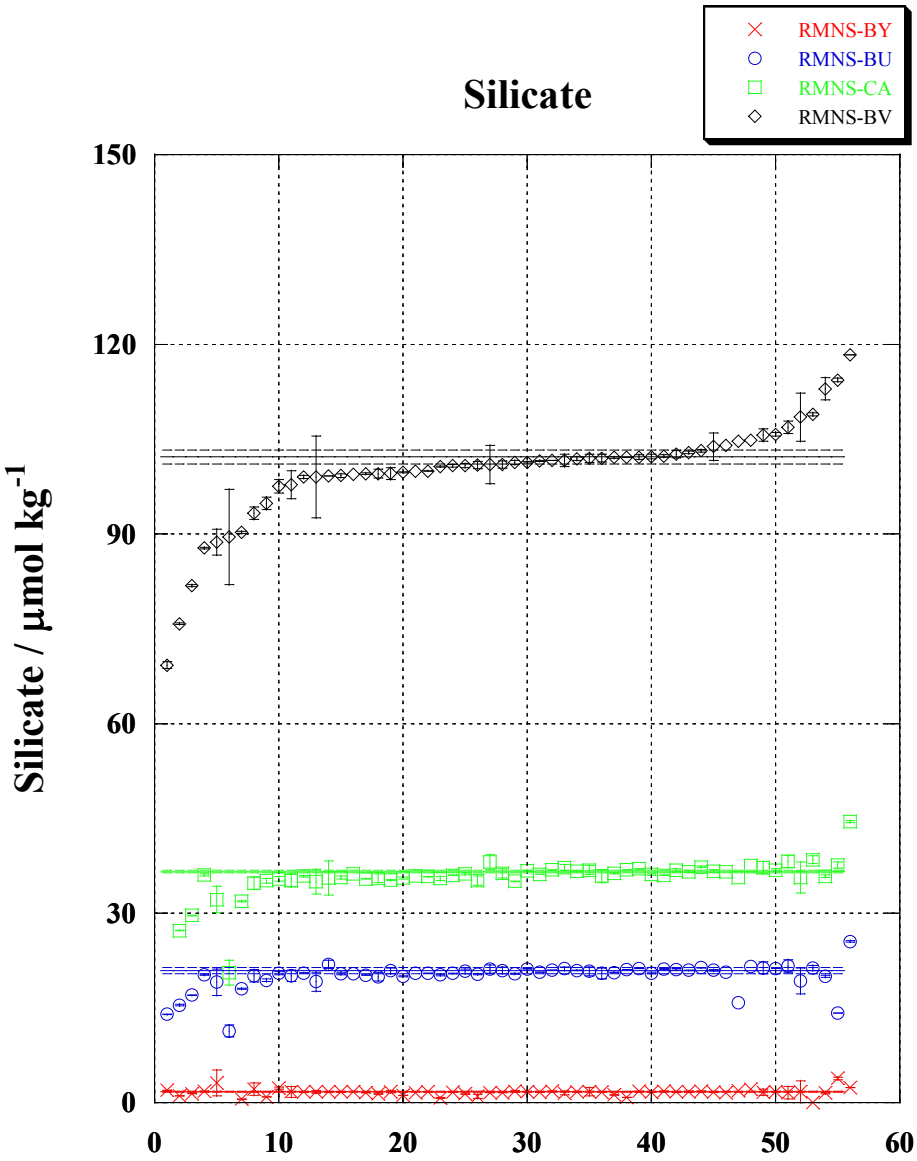

Figure 5-1. Silicate results for KANSO CRMs. Laboratories are ranked in order of concentrations reported for RM-BV.

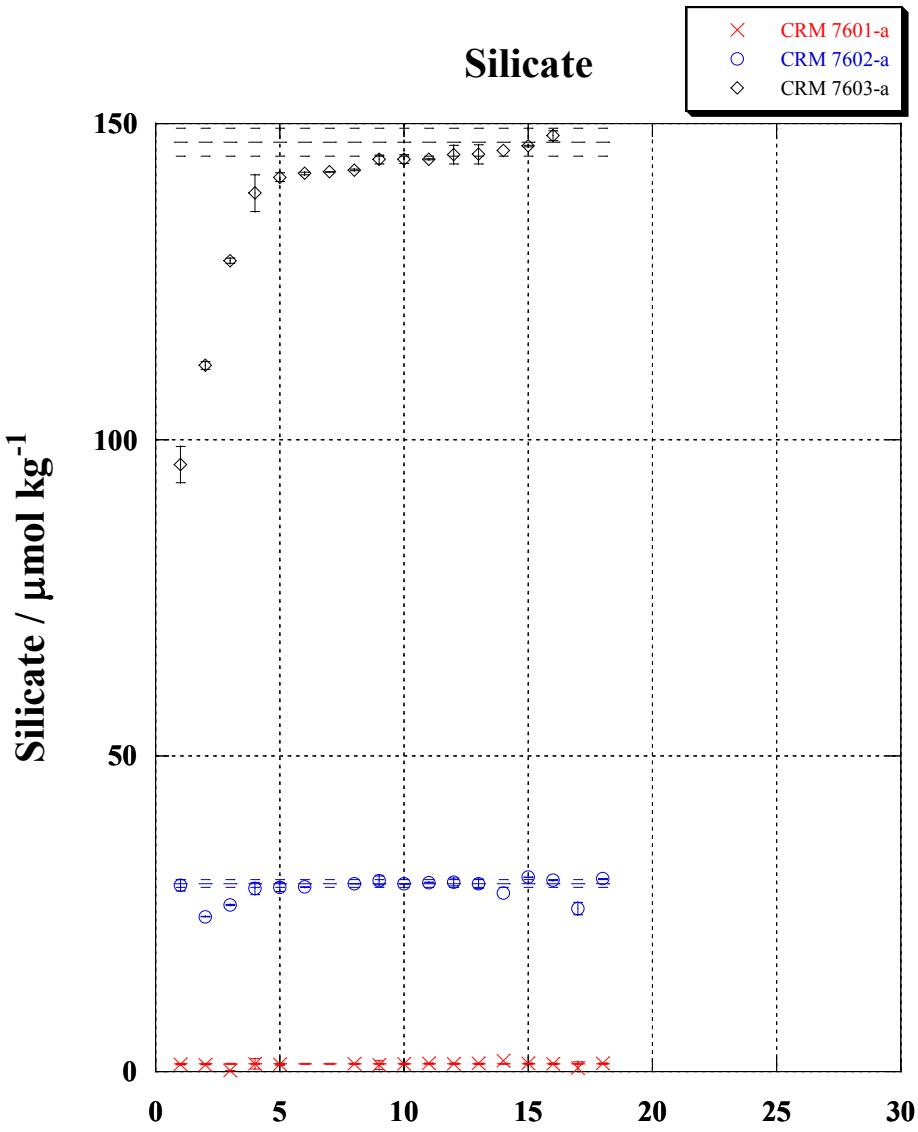

Figure 5-2. Silicate results for NMIJ CRMs. Laboratories are ranked in order of concentrations reported for CRM 7603-a.

5.2 Consensus means, medians, and standard deviations

The consensus means, medians, and standard deviations (Table 4) were calculated using the data that passed the successive *t*-test applications described in Section 4.1. The consensus means and medians are in close agreement for all parameters for all samples. The consensus means and medians for all parameters showed in good agreement with certified values by the providers of CRMs within uncertainty.

Table 4. Consensus means, medians, and standard deviations for 7 samples.

Sample #	n	Consensus Mean	Consensus Median	Consensus SD	Certified values	uncertainty (k =2)
		µmol kg-1	µmol kg-1	µmol kg-1	µmol kg-1	µmol kg-1
			Nitrate+Nitrite			
RM-BY	43 (51)	0.05	0.05	0.03	0.043	0.0275
RM-BU	32 (57)	3.98	3.98	0.05	4.009	0.0569
RM-CA	41 (58)	19.59	19.58	0.31	19.723	0.16
RM-BV	37 (57)	35.20	35.18	0.49	35.407	0.3573
CRM 7601-a	16 (18)	0.06	0.06	0.03	0.063	0.0124
CRM 7602-a	20 (21)	15.97	15.93	0.45	15.735	0.524
CRM 7603-a	18 (19)	44.47	44.46	1.10	44.526	0.5865
			Nitrate			
RM-BY	31 (37)	0.04	0.03	0.03	0.024	0.019
RM-BU	22 (43)	3.91	3.91	0.05	3.937	0.051
RM-CA	30 (43)	19.58	19.54	0.33	19.66	0.15
RM-BV	28 (43)	35.22	35.13	0.52	35.36	0.35
CRM 7601-a	11 (12)	0.03	0.04	0.02	0.015	0.0081
CRM 7602-a	14 (14)	15.60	15.62	0.44	15.3	0.48
CRM 7603-a	12 (13)	44.84	44.58	0.81	44.5	0.58
			Nitrite			
RM-BY	37 (42)	0.02	0.02	0.01	0.019	0.0085
RM-BU	36 (47)	0.07	0.07	0.01	0.072	0.0059
RM-CA	30 (46)	0.07	0.06	0.01	0.063	0.01
RM-BV	37 (45)	0.05	0.05	0.01	0.047	0.0073
CRM 7601-a	12 (13)	0.03	0.03	0.02	0.048	0.0043
CRM 7602-a	17 (18)	0.39	0.39	0.03	0.435	0.044
CRM 7603-a	12 (14)	0.03	0.03	0.01	0.026	0.0065

Table 4. Consensus means, medians, and standard deviations for 7 samples(continued).

Sample #	n	Consensus Mean	Consensus Median	Consensus SD	Certified values	uncertainty (k =2)
		µmol kg-1	µmol kg-1	µmol kg-1	µmol kg-1	µmol kg-1
			Phosphate			
RM-BY	37 (51)	0.04	0.03	0.01	0.039	0.01
RM-BU	41 (58)	0.35	0.35	0.02	0.345	0.0085
RM-CA	38 (58)	1.42	1.42	0.03	1.407	0.014
RM-BV	41 (58)	2.51	2.50	0.04	2.498	0.023
CRM 7601-a	14 (17)	0.04	0.04	0.01	0.038	0.0053
CRM 7602-a	18 (21)	1.13	1.13	0.03	1.12	0.12
CRM 7603-a	17 (19)	3.11	3.08	0.08	3.07	0.053
			Silicate			
RM-BY	25 (57)	1.75	1.75	0.04	1.763	0.063
RM-BU	44 (58)	20.75	20.75	0.45	20.92	0.49
RM-CA	45 (57)	36.06	36.02	0.66	36.58	0.22
RM-BV	34 (58)	101.00	101.14	1.22	102.2	1.1
CRM 7601-a	13 (18)	1.24	1.27	0.09	1.28	0.11
CRM 7602-a	13 (19)	29.86	29.78	0.54	29.8	0.64
CRM 7603-a	12 (18)	144.39	144.41	1.94	147.1	2.17

*Numbers in parentheses are the initial numbers of values before successive *t*-tests reduced the sample size to *n* (see text).

5.3 Summary of analytical precision of participating laboratories and consensus standard deviation

In tables 5-1 to 5-7, we compare median and range of analytical precision reported by participants (Analytical precision of participating laboratory in Tables) and the consensus standard deviation in terms of CV relative to consensus median shown in Table 4.

Table 5-1.Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in RM-BY.

Nutrient	Analytical precision of participating laboratories		Consensus coefficient of variation	
	N	Median% (range)	N	CV%
Nitrate+Nitrite	41	20 (0-900)	43	60
Phosphate	43	9.1 (0-142.9)	37	33.3
Silicate	51	2.1 (0-102.3)	25	2.3

Table 5-2.Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in RM-BU.

Nutrients	Analytical precision of participating laboratories		Consensus CV	
	n	**Median (range) %**	***n***	**CV %**
Nitrate+Nitrite	52	1.4 (0-89.3)	32	1.3
Phosphate	52	2.2 (0-92.2)	41	5.7
Silicate	53	0.6 (0-10.7)	44	2.2

Table 5-3.Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in RM-CA.

Nutrients	Analytical precision of participating laboratories		Consensus CV	
	n	Median (range) %	*n*	CV %
Nitrate+Nitrite	53	0.7 (0-18.2)	41	1.6
Phosphate	53	1.3 (0-18.9)	38	2.1
Silicate	52	0.5 (0-10.5)	45	1.8

Table 5-4.Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in RM-BV.

Nutrients	Analytical precision of participating laboratories		Consensus CV	
	n	Median (range) %	*n*	CV %
Nitrate+Nitrite	52	0.7 (0-12.7)	37	1.4
Phosphate	53	0.6 (0-19.6)	41	1.6
Silicate	53	0.3 (0-8.4)	34	1.2

Table 5-5.Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in CRM 7601-a.

Nutrients	Analytical precision of participating laboratories		Consensus CV	
	n	Median (range) %	*n*	CV %
Nitrate+Nitrite	17	20 (0-360)	16	50
Phosphate	16	7.2 (0-70.3)	14	25
Silicate	17	3.9 (0-163.3)	13	7.1

Table 5-6. Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in CRM 7602-a.

Nutrients	Analytical precision of participating laboratories		Consensus CV	
	n	Median (range) %	*n*	CV %
Nitrate+Nitrite	20	0.4 (0.1-5.9)	20	2.8
Phosphate	20	0.5 (0-11.2)	18	2.7
Silicate	18	0.2 (0-3.8)	13	1.8

Table 5-7. Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in CRM 7603-a.

Nutrients	Analytical precision of participating laboratories		Consensus CV	
	n	Median (range) %	*n*	CV %
Nitrate+Nitrite	18	0.3 (0-2.2)	18	2.5
Phosphate	18	0.3 (0.1-3.2)	17	2.6
Silicate	17	0.5 (0-3)	12	1.3

5.4 *Z*-scores

Tables 6-1 to 6-7 present *Z*-scores for participating laboratories computed as described in section 4.4. *Z*-scores indicate how the measurement of a particular determinant in a sample by an individual laboratory compares to the consensus value for that determinant in that sample as determined by all participating laboratories. *Z*-values are proportional to the consensus standard deviation, with a *Z*-value less than 1.0 indicating a measurement within ±1 SD of the consensus median value.

Table 6-1. *Z*-scores for nitrate+nitrite analyses.

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
4	3.7	2.4	0.8	0.6			
5		0.6	9.6	3.2	0.7	0.3	1.7
7	4.3	8.0	5.2	6.2			
8	3.0	0.4	3.1	2.8	2.7	1.9	1.7
10	1.7	3.6	1.5	1.6			
14		1.4	0.9	0.4		0.9	0.4
17	0.0	1.2	1.7	2.7			
19	1.0	1.4	1.4	1.7			
20	0.0	1.6	1.3	1.2			
23	0.7	0.4	0.6	0.9			
26	1.0	0.2	0.3	0.8			
27	0.0	2.6	1.1	1.0	0.3	1.1	1.8
28	2.0	0.0	1.7	0.9			
29	0.3	2.8	1.3	0.8	1.7	1.0	1.1
30	1.7	53.4	9.6	25.9			
32	7.3	14.2	3.7	6.8			
35	1.7	1.2	0.1	0.2		0.3	0.3
37							
38	0.7	0.6	1.2	1.2			
39	0.3	1.6	1.3	0.6			
40		6.4	0.1	4.1			
41	1.7	4.4	0.1	0.1			
45		23.4	0.6	1.8			
49_QuAAtro_1st	0.3	1.0	1.3	1.6	1.0	0.0	0.2
49_AA3_1st	1.7	0.2	0.7	0.8	0.3	0.1	0.1
49_QuAAtro_2nd					1.0	0.0	0.1
49_AA3_2nd					0.3	0.2	0.1
50	0.3	0.4	0.2	0.5			
51	21.0		12.2		75.7	1.5	
52	0.0	1.4	0.1	0.3			
56	1.0	6.4	0.8	0.2	0.3	1.0	0.5
57	1.7	0.2	0.0	0.2			
59	0.7	19.2	3.8	6.6			
64	0.7	0.6	0.0	0.8	0.3	0.2	0.8
65	0.7	1.8	1.8	2.4	0.7	1.2	1.6
80	79.0	41.0	5.1	6.2			
86	1.0	3.0	2.8	4.3		0.8	0.3
87	1.0	0.6	0.4	0.0			
88	43.0	11.8	0.8	1.5			
89	1.0	0.4	0.8	0.8			
90		14.0	13.0	14.3			
91	0.7	0.8	0.2	0.6			
92	0.3	0.8	0.5	0.8	0.7	0.6	
93	0.0	0.8	0.3	0.1			
95	2.0	0.6	0.7	0.0			
96	1.7	0.0	2.0	2.5	0.3	0.7	1.3
97	1.0	50.6	2.2	1.5			

Table 6-1. Z-scores for nitrate+nitrite analyses (continued).

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
98		7.2	6.7	8.8			
99		5.8	6.7	19.2			
100	1.3	0.6	1.0	6.1			
101	0.0	2.2	1.3	0.6	0.7	1.2	0.7
102	1.3	5.6	2.0	2.0	1.0	1.8	0.8
104	1.7	2.0	9.8	11.5	1.0	6.4	6.8
106	1.3	7.2	2.7	2.5			
107	1.3	0.4	0.9	0.2			
108	14.7	4.2	4.9	8.0			
109	1.0	4.6	2.3	1.6	1.3	1.0	0.2
111	1.7	4.4	0.7	1.2			
112	0.7	1.4	0.7	2.3			
113	0.7	0.6	0.1	0.2			
114	0.3	0.4	0.7	1.1			

Table 6-2. *Z*-scores for nitrate analyses.

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
4	3.7	2.4	0.5	0.6			
5		0.8	8.9	2.9	1.0	0.3	1.9
7	4.0	6.6	4.7	5.6			
8	1.7	0.0	2.7	2.4	2.5	1.8	1.9
10	1.3	3.4	1.6	1.6			
14		1.6	1.0	0.5		0.9	1.1
17	0.7	0.8	1.7	2.6			
19	1.3	1.2	1.2	1.4			
20	0.3	1.4	1.1	1.0			
23	0.7	0.2	0.7	1.0			
26	0.3	0.8	0.0	0.6			
27	0.3	2.8	1.2	1.1	0.5	1.2	2.9
28	2.0	0.2	1.4	1.0			
29							
30		54.0	9.1	24.5			
32	7.7	12.8	3.5	6.5			
35							
37							
38	1.0	0.6	0.9	1.0			
39	0.3	1.6	1.0	1.0			
40	1.0	5.8	0.2	3.6			
41	2.0	5.8	0.1	0.1			
45		24.0	0.9	1.8			
49_QuAAtro_1st	0.0	1.8	1.2	1.5	0.0	0.1	0.7
49_AA3_1st	1.7	0.6	0.6	0.7	1.0	0.1	0.4
49_QuAAtro_2nd					0.0	0.0	0.6
49_AA3_2nd					1.0	0.2	0.4
50	0.7	0.6	0.0	0.6			
51							
52							
56	1.3	6.6	0.9	0.3	1.0	1.2	1.2
57							
59	0.3	17.8	3.6	6.3			
64							
65							
80	78.7	41.2	5.4	6.0			
86	0.7	2.8	2.5	3.9		0.8	0.2
87	1.0	0.4	0.5	0.2			
88							
89							
90		13.2	12.2	13.6			
91							
92	0.3	1.2	0.6	0.9	1.0	0.6	
93	0.3	0.4	0.5	0.1			
95	1.7	1.0	0.8	0.2			
96							
97	1.3	51.2	2.3	1.3			

Table 6-2. Z-scores for nitrate analyses (continued).

Lab		RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
	98							
	99		9.6	6.9	17.9			
	100	3.0	1.2	0.6	5.4			
	101	0.3	2.2	1.4	0.4	0.5	1.3	0.4
	102	1.0	5.8	1.6	1.8	0.5	1.6	0.6
	104							
	106	1.3	7.0	2.6	2.5			
	107	1.3	0.8	0.9	0.3			
	108	12.3	12.8	5.7	8.2			
	109	0.0	4.2	2.0	1.4	0.5	1.0	0.3
	111	0.7	4.6	0.6	1.3			
	112							
	113	0.0	0.4	0.1	0.4			
	114							

Table 6-3. *Z*-scores for nitrite analyses.

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
4	1.0	1.0	4.0	1.0			
5	0.0	1.0	1.0	0.0	0.0	0.0	1.0
7	0.0	7.0	6.0	7.0			
8	3.0	2.0	1.0	1.0	1.5	0.7	0.0
10	2.0	1.0	1.0	0.0			
14		0.0	1.0	1.0		0.3	1.0
17		2.0	4.0	4.0			
19	0.0	1.0	0.0	0.0			
20	0.0	1.0	1.0	0.0			
23	1.0	0.0	2.0	1.0			
26	1.0	4.0	2.0	3.0			
27	0.0	0.0	1.0	0.0	0.0	0.3	1.0
28	1.0	1.0	2.0	2.0			
29	2.0	0.0	1.0	1.0	1.0	1.7	1.0
30	2.0	4.0	3.0	2.0			
32							
35	0.0	1.0	1.0	0.0		0.3	0.0
37							
38	0.0	1.0	0.0	0.0			
39	1.0	1.0	0.0	1.0			
40		1.0					
41	1.0	2.0	1.0	2.0			
45	2.0	3.0	6.0	2.0			
49_QuAAtro_1st		4.0	4.0	4.0		0.7	3.0
49_AA3_1st	2.0	2.0	3.0	2.0	0.5	1.3	
49_QuAAtro_2nd						1.0	2.0
49_AA3_2nd					0.5	1.0	
50	0.0	0.0	1.0	1.0			
51	2.0				4.5	0.7	
52							
56	0.0	1.0	0.0	0.0	0.5	0.7	0.0
57							
59	1.0	0.0	0.0	0.0			
64							
65							
80	0.0	1.0	14.0	2.0			
86	0.0	1.0	1.0	1.0		1.0	7.0
87	1.0	0.0	1.0	0.0			
88							
89	4.0	6.0	3.0	2.0			
90	1.0	4.0	5.0	2.0			
91							
92	1.0	1.0	0.0	0.0	0.0	0.0	
93	1.0	2.0	0.0	1.0			
95	0.0	2.0	0.0	1.0			
96							
97	6.0	3.0	2.0	0.0			

Table 6-3. Z-scores for nitrite analyses (continued).

Lab		RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
	98							
	99		6.0	4.0				
	100	12.0	10.0	8.0	9.0			
	101	1.0	0.0	1.0	1.0	0.5	1.0	1.0
	102		0.0	1.0	0.0	1.0	2.3	1.0
	104	2.0	1.0	1.0	2.0	0.0	1.0	0.0
	106	1.0	1.0	1.0	0.0			
	107	2.0	2.0	3.0	1.0			
	108	8.0	51.0	36.0	29.0			
	109	2.0	2.0	1.0	1.0	1.0	0.3	1.0
	111	1.0	1.0	2.0	0.0			
	112	1.0	0.0	1.0	1.0			
	113	1.0	1.0	1.0	1.0			
	114							

Table 6-4. *Z*-scores for phosphate analyses.

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
4	4.0	2.9	2.7	1.5			
5	0.8	0.2	2.2	1.8	0.6	0.3	1.5
7	1.2	6.1	18.2	23.2			
8	2.5	0.6	3.1	2.2	0.3	3.0	1.4
10	4.0	2.7	1.6	1.1			
14		0.3	0.8	0.2		1.1	0.4
17		0.0	4.4	2.4			
19	0.0	0.0	0.8	0.4			
20	1.0	0.2	0.2	0.0			
23	0.2	0.4	0.2	0.3			
26	2.0	1.9	1.1	0.8			
27	0.7	0.4	0.8	2.3	1.0	1.3	1.4
28	8.7	0.4	4.7	6.4			
29	2.6	0.3	1.0	1.8	0.3	0.3	0.7
30		12.3	10.4	6.1			
32	0.2	1.2	2.9	3.5			
35	0.1	0.4	0.4	0.5		0.9	0.8
37	1.1	0.1	0.2	0.1			
38	0.3	1.2	1.0	1.0			
39	0.8	0.6	0.7	0.4			
40		1.6	1.5	0.7			
41	6.7	4.0	0.5	5.2			
45							
49_QuAAtro_1st	2.0	0.1	1.2	1.6	1.1	1.9	2.9
49_AA3_1st	2.2	4.0	2.8	4.8	3.1	0.2	0.4
49_QuAAtro_2nd					1.1	1.9	3.0
49_AA3_2nd					2.8	0.0	0.4
50	0.1	1.0	0.6	0.3			
51		2.3	1.5	3.5		8.6	
52	1.4	0.8	0.2	0.4			
56	2.0	1.4	1.1	1.0	1.1	1.5	1.2
57	4.0	2.0	1.7	0.5			
59	12.1	6.7	2.4	0.0			
64	0.3	1.4	0.9	2.2	1.2	0.5	0.8
65	1.6	0.2	0.5	0.8	0.1	1.4	0.8
80	4.2	0.6	2.4	1.5			
86	2.2	1.6	0.7	1.0		1.1	1.0
87	0.9	0.1	0.2	0.5			
88	1.3	1.4	0.2	0.6			
89	1.4	20.9	21.9	44.9			
90	0.2	1.1	0.8	1.6			
91	0.7	0.7	1.1	0.7			
92	0.5	0.6	1.8	0.3	0.9	0.7	
93	1.0	0.1	0.1	0.2			
95	1.1	4.5	4.9	6.4			
96	1.4	1.0	0.6	0.5	0.7	1.1	0.4
97	6.9	0.9	2.1	1.1			

Table 6-4. Z-scores for phosphate analyses (continued).

Lab		RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
	98		0.9	13.6	2.0			
	99	8.2	4.4	5.1	5.9			
	100	18.4	4.5	1.5	1.0			
	101	0.3	1.5	0.1	0.2	0.1	0.9	0.8
	102	1.6	0.9	4.0	4.5	0.1	4.2	1.8
	104	0.9	1.0	2.6	4.9	3.8	0.9	1.3
	106	1.1	0.6	0.7	1.4			
	107	0.0	0.7	0.5	1.2			
	108		26.5	0.8	4.6			
	109	0.7	0.3	0.8	1.1	0.7	0.0	0.2
	111	0.9	0.4	0.4	0.5			
	112	0.1	0.1	0.1	0.2			
	113	0.7	0.5	0.6	0.9			
	114	14.6	7.0	2.6	1.6			

Table 6-5. *Z*-scores for silicate analyses.

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
4	0.8	3.3	0.6	6.1			
5	3.0	0.9	3.1	0.0	0.8	0.7	24.9
7	0.0	0.3	1.3	1.2			
8	7.5	8.2	9.7	15.7	1.4	9.8	16.8
10	2.3	1.4	1.8	3.8			
14	1.0	0.2	0.1	0.5	1.0	0.2	0.0
17	16.5	11.7	13.4	20.7			
19	0.3	0.5	0.8	1.6			
20	0.3	0.8	1.1	1.3			
23	14.5	0.5	1.0	2.8			
26	4.8	0.1	0.7	2.5			
27	1.0	0.5	0.9	2.3	0.2	0.8	1.9
28	5.3	1.1	1.7	0.6			
29	7.5	1.8	0.8	1.2	1.0	1.2	1.5
30	52.8	14.5	2.3	11.0			
32	0.3	1.1	1.2	3.9			
35	3.5	1.2	1.0	1.2		1.1	1.2
37							
38	0.8	0.5	0.3	1.6			
39	0.3	0.4	0.9	0.8			
40	4.8	1.6	0.3	9.8			
41	0.3	0.8	0.3	1.3			
45	16.8	10.6	12.8	14.2			
49_QuAAtro_1st	24.5	4.4	3.9	6.4	10.0	6.4	8.3
49_AA3_1st	29.3	6.0	6.3	8.8	11.6		
49_QuAAtro_2nd						6.4	8.2
49_AA3_2nd					11.9	4.8	6.4
50	2.0	1.0	0.1	1.1			
51	4.3	2.0	3.2	4.8	7.1	7.5	
52	0.3	0.5	0.1	0.2			
56	0.3	0.1	1.2	0.8	1.9	0.8	0.0
57	8.8	0.1	0.2	0.2			
59	24.3	1.1	0.9	0.3			
64	1.0	0.6	0.3	0.8	0.9	0.2	0.4
65	0.8	0.5	0.4	0.8	0.4	0.2	0.9
80	11.0	1.4	1.9	6.3			
86	22.5	0.7	1.2	0.9			1.0
87	3.5	0.6	0.3	0.9			
88	10.0	1.8	2.3	3.1			
89	13.3	1.7	0.7	1.0			
90	18.0	0.9	1.3	0.1			
91	1.0	0.5	0.1	1.0			
92	1.0	1.0	1.0	0.3	1.1	1.3	
93	0.5	0.6	0.6	1.4			
95	0.0	3.5	1.6	1.6			
96	1.0	0.6	0.1	0.2	0.1	0.2	0.0
97	43.8	1.3	3.7	6.5			

Table 6-5. Z-scores for silicate analyses (continued).

Lab		RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
	98		20.8	23.4	9.4			
	99	20.8	3.1	1.4	5.0			
	100	2.3	0.6	1.2	0.6			
	101	0.3	1.4	1.3	2.6	0.3	1.6	2.8
	102	3.3	0.4	0.4	0.0	0.6	0.3	0.4
	104	4.5	10.8	0.6	3.0	5.7	2.9	0.7
	106	3.0	1.0	0.1	10.8			
	107	1.8	0.7	1.5	0.3			
	108	34.5	3.8	21.7	10.1			
	109	1.5	1.4	1.9	1.8	1.3	1.7	1.1
	111	0.0	2.6	0.7	1.5			
	112	11.8	0.3	0.4	0.9			
	113	1.8	1.1	1.5	1.0			
	114	5.5	15.0		26.0			

Table 6-6. Combined *Z*-scores for phosphate and nitrate+nitrite analyses.

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
4	3.9	2.7	1.8	1.1			
5		0.4	5.9	2.5	0.7	0.3	1.6
7	2.8	7.1	11.7	14.7			
8	2.8	0.5	3.1	2.5	1.5	2.5	1.6
10	2.9	3.2	1.6	1.4			
14		0.9	0.9	0.3		1.0	0.4
17		0.6	3.1	2.6			
19	0.5	0.7	1.1	1.1			
20	0.5	0.9	0.8	0.6			
23	0.5	0.4	0.4	0.6			
26	1.5	1.1	0.7	0.8			
27	0.4	1.5	1.0	1.7	0.7	1.2	1.6
28	5.4	0.2	3.2	3.7			
29	1.5	1.6	1.2	1.3	1.0	0.7	0.9
30		32.9	10.0	16.0			
32	3.8	7.7	3.3	5.2			
35	0.9	0.8	0.3	0.4		0.6	0.6
37							
38	0.5	0.9	1.1	1.1			
39	0.6	1.1	1.0	0.5			
40		4.0	0.8	2.4			
41	4.2	4.2	0.3	2.7			
45							
49_QuAAtro_1st	1.2	0.6	1.3	1.6	1.1	1.0	1.6
49_AA3_1st	2.0	2.1	1.8	2.8	1.7	0.2	0.3
49_QuAAtro_2nd					1.1	1.0	1.6
49_AA3_2nd					1.6	0.1	0.3
50	0.2	0.7	0.4	0.4			
51			6.9			5.1	
52	0.7	1.1	0.2	0.4			
56	1.5	3.9	1.0	0.6	0.7	1.3	0.9
57	2.9	1.1	0.9	0.4			
59	6.4	13.0	3.1	3.3			
64	0.5	1.0	0.5	1.5	0.8	0.4	0.8
65	1.2	1.0	1.2	1.6	0.4	1.3	1.2
80	41.6	20.8	3.8	3.9			
86	1.6	2.3	1.8	2.7		1.0	0.7
87	1.0	0.4	0.3	0.3			
88	22.2	6.6	0.5	1.1			
89	1.2	10.7	11.4	22.9			
90		7.6	6.9	8.0			
91	0.7	0.8	0.7	0.7			
92	0.4	0.7	1.2	0.6	0.8	0.7	
93	0.5	0.5	0.2	0.2			
95	1.6	2.6	2.8	3.2			
96	1.6	0.5	1.3	1.5	0.5	0.9	0.9
97	4.0	25.8	2.2	1.3			

Table 6-6. Combined Z-scores for phosphate and nitrate+nitrite analyses (continued).

Lab		RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
	98		4.1	10.2	5.4			
	99		5.1	5.9	12.6			
	100	9.9	2.6	1.3	3.6			
	101	0.2	1.9	0.7	0.4	0.4	1.1	0.8
	102	1.5	3.3	3.0	3.3	0.6	3.0	1.3
	104	1.3	1.5	6.2	8.2	2.4	3.7	4.1
	106	1.2	3.9	1.7	2.0			
	107	0.7	0.6	0.7	0.7			
	108		15.4	2.9	6.3			
	109	0.9	2.5	1.6	1.4	1.0	0.5	0.2
	111	1.3	2.4	0.6	0.9			
	112	0.4	0.8	0.4	1.3			
	113	0.7	0.6	0.4	0.6			
	114	7.5	3.7	1.7	1.4			

Table 6-7. Combined *Z*-scores for phosphate, nitrate+nitrite, and silicate analyses.

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
4	2.8	2.9	1.4	2.7			
5		0.6	5.0	1.7	0.7	0.4	9.4
7	1.8	4.8	8.2	10.2			
8	4.3	3.1	5.3	6.9	1.5	4.9	6.6
10	2.7	2.6	1.6	2.2			
14		0.6	0.6	0.4		0.7	0.3
17		4.3	6.5	8.6			
19	0.4	0.6	1.0	1.2			
20	0.4	0.9	0.9	0.8			
23	5.1	0.4	0.6	1.3			
26	2.6	0.7	0.7	1.4			
27	0.6	1.2	0.9	1.9	0.5	1.1	1.7
28	5.3	0.5	2.7	2.6			
29	3.5	1.6	1.0	1.3	1.0	0.8	1.1
30		26.7	7.4	14.3			
32	2.6	5.5	2.6	4.7			
35	1.8	0.9	0.5	0.6		0.8	0.8
37							
38	0.6	0.8	0.8	1.3			
39	0.5	0.9	1.0	0.6			
40		3.2	0.6	4.9			
41	2.9	3.1	0.3	2.2			
45							
49_QuAAtro_1st	8.9	1.8	2.1	3.2	4.0	2.8	3.8
49_AA3_1st	11.1	3.4	3.3	4.8	5.0		
49_QuAAtro_2nd						2.8	3.8
49_AA3_2nd					5.0	1.7	2.3
50	0.8	0.8	0.3	0.6			
51			5.6			5.9	
52	0.6	0.9	0.1	0.3			
56	1.1	2.6	1.0	0.7	1.1	1.1	0.6
57	4.8	0.8	0.6	0.3			
59	12.4	9.0	2.4	2.3			
64	0.7	0.9	0.4	1.3	0.8	0.3	0.7
65	1.0	0.8	0.9	1.3	0.4	0.9	1.1
80	31.4	14.3	3.1	4.7			
86	8.6	1.8	1.6	2.1			0.8
87	1.8	0.4	0.3	0.5			
88	18.1	5.0	1.1	1.7			
89	5.2	7.7	7.8	15.6			
90		5.3	5.0	5.3			
91	0.8	0.7	0.5	0.8			
92	0.6	0.8	1.1	0.5	0.9	0.9	
93	0.5	0.5	0.3	0.6			
95	1.0	2.9	2.4	2.7			
96	1.4	0.5	0.9	1.1	0.4	0.7	0.6
97	17.2	17.6	2.7	3.0			

Table 6-7. Combined Z-scores for phosphate, nitrate+nitrite, and silicate analyses (continued).

Lab	RM-BY	RM-BU	RM-CA	RM-BV	CRM 7601-a	CRM 7602-a	CRM 7603-a
98		9.6	14.6	6.7			
99		4.4	4.4	10.0			
100	7.3	1.9	1.2	2.6			
101	0.2	1.7	0.9	1.1	0.4	1.2	1.4
102	2.1	2.3	2.1	2.2	0.6	2.1	1.0
104	2.4	4.6	4.3	6.5	3.5	3.4	2.9
106	1.8	2.9	1.2	4.9			
107	1.0	0.6	1.0	0.6			
108		11.5	9.1	7.6			
109	1.1	2.1	1.7	1.5	1.1	0.9	0.5
111	0.9	2.5	0.6	1.1			
112	4.2	0.6	0.4	1.1			
113	1.1	0.7	0.7	0.7			
114	6.8	7.5		9.6			

5.5 Normalized Cumulative distribution of reported nitrate, phosphate and silicate concentrations in 2008, 2012 and 2015 I/C studies

Normalized cumulative distributions of reported nitrate, phosphate and silicate concentrations in 2008, 2012 and 2015 I/C studies are shown in Figures 6 – 8.

Each reported concentration from participating laboratory was divided by the consensus median of each comparison study to compare comparability among the laboratories in each comparison study in 2008, 2012 and 2015. In general, normalized cumulative distributions for nitrate and silicate are quite similar, thus magnitude of comparability during these three I/C studies were similar while those for phosphate were going to relatively flat which may indicate that comparability of phosphate analysis becomes better.

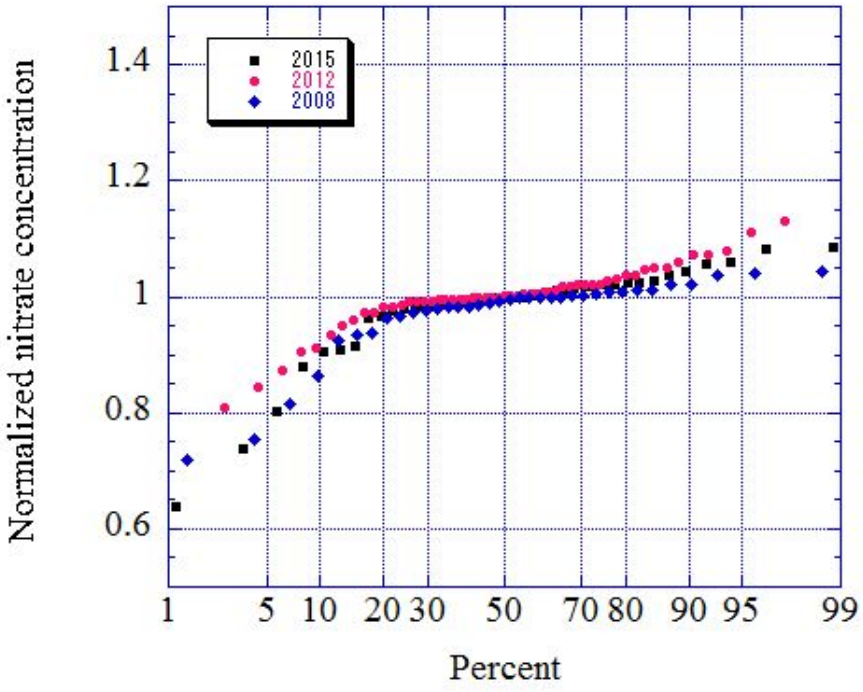

Figure 6. Cumulative distribution of reported nitrate concentrations in 2008, 2012 and 2015 I/C studies.

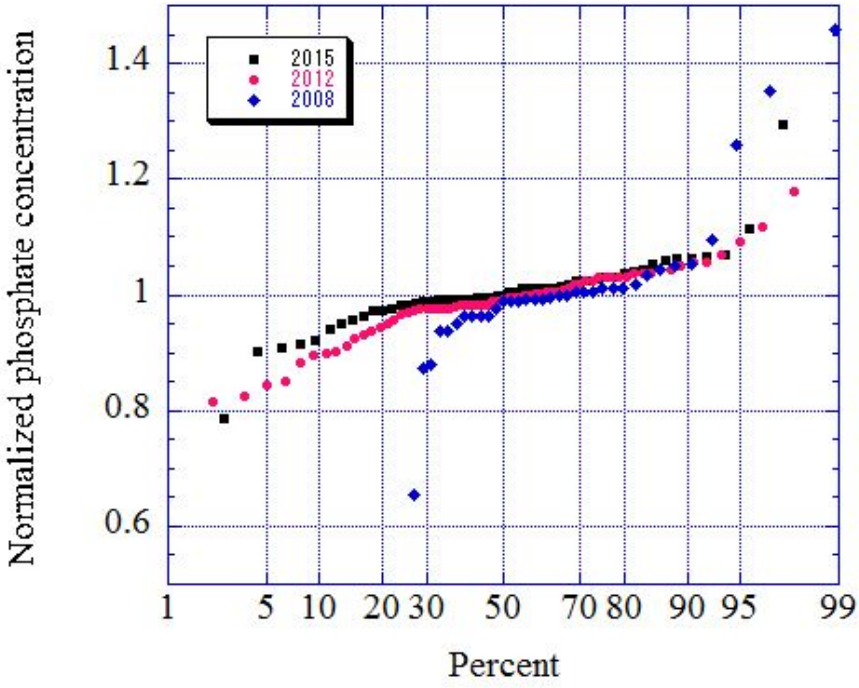

Figure 7. Cumulative distribution of reported phosphate concentrations in 2008, 2012 and 2015 I/C studies.

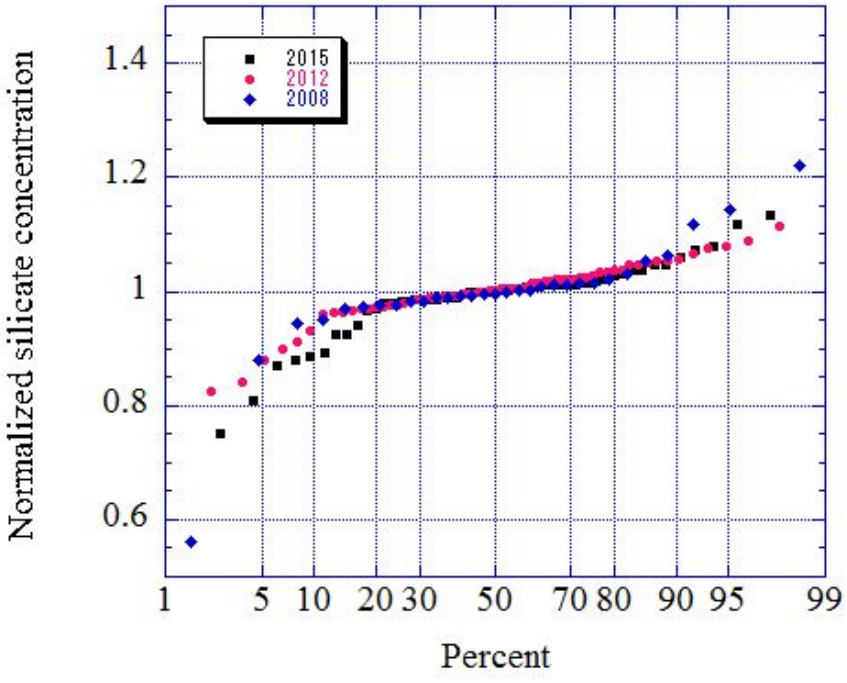

Figure 8. Cumulative distribution of reported silicate concentrations in 2008, 2012 and 2015 I/C studies.

6. Comparison with certified values

KANSO and JAMTEC jointly certified CRMs, lot. BY, BU, CA and BV, which was used in this I/C study. The new certified values were issued on 24 June 2015 and the certified values are summarized in Table 1. The detail of certification processes will be presented elsewhere later. We see excellent agreement between consensus median/mean and certified values as shown in Table 4. It is however small discrepancies between core laboratories who reported close to consensus values and certified values as shown in the Figures 1-1 to 5-2.

7. Discussion and conclusions

When we look at table 3 and 4 and Figures 1-1 to 5-2 and 7-9, it is clear that present comparability among the participants in 2015 I/C exercise is quite similar with previously obtained comparability in 2012 I/C study and previous I/C studies. Consensus standard deviations of all determinands are one order of magnitude large rather than homogeneity of the CRMs distributed and consensus standard deviations are about double of reported precision of measurements of the laboratories. Therefore these I/C results show that use of CRM will be able to greatly improve comparability of nutrient data among the laboratories in the world.

There are good signal in the results that although consensus standard deviations are relatively large, consensus median/mean of each samples showed good agreement with certified values of the samples within consensus SDs. This implies that majority of the participating laboratories have good capability to measure nutrients concentration in seawater and using CRM will increase more on the comparability and could be their results to be SI traceable quickly.

Thus, the use of a common reference material and the adoption of an internationally agreed-upon nutrient scale system and the common use of the methodology of nutrients measurements would increase comparability among laboratories worldwide, and the use of a certified reference material would establish traceability, based on the current high level of analytical performance at participating laboratories.

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Appendix I

Table A1 List of participants

Table A2 Cross reference for Lab numbers in 2015, 2012, 2008, 2006 and 2003 I/C studies

Table A1 List of participants

Lab#	Name	Affliation	Country
4	Gary Prove	Queensland Health Forensic and Scientific Services	Australia
5	Marc Knockaert	OD NATURE – ECOCHEM	Belgium
6	Steven Bell	Bermuda Institute of Ocean Sciences	Bermuda
7	Elisabete de Santis Braga	Laboratório de Nutrientes, Micronutrientes e Traços nos Oceanos (LABNUT-IOUSP), Instituto Oceanográfico da Universidade de São Paulo	Brazil
8	Rodolfo Paranhos	Institute of Biology, Rio de Janeiro Federal University	Brazil
10	Chris Payne	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences	Canada
14	Lifang Wang Tao Wang Minhan Dai	State Key laboratory of Marine Environmental Science, Xiamen University	China
17	Jun Sun	College of Marine and Environmental Sciences, Tianjin University of Science and Technology	China
19	Florian Caradec Anne Daniel	Ifremer, DYNECO/PELAGOS, Plouzané	France
20	Emilie Rabiller Olivier Pierre-Duplessix	Ifremer, LERN, Port en Bessin	France
23	Patrick Raimbault	Mediterranean Institute of Oceanology (MIO) Campus de Luminy	France
26	Günther Nausch	Leibniz-Institute for Baltic Sea Research Warnemünde (IOW)	Germany
27	Rita Kramer	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf	Germany
28	Kai-Uwe Ludwichowski	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research	Germany

Lab#	Name	Affliation	Country
29	Sólveig Rósa Ólafsdóttir	Marine Research Institute	Iceland
30	Muhamed Ashraf P	Central Institute of Fisheries Technology	India
32	Nurit Kress	Israel Oceanographic & Limnological Res, National Institute of Oceanography	Israel
35	Sukeyoshi Takatani	Japan Meteorological Agency	Japan
37	Takeshi Yoshimura	Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry	Japan
38	Taketoshi Komada	Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency	Japan
39	Jan van Ooijen	Royal NIOZ	Netherlands
40	Mike Crump	National Institute of Water and Atmospheric Research (NIWA)	New Zealand
41	Kjell Gundersen	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research	Norway
45	Howard Waldron Raymond Roman	University of Cape town, Dept of Oceanography	South Africa
49	Sinhué Torres-Valdés	National Oceanography Centre, Southampton	UK
50	E. Malcolm S. Woodward	Plymouth Marine Laboratory	UK
51	Pamela Walsham Alison Taylor	Marine Scotland - Science	UK
52	Claire Mahaffey Clare Davis	Department of Earth, Ocean and Ecological Sciences, SOES, University of Liverpool	UK
56	Susan Becker	Scripps Institution of Oceanography	USA
57	Jia-Zhong Zhang	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida	USA

Lab#	Name	Affliation	Country
59	Marguerite Blum	Monterey Bay Aquarium Research Institute	USA
64	Rebecca Briggs	University of Hawaii, SOEST Laboratory for Analytical Biogeochemistry (S-LAB)	USA
65	Susan Curless Matt Church	Hawaii Ocean Time-series	USA
80	Jesús Ledesma	Instituto del Mar del Perú	Peru
86	Martina Kralj	Istituto Nazionale di Oceanografia e Geofisica Sperimentale	Italy
87	Peter Thamer	Department of Fisheries and Oceans Canada	Canada
88	Sólvá Jacobsen	Faroe Marine Research Institute	Faroe Islands
89	Trevor McCormack	Scottish Environment Protection Agency	UK
90	Adil Bakir	School of Earth and Environmental Science,University of Portsmouth	UK
91	Linda White	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences	Canada
92	Thierry Cariou	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie	France
93	Frank Malien Martina Lohmann	GEOMAR Helmholtz Center for Ocean Research, Kiel	Germany
95	Hema Naik	National Institute of Oceanography	India
96	Tamara Fraser	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences	Canada
97	Xinxin Li	Geochemical & Environmental Research Group, Texas A&M University	USA
98	Silvie Lainela	University of Tartu, Estonian Marine Institute	Estonia
99	Iban Murillo	Centro de Investigaciones Biológicas del, Noroeste SC.	Mexico

Lab#	Name	Affliation	Country
100	Laura Reed	URI/Grad. School of Oceanography	USA
101	Jae-Hyun Lim	Marine Environment Research Division,National Institue of Fisheries Science	Republic of Korea
102	Francesca Margiotta	Stazione Zoologica Anton Dohrn	Italy
104	Christian Lønborg	Australian Institute of Marine Science	Australia
106	Mara Abad Elisa Berdalet	Institut de Ciències del Mar (ICM-CSIC), Barcelona	Spain
107	Laurent Coppola	Observatoire oceanologique de Villefranche-sur-Mer (CNRS-UPMC)	France
108	Katherine Trahanovsky	School of Fisheries and Ocean Sciences (SFOS) University of Alaska Fairbanks (UAF)	USA
109	TaeKeun Rho	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology	Republic of Korea
111	Beata Szymczycha	Institute of Oceanology Polish Academy of Sciences, Marine Chemistry and Biochemistry Department	Poland
112	Carol Anstey Christine Rees	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research	Australia
113	David Faber Lindsey Ekern	Scripps Institution of Oceanography, CalCOFI Group, UC San Diego	USA
114	Miriam E. Solis	LOQyCA - Centro Nacional Patagonico (CONICET)	Argentina

Table A2 Cross reference for Lab numbers in 2015, 2012, 2008, 2006 and 2003 I/C studies

2015 I/C	2012 I/C	2008 I/C	2006 I/C	2003 I/C
	1			
	2			
	3			
4	4	72		
5	5	45	45	
6	6			
7	7			
8	8			
9	9	33	33	
10	10	43	43	
11	11	48	48	
12	12			
	13			
14	14	5	5	1
	15	50	50	
	16			
17	17			
	18	42	42	
19	19	7	7	6
20	20	19	19	
	21	23	23	
	22	73		
23	23	71		
	24	17	17	
	25	37	37	
26	26	53	53	
27	27	66		
28	28			
29	29	61		
30	30			
	31			
32	32	1	1	2
	33			
	34	10	10	17
35	35	29	29	9
				7

2015 I/C	2012 I/C	2008 I/C	2006 I/C	2003 I/C
	36	38	38	13
37	37	40	40	
38	38	65		8
39	39	25	25	
40	40			
41	41			
	42			
	43			
	44			
45	45			
	46			
	47			
48	48			
49	49	6	6	
50	50	14	14	
51	51	62		
52	52	75		
	53	28-1	28	
	54			
	55			
56	56	3	3	3
57	57	4	4	
58	58	9	9	
59	59	34	34	
60	60	36	36	
61	61			
	62			
63	63			
64	64			
65	65			
	66			
	67			
	68	63		
69	69			
72				
80				
84				
86				
87				
88				

2015 I/C	2012 I/C	2008 I/C	2006 I/C	2003 I/C
89				
90				
91				
92				
93				
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96				
97				
98				
99				
100				
101				
102				
103				
104				
106				
107				
108				
109				
110				
111				
112				
113				
114				
		2	2	10
		11	11	15
		13	13	5
		18	18	11
		20	20	
		24	24	
		26	26	16
		27	27	
		28-2		
		46	46	
		51	51	
		52	52	7
		55	55	14
		56	56	
		57		
		58		

2015 I/C	2012 I/C	2008 I/C	2006 I/C	2003 I/C
		59		
		60		
		64		
		68		
		69		
		70		
		71-2		
		74		
			12	
			15	18
			16	
			30	
			31	
			32	
			35	
			39	
			44	
			47	
			49	
			54	

Appendix II

Results reported by participants

Table A3 Nutirient results reported by the participants

Table A4 Ammonia results reported by the participants

Table A5 DOP results reported by the participants

Table A6 DON results reported by the participants

Table A7 DOC results reported by the participants

(Concentrations in Talbes A3-A7 are in units of μmol kg^{-1})

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
4																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	19	24	4.1	0.28	2	4.03	0.28	2	0.08	0.14	2	0.293	0.059	2	19.25	2.05	2	
	RM-BV	2015	01	19	24	34.89	1.56	2	34.89	1.56	2	0.04	0.14	2	2.57	0.156	2	108.49	3.81	2	
	RM-BY	2015	01	19	24	0.16	0.14	2	0.15	0.14	2	0.01	0.14	2	0	0.059	2	1.72	1.76	2	
	RM-CA	2015	01	19	24	19.84	0.91	2	19.74	0.91	2	0.03	0.14	2	1.339	0.127	2	35.67	2.44	2	
5																					
	CRM 7601-a	2015	02	15	22	0.04	0	2	0.01	0	2	0.03	0.1	2	0.046	0	2	1.17	0.04	2	
	CRM 7602-a	2015	02	15	22	15.85	0.16	2	15.46	0.16	2	0.39	0.1	2	1.14	0.02	2	29.49	0.89	2	
	CRM 7603-a	2015	02	15	22	46.36	0.46	2	46.34	0.46	2	0.02	0.1	2	3.229	0.068	2	96.08	2.88	2	
	RM-BU	2015	02	15	22	3.95	0.04	2	3.87	0.04	2	0.08	0.1	2	0.354	0.007	2	21.16	0.63	2	
	RM-BV	2015	02	15	22	36.76	0.36	2	36.72	0.36	2	0.05	0.1	2	2.58	0.049	2	101	3.03	2	
	RM-BY	2015	02	15	22	<0.24		5	<0.24		5	0.02	0.1	2	0.032	0	2	1.63	0.05	2	
	RM-CA	2015	02	15	22	22.56	0.22	2	22.5	0.22	2	0.06	0.1	2	1.486	0.029	2	38.13	1.14	2	
7																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	03	31	22	4.38	0.02	2	4.24	0.02	2	0.14	0	2	0.228	0.005	2	20.89	0.47	2	
	RM-BV	2015	03	31	22	38.23	0.36	2	38.11	0.36	2	0.12	0	2	1.584	0.01	2	99.57	0.97	2	
	RM-BY	2015	03	31	22	0.18	0.06	2	0.16	0.06	2	0.02	0	2	0.028	0.013	2	1.75	0.17	2	
	RM-CA	2015	03	31	22	21.21	0.17	2	21.12	0.22	2	0.13	0	2	0.873	0.01	2	35.22	0.08	2	
8																					
	CRM 7601-a	2015	02	24	23	0.14	0	2	0.08	0.01	2	0.06	0	2	0.037	0.026	2	1.11	0.04	2	
	CRM 7602-a	2015	02	26	23	16.81	0.18	2	16.4	0.17	2	0.41	0	2	1.04	0.004	2	24.56	0.06	2	
	CRM 7603-a	2015	02	26	23	46.37	0.14	2	46.34	0.14	2	0.03	0	2	2.995	0.005	2	111.77	0.63	2	
	RM-BU	2015	02	26	23	4	0.08	2	3.91	0.08	2	0.09	0	2	0.339	0.006	2	17.06	0.04	2	
	RM-BV	2015	02	26	23	36.55	0.2	2	36.48	0.17	2	0.06	0	2	2.421	0.006	2	81.85	0.16	2	
	RM-BY	2015	02	24	23	0.14	0	2	0.09	0.02	2	0.05	0	2	0.065	0.003	2	1.45	0.03	2	
	RM-CA	2015	02	26	23	20.55	0.04	2	20.47	0.05	2	0.06	0	2	1.326	0.006	2	29.64	0.05	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
10																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	03	26	21	3.8	0.29	2	3.74	0.29	2	0.06	0.02	2	0.297	0.049	2	21.37	0.98	2	
	RM-BV	2015	03	26	21	34.42	0.29	2	34.37	0.29	2	0.05	0.02	2	2.467	0.049	2	105.69	0.98	2	
	RM-BY	2015	03	26	21	0	0.29	2	0	0.29	2	0	0.02	2	0	0.049	2	1.66	0.49	2	
	RM-CA	2015	03	26	21	19.13	0.29	2	19.07	0.29	2	0.06	0.02	2	1.371	0.049	2	37.24	0.98	2	
14																					
	CRM 7601-a	2015	01	28	18.3	<0.1		5	<0.1		5	<0.04		5				1.33	0	2	
	CRM 7602-a	2015	01	28	18.3	15.58	0.02	2	15.19	0.02	2	0.4	0	2	1.096	0.003	2	29.94	0.04	2	
	CRM 7603-a	2015	01	28	18.3	44.01	0.06	2	43.99	0.06	2	0.02	0	2	3.081	0.003	2	144.42	0.07	2	
	RM-BU	2015	01	28	18.3	3.91	0.01	2	3.83	0.01	2	0.07	0	2	0.355	0.001	2	20.65	0	2	
	RM-BV	2015	01	28	18.3	34.99	0.15	2	34.95	0.14	2	0.04	0	2	2.517	0.008	2	101.55	0.09	2	
	RM-BY	2015	01	28	18.3	<0.1		5	<0.1		5	<0.04		5	<0.08		5	1.71	0.01	2	
	RM-CA	2015	01	28	18.3	19.31	0.05	2	19.25	0.05	2	0.06	0	2	1.396	0.003	2	36.15	0.03	2	
17																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	03	24.5	3.92	0.15	2	3.87	0.15	2	0.05	0	2	0.35	0.029	2	15.47	0.11	2	
	RM-BV	2015	02	03	24.5	33.9	0.79	2	33.89	0.79	2	0.01	0	2	2.413	0.018	2	75.8	0.13	2	
	RM-BY	2015	02	03	24.5	0.05	0.01	2	0.06	0.01	2	NA	NA	5	NA	NA	5	1.09	0.02	2	
	RM-CA	2015	02	03	24.5	19.06	0.57	2	19.03	0.57	2	0.03	0	2	1.289	0.06	2	27.25	0.06	2	
19																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	15	19	4.05	0.1	2	3.97	0.1	2	0.08	0	2	0.35	0.01	2	20.98	0.05	2	
	RM-BV	2015	02	15	19	36.01	0.1	2	35.96	0.1	2	0.05	0	2	2.494	0.005	2	102.89	0.2	2	
	RM-BY	2015	02	15	19	0.02	0.03	2	0	0.03	2	0.02	0	2	0.04	0.005	2	1.76	0.05	2	
	RM-CA	2015	02	15	19	20.03	0.03	2	19.97	0.03	2	0.07	0	2	1.397	0.005	2	36.59	0.1	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
20																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	06	21	4.06	0.08	2	3.98	0.08	2	0.08	0	2	0.346	0.021	2	21.12	0.15	2	
	RM-BV	2015	02	06	21	35.79	0.82	2	35.74	0.82	2	0.05	0	2	2.51	0.02	2	102.64	0.59	2	
	RM-BY	2015	02	06	21	0.05	0	2	0.03	0	2	0.02	0	2	0.03	0.002	2	1.74	0.03	2	
	RM-CA	2015	02	06	21	19.99	0.6	2	19.93	0.6	2	0.06	0	2	1.426	0.029	2	36.8	0.22	2	
23																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	03	26	19	3.96	0.01	2	3.9	0.01	2	0.07	0	2	0.357	0.012	2	20.51	0.27	2	
	RM-BV	2015	03	26	19	34.74	0.12	2	34.7	0.12	2	0.04	0.01	2	2.499	0.018	2	97.57	1.05	2	
	RM-BY	2015	03	26	19	0.03	0.02	2	0.02	0.02	2	0.01	0	2	0.038	0.004	2	2.33	0.19	2	
	RM-CA	2015	03	26	19	19.4	0.05	2	19.35	0.05	2	0.05	0.01	2	1.426	0.012	2	35.42	0.37	2	
26																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	25	21	3.97		2	3.87		2	0.11		2	0.312		2	20.7		2	
	RM-BV	2015	02	25	21	35.6		2	35.52		2	0.08		2	2.48		2	104		2	
	RM-BY	2015	02	25	21	0.08		2	0.05		2	0.03		2	0.02		2	1.56		2	
	RM-CA	2015	02	25	21	19.68		2	19.59		2	0.09		2	1.387		2	36.52		2	
27																					
	CRM 7601-a	2015	02	16	21.5	0.07	0.02	2	0.04	0.02	2	0.03	0.01	2	0.05	0.004	2	1.26	0.08	2	
	CRM 7602-a	2015	02	16	21.5	15.47	0.15	2	15.09	0.15	2	0.38	0.01	2	1.092	0.018	2	30.3	0.01	2	
	CRM 7603-a	2015	02	16	21.5	42.55	0.52	2	42.53	0.52	2	0.02	0	2	2.995	0.08	2	148.12	0.78	2	
	RM-BU	2015	02	16	21.5	3.85	0.07	2	3.77	0.07	2	0.07	0.01	2	0.343	0.004	2	20.97	0.12	2	
	RM-BV	2015	02	16	21.5	34.72	0.36	2	34.67	0.36	2	0.05	0.01	2	2.419	0.053	2	103.84	2.15	2	
	RM-BY	2015	02	16	21.5	0.05	0.02	2	0.03	0.02	2	0.02	0.01	2	0.033	0.003	2	1.71	0.05	2	
	RM-CA	2015	02	16	21.5	19.24	0.21	2	19.18	0.21	2	0.06	0.01	2	1.397	0.022	2	36.67	0.21	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
28																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	15	22	3.98	0.2	2	3.92	0.2	2	0.06	0	2	0.342	0.049	2	21.23	0.29	2	
	RM-BV	2015	02	15	22	34.74	0.29	2	34.71	0.29	2	0.03	0	2	2.256	0.049	2	101.68	0.98	2	
	RM-BY	2015	02	15	22	0.11	0.05	2	0.1	0.02	2	0.01	0	2	0.127	0.049	2	1.54	0.29	2	
	RM-CA	2015	02	15	22	20.1	0.24	2	20.05	0.24	2	0.05	0	2	1.28	0.049	2	37.18	0.49	2	
29																					
	CRM 7601-a	2015	01	19	20	0.11	0.1	2				0.01	0.01	2	0.037	0.02	2	1.15	0.1	2	
	CRM 7602-a	2015	01	19	20	15.52	0.1	2				0.44	0.01	2	1.139	0.059	2	29.21	0.68	2	
	CRM 7603-a	2015	01	19	20	43.22	0.29	2				0.02	0.01	2	3.167	0.059	2	141.56	0.68	2	
	RM-BU	2015	01	19	20	3.84	0.1	2				0.07	0.01	2	0.355	0.02	2	19.95	0.68	2	
	RM-BV	2015	01	19	20	34.83	0.29	2				0.04	0.01	2	2.583	0.059	2	99.56	0.68	2	
	RM-BY	2015	01	19	20	0.06	0.1	2				0	0.01	2	0.014	0.02	2	1.45	0.1	2	
	RM-CA	2015	01	19	20	19.2	0.1	2				0.06	0.01	2	1.449	0.059	2	35.53	0.68	2	
30																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	25	25	1.31	1.17	2	1.21	0.27	2	0.11	0	2	0.595	0.031	2	14.21	0.02	2	
	RM-BV	2015	02	25	25	22.51	2.85	2	22.47	2.85	2	0.03	0	2	2.265	0.061	2	114.37	0.29	2	
	RM-BY	2015	02	25	25	0	0	2	ND	ND	5	0	0	2	ND	ND	5	3.86	0.2	2	
	RM-CA	2015	02	25	25	16.61	3.03	2	16.57	0.29	2	0.04	0	2	1.109	0.047	2	37.6	0.49	2	
32																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	02	25	3.27	0.69	2	3.27		2	<0.06		5	0.374	0.032	2	21.26	0.03	2	
	RM-BV	2015	02	02	25	31.85	1.84	2	31.85		2	<0.06		5	2.649	0.078	2	105.78	0.29	2	
	RM-BY	2015	02	02	25	0.27	0.02	2	0.27		2	<0.06		5	0.042	0.014	2	1.74	0.01	2	
	RM-CA	2015	02	02	25	18.43	1.33	2	18.43		2	<0.06		5	1.506	0.049	2	36.83	0.21	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
35																					
	CRM 7601-a																				
	CRM 7602-a	2015	02	17	24.1	15.82	0.01	2				0.4	0	2	1.104	0	2	29.26	0.04	2	
	CRM 7603-a	2015	02	17	24.1	44.19	0.04	2				0.03	0	2	3.049	0.01	2	142.16	0.21	2	
	RM-BU	2015	02	17	24.1	3.92	0	2				0.08	0	2	0.342	0	2	20.2	0.03	2	
	RM-BV	2015	02	17	24.1	35.3	0.03	2				0.05	0	2	2.492	0	2	99.54	0.14	2	
	RM-BY	2015	02	17	24.1	0	0	2				0.02	0	2	0.039	0	2	1.61	0	2	
	RM-CA	2015	02	17	24.1	19.56	0.02	2				0.06	0	2	1.407	0	2	35.43	0.05	2	
37																					
	CRM 7601-a	None		ne																	
	CRM 7602-a	None		ne																	
	CRM 7603-a	None		ne																	
	RM-BU	2015	02	05	25										0.352	0.01	2				
	RM-BV	2015	02	05	25										2.513	0.01	2				
	RM-BY	2015	02	05	25										0.029	0	2				
	RM-CA	2015	02	05	25										1.427	0.01	2				
38																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	22	20	3.95	0.06	2	3.88	0.06	2	0.08	0.03	2	0.327	0.002	2	20.53	0.04	2	
	RM-BV	2015	01	22	20	35.81	0.48	2	35.76	0.48	2	0.05	0.02	2	2.471	0.004	2	99.03	0.21	2	
	RM-BY	2015	01	22	20	0.03	0.03	2	0.01	0.03	2	0.02	0.01	2	0.043	0.002	2	1.72	0.01	2	
	RM-CA	2015	01	22	20	19.95	0.3	2	19.89	0.3	2	0.07	0.03	2	1.39	0.003	2	35.89	0.13	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
39																					
	CRM 7601-a	2015	01	15																	
	CRM 7602-a	2015	01	15																	
	CRM 7603-a	2015	01	15																	
	RM-AX	2015	01	15	22.5	22.03	0.2	2	21.65	0.2	2	0.38	0.01	2	1.599	0.02	2	59.37	0.2	2	
	RM-AZ	2015	01	15	22.5	42.8	0.39	2	42.75	0.39	2	0.05	0.01	2	3.036	0.039	2	136.08	0.39	2	
	RM-BD	2015	01	15	22.5	29.97	0.29	2	29.93	0.29	2	0.04	0.01	2	2.173	0.039	2	66.06	0.2	2	
	RM-BP	2015	01	15	22.5	0.09	0.02	2	0.04	0.02	2	0.05	0.01	2	0.044	0.005	2	1.31	0.04	2	
	RM-BQ	2015	01	15	22.5	44.46	0.39	2	44.42	0.39	2	0.04	0.01	2	3.077	0.039	2	144.68	0.49	2	
	RM-BU	2015	01	15	22.5	4.06	0.04	2	3.99	0.04	2	0.08	0.01	2	0.338	0.01	2	20.93	0.05	2	
	RM-BV	2015	01	15	22.5	35.48	0.39	2	35.72	0.39	2	0.06	0.01	2	2.526	0.039	2	101.93	0.29	2	
	RM-BY	2015	01	15	22.5	0.06	0.02	2	0.03	0.02	2	0.03	0.01	2	0.032	0.005	2	1.76	0.04	2	
	RM-CA	2015	01	15	22.5	20	0.2	2	19.92	0.2	2	0.07	0.01	2	1.398	0.02	2	36.65	0.1	2	
40																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	09	21	4.3	0.1	2	4.2	0.1	2	0.08	0.1	2	0.381	0.029	2	20.02	0.2	2	
	RM-BV	2015	02	09	21	37.21	0.29	2	37.11	0.29	2	<0.08	0.29	5	2.539	0.059	2	112.99	1.76	2	
	RM-BY	2015	02	09	21	<0.07	0.07	5	0.07	0.07	2	<0.08	0.07	5	<0.03	0.029	5	1.56	0.1	2	
	RM-CA	2015	02	09	21	19.63	0.29	2	19.53	0.29	2	<0.08	0.29	5	1.465	0.059	2	35.84	0.2	2	
41																					
	CRM 7601-a	2015	02	02	22																
	CRM 7602-a	2015	02	02	22																
	CRM 7603-a	2015	02	02	22																
	RM-BU	2015	02	02	22	4.2		2	4.2		2	0.09		2	0.43		2	20.41		2	
	RM-BV	2015	02	02	22	35.26		2	35.26		2	0.07		2	2.716		2	99.44		2	
	RM-BY	2015	02	02	22	0.1		2	0.1		2	0.03		2	0.107		2	1.76		2	
	RM-CA	2015	02	02	22	19.63		2	19.54		2	0.08		2	1.436		2	36.24		2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
45																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	05	01	27	2.81	0.05	2	2.71	0.06	2	0.1	0.12	2				25.53	0.1	2	
	RM-BV	2015	05	01	27	34.3	0.43	2	34.27	0.43	2	0.03	0.01	2				118.37	0	2	
	RM-BY	2015	05	01	27	NAN		5	NAN		5	0.04	0.01	2				2.42	0.03	2	
	RM-CA	2015	05	01	27	19.4	0.09	2	19.27	0.09	2	0.13	0.02	2				44.48	0.16	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
49																					
	CRM 7601-a	2015	01	27	21	0.03	0	2	0.03	0	2	LD		5	0.029	0	2	0.34	0.02	2	
	CRM 7601-a	2015	01	27	21	0.07	0.01	2	0.05	0.01	2	0.02	0	2	0.068	0	2	0.17	0.01	2	
	CRM 7601-a	2015	01	27	21	0.03	0	2	0.03	0.01	2	LD		5	0.029	0	2				
	CRM 7601-a	2015	01	27	21	0.07	0.03	2	0.05	0.03	2	0.02	0	2	0.071	0.006	2	0.2	0.01	2	
	CRM 7602-a	2015	01	27	21	15.98	0.06	2	15.62	0.06	2	0.37	0	2	1.188	0.006	2	26.42	0.1	2	
	CRM 7602-a	2015	01	27	21	15.97	0.05	2	15.61	0.05	2	0.36	0	2	1.188	0.006	2	26.39	0.05	2	
	CRM 7602-a	2015	01	27	21	16	0.03	2	15.65	0.03	2	0.35	0.01	2	1.123	0	2				
	CRM 7602-a	2015	01	27	21	16.05	0.06	2	15.69	0.06	2	0.36	0	2	1.13	0.006	2	27.25	0.03	2	
	CRM 7603-a	2015	01	27	21	44.53	0.13	2	44.53	0.13	2	LD		5	3.141	0.006	2				
	CRM 7603-a	2015	01	27	21	44.3	0.07	2	44.3	0.07	2	0	0	2	3.343	0.098	2	128.36	0.43	2	
	CRM 7603-a	2015	01	27	21	44.38	0.11	2	44.37	0.11	2	0.01	0	2	3.349	0.01	2	128.58	0.49	2	
	CRM 7603-a	2015	01	27	21	44.55	0.15	2	44.55	0.14	2	LD		5	3.141	0.006	2	132.07	0.49	2	
	RM-BU																				
	RM-BU	2015	01	27	21	4.03	0.01	2	4	0.01	2	0.03	0.01	2	0.352	0	2	18.76	0.04	2	
	RM-BU	2015	01	27	21	3.99	0.01	2	3.94	0.01	2	0.05	0	2	0.43	0	2	18.03	0.09	2	
	RM-BU																				
	RM-BV	2015	01	27	21	35.99	0.06	2	35.98	0.06	2	0.01	0	2	2.575	0.006	2	93.25	0.19	2	
	RM-BV	2015	01	27	21	35.6	0.1	2	35.57	0.1	2	0.03	0	2	2.702	0.006	2	90.27	0.15	2	
	RM-BV																				
	RM-BV																				
	RM-BY																				
	RM-BY	2015	01	27	21	0.1	0.03	2	0.09	0.03	2	0	0	2	0.062	0.006	2	0.58	0.02	2	
	RM-BY																				
	RM-BY	2015	01	27	21	0.04	0.01	2	0.04	0.01	2	LD		5	0.02	0	2	0.77	0.02	2	
	RM-CA																				
	RM-CA	2015	01	27	21	19.79	0.03	2	19.76	0.03	2	0.04	0	2	1.504	0	2	31.89	0.11	2	
	RM-CA	2015	01	27	21	20	0.06	2	19.97	0.06	2	0.03	0	2	1.455	0	2	33.5	0.04	2	
	RM-CA																				

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
50																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	29	23.6	4	0.02	2	3.94	0.02	2	0.07	0	2	0.37	0.002	2	21.18	0.08	2	
	RM-BV	2015	01	29	23.7	34.96	0.23	2	34.9	0.24	2	0.06	0	2	2.499	0.002	2	102.33	0.22	2	
	RM-BY	2015	01	29	23.6	0.04	0.01	2	0.02	0	2	0.02	0	2	0.039	0.002	2	1.83	0.01	2	
	RM-CA	2015	01	29	23.6	19.65	0.03	2	19.57	0.03	2	0.08	0	2	1.402	0.029	2	36.02	0.06	2	
51																					
	CRM 7601-a	2015	02	09	21	2.33	0.98	2				0.12	0.1	2	LOD	0.098	5	0.6	0.98	2	
	CRM 7602-a	2015	02	09	21	16.64	0.98	2				0.41	0.1	2	0.872	0.098	2	25.81	0.98	2	
	CRM 7603-a	2015	02	09																	
	RM-BU	2015	02	09	21										0.305	0.098	2	21.64	0.98	2	
	RM-BV	2015	02	09	21										2.37	0.098	2	106.91	0.98	2	
	RM-BY	2015	02	09	21	0.68	0.98	2				0.04	0.1	2	LOD	0.098	5	1.58	0.98	2	
	RM-CA	2015	02	09	21	23.37	0.98	2							1.375	0.098	2	38.2	0.98	2	
52																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	03	11	14	3.91	0.02	2	na	na	9	na	na	9	0.366	0.006	2	20.99	0.07	2	
	RM-BV	2015	03	11	14	35.35	0.04	2	na	na	9	na	na	9	2.496	0.029	2	101.26	0.12	2	
	RM-BY	2015	03	11	14	0.05	0	2	na	na	9	na	na	9	0.026	0.003	2	1.76	0.02	2	
	RM-CA	2015	03	11	14	19.55	0.09	2	na	na	9	na	na	9	1.414	0.012	2	36.1	0.09	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
56																					
	CRM 7601-a	2015	02	24	22	0.05	0.18	2	0.01	0.18	2	0.04	0.01	2	0.029	0.01	2	1.07	0.68	2	
	CRM 7602-a	2015	02	24	22	15.5	0.18	2	15.09	0.18	2	0.41	0.01	2	1.084	0.01	2	30.28	0.68	2	
	CRM 7603-a	2015	02	24	22	43.91	0.18	2	43.89	0.18	2	0.03	0.01	2	3.018	0.01	2	144.36	0.68	2	
	RM-AX	2015	02	24	22	21.55	0.18	2	21.16	0.18	2	0.39	0.01	2	1.57	0.01	2	59.87	0.68	2	
	RM-AZ	2015	02	24	22	42.13	0.18	2	42.09	0.18	2	0.04	0.01	2	2.97	0.01	2	136.26	0.68	2	
	RM-BD	2015	02	24	22	29.5	0.18	2	29.45	0.18	2	0.05	0.01	2	2.15	0.01	2	66.23	0.68	2	
	RM-BP	2015	02	24	22	0.04	0.18	2	0	0.18	2	0.04	0.01	2	0.03	0.01	2	1.17	0.68	2	
	RM-BQ	2015	02	24	22	43.92	0.18	2	43.9	0.18	2	0.03	0.01	2	3.03	0.01	2	144.95	0.68	2	
	RM-BU	2015	02	24	22	3.66	0.18	2	3.58	0.18	2	0.08	0.01	2	0.322	0.01	2	20.8	0.68	2	
	RM-BV	2015	02	24	22	35.12	0.18	2	35.07	0.18	2	0.05	0.01	2	2.471	0.01	2	101.98	0.68	2	
	RM-BY	2015	02	24	22	0.02	0.18	2	0	0.18	2	0.02	0.01	2	0.02	0.01	2	1.76	0.68	2	
	RM-CA	2015	02	24	22	19.34	0.18	2	19.27	0.18	2	0.07	0.01	2	1.387	0.01	2	36.83	0.68	2	
57																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	25		3.99	0	2							0.31	0	2	20.8	0.35	2	
	RM-BV	2015	02	25		35.29	0.22	2							2.49	0.01	2	100.8	0.32	2	
	RM-BY	2015	02	25		0	0	2							0	0.01	2	1.4	0.02	2	
	RM-CA	2015	02	25		19.58	0.13	2							1.37	0.01	2	36.2	0.16	2	
59																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	26	22	3.02	0.11	2	3.02	0.11	2	0.07	0	2	0.216	0.001	2	20.24	0.14	2	
	RM-BV	2015	01	26	22	31.95	0.5	2	31.94	0.5	2	0.05	0	2	2.511	0.107	2	100.69	0.08	2	
	RM-BY	2015	01	26	22	0.03	0	2	0.03	0	2	0.03	0	2	0.161	0.005	2	0.78	0.05	2	
	RM-CA	2015	01	26	22	18.41	0.9	2	18.41	0.9	2	0.07	0.01	2	1.347	0.034	2	35.48	0.35	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
64																					
	CRM 7601-a	2015	01	29	22.8	0.05	0.01	2							0.052	0.008	2	1.32	0.03	2	
	CRM 7602-a	2015	01	29	22.8	15.88	0.19	2							1.146	0.01	2	29.78	0.76	2	
	CRM 7603-a	2015	01	29	22.8	43.55	0.47	2							3.177	0.028	2	145.17	1.53	2	
	RM-BU	2015	01	29	22.8	4.01	0.08	2							0.378	0.01	2	20.47	0.83	2	
	RM-BV	2015	01	29	22.8	34.81	0.35	2							2.596	0.005	2	102.01	0.61	2	
	RM-BY	2015	01	29	22.8	0.07	0.01	2							0.043	0.01	2	1.71	0.03	2	
	RM-CA	2015	01	29	22.8	19.59	0.17	2							1.446	0.004	2	35.87	1.02	2	
65																					
	CRM 7601-a	2015	03	10	20.03	0.08	0	2							0.039	0.002	2	1.28	0.02	2	
	CRM 7602-a	2015	03	09	21.9	15.41	0.05	2							1.088	0.004	2	29.76	0.01	2	
	CRM 7603-a	2015	03	09	21.9	42.73	0.04	2							3.043	0.006	2	142.69	0.13	2	
	RM-BU	2015	03	09	21.9	3.89	0.01	2							0.353	0.001	2	20.51	0.04	2	
	RM-BV	2015	03	09	21.9	34.02	0.02	2							2.478	0.002	2	99.97	0.03	2	
	RM-BY	2015	03	10	20.03	0.07	0	2							0.024	0.002	2	1.72	0	2	
	RM-CA	2015	03	09	21.9	19.02	0.07	2							1.404	0	2	35.81	0.03	2	
80																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	18	21	6.03	0.98	2	5.97	0.98	2	0.06	0.1	2	0.339	0.098	2	20.1	0.98	2	
	RM-BV	2015	02	18	21	32.15	0.98	2	32.12	0.98	2	0.03	0.1	2	2.451	0.098	2	93.29	0.98	2	
	RM-BY	2015	02	18	21	2.42	0.98	2	2.4	0.98	2	0.02	0.1	2	0.082	0.098	2	2.19	0.98	2	
	RM-CA	2015	02	18	21	18.01	0.98	2	17.8	0.98	2	0.21	0.1	2	1.492	0.098	2	34.78	0.98	2	
86																					
	CRM 7601-a																				
	CRM 7602-a	2015	02	26	40	16.32	0.09	2	15.96	0.1	2	0.36	0	2	1.162	0.03	2			2	
	CRM 7603-a	2015	02	26	40	44.75	0.02	2	44.66	0.02	2	0.1	0	2	3.032	0.004	2	142.41	0.04	2	
	RM-BU	2015	02	26	40	4.13	0	2	4.05	0	2	0.08	0	2	0.319	0	2	21.08	0.01	2	
	RM-BV	2015	02	26	40	37.31	0.02	2	37.27	0.02	2	0.04	0	2	2.471	0.006	2	102.14	0.03	2	
	RM-BY	2015	02	26	40	0.08	0.01	2	0.06	0.01	2	0.02	0	2	0.018	0.007	2	0.85	0	2	
	RM-CA	2015	02	26	40	20.45	0.01	2	20.39	0.01	2	0.06	0	2	1.4	0.003	2	36.87	0.01	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
87																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	22	21	3.95		2	3.89		2	0.07		2	0.352		2	20.47		2	
	RM-BV	2015	01	22	21	35.18		2	35.13		2	0.05		2	2.529		2	99.9		2	
	RM-BY	2015	01	22	21	0.02		2	0.01		2	0.01		2	0.049		2	1.61		2	
	RM-CA	2015	01	22	21	19.48		2	19.42		2	0.06		2	1.426		2	35.87		2	
88																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	20	21	4.57		2							0.378		2	21.56		2	
	RM-BV	2015	01	20	21	34.49		2							2.532		2	104.83		2	
	RM-BY	2015	01	20	21	1.34		2							0.053		2	2.15		2	
	RM-CA	2015	01	20	21	19.35		2							1.426		2	37.57		2	
89																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	15	21	3.96	0.02	2				0.13	0.01	2	0.768	0.004	2	20	0.09	2	
	RM-BV	2015	01	15	21	34.8	0.03	2				0.07	0.01	2	4.305	0.007	2	99.77	0.09	2	
	RM-BY	2015	01	15	21	0.08	0.01	2				0.06	0.01	2	0.054	0.001	2	1.22	0	2	
	RM-CA	2015	01	15	21	19.33	0.1	2				0.1	0.01	2	2.077	0.008	2	35.59	0.15	2	
90																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	26	20	3.28	0.18	2	3.25	0.17	2	0.03	0	2	0.328	0.02	2	20.34	0.11	2	
	RM-BV	2015	02	26	20	28.2	0.7	2	28.17	0.7	2	0.03	0	2	2.574	0.006	2	100.94	0.57	2	
	RM-BY	2015	02	26	20			2	LOD		5	0.01	0.01	2	0.038	0.02	2	1.03	0.32	2	
	RM-CA	2015	02	26	20	15.57	0.15	2	15.56	0.12	2	0.02	0.03	2	1.443	0.005	2	35.19	0.73	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
91																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	23	21.5	3.94	0.02	2							0.364	0.002	2	20.52	0.13	2	
	RM-BV	2015	01	23	21.5	35.5	0.23	2							2.537	0.016	2	102.26	0.35	2	
	RM-BY	2015	01	23	21.5	0.03	0.01	2							0.047	0.001	2	1.71	0.02	2	
	RM-CA	2015	01	23	21.5	19.66	0.04	2							1.454	0.003	2	36.13	0.14	2	
92																					
	CRM 7601-a	2015	01	12	18	0.08	0.01	2	0.05	0	2	0.03	0	2	0.049	0.005	2	1.34	0.01	2	
	CRM 7602-a	2015	01	09	18	15.72	0.05	2	15.33	0.05	2	0.39	0	2	1.151	0.004	2	30.56	0.04	2	
	CRM 7603-a	NA		NA		NA		9	NA		9	NA		9	NA		9	NA		9	
	RM-BU	2015	01	07	18	3.94	0.03	2	3.85	0.03	2	0.08	0	2	0.361	0.003	2	21.18	0.05	2	
	RM-BV	2015	01	08	18	34.81	0.06	2	34.76	0.06	2	0.05	0	2	2.498	0.006	2	101.34	0.11	2	
	RM-BY	2015	01	12	18	0.06	0	2	0.05	0	2	0.01	0	2	0.035	0.005	2	1.79	0.01	2	
	RM-CA	2015	01	09	18	19.45	0.04	2	19.38	0.04	2	0.07	0.01	2	1.473	0.004	2	36.71	0.09	2	
93																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	30	22.8	4.02	0.02	2	3.93	0.03	2	0.09	0	2	0.348	0.003	2	20.46	0.19	2	
	RM-BV	2015	01	30	22.8	35.23	0.18	2	35.17	0.18	2	0.06	0	2	2.501	0.006	2	99.25	0.28	2	
	RM-BY	2015	01	30	22.8	0.05	0.01	2	0.03	0.01	2	0.03	0	2	0.03	0.001	2	1.73	0.02	2	
	RM-CA	2015	01	30	22.8	19.5	0.18	2	19.43	0.18	2	0.07	0	2	1.416	0.018	2	35.66	0.21	2	
95																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	03	26	25	3.95	0.05	2	3.86	0.04	2	0.09	0.01	2	0.261	0.006	2	19.16	1.48	2	
	RM-BV	2015	03	26	25	35.18	0.25	2	35.12	0.25	2	0.06	0	2	2.255	0.113	2	99.03	6.49	2	
	RM-BY	2015	03	26	25	0.11	0.05	2	0.09	0.04	2	0.02	0.01	2	0.029	0.01	2	1.75	0.2	2	
	RM-CA	2015	03	26	25	19.38	0.11	2	19.31	0.11	2	0.07	0.01	2	1.274	0.041	2	35.01	1.98	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
96																					
	CRM 7601-a	2015	01	28	22	0.05	0.01	2							0.047	0.002	2	1.23	0.03	2	
	CRM 7602-a	2015	01	28	22	16.3	0.06	2							1.096	0.004	2	29.73	0.07	2	
	CRM 7603-a	2015	01	28	22	45.91	0.1	2							3.08	0.01	2	144.4	0.7	2	
	RM-BU	2015	01	28	22	3.98	0.02	2							0.331	0.001	2	20.49	0.03	2	
	RM-BV	2015	01	28	22	36.44	0.1	2							2.49	0.006	2	100.8	0.2	2	
	RM-BY	2015	01	28	22	0	0.01	2							0.026	0.002	2	1.71	0.02	2	
	RM-CA	2015	01	28	22	20.22	0.1	2							1.401	0.002	2	36.01	0.05	2	
97																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	09	21	1.45	0.16	2	1.35	0.16	2	0.1	0.02	2	0.332	0.01	2	21.34	0.39	2	
	RM-BV	2015	02	09	21	35.94	0.63	2	35.88	0.62	2	0.05	0.01	2	2.466	0.01	2	108.92	0.26	2	
	RM-BY	2015	02	09	21	0.08	0	2	0		2	0.08	0	2	0.109	0.006	2	0		2	
	RM-CA	2015	02	09	21	18.92	0.52	2	18.83	0.51	2	0.09	0.01	2	1.357	0.02	2	38.47	0.61	2	
98																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	26	22.4	3.62	0.2	2				BLOQ		5	0.332		2	11.38	0.98	2	
	RM-BV	2015	02	26	22.4	30.9	1.95	2				BLOQ		5	2.589	0.488	2	89.53	7.52	2	
	RM-BY	2015	02	26	22.4	BLOQ		5				BLOQ		5	BLOQ		5	BLOQ		5	
	RM-CA	2015	02	26	22.4	17.5	0.98	2				BLOQ		5	1.827	0.342	2	20.59	1.95	2	
99																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	11	23.0	3.69	0.28	2	3.43	0.27	2	0.13	0.01	2	0.438	0.004	2	19.37	0.2	2	
	RM-BV	2015	02	11	23.5	25.8	1.95	2	25.9	1.94	2	<0.1		5	2.746	0.027	2	94.86	0.97	2	
	RM-BY	2015	02	11	23.5	<0.1		5	<0.1		5	<0.1		5	0.122	0.001	2	0.92	0.01	2	
	RM-CA	2015	02	11	23.0	17.5	1.31	2	17.29	1.3	2	0.11	0.01	2	1.573	0.016	2	35.13	0.36	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
100																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	30	20	4.01	0.01	2	3.85	0.01	2	0.17	0.01	2	0.439	0.02	2	21.03	0.01	2	
	RM-BV	2015	01	30	20	38.17	0.01	2	38.04	0.01	2	0.14	0.01	2	2.548	0.02	2	101.67	0.01	2	
	RM-BY	2015	01	30	20	0.09	0.01	2	-0.05	0.01	2	0.14	0.01	2	0.224	0.02	2	1.84	0.01	2	
	RM-CA	2015	01	30	20	19.91	0.01	2	19.76	0.01	2	0.15	0.01	2	1.464	0.02	2	36.85	0.01	2	
101																					
	CRM 7601-a	2015	02	04	21.5	0.08	0.03	2	0.04		2	0.04	0.03	2	0.039	0.016	2	1.27	0.85	2	
	CRM 7602-a	2015	02	04	21.5	15.44	0.35	2	15.03		2	0.42	0.02	2	1.102	0.027	2	29.02	0.94	2	
	CRM 7603-a	2015	02	04	21.5	45.18	0.97	2	45.15		2	0.02	0.02	2	3.05	0.063	2	139.03	2.89	2	
	RM-BU	2015	02	04	21.5	3.87	0.08	2	3.8		2	0.07	0.02	2	0.38	0.016	2	20.1	0.88	2	
	RM-BV	2015	02	04	21.5	35.47	0.75	2	35.43		2	0.04	0.02	2	2.503	0.057	2	97.79	2.22	2	
	RM-BY	2015	02	04	21.5	0.05	0.04	2	0.03		2	0.01	0.02	2	0.043	0.016	2	1.76	0.86	2	
	RM-CA	2015	02	04	21.5	19.19	0.4	2	19.13		2	0.06	0.02	2	1.424	0.032	2	35.2	1.03	2	
102																					
	CRM 7601-a	2015	02	27	20	0.03	0.01	2	0.02	0.01	2	0.01	0	2	0.039	0.002	2	1.29	0.05	2	
	CRM 7602-a	2015	02	27	20	16.76	0.04	2	16.3	0.03	2	0.46	0.01	2	1.003	0.007	2	30.04	0.62	2	
	CRM 7603-a	2015	02	27	20	45.37	0.11	2	45.33	0.12	2	0.04	0.02	2	3.255	0.104	2	145.12	1.49	2	
	RM-BU	2015	02	27	20	4.26	0.08	2	4.2	0.08	2	0.07	0.01	2	0.368	0.029	2	20.95	0.56	2	
	RM-BV	2015	02	27	20	36.18	0.3	2	36.13	0.3	2	0.05	0	2	2.332	0.055	2	101.01	0.59	2	
	RM-BY	2015	02	27	20	0.01	0	2	0.01	0	2			2	0.024	0.003	2	1.62	0.04	2	
	RM-CA	2015	02	27	20	20.2	0.12	2	20.12	0.12	2	0.08	0.01	2	1.299	0.027	2	36.31	0.77	2	
104																					
	CRM 7601-a					0.03		2				0.03		2	0.078		2	1.75		2	
	CRM 7602-a					13.09		2				0.36		2	1.158		2	28.29		2	
	CRM 7603-a					37.04		2				0.03		2	3.211		2	145.81		2	
	RM-BU					3.88		2				0.06		2	0.37		2	15.87		2	
	RM-BV					29.56		2				0.03		2	2.705		2	104.65		2	
	RM-BY					0.1		2				0		2	0.049		2	1.93		2	
	RM-CA					16.54		2				0.06		2	1.499		2	35.64		2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
106																					
	CRM 7601-a	2015	02	26																	
	CRM 7602-a	2015	02	26																	
	CRM 7603-a	2015	02	26																	
	RM-BU	2015	02	26	22	3.62	0.02	2	3.56	0.02	2	0.06	0	2	0.339	0.013	2	20.28	0.07	2	
	RM-BV	2015	02	26	22	33.98	0.09	2	33.93	0.09	2	0.05	0	2	2.455	0.045	2	87.79	0.12	2	
	RM-BY	2015	02	26	22	0.01	0	2	0	0	2	0.01	0	2	0.029	0.002	2	1.87	0.01	2	
	RM-CA	2015	02	26	22	18.77	0.18	2	18.71	0.18	2	0.06	0	2	1.4	0.038	2	36.09	0.17	2	
107																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	16	20	4	0.12	2	3.95	0.11	2	0.05	0.01	2	0.364	0.007	2	20.43	0.08	2	
	RM-BV	2015	02	16	20	35.1	0.07	2	35.07	0.06	2	0.04	0	2	2.464	0.005	2	101.31	0.33	2	
	RM-BY	2015	02	16	20	0.09	0.01	2	0.08	0	2	0	0	2	0.04	0.007	2	1.82	0.08	2	
	RM-CA	2015	02	16	20	19.32	0.06	2	19.28	0.06	2	0.04	0	2	1.406	0.001	2	35.06	0.06	2	
108																					
	CRM 7601-a	na		na	na	na	na	9	na	na	9	na	na	9	na	na	9	na	na	9	
	CRM 7602-a	na		na	na	na	na	9	na	na	9	na	na	9	na	na	9	na	na	9	
	CRM 7603-a	na		na	na	na	na	9	na	na	9	na	na	9	na	na	9	na	na	9	
	RM-BU	2015	02	26	21	3.77	0.64	2	3.27	0.8	2	0.58	0.24	2	0.879	0.41	2	19.03	0.74	2	
	RM-BV	2015	02	26	21	31.3	1.06	2	30.96	1.16	2	0.34	0.19	2	2.695	0.264	2	88.66	1.22	2	
	RM-BY	2015	02	26	21	0.49	0.29	2	0.41	0.26	2	0.1	0.09	2	ND	NA	5	3.13	0.89	2	
	RM-CA	2015	02	26	21	18.08	0.53	2	17.71	0.69	2	0.43	0.08	2	1.445	0.137	2	21.74	1.15	2	
109																					
	CRM 7601-a	2015	02	23	19.4	0.1	0	2	0.04	0	2	0.05	0	2	0.047	0.003	2	1.36	0	2	
	CRM 7602-a	2015	02	23	19.4	16.44	0.03	2	16.04	0.03	2	0.4	0	2	1.13	0.002	2	30.8	0.04	2	
	CRM 7603-a	2015	02	23	19.4	44.64	0.1	2	44.6	0.1	2	0.04	0	2	3.127	0.011	2	146.49	0.13	2	
	RM-BU	2015	02	23	19.4	4.21	0.01	2	4.12	0.01	2	0.09	0	2	0.356	0.003	2	21.38	0.02	2	
	RM-BV	2015	02	23	19.4	35.99	0.07	2	35.93	0.07	2	0.06	0	2	2.553	0.008	2	103.19	0.2	2	
	RM-BY	2015	02	23	19.4	0.08	0	2	0.04	0	2	0.04	0	2	0.033	0.004	2	1.81	0	2	
	RM-CA	2015	02	23	19.4	20.31	0.04	2	20.23	0.04	2	0.08	0	2	1.444	0.007	2	37.33	0.09	2	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
111																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	27	21	4.2	0	2	4.14	0	2	0.06	0	2	0.358	0.029	2	21.9	0.65	2	
	RM-BV	2015	01	27	21	34.62	0	2	34.57	0.48	2	0.05	0	2	2.49	0.045	2	99.2	0	2	
	RM-BY	2015	01	27	21	0.1	0	2	0.02	0	2	0.01	0	2	0.049	0	2	1.75	0	2	
	RM-CA	2015	01	27	21	19.82	0	2	19.77	0	2	0.05	0	2	1.432	0.066	2	35.59	2.72	2	
112																					
	CRM 7601-a	N/A																			
	CRM 7602-a	N/A																			
	CRM 7603-a	N/A																			
	RM-BU	2015	02	13	23.3	4.05	0.01	2	NA		9	0.07	0.01	2	0.352	0	2	20.63	0.07	2	
	RM-BV	2015	02	13	23.3	36.33	0.06	2	NA		9	0.04	0	2	2.502	0	2	102.11	0.12	2	
	RM-BY	2015	02	13	23.3	0.07	0.01	2	NA		9	0.01	0	2	0.039	0.01	2	1.28	0.07	2	
	RM-CA	2015	02	13	23.3	19.8	0.02	2	NA		9	0.06	0	2	1.417	0.01	2	36.29	0.08	2	
113																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	01	21	21	4.01	0.01	2	3.93	0.01	2	0.08	0	2	0.34	0.002	2	21.24	0.02	2	
	RM-BV	2015	01	21	21	35.09	0.08	2	35.03	0.08	2	0.06	0	2	2.476	0.011	2	102.16	0.37	2	
	RM-BY	2015	01	21	21	0.07	0.01	2	0.04	0.01	2	0.03	0	2	0.033	0.001	2	1.82	0.02	2	
	RM-CA	2015	01	21	21	19.61	0.03	2	19.54	0.03	2	0.08	0	2	1.403	0.007	2	37.02	0.03	2	
114																					
	CRM 7601-a																				
	CRM 7602-a																				
	CRM 7603-a																				
	RM-BU	2015	02	02	27.5	4	0.04	2							0.489	0.002	2	14.01	0.05	2	
	RM-BV	2015	02	03	27.4	34.67	0.07	2							2.573	0.001	2	69.24	0.54	2	
	RM-BY	2015	02	02	27.5	0.06	0	2							0.186	0	2	1.97	0.01	2	
	RM-CA	2015	02	03	27.4	19.38	0.13	2							1.497	0.039	2			2	

Table A4 Ammonia

Lab	Sample	Ammonia	err	Nitrite	err	Nitrate	err	Nitrate+Nitrite	err
4									
	RM-BU	1.39	0.21	0.08	0.14	4.03	0.28	4.1	0.28
	RM-BV	1.77	0.21	0.04	0.14	34.89	1.56	34.89	1.56
	RM-BY	1.39	0.21	0.01	0.14	0.15	0.14	0.16	0.14
	RM-CA	0.86	0.14	0.03	0.14	19.74	0.91	19.84	0.91
5									
	CRM 7601-a	7.91	0.23	0.03	0.1	0.01	0	0.04	0
	CRM 7602-a	4.98	0.15	0.39	0.1	15.46	0.16	15.85	0.16
	CRM 7603-a	6.17	0.19	0.02	0.1	46.34	0.46	46.36	0.46
	RM-BU	1.11	0.03	0.08	0.1	3.87	0.04	3.95	0.04
	RM-BV	1.32	0.04	0.05	0.1	36.72	0.36	36.76	0.36
	RM-BY	0.78	0.02	0.02	0.1	<0.24		<0.24	
	RM-CA	0.59	0.02	0.06	0.1	22.5	0.22	22.56	0.22
8									
	CRM 7602-a	5.93	0.06	0.41	0	16.4	0.17	16.81	0.18
	CRM 7603-a	11.3	0.16	0.03	0	46.34	0.14	46.37	0.14
	RM-BU	1.4	0.1	0.09	0	3.91	0.08	4	0.08
	RM-BV	2.41	0.27	0.06	0	36.48	0.17	36.55	0.2
	RM-CA	1.11	0.08	0.06	0	20.47	0.05	20.55	0.04
19									
	RM-BU	1.23	0	0.08	0	3.97	0.1	4.05	0.1
	RM-BV	1.44	0	0.05	0	35.96	0.1	36.01	0.1
	RM-BY	0.98	0	0.02	0	0	0.03	0.02	0.03
	RM-CA	0.68	0	0.07	0	19.97	0.03	20.03	0.03
20									
	RM-BU	1.4	0.21	0.08	0	3.98	0.08	4.06	0.08
	RM-BV	1.34	0.21	0.05	0	35.74	0.82	35.79	0.82
	RM-BY	0.87	0.13	0.02	0	0.03	0	0.05	0
	RM-CA	0.72	0.11	0.06	0	19.93	0.6	19.99	0.6
27									
	CRM 7601-a	5.86	0.1	0.03	0.01	0.04	0.02	0.07	0.02
	CRM 7602-a	5.86	0.1	0.38	0.01	15.09	0.15	15.47	0.15
	CRM 7603-a	5.86	0.1	0.02	0	42.53	0.52	42.55	0.52
	RM-BU	5.86	0.1	0.07	0.01	3.77	0.07	3.85	0.07
	RM-BV	5.86	0.1	0.05	0.01	34.67	0.36	34.72	0.36
	RM-BY	5.86	0.1	0.02	0.01	0.03	0.02	0.05	0.02
	RM-CA	5.86	0.1	0.06	0.01	19.18	0.21	19.24	0.21

IOCCP-JAMSTEC 2015 Inter calibration exercise

Lab	Sample	Ammonia	err	Nitrite	err	Nitrate	err	Nitrate+Nitrite	err
28									
	RM-BU	1.44	0.1	0.06	0	3.92	0.2	3.98	0.2
	RM-BV	1.52	0.1	0.03	0	34.71	0.29	34.74	0.29
	RM-BY	0.99	0.1	0.01	0	0.1	0.02	0.11	0.05
	RM-CA	0.56	0.1	0.05	0	20.05	0.24	20.1	0.24
30									
	RM-BU	5.31	0.33	0.11	0	1.21	0.27	1.31	1.17
	RM-BV	0.26	0.04	0.03	0	22.47	2.85	22.51	2.85
	RM-BY	ND	ND	0	0	ND	ND	0	0
	RM-CA	0.53	0.06	0.04	0	16.57	0.29	16.61	3.03
32									
	RM-BU	1.35	0.19	<0.06		3.27		3.27	0.69
	RM-BV	1.65	0.06	<0.06		31.85		31.85	1.84
	RM-BY	0.71	0.05	<0.06		0.27		0.27	0.02
	RM-CA	0.47	0.01	<0.06		18.43		18.43	1.33
40									
	RM-BU	4.49	0.2	0.08	0.1	4.2	0.1	4.3	0.1
	RM-BV	4.79	0.2	<0.08	0.29	37.11	0.29	37.21	0.29
	RM-BY	3.81	0.2	<0.08	0.07	0.07	0.07	<0.07	0.07
	RM-CA	3.32	0.2	<0.08	0.29	19.53	0.29	19.63	0.29
50									
	RM-BU	1.35	0.02	0.07	0	3.94	0.02	4	0.02
	RM-BV	1.4	0.02	0.06	0	34.9	0.24	34.96	0.23
	RM-BY	0.92	0.01	0.02	0	0.02	0	0.04	0.01
	RM-CA	0.7	0.01	0.08	0	19.57	0.03	19.65	0.03
51									
	CRM 7601-a	10.37	0.1	0.12	0.1			2.33	0.98
	CRM 7602-a	5.09	0.1	0.41	0.1			16.64	0.98
	RM-BU	1.41	0.1						
	RM-BV	1.88	0.1						
	RM-BY	1.01	0.1	0.04	0.1			0.68	0.98
	RM-CA	0.82	0.1					23.37	0.98
52									
	RM-BU	na	na	na	na	na	na	3.91	0.02
	RM-BV	na	na	na	na	na	na	35.35	0.04
	RM-BY	na	na	na	na	na	na	0.05	0
	RM-CA	na	na	na	na	na	na	19.55	0.09

IOCCP-JAMSTEC 2015 Inter calibration exercise

Lab	Sample	Ammonia	err	Nitrite	err	Nitrate	err	Nitrate+Nitrite	err
56									
	CRM 7601-a	10.87	0	0.04	0.01	0.01	0.18	0.05	0.18
	CRM 7602-a	5.08	0	0.41	0.01	15.09	0.18	15.5	0.18
	CRM 7603-a	5.63	0	0.03	0.01	43.89	0.18	43.91	0.18
	RM-AX	0.75	0	0.39	0.01	21.16	0.18	21.55	0.18
	RM-AZ	0.7	0	0.04	0.01	42.09	0.18	42.13	0.18
	RM-BD	5.83	0	0.05	0.01	29.45	0.18	29.5	0.18
	RM-BP	3.32	0	0.04	0.01	0	0.18	0.04	0.18
	RM-BQ	1.67	0	0.03	0.01	43.9	0.18	43.92	0.18
	RM-BU	0.99	0	0.08	0.01	3.58	0.18	3.66	0.18
	RM-BV	1.63	0	0.05	0.01	35.07	0.18	35.12	0.18
	RM-BY	0.93	0	0.02	0.01	0	0.18	0.02	0.18
	RM-CA	0.65	0	0.07	0.01	19.27	0.18	19.34	0.18
59									
	RM-BU	0.9	0.05	0.07	0	3.02	0.11	3.02	0.11
	RM-BV	0.92	0.1	0.05	0	31.94	0.5	31.95	0.5
	RM-BY	0.63	0	0.03	0	0.03	0	0.03	0
	RM-CA	0.46	0.03	0.07	0.01	18.41	0.9	18.41	0.9
86									
	CRM 7602-a	7.82	0.61	0.36	0	15.96	0.1	16.32	0.09
	CRM 7603-a	9.26	0.06	0.1	0	44.66	0.02	44.75	0.02
	RM-BU	1.05	0.04	0.08	0	4.05	0	4.13	0
	RM-BV	1.57	0.02	0.04	0	37.27	0.02	37.31	0.02
	RM-BY	0.69	0.01	0.02	0	0.06	0.01	0.08	0.01
	RM-CA	0.58	0.01	0.06	0	20.39	0.01	20.45	0.01
87									
	RM-BU	1.69		0.07		3.89		3.95	
	RM-BV	1.84		0.05		35.13		35.18	
	RM-BY	1.23		0.01		0.01		0.02	
	RM-CA	1		0.06		19.42		19.48	
89									
	RM-BU	1.5	0	0.13	0.01			3.96	0.02
	RM-BV	1.75	0	0.07	0.01			34.8	0.03
	RM-BY	1.09	0.03	0.06	0.01			0.08	0.01
	RM-CA	0.72	0	0.1	0.01			19.33	0.1
95									
	RM-BU	0.91	0.05	0.09	0.01	3.86	0.04	3.95	0.05
	RM-BV	0.97	0.05	0.06	0	35.12	0.25	35.18	0.25
	RM-BY	0.51	0.07	0.02	0.01	0.09	0.04	0.11	0.05
	RM-CA	0.41	0.06	0.07	0.01	19.31	0.11	19.38	0.11

IOCCP-JAMSTEC 2015 Inter calibration exercise

Lab	Sample	Ammonia	err	Nitrite	err	Nitrate	err	Nitrate+Nitrite	err
97									
	RM-BU	0.83	0	0.1	0.02	1.35	0.16	1.45	0.16
	RM-BV	1.51	0.05	0.05	0.01	35.88	0.62	35.94	0.63
	RM-BY	0.51	0.02	0.08	0	0		0.08	0
	RM-CA	0.3	0.03	0.09	0.01	18.83	0.51	18.92	0.52
98									
	RM-BU	1.25	0.2	BLOQ				3.62	0.2
	RM-BV	1.14	0.2	BLOQ				30.9	1.95
	RM-BY	0.9	0.1	BLOQ				BLOQ	
	RM-CA	0.51	0.1	BLOQ				17.5	0.98
99									
	RM-BU	1.56	0.16	0.13	0.01	3.43	0.27	3.69	0.28
	RM-BV	1.93	0.19	<0.1		25.9	1.94	25.8	1.95
	RM-BY	1.11	0.11	<0.1		<0.1		<0.1	
	RM-CA	0.92	0.09	0.11	0.01	17.29	1.3	17.5	1.31
100									
	RM-BU	1.57	0.02	0.17	0.01	3.85	0.01	4.01	0.01
	RM-BV	2.03	0.02	0.14	0.01	38.04	0.01	38.17	0.01
	RM-BY	1.16	0.02	0.14	0.01	-0.05	0.01	0.09	0.01
	RM-CA	1.22	0.02	0.15	0.01	19.76	0.01	19.91	0.01
101									
	CRM 7601-a	11.27	0.29	0.04	0.03	0.04		0.08	0.03
	CRM 7602-a	4.57	0.2	0.42	0.02	15.03		15.44	0.35
	CRM 7603-a	7.15	0.22	0.02	0.02	45.15		45.18	0.97
	RM-BU	1.44	0.21	0.07	0.02	3.8		3.87	0.08
	RM-BV	1.77	0.2	0.04	0.02	35.43		35.47	0.75
	RM-BY	1.2	0.21	0.01	0.02	0.03		0.05	0.04
	RM-CA	1.04	0.2	0.06	0.02	19.13		19.19	0.4
102									
	CRM 7601-a	6.99	0.03	0.01	0	0.02	0.01	0.03	0.01
	CRM 7602-a	3.04	0.23	0.46	0.01	16.3	0.03	16.76	0.04
	CRM 7603-a	7.44	0.34	0.04	0.02	45.33	0.12	45.37	0.11
	RM-BU	0.41	0.13	0.07	0.01	4.2	0.08	4.26	0.08
	RM-BV	1.61	0.08	0.05	0	36.13	0.3	36.18	0.3
	RM-BY	0.88	0.05			0.01	0	0.01	0
	RM-CA	0.28	0.09	0.08	0.01	20.12	0.12	20.2	0.12

IOCCP-JAMSTEC 2015 Inter calibration exercise

Lab	Sample	Ammonia	err	Nitrite	err	Nitrate	err	Nitrate+Nitrite	err
104									
	CRM 7601-a	6.16		0.03				0.03	
	CRM 7602-a	4.34		0.36				13.09	
	CRM 7603-a	6.06		0.03				37.04	
	RM-BU	1.21		0.06				3.88	
	RM-BV	1.64		0.03				29.56	
	RM-BY	0.83		0				0.1	
	RM-CA	0.83		0.06				16.54	
106									
	RM-BU	1.5	0.03	0.06	0	3.56	0.02	3.62	0.02
	RM-BV	1.76	0.02	0.05	0	33.93	0.09	33.98	0.09
	RM-BY	1.06	0.02	0.01	0	0	0	0.01	0
	RM-CA	0.65	0	0.06	0	18.71	0.18	18.77	0.18
108									
	CRM 7601-a	na	na	na	na	na	na	na	na
	CRM 7602-a	na	na	na	na	na	na	na	na
	CRM 7603-a	na	na	na	na	na	na	na	na
	RM-BU	1.41	0.11	0.58	0.24	3.27	0.8	3.77	0.64
	RM-BV	1.58	0.09	0.34	0.19	30.96	1.16	31.3	1.06
	RM-BY	1.18	0.12	0.1	0.09	0.41	0.26	0.49	0.29
	RM-CA	0.9	0.08	0.43	0.08	17.71	0.69	18.08	0.53
109									
	CRM 7601-a	9.99	0.04	0.05	0	0.04	0	0.1	0
	CRM 7602-a	3.72	0	0.4	0	16.04	0.03	16.44	0.03
	CRM 7603-a	5.64	0.02	0.04	0	44.6	0.1	44.64	0.1
	RM-BU	1.59	0.01	0.09	0	4.12	0.01	4.21	0.01
	RM-BV	2.04	0.01	0.06	0	35.93	0.07	35.99	0.07
	RM-BY	1.32	0.01	0.04	0	0.04	0	0.08	0
	RM-CA	1.05	0.01	0.08	0	20.23	0.04	20.31	0.04
112									
	RM-BU	1.22	0.01	0.07	0.01	NA		4.05	0.01
	RM-BV	1.59	0.01	0.04	0	NA		36.33	0.06
	RM-BY	0.84	0.01	0.01	0	NA		0.07	0.01
	RM-CA	0.75	0	0.06	0	NA		19.8	0.02
113									
	RM-BU	1.16	0.01	0.08	0	3.93	0.01	4.01	0.01
	RM-BV	1.65	0.01	0.06	0	35.03	0.08	35.09	0.08
	RM-BY	0.97	0	0.03	0	0.04	0.01	0.07	0.01
	RM-CA	0.84	0	0.08	0	19.54	0.03	19.61	0.03

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Table A5 DOP

Lab	Sample	Phosphate	err	DOP	err
32					
	RM-BU	0.374	0.032	0.65	0
	RM-BV	2.649	0.078	2.87	0.06
	RM-BY	0.042	0.014	0.29	0.01
	RM-CA	1.506	0.049	1.62	0.02
37					
	RM-BU	0.352	0.01	0.29	0.01
	RM-BV	2.513	0.01	0.39	0.01
	RM-BY	0.029	0	0.26	0
	RM-CA	1.427	0.01	0.18	0.02
40					
	RM-BU	0.381	0.029	0.2	0.1
	RM-BV	2.539	0.059	0.29	0.1
	RM-BY	<0.03	0.029	<0.1	0.1
	RM-CA	1.465	0.059	<0.1	0.1
49					
	CRM 7601-a	0.068	0	0.84	
	CRM 7601-a	0.071	0.006	0.62	
	CRM 7601-a	0.029	0	0.6	0
	CRM 7601-a	0.029	0	0.61	0
	CRM 7602-a	1.13	0.006	0.84	0.01
	CRM 7602-a	1.123	0	0.22	0.1
	CRM 7602-a	1.188	0.006	0.88	
	CRM 7602-a	1.188	0.006	0.57	
	CRM 7603-a	3.141	0.006	0.52	0.12
	CRM 7603-a	3.343	0.098	0.6	
	CRM 7603-a	3.141	0.006	0.45	0.01
	CRM 7603-a	3.349	0.01	0.46	
	RM-BU	0.43	0	0.48	
	RM-BU	0.352	0	0.29	0
	RM-BV	2.702	0.006	0.65	
	RM-BV	2.575	0.006	0.46	0.01
	RM-BY	0.062	0.006	0.41	
	RM-BY	0.02	0	0.33	0.01
	RM-CA	1.504	0	0.38	
	RM-CA	1.455	0	0.26	0

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Lab	Sample	Phosphate	err	DOP	err
86					
	RM-BU	0.319	0	0.34	0
	RM-BV	2.471	0.006	0.35	0.02
	RM-BY	0.018	0.007	0.31	0.05
	RM-CA	1.4	0.003	0.05	0.03
102					
	CRM 7601-a	0.039	0.002	0.89	0.05
	CRM 7602-a	1.003	0.007	1.12	0.05
	CRM 7603-a	3.255	0.104	0.26	0.06
	RM-BU	0.368	0.029	0.54	0.13
	RM-BV	2.332	0.055	0.18	0.03
	RM-BY	0.024	0.003	0.5	0.05
	RM-CA	1.299	0.027	0.38	0.1
104					
	CRM 7601-a	0.078		0.99	
	CRM 7602-a	1.158		0.43	
	CRM 7603-a	3.211		0.76	
	RM-BU	0.37		0.31	
	RM-BV	2.705		0.52	
	RM-BY	0.049		0.28	
	RM-CA	1.499		0.38	

Table A6 DON

Lab	Sample	DON	err	Nitrate	err	Nitrite	err	Nitrate+Nitrite	err	Ammonia	err
32											
	RM-BU	8.65	0.12	3.27		<0.06		3.27	0.69	1.35	0.19
	RM-BV	32.03	0.48	31.85		<0.06		31.85	1.84	1.65	0.06
	RM-BY	5.46	0.06	0.27		<0.06		0.27	0.02	0.71	0.05
	RM-CA	19.45	0.07	18.43		<0.06		18.43	1.33	0.47	0.01
40											
	RM-BU	2.54	0.68	4.2	0.1	0.08	0.1	4.3	0.1	4.49	0.2
	RM-BV	3.12	0.68	37.11	0.29	<0.08	0.29	37.21	0.29	4.79	0.2
	RM-BY	2.25	0.68	0.07	0.07	<0.08	0.07	<0.07	0.07	3.81	0.2
	RM-CA	3.61	0.68	19.53	0.29	<0.08	0.29	19.63	0.29	3.32	0.2
49											
	CRM 7601-	15.13	0.04	0.03	0	LD		0.03	0		
	CRM 7601-	14.68		0.05	0.01	0.02	0	0.07	0.01		
	CRM 7601-	14.43		0.05	0.03	0.02	0	0.07	0.03		
	CRM 7601-	14.92	0.07	0.03	0.01	LD		0.03	0		
	CRM 7602-	9.73	0.08	15.65	0.03	0.35	0.01	16	0.03		
	CRM 7602-	9.11		15.61	0.05	0.36	0	15.97	0.05		
	CRM 7602-	9.56	0.09	15.69	0.06	0.36	0	16.05	0.06		
	CRM 7602-	8.85		15.62	0.06	0.37	0	15.98	0.06		
	CRM 7603-	8.37		44.3	0.07	0	0	44.3	0.07		
	CRM 7603-	10.15	0.29	44.53	0.13	LD		44.53	0.13		
	CRM 7603-	8.34		44.37	0.11	0.01	0	44.38	0.11		
	CRM 7603-	10.18	0.26	44.55	0.14	LD		44.55	0.15		
	RM-BU	6.32	0.03	4	0.01	0.03	0.01	4.03	0.01		
	RM-BU	5.7		3.94	0.01	0.05	0	3.99	0.01		
	RM-BV	3.31		35.57	0.1	0.03	0	35.6	0.1		
	RM-BV	4.37	0.06	35.98	0.06	0.01	0	35.99	0.06		
	RM-BY	4.37		0.09	0.03	0	0	0.1	0.03		
	RM-BY	4.94	0.02	0.04	0.01	LD		0.04	0.01		
	RM-CA	3.59	0.11	19.97	0.06	0.03	0	20	0.06		
	RM-CA	3.13		19.76	0.03	0.04	0	19.79	0.03		
86											
	RM-BU	3.95	0.07	4.05	0	0.08	0	4.13	0	1.05	0.04
	RM-BV	0.27	0.13	37.27	0.02	0.04	0	37.31	0.02	1.57	0.02
	RM-BY	3.74	0.08	0.06	0.01	0.02	0	0.08	0.01	0.69	0.01
	RM-CA	1.97	0.11	20.39	0.01	0.06	0	20.45	0.01	0.58	0.01
102											
	CRM 7601-	5.35	0.12	0.02	0.01	0.01	0	0.03	0.01	6.99	0.03
	CRM 7602-	5.06	0.14	16.3	0.03	0.46	0.01	16.76	0.04	3.04	0.23
	CRM 7603-	0.99	0.13	45.33	0.12	0.04	0.02	45.37	0.11	7.44	0.34

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Lab	Sample	DON	err	Nitrate	err	Nitrite	err	Nitrate+Nitrite	err	Ammonia	err
	RM-BU	4.28	0.02	4.2	0.08	0.07	0.01	4.26	0.08	0.41	0.13
	RM-BV	0.98	0.17	36.13	0.3	0.05	0	36.18	0.3	1.61	0.08
	RM-BY	3.83	0.04	0.01	0			0.01	0	0.88	0.05
	RM-CA	3.82	0.11	20.12	0.12	0.08	0.01	20.2	0.12	0.28	0.09
104											
	CRM 7601-	3.66				0.03		0.03		6.16	
	CRM 7602-	2.96				0.36		13.09		4.34	
	CRM 7603-	-0.8				0.03		37.04		6.06	
	RM-BU	3.08				0.06		3.88		1.21	
	RM-BV	-0.73				0.03		29.56		1.64	
	RM-BY	3.09				0		0.1		0.83	
	RM-CA	1.23				0.06		16.54		0.83	
106											
	RM-BU	19.53		3.56	0.02	0.06	0	3.62	0.02	1.5	0.03
	RM-BV	36.65		33.93	0.09	0.05	0	33.98	0.09	1.76	0.02
	RM-BY	5.02		0	0	0.01	0	0.01	0	1.06	0.02
	RM-CA	21.18		18.71	0.18	0.06	0	18.77	0.18	0.65	0

Table A7 DOC

Lab	Sample	DOC	err
106			
	RM-BU	168.58	2.02
	RM-BV	119.95	1.1
	RM-BY	133.98	1.56
	RM-CA	101.29	1.68

Appendix III

Table A8-1 Cross reference table of ranked order and Lab # for Figure 1-1

rank	Lab No.	Lab name
1	**30**	Central Institute of Fisheries Technology, India
2	**99**	Centro de Investigaciones Biológicas del, Noroeste SC., Mexico
3	**90**	School of Earth and Environmental Science,University of Portsmouth, UK
4	**104**	Australian Institute of Marine Science, Australia
5	**98**	University of Tartu, Estonian Marine Institute, Estonia
6	**108**	School of Fisheries and Ocean Sciences (SFOS) University of Alaska Fairbanks (UAF), USA
7	**32**	Israel Oceanographic & Limnological Res, National Institute of Oceanography, Israel
8	**59**	Monterey Bay Aquarium Research Institute, USA
9	**80**	Instituto del Mar del Perú, Peru
10	**17**	College of Marine and Environmental Sciences, Tianjin University of Science and Technology, China
11	**106**	Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain
12	**65**	Hawaii Ocean Time-series, USA
13	**45**	University of Cape town, Dept of Oceanography, South Africa
14	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
15	**88**	Faroe Marine Research Institute, Faroe Islands
16	**111**	Institute of Oceanology Polish Academy of Sciences, Marine Chemistry and Biochemistry Department, Poland
17	**114**	LOQyCA - Centro Nacional Patagonico (CONICET), Argentina
18	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
19	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
20	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
21	**89**	Scottish Environment Protection Agency, UK
22	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
23	**64**	University of Hawaii, SOEST Laboratory for Analytical Biogeochemistry (S-LAB), USA
24	**29**	Marine Research Institute, Iceland
25	**4**	Queensland Health Forensic and Scientific Services, Australia
26	**50**	Plymouth Marine Laboratory, UK
27	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
28	**113**	Scripps Institution of Oceanography, CalCOFI Group, UC San Diego, USA
29	**107**	Observatoire oceanologique de Villefranche-sur-Mer (CNRS-UPMC), France
30	**56**	Scripps Institution of Oceanography, USA

rank	Lab No.	Lab name
31	**95**	National Institute of Oceanography, India
32	**87**	Department of Fisheries and Oceans Canada, Canada
33	**93**	GEOMAR Helmholtz Center for Ocean Research, Kiel, Germany
34	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
35	**57**	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, USA
36	**35**	Japan Meteorological Agency, Japan
37	**52**	Department of Earth, Ocean and Ecological Sciences, SOES, University of Liverpool, UK
38	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
39	**39**	Royal NIOZ, Netherlands
40	**91**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
41	**49**	National Oceanography Centre, Southampton, UK
42	**26**	Leibniz-Institute for Baltic Sea Research Warnemünde (IOW), Germany
43	**20**	Ifremer, LERN, Port en Bessin, France
44	**38**	Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Japan
45	**97**	Geochemical & Environmental Research Group, Texas A&M University, USA
46	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
47	**19**	Ifremer, DYNECO/PELAGOS, Plouzané, France
48	**102**	Stazione Zoologica Anton Dohrn, Italy
49	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
50	**96**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
51	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
52	**5**	OD NATURE – ECOCHEM, Belgium
53	**40**	National Institute of Water and Atmospheric Research (NIWA), New Zealand
54	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
55	**100**	URI/Grad. School of Oceanography, USA
56	**7**	Laboratório de Nutrientes, Micronutrientes e Traços nos Oceanos (LABNUT-IOUSP), Instituto Oceanográfico da Universidade de São Paulo, Brazil
57	**51**	Marine Scotland - Science, UK

Table A8-2 Cross reference table of ranked order and Lab # for Figure 1-2

rank	Lab No.	Lab name
1	**104**	Australian Institute of Marine Science, Australia
2	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
3	**65**	Hawaii Ocean Time-series, USA
4	**29**	Marine Research Institute, Iceland
5	**64**	University of Hawaii, SOEST Laboratory for Analytical Biogeochemistry (S-LAB), USA
6	**56**	Scripps Institution of Oceanography, USA
7	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
8	**35**	Japan Meteorological Agency, Japan
9	**49**	National Oceanography Centre, Southampton, UK
10	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
11	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
12	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
13	**102**	Stazione Zoologica Anton Dohrn, Italy
14	**96**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
15	**5**	OD NATURE – ECOCHEM, Belgium
16	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
17	**51**	Marine Scotland - Science, UK
18	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France

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Table A8-3 Cross reference table of ranked order and Lab # for Figure 2-1

rank	Lab No.	Lab name
1	**30**	Central Institute of Fisheries Technology, India
2	**99**	Centro de Investigaciones Biológicas del, Noroeste SC., Mexico
3	**90**	School of Earth and Environmental Science,University of Portsmouth, UK
4	**108**	School of Fisheries and Ocean Sciences (SFOS) University of Alaska Fairbanks (UAF), USA
5	**32**	Israel Oceanographic & Limnological Res, National Institute of Oceanography, Israel
6	**59**	Monterey Bay Aquarium Research Institute, USA
7	**80**	Instituto del Mar del Perú, Peru
8	**17**	College of Marine and Environmental Sciences, Tianjin University of Science and Technology, China
9	**106**	Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain
10	**45**	University of Cape town, Dept of Oceanography, South Africa
11	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
12	**111**	Institute of Oceanology Polish Academy of Sciences, Marine Chemistry and Biochemistry Department, Poland
13	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
14	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
15	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
16	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
17	**4**	Queensland Health Forensic and Scientific Services, Australia
18	**50**	Plymouth Marine Laboratory, UK
19	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
20	**113**	Scripps Institution of Oceanography, CalCOFI Group, UC San Diego, USA
21	**56**	Scripps Institution of Oceanography, USA
22	**107**	Observatoire oceanologique de Villefranche-sur-Mer (CNRS-UPMC), France
23	**95**	National Institute of Oceanography, India
24	**87**	Department of Fisheries and Oceans Canada, Canada
25	**93**	GEOMAR Helmholtz Center for Ocean Research, Kiel, Germany
26	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
27	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
28	**26**	Leibniz-Institute for Baltic Sea Research Warnemünde (IOW), Germany
29	**49**	National Oceanography Centre, Southampton, UK

rank	Lab No.	Lab name
30	**39**	Royal NIOZ, Netherlands
31	**20**	Ifremer, LERN, Port en Bessin, France
32	**38**	Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Japan
33	**97**	Geochemical & Environmental Research Group, Texas A&M University, USA
34	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
35	**19**	Ifremer, DYNECO/PELAGOS, Plouzané, France
36	**102**	Stazione Zoologica Anton Dohrn, Italy
37	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
38	**5**	OD NATURE – ECOCHEM, Belgium
39	**40**	National Institute of Water and Atmospheric Research (NIWA), New Zealand
40	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
41	**100**	URI/Grad. School of Oceanography, USA
42	**7**	Laboratório de Nutrientes, Micronutrientes e Traços nos Oceanos (LABNUT-IOUSP), Instituto Oceanográfico da Universidade de São Paulo, Brazil

Table A8-4 Cross reference table of ranked order and Lab # for Figure 2-2

rank	Lab No.	Lab name
1	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
2	**56**	Scripps Institution of Oceanography, USA
3	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
4	**49**	National Oceanography Centre, Southampton, UK
5	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
6	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
7	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
8	**102**	Stazione Zoologica Anton Dohrn, Italy
9	**5**	OD NATURE – ECOCHEM, Belgium
10	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
11	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France

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Table A8-5 Cross reference table of ranked order and Lab # for Figure 3-1

rank	Lab No.	Lab name
1	**90**	School of Earth and Environmental Science,University of Portsmouth, UK
2	**17**	College of Marine and Environmental Sciences, Tianjin University of Science and Technology, China
3	**49**	National Oceanography Centre, Southampton, UK
4	**107**	Observatoire oceanologique de Villefranche-sur-Mer (CNRS-UPMC), France
5	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
6	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
7	**80**	Instituto del Mar del Perú, Peru
8	**104**	Australian Institute of Marine Science, Australia
9	**106**	Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain
10	**111**	Institute of Oceanology Polish Academy of Sciences, Marine Chemistry and Biochemistry Department, Poland
11	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
12	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
13	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
14	**29**	Marine Research Institute, Iceland
15	**50**	Plymouth Marine Laboratory, UK
16	**59**	Monterey Bay Aquarium Research Institute, USA
17	**87**	Department of Fisheries and Oceans Canada, Canada
18	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
19	**102**	Stazione Zoologica Anton Dohrn, Italy
20	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
21	**4**	Queensland Health Forensic and Scientific Services, Australia
22	**5**	OD NATURE – ECOCHEM, Belgium
23	**19**	Ifremer, DYNECO/PELAGOS, Plouzané, France
24	**20**	Ifremer, LERN, Port en Bessin, France
25	**35**	Japan Meteorological Agency, Japan
26	**38**	Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Japan
27	**39**	Royal NIOZ, Netherlands
28	**40**	National Institute of Water and Atmospheric Research (NIWA), New Zealand
29	**56**	Scripps Institution of Oceanography, USA
30	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy

rank	Lab No.	Lab name
31	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
32	**113**	Scripps Institution of Oceanography, CalCOFI Group, UC San Diego, USA
33	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
34	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
35	**93**	GEOMAR Helmholtz Center for Ocean Research, Kiel, Germany
36	**95**	National Institute of Oceanography, India
37	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
38	**45**	University of Cape town, Dept of Oceanography, South Africa
39	**97**	Geochemical & Environmental Research Group, Texas A&M University, USA
40	**26**	Leibniz-Institute for Baltic Sea Research Warnemünde (IOW), Germany
41	**30**	Central Institute of Fisheries Technology, India
42	**89**	Scottish Environment Protection Agency, UK
43	**99**	Centro de Investigaciones Biológicas del, Noroeste SC., Mexico
44	**7**	Laboratório de Nutrientes, Micronutrientes e Traços nos Oceanos (LABNUT-IOUSP), Instituto Oceanográfico da Universidade de São Paulo, Brazil
45	**100**	URI/Grad. School of Oceanography, USA
46	**108**	School of Fisheries and Ocean Sciences (SFOS) University of Alaska Fairbanks (UAF), USA
47	**51**	Marine Scotland - Science, UK

Table A8-6 Cross reference table of ranked order and Lab # for Figure 3-2

rank	Lab No.	Lab name
1	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
2	**104**	Australian Institute of Marine Science, Australia
3	**49**	National Oceanography Centre, Southampton, UK
4	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
5	**5**	OD NATURE – ECOCHEM, Belgium
6	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
7	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
8	**35**	Japan Meteorological Agency, Japan
9	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
10	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
11	**51**	Marine Scotland - Science, UK
12	**56**	Scripps Institution of Oceanography, USA
13	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
14	**29**	Marine Research Institute, Iceland
15	**102**	Stazione Zoologica Anton Dohrn, Italy

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Table A8-7 Cross reference table of ranked order and Lab # for Figure 4-1

rank	Lab No.	Lab name
1	**7**	Laboratório de Nutrientes, Micronutrientes e Traços nos Oceanos (LABNUT-IOUSP), Instituto Oceanográfico da Universidade de São Paulo, Brazil
2	**95**	National Institute of Oceanography, India
3	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
4	**30**	Central Institute of Fisheries Technology, India
5	**102**	Stazione Zoologica Anton Dohrn, Italy
6	**51**	Marine Scotland - Science, UK
7	**17**	College of Marine and Environmental Sciences, Tianjin University of Science and Technology, China
8	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
9	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
10	**80**	Instituto del Mar del Perú, Peru
11	**106**	Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain
12	**107**	Observatoire oceanologique de Villefranche-sur-Mer (CNRS-UPMC), France
13	**97**	Geochemical & Environmental Research Group, Texas A&M University, USA
14	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
15	**38**	Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Japan
16	**56**	Scripps Institution of Oceanography, USA
17	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
18	**113**	Scripps Institution of Oceanography, CalCOFI Group, UC San Diego, USA
19	**65**	Hawaii Ocean Time-series, USA
20	**26**	Leibniz-Institute for Baltic Sea Research Warnemünde (IOW), Germany
21	**57**	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, USA
22	**96**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
23	**111**	Institute of Oceanology Polish Academy of Sciences, Marine Chemistry and Biochemistry Department, Poland
24	**35**	Japan Meteorological Agency, Japan
25	**19**	Ifremer, DYNECO/PELAGOS, Plouzané, France
26	**52**	Department of Earth, Ocean and Ecological Sciences, SOES, University of Liverpool, UK
27	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
28	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France

rank	Lab No.	Lab name
29	**50**	Plymouth Marine Laboratory, UK
30	**93**	GEOMAR Helmholtz Center for Ocean Research, Kiel, Germany
31	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
32	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
33	**20**	Ifremer, LERN, Port en Bessin, France
34	**59**	Monterey Bay Aquarium Research Institute, USA
35	**37**	Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, Japan
36	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
37	**39**	Royal NIOZ, Netherlands
38	**87**	Department of Fisheries and Oceans Canada, Canada
39	**88**	Faroe Marine Research Institute, Faroe Islands
40	**91**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
41	**40**	National Institute of Water and Atmospheric Research (NIWA), New Zealand
42	**100**	URI/Grad. School of Oceanography, USA
43	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
44	**4**	Queensland Health Forensic and Scientific Services, Australia
45	**114**	LOQyCA - Centro Nacional Patagonico (CONICET), Argentina
46	**90**	School of Earth and Environmental Science,University of Portsmouth, UK
47	**5**	OD NATURE – ECOCHEM, Belgium
48	**29**	Marine Research Institute, Iceland
49	**98**	University of Tartu, Estonian Marine Institute, Estonia
50	**64**	University of Hawaii, SOEST Laboratory for Analytical Biogeochemistry (S-LAB), USA
51	**32**	Israel Oceanographic & Limnological Res, National Institute of Oceanography, Israel
52	**108**	School of Fisheries and Ocean Sciences (SFOS) University of Alaska Fairbanks (UAF), USA
53	**49**	National Oceanography Centre, Southampton, UK
54	**104**	Australian Institute of Marine Science, Australia
55	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
56	**99**	Centro de Investigaciones Biológicas del, Noroeste SC., Mexico
57	**89**	Scottish Environment Protection Agency, UK

Table A8-8 Cross reference table of ranked order and Lab # for Figure 4-2

rank	Lab No.	Lab name
1	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
2	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
3	**56**	Scripps Institution of Oceanography, USA
4	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
5	**65**	Hawaii Ocean Time-series, USA
6	**35**	Japan Meteorological Agency, Japan
7	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
8	**96**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
9	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
10	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
11	**29**	Marine Research Institute, Iceland
12	**64**	University of Hawaii, SOEST Laboratory for Analytical Biogeochemistry (S-LAB), USA
13	**104**	Australian Institute of Marine Science, Australia
14	**5**	OD NATURE – ECOCHEM, Belgium
15	**102**	Stazione Zoologica Anton Dohrn, Italy
16	**49**	National Oceanography Centre, Southampton, UK
17	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
18	**51**	Marine Scotland - Science, UK

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Table A8-9 Cross reference table of ranked order and Lab # for Figure 5-1

rank	Lab No.	Lab name
1	**114**	LOQyCA - Centro Nacional Patagonico (CONICET), Argentina
2	**17**	College of Marine and Environmental Sciences, Tianjin University of Science and Technology, China
3	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
4	**106**	Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain
5	**108**	School of Fisheries and Ocean Sciences (SFOS) University of Alaska Fairbanks (UAF), USA
6	**98**	University of Tartu, Estonian Marine Institute, Estonia
7	**49**	National Oceanography Centre, Southampton, UK
8	**80**	Instituto del Mar del Perú, Peru
9	**99**	Centro de Investigaciones Biológicas del, Noroeste SC., Mexico
10	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
11	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
12	**38**	Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Japan
13	**95**	National Institute of Oceanography, India
14	**111**	Institute of Oceanology Polish Academy of Sciences, Marine Chemistry and Biochemistry Department, Poland
15	**93**	GEOMAR Helmholtz Center for Ocean Research, Kiel, Germany
16	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
17	**35**	Japan Meteorological Agency, Japan
18	**29**	Marine Research Institute, Iceland
19	**7**	Laboratório de Nutrientes, Micronutrientes e Traços nos Oceanos (LABNUT-IOUSP), Instituto Oceanográfico da Universidade de São Paulo, Brazil
20	**89**	Scottish Environment Protection Agency, UK
21	**87**	Department of Fisheries and Oceans Canada, Canada
22	**65**	Hawaii Ocean Time-series, USA
23	**59**	Monterey Bay Aquarium Research Institute, USA
24	**57**	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, USA
25	**96**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
26	**90**	School of Earth and Environmental Science,University of Portsmouth, UK
27	**5**	OD NATURE – ECOCHEM, Belgium
28	**102**	Stazione Zoologica Anton Dohrn, Italy
29	**52**	Department of Earth, Ocean and Ecological Sciences, SOES, University of Liverpool, UK
30	**107**	Observatoire oceanologique de Villefranche-sur-Mer (CNRS-UPMC), France

rank	Lab No.	Lab name
31	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
32	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
33	**100**	URI/Grad. School of Oceanography, USA
34	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
35	**39**	Royal NIOZ, Netherlands
36	**56**	Scripps Institution of Oceanography, USA
37	**64**	University of Hawaii, SOEST Laboratory for Analytical Biogeochemistry (S-LAB), USA
38	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
39	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
40	**113**	Scripps Institution of Oceanography, CalCOFI Group, UC San Diego, USA
41	**91**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
42	**50**	Plymouth Marine Laboratory, UK
43	**20**	Ifremer, LERN, Port en Bessin, France
44	**19**	Ifremer, DYNECO/PELAGOS, Plouzané, France
45	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
46	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
47	**26**	Leibniz-Institute for Baltic Sea Research Warnemünde (IOW), Germany
48	**104**	Australian Institute of Marine Science, Australia
49	**88**	Faroe Marine Research Institute, Faroe Islands
50	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
51	**32**	Israel Oceanographic & Limnological Res, National Institute of Oceanography, Israel
52	**51**	Marine Scotland - Science, UK
53	**4**	Queensland Health Forensic and Scientific Services, Australia
54	**97**	Geochemical & Environmental Research Group, Texas A&M University, USA
55	**40**	National Institute of Water and Atmospheric Research (NIWA), New Zealand
56	**30**	Central Institute of Fisheries Technology, India
57	**45**	University of Cape town, Dept of Oceanography, South Africa

Table A8-10 Cross reference table of ranked order and Lab # for Figure 5-2

rank	Lab No.	Lab name
1	**5**	OD NATURE – ECOCHEM, Belgium
2	**8**	Institute of Biology, Rio de Janeiro Federal University, Brazil
3	**49**	National Oceanography Centre, Southampton, UK
4	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
5	**29**	Marine Research Institute, Iceland
6	**35**	Japan Meteorological Agency, Japan
7	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
8	**65**	Hawaii Ocean Time-series, USA
9	**56**	Scripps Institution of Oceanography, USA
10	**96**	Department of Fisheries and Oceans Canada, Institute of Ocean Sciences, Canada
11	**14**	State Key laboratory of Marine Environmental Science, Xiamen University, China
12	**102**	Stazione Zoologica Anton Dohrn, Italy
13	**64**	University of Hawaii, SOEST Laboratory for Analytical Biogeochemistry (S-LAB), USA
14	**104**	Australian Institute of Marine Science, Australia
15	**109**	Oceanographic Measurement & Instrument Calibration Service Center (OMICS)/Korea Institute of Ocean Science & Technology, Republic of Korea
16	**27**	Bundesamt für Seeschifffahrt und Hydrographie (BSH), Laboratorium Sülldorf, Germany
17	**51**	Marine Scotland - Science, UK
18	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France

Appendix IV

Invitation letter to 2015 I/C exercise

24 October 2014

Dear Colleague,

The International Ocean Carbon Coordination Project (IOCCP) and Japan Agency for Marine-Earth Science and Technology (JAMATEC) are pleased to invite you to participate in the 4th International Inter-Calibration Exercise, the "2014 inter-laboratory comparison study of Certified Reference Material of Nutrients in Seawater and Reference Material of Nutrients in Seawater (CRM & RMNS)".

This "2014 Inter-comparison study of Certified Reference Material of Nutrients in Seawater and Reference Material of Nutrients in Seawater (CRM & RMNS)" is planned to test the global comparability of nutrient measurements and to promote the use of CRM/RM of nutrients in seawater. As with the previous four inter-comparison studies organized by MRI-JMA, the aim is also to improve the level of comparability by exchange of knowledge between participating laboratories. Therefore, if you join this inter-comparison study, you will be asked to report (1) the concentrations of nutrients in the samples we send you and (2) details of analytical methods you used. The scale of the study has been expanded and a total of 85 laboratories are receiving this invitation across five continents.

You can consult the reports from previous inter-laboratory comparison studies of Reference Material of Nutrients in Seawater (RMNS) conducted in 2006, 2008 and 2012 at the MRI's web site:

http://www.mri-jma.go.jp/Dep/oc/oc_3/RMNScomp2012/RMNScomp2012.html (2012)
http://www.mri-jma.go.jp/Publish/Technical/DATA/VOL_60/60_en.html (2008)
http://www.mri-jma.go.jp/Publish/Technical/DATA/VOL_58/58_en.html (2006)

A chapter of the GO-SHIP manual on nutrient methods entitled *Recommendations for the Determination of Nutrients in Seawater to High Levels of Precision and Inter-Comparability using Continuous Flow Analyzers* (Hydes et al., 2010) produced following the 2012 inter-comparison is available from the GO-SHIP website at http://www.go-ship.org/HydroMan.html

Please use the attached reply form to confirm your participation. Take note of the following timetable and important points:

1. Your acceptance must be received by 30 November 2014.
2. We will acknowledge receipt of your reply and send out a list of the participants by 15 December 2014. If you do not receive an acknowledgement by 15 December 2014, please contact us.
3. A positive reply to us confirms: (1) your wish to participate in this inter-comparison study and (2) your ability to meet the reporting deadline of 28 February 2015.
4. You will receive four samples of RMNS free of charge from experiment organizers. If you want to analyze three levels of CRMs distributed by NMIJ, Japan or/and MOOS-3 by NRC, Canada, you will need to pay for them. A cost per bottle is about JPY 22,000 (roughly 200 USD). Credit card or bank transfer will be accepted

methods of payment. We realize that the cost of CRMs might be substantial for some laboratories but for the benefit of the final results we would like to strongly encourage all participants to analyze the CRMs. Details of the payment will be sent separately when you order CRMs.

5. We expect to receive data on concentrations for nitrate, nitrite, phosphate and silicate from all participants.
6. We also welcome data for concentrations of ammonia and dissolved organic nitrogen and phosphorus from labs able to perform such analyses.
7. All resulting data reports will fully acknowledge the contribution of each participant.
8. The data set will be archived at CDIAC and will receive a digital object identifier number (doi).

Best regards,

Prof. Michio AOYAMA, Dr.
Principal Research Scientist, RCGC - JAMSTEC
Professor, Institute of Environmental Radioactivity, Fukushima University, Japan
IOCCP Scientific Steering Group Expert for Nutrients (www.ioccp.org/nutrients)
Tel: +81-24-504-2882
E-mail: r706@ipc.fukushima-u.ac.jp

2014 Inter-comparison study of Reference Material of Nutrients (RMNS) in seawater

Important Dates

Deadline for Reply:	30 November 2014
List of Participants:	15 December 2014
Samples Shipped by:	Mid-December 2014
Reporting Deadline:	28 February 2015
Expected Draft of Inter-comparison Summary:	30 June 2015

Application form for 2014 Inter-comparison study of Reference Material of Nutrients in Seawater (RMNS)

I have received your letter and now return this sheet to confirm my intention to participate.

Name:		
Affiliation:		
Full postal address to receive samples:		
E-mail		
Date:		
The geographical coordinate of your laboratory as latitude and longitude (we use this data to make a plot of geographical distribution of participating laboratory)	Lat.	
	Long.	
I agree to pay for MOOS-3	YES NO	
I agree to pay for NMIJ CRM 7601-a	YES NO	
I agree to pay for NMIJ CRM 7602-a	YES NO	
I agree to pay for NMIJ CRM 7603-a	YES NO	
Your comment:		

PLEASE RETURN APPLICATION FORM TO

By email to: ic_crm_rmns@jamstec.go.jp
And by standard mail to:

Prof. Michio AOYAMA, Dr.
Institute of Environmental Radioactivity, Fukushima University
Kanayagawa-1, Fukushima, 963-1260, Japan

Appendix V

Description on KIOST Nutrient Reference Materials for Seawater (K-RMS)

Contents

List of Tables and Figures

Description on KIOST Nutrient Reference Materials for Seawater (K-RMS)

1. Source seawater

Natural seawater was collected from the surface at the coastal station (37º 3' 52.91"N, 129º 25' 32.94"E) in Korea and from the surface and 1500 m depth at a station (37 ºN, 131 ºE) in the Ulleung Basin of the East/Japan Sea. Seawater from the surface of coastal station was collected using acid cleaned bucket on February, 2013 and seawater from the surface and 1500 m of open station was collected Niskin bottles on R/V Eardo on May, 2014.

2. Pasteurization

Natural Seawater was filtered into a 100L titanium tank through 0.22-um pore size membrane filter and was autoclaved at 120 ºC 210 kPa for 2 hours. Then it was cooled down to room temperature with homogenizing on rotary turn table.

3. Bottling

Pasteurized seawater was directly transferred to sterilized 15ml test tube with screw cap (Kartell, Germany) for one day within Class 100 clean bench in a class 1000 clean room. 1000 tubes were produced for each batch of K-RMS and three batches were produced in total.

4. Package

Three batches of K-RMS were vacuum sealed with aluminum film bag in the clean room. Total dimension of package is 10 cm*10 cm*3cm and total weight will be less than 50 g. Each bottle contains only 12 ml of reference material.

5. Homogeneity

Nutrients were analyzed using QuAAtro CFA system (SEAL analytical). During the

analysis, reference materials of nutrients in seawater (KANSO techno, MOOS-2) were analyzed simultaneously. Our results of reference material were remained within the expanded uncertainty provided by the manufacturers.

Table KIOST 1-1 Comparison between certified value by KANSO and measured value by KIOST

RM		Nitrite μmol kg^{-1}	Nitrate+Nitrite μmol kg^{-1}	Ammonium μmol kg^{-1}	Phosphate μmol kg^{-1}	Silicate μmol kg^{-1}
KANSO BT measured	Average	0.466	18.624	2.023	1.297	152.789
	SD	0.024	0.122	0.206	0.010	0.979
	n	24	24	30	9	30
KANSO BT certified	Average	0.471	18.621	-	1.296	154.20
	SD	0.011	0.24	-	0.027	0.400

20 tubes out of each batch were analyzed for homogeneity test.

Table KIOST 1-2 Homegeneity of K-RMS

K-RMS (Salinity)		Nitrite μmol kg^{-1}	Nitrate+Nitrite μmol kg^{-1}	Ammonium μmol kg^{-1}	Phosphate μmol kg^{-1}	Silicate μmol kg^{-1}
K-RMS NAD (28.140)	Average	0.6	13.34	5.97	0.462	14.13
	SD	0.05	0.07	0.19	0.005	0.02
	CV, %	0.67	0.51	3.2	1.06	0.19
K-RMS NAE (34.191)	Average	0.96	6.29	1.7	0.197	9.05
	SD	0.01	0.03	0.06	0.02	0.02
	CV, %	0.82	0.45	3.5	9.90	0.27
K-RMS NAF (34.000)	Average	0.61	20.51	1.22	1.641	78.83
	SD	0.020	0.08	0.11	0.02	0.1
	CV, %	3.19	0.40	9.4	1.01	0.13

K-RMS NAG (34.210)	Average	0.21	11.02	1.17	0.775	40.04
	SD	0.00	0.05	0.02	0.007	0.1
	CV, %	1.9	0.44	1.9	0.882	0.25

6. Assigned value

Property values of K-RMS were assigned based on 15 measurements for 3~5 months. Randomly selected K-RMS were analyzed with triplicate.

Table KIOST 1-3 Assigned values of KIOST RMS

K-RMS (Salinity)		Nitrite μmol kg^{-1}	Nitrate+Nitrite μmol kg^{-1}	Ammonium μmol kg^{-1}	Phosphate μmol kg^{-1}	Silicate μmol kg^{-1}
K-RMS NAD (28.140)	Average	0.56	13.34	5.97	0.457	14.13
	SD	0.09	0.36	0.19	0.026	0.05
	CV, %	10.8	2.71	3.20	5.79	0.36
K-RMS NAE (34.191)	Average	0.96	6.27	1.7	0.208	9.02
	SD	0.01	0.06	0.06	0.034	0.04
	CV, %	0.919	0.935	3.51	16.4	0.43
K-RMS NAF (34.000)	Average	0.60	20.51	1.22	1.641	78.54
	SD	0.02	0.24	0.117	0.036	0.38
	CV, %	3.73	1.16	9.36	2.20	0.49
K-RMS NAG (34.210)	Average	0.19	11.02	1.17	0.787	39.95
	SD	0.01	0.09	0.02	0.027	0.23
	CV, %	5.02	0.809	1.92	3.47	0.57

7. Ranked scatter-plots

Ranked scatter-plots of nitrate+nitrite, nitrate, nitrite, phosphate and silicate of four K-RMS are shown at Figure 1 to 5. For nitrate+nitrite, nitrate, phosphate and silicate, the laboratories results were sorted in order of the concentrations reported for NAF. For nitrite, the laboratories results were sorted in order of the concentrations for NAE. General trends of ranked scatter-plots of K-RMS are similar to those of KANSO

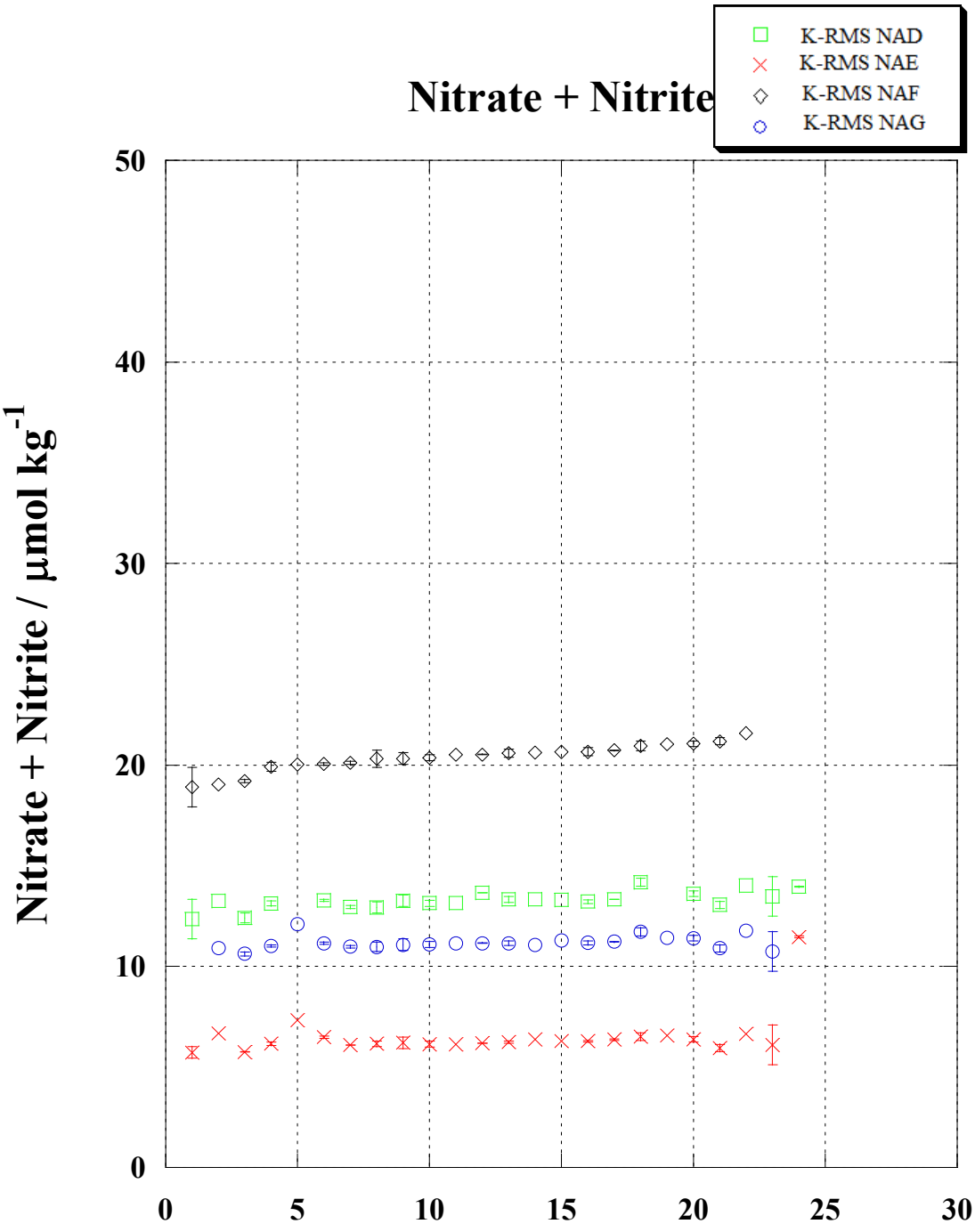

Figure KIOST 1. Nitrate+Nitrite results for KIOST RMs. Laboratories are ranked in order of concentrations reported for NAF.

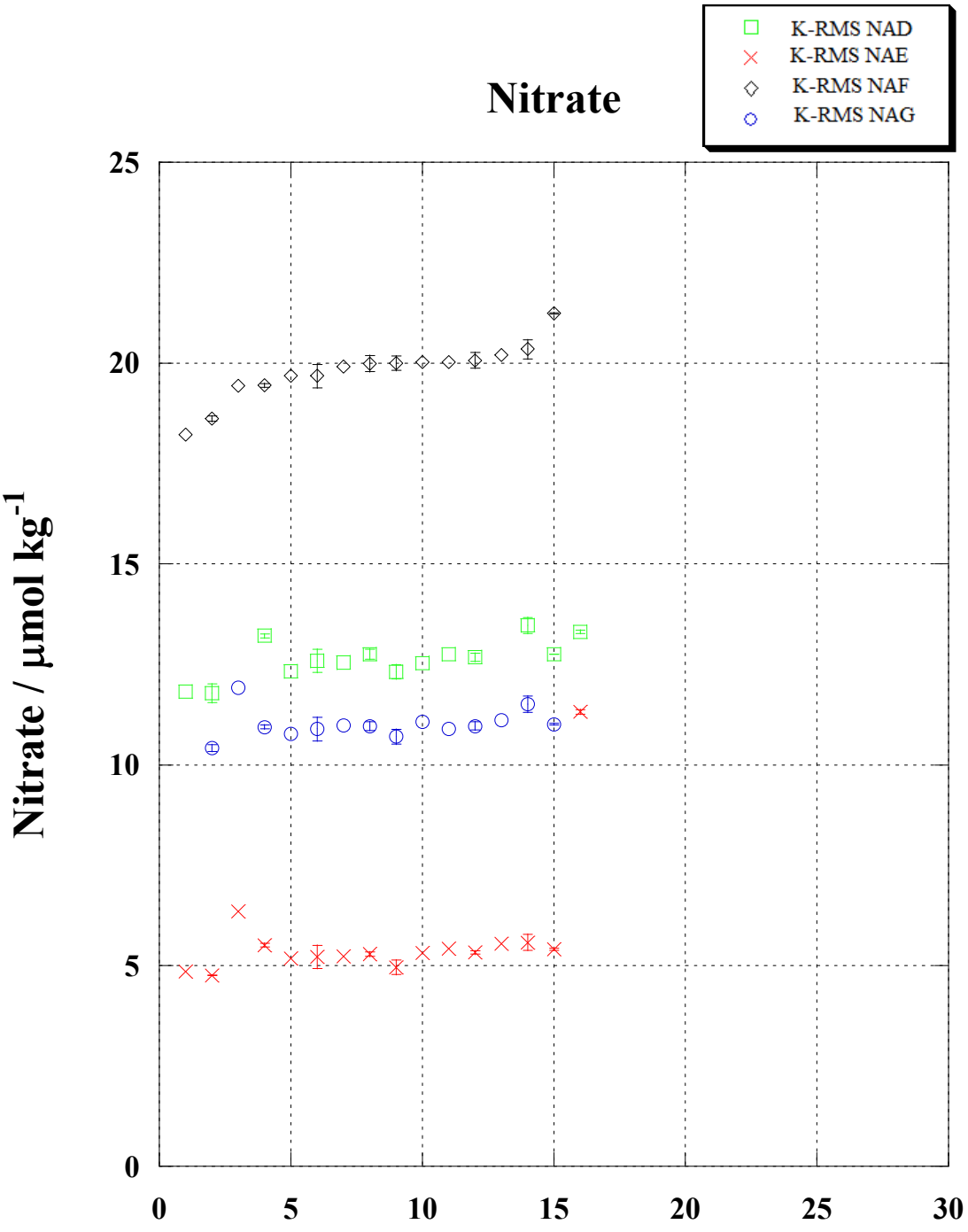

Figure KIOST 2. Nitrate results for KIOST RMs. Laboratories are ranked in order of concentrations reported for NAF.

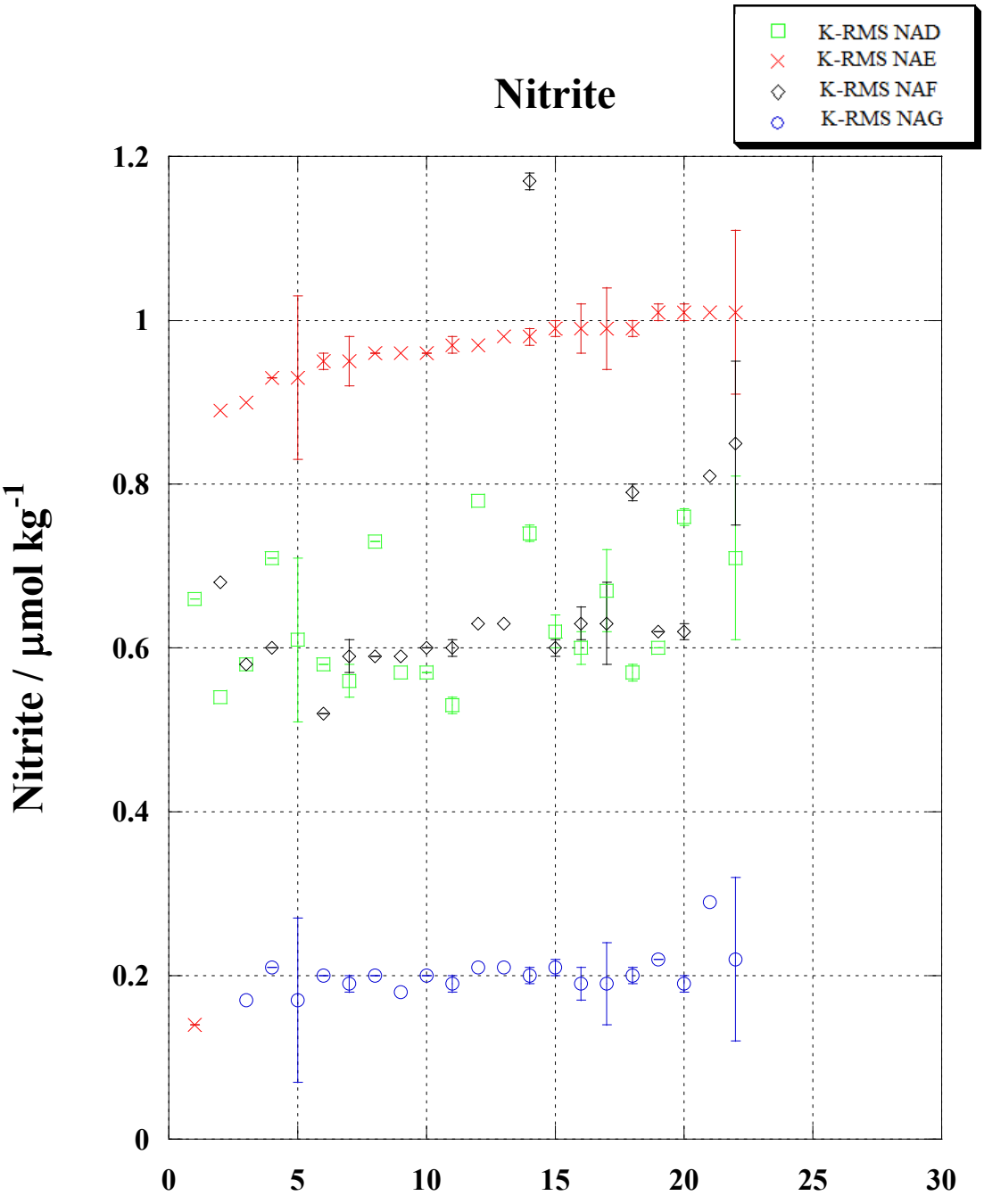

Figure KIOST 3. Nitrite results for KIOST RMs. Laboratories are ranked in order of concentrations reported for NAE.

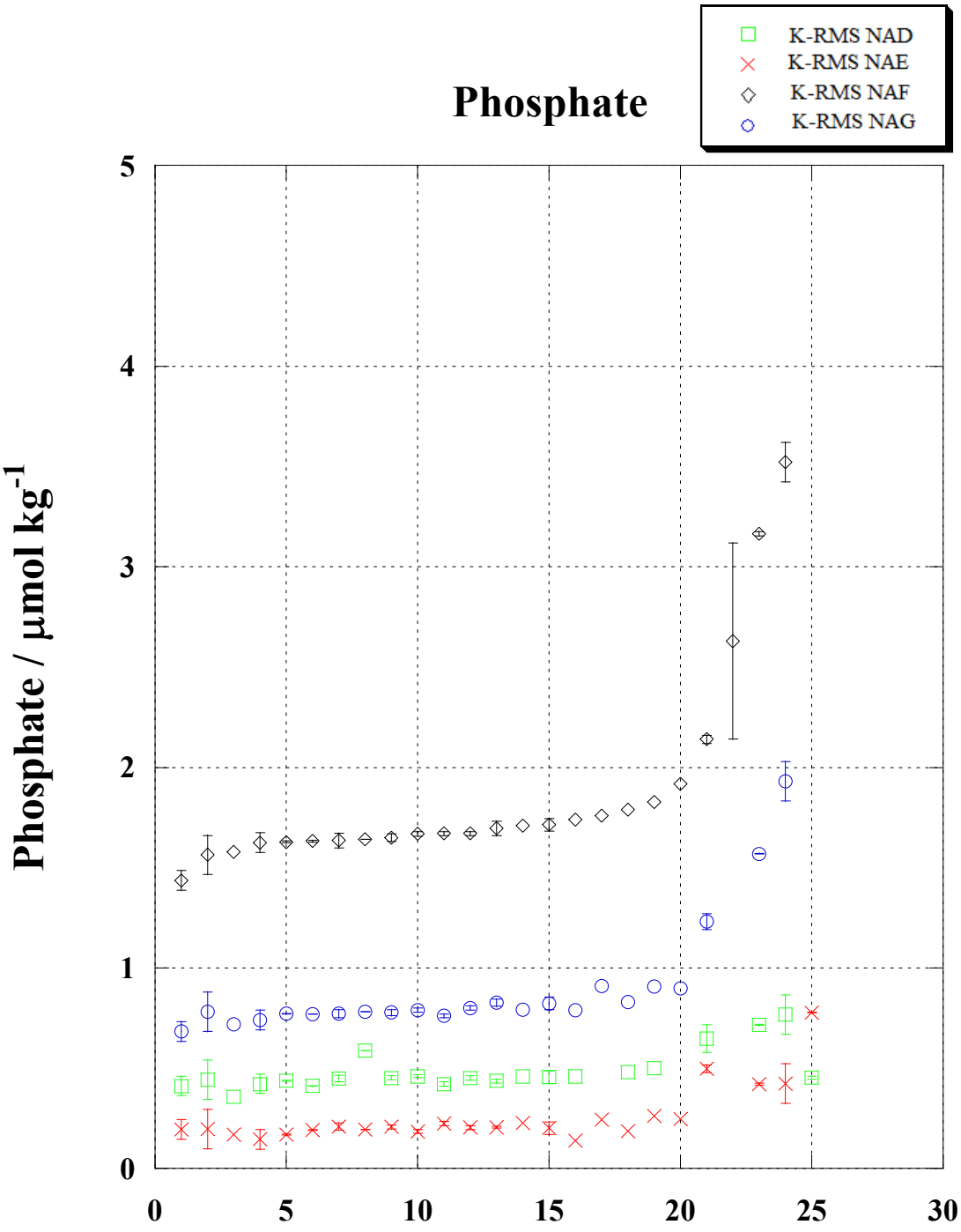

Figure KIOST 4. Phosphate results for KIOST RMs. Laboratories are ranked in order of concentrations reported for NAF.

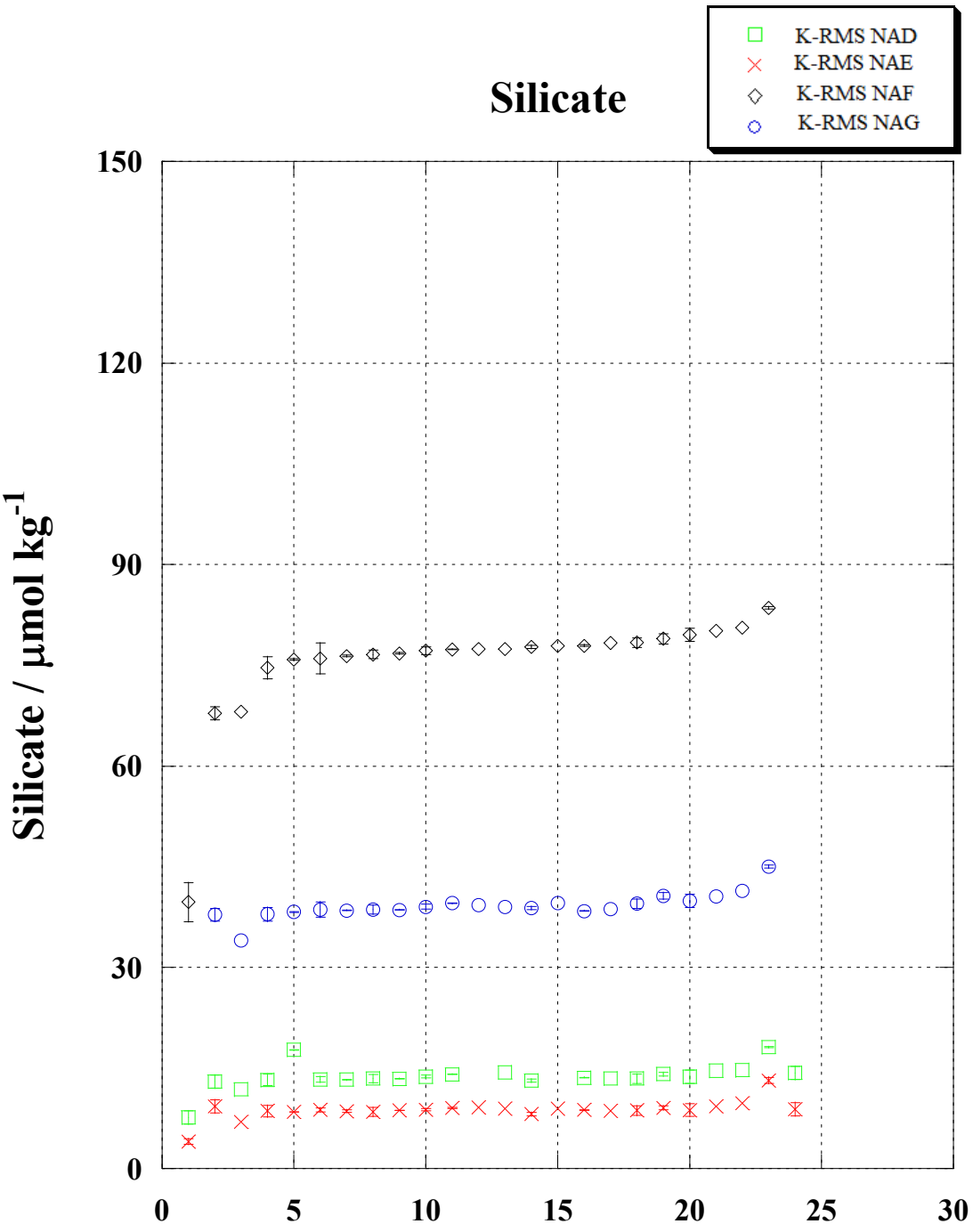

Figure KIOST 5. Silicate results for KIOST RMs. Laboratories are ranked in order of concentrations reported for NAF.

8. Participants and response

During 2104 IOCCP/JAMSTEC co-organized inter-laboratory comparison study of nutrient reference material, 34 laboratories from 20 countries were voluntarily participated for the analysis of KIOST nutrient reference material (K-RMS). Results were submitted by 27 laboratories. Table KIOST-2 summarizes numbers of response from participants and participant numbers used for statistical treatment in this report.

Table KIOST 2. Summary of responses from participants.

Nutrient	Sample #	Number of results		Nutrient	Sample #	Number of results	
		Received	Statistically treated			Received	Statistically treated
Nitrate +Nitrite	NAE	26	26	Phosphate	NAE	26	26
	NAG	25	25		NAG	26	26
	NAD	23	23		NAD	23	23
	NAF	25	25		NAF	27	27
Nitrate	NAE	18	18	Silicate	NAE	26	26
	NAG	17	17		NAG	25	25
	NAD	15	15		NAD	23	23
	NAF	18	18		NAF	26	26
Nitrite	NAE	24	24	Ammonia	NAE	12	12
	NAG	23	23		NAG	12	12
	NAD	21	21		NAD	9	9
	NAF	23	23		NAF	12	12

9. Consensus means, medians, and standard deviations

The consensus means and medians for all parameters are in good agreement with the assigned values within the standard deviations.

Table KIOST 3. Raw and robust statistics for nutrient concentrations calculated using all reported values.

Nutrient	Sample #	n	Raw Mean	Raw Median	Raw SD	Robust mean	Robust SD
			µmol kg^{-1}	µmol kg^{-1}	µmol kg^{-1}	µmol kg^{-1}	µmol kg^{-1}
Nitrate+Nitrite	NAE	26	6.51	6.29	1.06	6.31	0.28
	NAG	25	11.23	11.16	0.35	11.22	0.35
	NAD	23	13.29	13.27	0.43	13.29	0.32
	NAF	25	20.49	20.58	0.71	20.54	0.63
Nitrate	NAE	18	5.68	5.37	1.45	5.36	0.29
	NAG	17	11.09	10.98	0.37	11.07	0.34
	NAD	15	12.65	12.68	0.48	12.66	0.46
	NAF	18	19.96	20.01	0.77	19.98	0.55
Nitrite	NAE	24	0.93	0.97	0.17	0.97	0.04
	NAG	23	0.21	0.20	0.04	0.20	0.02
	NAD	21	0.63	0.60	0.08	0.63	0.09
	NAF	23	0.67	0.62	0.14	0.65	0.10
Phosphate	NAE	26	0.25	0.21	0.14	0.21	0.04
	NAG	26	0.89	0.80	0.28	0.82	0.08
	NAD	23	0.48	0.45	0.10	0.46	0.04
	NAF	27	1.86	1.70	0.48	1.73	0.14
Silicate	NAE	26	8.71	8.77	1.40	8.78	0.43
	NAG	25	39.07	39.00	1.92	39.21	0.99
	NAD	23	13.66	13.49	1.94	13.65	0.86
	NAF	26	75.58	77.39	8.11	77.27	2.56

Table KIOST 4. Consensus means, medians, and standard deviations for 4 samples.

Nutrient	Sample #	n	Consensus Mean	Consensus Median	Consensus SD
			μmol kg^{-1}	μmol kg^{-1}	μmol kg^{-1}
Nitrate+Nitrite	NAE	22 (26)	6.31	6.29	0.20
	NAG	24 (25)	11.20	11.15	0.31
	NAD	16 (23)	13.22	13.26	0.15
	NAF	20 (25)	20.59	20.60	0.40
Nitrate	NAE	13 (18)	5.39	5.41	0.14
	NAG	16 (17)	11.04	10.98	0.31
	NAD	15 (15)	12.65	12.68	0.48
	NAF	14 (18)	19.98	20.01	0.33
Nitrite	NAE	21 (24)	0.97	0.98	0.03
	NAG	19 (23)	0.20	0.20	0.01
	NAD	21 (21)	0.63	0.60	0.08
	NAF	15 (23)	0.61	0.60	0.02
Phosphate	NAE	19 (26)	0.21	0.21	0.02
	NAG	22 (26)	0.81	0.79	0.05
	NAD	17 (23)	0.45	0.45	0.02
	NAF	18 (27)	1.66	1.66	0.05
Silicate	NAE	20 (26)	8.84	8.78	0.24
	NAG	19 (25)	38.91	38.84	0.63
	NAD	18 (23)	13.72	13.53	0.52
	NAF	16 (26)	77.38	77.39	0.87

Table KIOST 5-1. Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in NAE.

Nutrients	Analytical precision of participating laboratories		Consensus coefficient of variation	
	n	Median% (range)	n	CV%
Nitrate+Nitrite	17	1.3 (0-16.1)	22	3.2
Phosphate	17	4.8 (0-49.8)	19	9.5
Silicate	17	3.2 (0-11.2)	20	2.7

Table KIOST 5-2. Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in NAG.

Nutrients	Analytical precision of participating laboratories		Consensus coefficient of variation	
	n	Median% (range)	n	CV%
Nitrate+Nitrite	15	1 (0.1-9.1)	24	2.8
Phosphate	16	2 (0-12.5)	22	6.3
Silicate	15	1 (0.1-3)	19	1.6

Table KIOST 5-3. Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in NAD.

Nutrients	Analytical precision of participating laboratories		Consensus coefficient of variation	
	n	Median% (range)	n	CV%
Nitrate+Nitrite	17	1.1 (0-7.9)	16	1.1
Phosphate	17	2.2 (0-22.1)	17	4.4
Silicate	17	2.1 (0.1-12.8)	18	3.8

Table KIOST 5-4. Median and range of analytical precision of participating laboratories, and consensus coefficient of variation for analyses of nutrients in NAF.

Nutrients	Analytical precision of participating laboratories		Consensus coefficient of variation	
	n	Median% (range)	n	CV%
Nitrate+Nitrite	15	0.9 (0.1-5.2)	20	1.9
Phosphate	17	1.2 (0-18.6)	18	3
Silicate	16	0.8 (0.1-7.4)	16	1.1

10. Z-score

Table KIOST 6-1. *Z*-scores for nitrate+nitrite analyses.

Lab	NAE	NAG	NAD	NAF
5	0.4	0.1	0.7	0.0
6	2.8	1.9	5.5	3.5
10	0.6	0.4	0.3	0.7
23	0.1	0.3	0.6	0.2
28	1.0	1.7	6.4	0.9
29	0.9	0.4	0.5	0.6
35	0.7	0.1	2.9	0.2
39	0.1	0.1	0.1	0.2
41	5.1	2.9		1.4
49_AA3	0.9	0.2	0.5	0.2
49_QuAAtro	0.3	0.7	1.1	0.9
50	0.3	0.1	0.7	0.3
51	1.1	1.5	1.7	
56	1.9	1.0	1.1	1.5
57	1.7	1.8	5.3	2.5
65	1.1	0.7	1.8	1.2
80				
86	25.8		5.0	
87	0.4	0.4	0.7	0.1
88	1.9	0.9	0.2	3.9
89	0.8	0.6	0.7	1.7
92	0.9	0.2	0.3	1.4
98	2.9		5.7	4.2
101	0.8	0.8	2.0	0.7
102	1.3	0.7		1.1
102	1.3	1.7		1.8
102		1.6		2.8
112	0.3	0.6	2.6	1.2

Table KIOST-6-2. *Z*-scores for nitrate analyses.

Lab	NAE	NAG	NAD	NAF
5	0.7	0.2	0.2	0.0
6	4.5	2.0	1.8	4.1
10	1.2	0.5	0.1	0.9
23	0.5	0.1	0.2	0.1
28	1.4	1.5	1.7	1.1
29				
35				
39	0.4	0.2	0.1	0.3
41	6.9	2.8		1.6
49_AA3	1.1	0.2	0.2	0.2
49_QuAAtro	0.4	0.7	0.4	1.2
50	0.1	0.1	0.2	3.8
51				
56	3.1	1.1	0.7	0.1
57				
65				
80				
86	42.4		1.4	
87	0.2	0.5	0.2	0.1
88				
89				
92	0.9	0.3	1.2	1.6
98	3.9		1.7	5.3
101	1.5	0.9	0.7	0.9
102	1.1	0.3		0.7
102	1.3	1.3		1.8
102		2.0		4.4
112				

Table KIOST-6-3. *Z*-scores for nitrite analyses.

Lab	NAE	NAG	NAD	NAF
5	0.7	1.0	0.9	1.0
6	0.7	1.0	0.1	0.5
10	0.7	1.0	0.5	1.0
23	0.0	1.0	1.9	1.0
28	1.3	1.0	1.0	0.5
29	1.3	1.0	1.6	0.5
35	0.3	0.0	1.3	1.0
39	0.0	1.0	1.3	0.5
41	0.3	1.0		1.0
49_AA3	2.3	3.0	0.6	1.5
49_QuAAtro	1.7	4.0	1.0	2.0
50	0.7	0.0	0.6	4.5
51	1.3	3.0	0.3	
56	0.3	0.0	1.4	28.0
57				
65				
80	1.3	2.0	1.0	12.0
86	27.7		0.4	
87	0.3	2.0	0.8	1.0
88				
89	1.3	2.0	0.4	0.5
92	0.3	0.0	0.8	0.5
98	2.7		1.1	3.5
101	0.7	1.0	0.4	1.0
102	1.3	9.0		10.0
102	1.0	9.0		7.0
102		11.8		9.0
112	0.7	0.0	0.8	9.0

Table KIOST-6-4. *Z*-scores for phosphate analyses.

Lab	NAE	NAG	NAD	NAF
5	0.2	0.3	0.7	0.7
6	14.4	8.4	9.9	9.6
10	3.2	1.4	1.4	0.7
23	1.2	0.4	1.6	2.6
28	0.8	2.5	1.9	4.5
29	0.4	0.3	0.3	1.1
35	0.7	0.6	7.0	0.4
39	0.1	0.6	0.2	0.2
41	1.7	2.0		2.0
49_AA3	2.7	2.0	2.5	3.3
49_QuAAtro	0.3	0.0	0.1	0.8
50	2.0	0.7	0.6	0.6
51	0.7	0.5	0.3	1.9
56	0.8	1.0	1.4	0.2
57	2.0	1.8	4.5	1.6
65	0.9	0.8	1.9	0.5
80	10.7	22.4	16.0	37.2
86	28.4		0.2	
87	1.0	0.3	0.5	1.0
88	3.5	0.4	0.6	1.6
89	10.6	15.2	13.3	30.1
92	1.3	0.4	0.6	0.2
98				19.4
101	0.0	0.7	0.1	0.5
102	1.9	1.8		5.1
102	0.7	1.4		4.4
102		1.5		0.1
112	0.3	0.2	0.1	0.2

Table KIOST-6-5. *Z*-scores for silicate analyses.

Lab	NAE	NAG	NAD	NAF
5	0.3	0.5	0.8	1.6
6	18.0	9.7	8.5	7.1
10	0.3	1.6	0.0	2.5
23	4.1	4.0	1.9	3.7
28	0.9	2.8	0.7	1.8
29	1.5	0.5	0.5	0.9
35	1.5	1.1	7.7	1.7
39	0.2	0.2	0.0	0.2
41	1.0	0.6		0.0
49_AA3	7.6	7.8	3.7	10.7
49_QuAAtro	5.6	4.8	3.3	6.9
50	0.3	0.8	0.3	0.6
51	0.0		1.1	
56	0.6	0.9	0.5	1.1
57	0.7	0.1	1.3	0.0
65	0.6	0.6	0.6	0.7
80	1.9	1.7	1.4	10.9
86				
87	0.9	0.4	0.4	1.1
88	2.0	2.6	1.7	3.1
89	1.0	0.7	0.9	1.2
92	0.9	1.0	0.7	0.0
98	19.9		11.7	43.3
101	1.0	1.6	0.9	3.2
102	0.4	1.0		0.6
102	0.6	1.6		0.6
102		0.8		5.0
112	2.9	0.1	1.1	0.4

Table KIOST-6-6. Combined *Z*-scores for phosphate and nitrate+nitrite analyses.

Lab	NAE	NAG	NAD	NAF
5	0.3	0.2	0.7	0.4
6	8.6	5.2	7.7	6.6
10	1.9	0.9	0.9	0.7
23	0.7	0.4	1.1	1.4
28	0.9	2.1	4.2	2.7
29	0.7	0.4	0.4	0.9
35	0.7	0.4	5.0	0.3
39	0.1	0.4	0.2	0.2
41	3.4	2.5		1.7
49_AA3	1.8	1.1	1.5	1.8
49_QuAAtro	0.3	0.4	0.6	0.9
50	1.2	0.4	0.7	0.5
51	0.9	1.0	1.0	
56	1.4	1.0	1.3	0.9
57	1.9	1.8	4.9	2.1
65	1.0	0.8	1.9	0.9
80				
86	27.1		2.6	
87	0.7	0.4	0.6	0.6
88	2.7	0.7	0.4	2.8
89	5.7	7.9	7.0	15.9
92	1.1	0.3	0.5	0.8
98				11.8
101	0.4	0.8	1.1	0.6
102	1.6	1.3		3.1
102	1.0	1.6		3.1
102		1.6		1.5
112	0.3	0.4	1.4	0.7

Table KIOST-6-7. Combined *Z*-scores for phosphate, nitrate+nitrite, and silicate analyses.

Lab	NAE	NAG	NAD	NAF
5	0.3	0.3	0.7	0.8
6	11.7	6.7	8.0	6.7
10	1.4	1.1	0.6	1.3
23	1.8	1.6	1.4	2.2
28	0.9	2.3	3.0	2.4
29	0.9	0.4	0.4	0.9
35	1.0	0.6	5.9	0.8
39	0.1	0.3	0.1	0.2
41	2.6	1.8		1.1
49_AA3	3.7	3.3	2.2	4.7
49_QuAAtro	2.1	1.8	1.5	2.9
50	0.9	0.5	0.5	0.5
51	0.6		1.0	
56	1.1	1.0	1.0	0.9
57	1.5	1.2	3.7	1.4
65	0.9	0.7	1.4	0.8
80				
86				
87	0.8	0.4	0.5	0.7
88	2.5	1.3	0.8	2.9
89	4.1	5.5	5.0	11.0
92	1.0	0.5	0.5	0.5
98				22.3
101	0.6	1.0	1.0	1.5
102	1.2	1.2		2.3
102	0.9	1.6		2.3
102		1.3		2.6
112	1.2	0.3	1.3	0.6

Table KIOST-A1. List of participants.

Lab#	Name	Affliation	Country
5	Marc Knockaert	OD NATURE – ECOCHEM	Belgium
6	Steven Bell	Bermuda Institute of Ocean Sciences	Bermuda
10	Chris Payne	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences	Canada
23	Patrick Raimbault	Mediterranean Institute of Oceanology (MIO) Campus de Luminy	France
28	Kai-Uwe Ludwichowski	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research	Germany
29	Sólveig Rósa Ólafsdóttir	Marine Research Institute	Iceland
35	Sukeyoshi Takatani	Japan Meteorological Agency	Japan
39	Jan van Ooijen	Royal NIOZ	Netherlands
41	Kjell Gundersen	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research	Norway
49	Sinhué Torres-Valdés	National Oceanography Centre, Southampton	UK
50	E. Malcolm S. Woodward	Plymouth Marine Laboratory	UK
51	Pamela Walsham Alison Taylor	Marine Scotland - Science	UK
56	Susan Becker	Scripps Institution of Oceanography	USA
57	Jia-Zhong Zhang	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida	USA
65	Susan Curless Matt Church	Hawaii Ocean Time-series	USA
80	Jesús Ledesma	Instituto del Mar del Perú	Peru
86	Martina Kralj	Istituto Nazionale di Oceanografia e Geofisica Sperimentale	Italy
87	Peter Thamer	Department of Fisheries and Oceans Canada	Canada
88	Sólvá Jacobsen	Faroe Marine Research Institute	Faroe Islands

Lab#	Name	Affliation	Country
89	Trevor McCormack	Scottish Environment Protection Agency	UK
92	Thierry Cariou	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie	France
98	Silvie Lainela	University of Tartu, Estonian Marine Institute	Estonia
101	Jae-Hyun Lim	Marine Environment Research Division, National Institute of Fisheries Science	Republic of Korea
102	Francesca Margiotta	Stazione Zoologica Anton Dohrn	Italy
112	Carol Anstey Christine Rees	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research	Australia

Table KIOST-A2. Results reported by the participants.

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
5																					
	NAD-1362	2015	05	15	22	13.32	0.14	2	12.75	0.12	2	0.56	0.02	2	0.437	0.009	2	13.31	0.4	2	
	NAE-0887	2015	05	15	22	6.24	0.06	2	5.29	0.05	2	0.95	0.03	2	0.207	0.004	2	8.77	0.26	2	
	NAF-0705	2015	05	15	22	20.58	0.21	2	19.99	0.2	2	0.59	0.02	2	1.697	0.035	2	76.01	2.28	2	
	NAG-0817	2015	05	15	22	11.16	0.11	2	10.97	0.11	2	0.19	0.01	2	0.827	0.017	2	38.59	1.16	3	
6																					
	NAD-1504	2015	02	26	22.6	12.4	0.25	2	11.78	0.23	2	0.62	0.02	2	0.648	0.069	2	18.13	0.11	2	
	NAE-0867	2015	02	26	22.6	5.75	0.01	2	4.76	0.01	2	0.99	0.01	2	0.498	0.02	2	13.16	0.44	2	
	NAF-0861	2015	02	26	22.6	19.21	0.08	2	18.62	0.07	2	0.6	0.01	2	2.14	0.02	2	83.53	0.15	2	
	NAG-0890	2015	02	26	22.6	10.62	0.09	2	10.42	0.08	2	0.21	0.01	2	1.231	0.039	2	45	0.2	3	
10																					
	NAD-1528	2015	03	26	21	13.26	0.29	2	12.59	0.29	2	0.67	0.05	2	0.423	0.049	2	13.73	0.98	2	
	NAE-0859	2015	03	26	21	6.2	0.29	2	5.22	0.29	2	0.99	0.05	2	0.147	0.049	2	8.76	0.98	2	
	NAF-0858	2015	03	26	21	20.32	0.29	2	19.68	0.29	2	0.63	0.05	2	1.625	0.049	2	79.56	0.98	2	
	NAG-0873	2015	03	26	21	11.08	0.29	2	10.89	0.29	2	0.19	0.05	2	0.74	0.049	2	39.93	0.98	3	
23																					
	NAD-350	2015	02	09	21	13.31		2	12.54		2	0.78		2	0.481		2	14.73		2	
	NAE-0142	2015	02	09	21	6.29		2	5.32		2	0.97		2	0.186		2	9.82		2	
	NAF-0070	2015	02	09	21	20.65		2	20.02		2	0.63		2	1.788		2	80.59		2	
	NAG-0100	2015	02	09	21	11.28		2	11.08		2	0.21		2	0.832		2	41.43		3	
28																					
	NAD-1359	2015	02	15	22	14.18	0.2	2	13.47	0.2	2	0.71	0	2	0.412	0.049	2	14.09	0.29	2	
	NAE-0817	2015	02	15	22	6.51	0.2	2	5.58	0.2	2	0.93	0	2	0.195	0.049	2	9.06	0.29	2	
	NAF-0704	2015	02	15	22	20.95	0.24	2	20.35	0.24	2	0.6	0	2	1.436	0.049	2	78.94	0.78	2	
	NAG-0816	2015	02	15	22	11.71	0.2	2	11.51	0.2	2	0.21	0	2	0.684	0.049	2	40.64	0.49	3	
29																					
	NAD-1516	2015	01	19	21	13.14	0.15	2				0.76	0.01	2	0.456	0.032	2	13.44	0.63	2	
	NAE-0898	2015	01	19	21	6.14	0.15	2				1.01	0.01	2	0.202	0.032	2	8.49	0.63	2	
	NAF-0846	2015	01	19	21	20.36	0.15	2				0.62	0.01	2	1.714	0.032	2	76.62	0.63	2	
	NAG-0865	2015	01	19	21	11.09	0.15	2				0.19	0.01	2	0.824	0.032	2	38.62	0.63	3	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
35																					
	NAD-1413	2015	02	17	24.1	13.66	0.01	2				0.73	0	2	0.589	0	2	17.7	0.03	2	
	NAE-0858	2015	02	17	24.1	6.18	0	2				0.96	0	2	0.196	0	2	8.48	0.01	2	
	NAF-0852	2015	02	17	24.1	20.52	0.02	2				0.59	0	2	1.642	0	2	75.88	0.11	2	
	NAG-0837	2015	02	17	24.1	11.16	0.01	2				0.2	0	2	0.782	0	2	38.24	0.06	3	
39																					
	NAD-1354	2015	01	15	22.5	13.21	0.1	2	12.68	0.1	2	0.53	0.01	2	0.453	0.01	2	13.72	0.2	2	
	NAE-0834	2015	01	15	22.5	6.29	0.04	2	5.33	0.04	2	0.97	0.01	2	0.208	0.01	2	8.79	0.15	2	
	NAF-0701	2015	01	15	22.5	20.66	0.2	2	20.07	0.2	2	0.6	0.01	2	1.65	0.02	2	77.17	0.59	2	
	NAG-0828	2015	01	15	22.5	11.17	0.1	2	10.97	0.1	2	0.19	0.01	2	0.778	0.015	2	39.05	0.39	3	
41																					
	NAD																				
	NAE	2015	02	02	22	7.33		2	6.35		2	0.98		2	0.244		2	9.09		2	
	NAF	2015	02	02	22	20.03		2	19.44		2	0.63		2	1.759		2	77.38		2	
	NAG	2015	02	02	22	12.11		2	11.92		2	0.21		2	0.909		2	39.27		3	
49																					
	NAD-1358	2015	01	27	21	13.38		2	12.83		2	0.55		2	0.451		2	11.99		2	
	NAD-1358	2015	01	27	21	13.14		2	12.55		2	0.58		2	0.5		2	11.8		2	
	NAE-0587	2015	01	27	21	6.37		2	5.45		2	0.92		2	0.205		2	7.5		2	
	NAE-0587	2015	01	27	21	6.14		2	5.24		2	0.9		2	0.264		2	7.01		2	
	NAF-0773	2015	01	27	21	20.93		2	20.37		2	0.57		2	1.7		2	71.39		2	
	NAF-0773	2015	01	27	21	20.5		2	19.92		2	0.58		2	1.827		2	68.06		2	
	NAG-0832	2015	01	27	21	11.14		2	10.98		2	0.17		2	0.908		2	34.02		3	
	NAG-0832	2015	01	27	21	11.41		2	11.25		2	0.16		2	0.811		2	35.88		3	
50																					
	NAD-1557+1565	2015	01	29	21	13.33	0	2	12.75	0	2	0.58	0	2	0.439	0.003	2	13.57	0.04	2	
	NAE-0706+0756	2015	01	29	21	6.36	0.03	2	5.41	0.03	2	0.95	0.01	2	0.17	0.002	2	8.77	0.03	2	
	NAF-0810+0822	2015	01	29	21	20.72	0.02	2	21.24	0.02	2	0.52	0	2	1.629	0.004	2	77.94	0.1	2	
	NAG-0857+0876	2015	01	29	21	11.22	0.02	2	11.01	0.02	2	0.2	0	2	0.773	0.002	2	38.4	0.02	3	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
51																					
	NAD-XXXX	2015	03	06	18	13.47	0.98	2			2	0.61	0.1	2	0.444	0.098	2	14.3	0.98	2	
	NAE-XXXX	2015	03	06	18	6.09	0.98	2			2	0.93	0.1	2	0.197	0.098	2	8.85	0.98	2	
	NAF-XXXX	2015	03	06	18										1.564	0.098	2				
	NAG-XXXX	2015	03	06	18	10.73	0.98	2			2	0.17	0.1	2	0.783	0.098	2			3	
56																					
	NAD-1560	2015	02	24	22	13.05	0.18	2	12.32	0.18	2	0.74	0.01	2	0.422	0.01	2	13.44	0.69	2	
	NAE-0748	2015	02	24	22	5.94	0.18	2	4.96	0.18	2	0.98	0.01	2	0.225	0.01	2	8.69	0.68	2	
	NAF-0883	2015	02	24	22	21.17	0.18	2	20	0.18	2	1.17	0.01	2	1.671	0.01	2	78.36	0.68	2	
	NAG-0875	2015	02	24	22	10.89	0.18	2	10.7	0.18	2	0.2	0.01	2	0.762	0.01	2	39.47	0.68	3	
57																					
	NAD-	2015	02	25		14.01		2							0.36		2	14.4		2	
	NAE-	2015	02	25		6.65		2							0.17		2	9		2	
	NAF-	2015	02	25		21.57		2							1.58		2	77.4		2	
	NAG-	2015	02	25		11.77		2							0.72		2	39		3	
65																					
	NAD-1403	2015	03	09	21.9	12.95	0.07	2							0.413	0.001	2	13.42	0.01	2	
	NAE-0893	2015	03	09	21.9	6.1	0	2							0.193	0.002	2	8.69	0	2	
	NAF-0872	2015	03	09	21.9	20.1	0.08	2							1.633	0.004	2	76.79	0.15	2	
	NAG-0885	2015	03	09	21.9	10.98	0.07	2							0.772	0	2	38.55	0.04	3	
80																					
	NAD	2015	02	18	21							0.71	0.1	2	0.769	0.098	2	13	0.98	2	
	NAE	2015	02	18	21							1.01	0.1	2	0.424	0.098	2	9.3	0.98	2	
	NAF	2015	02	18	21							0.85	0.1	2	3.522	0.098	2	67.86	0.98	2	
	NAG	2015	02	18	21							0.22	0.1	2	1.932	0.098	2	37.83	0.98	3	
86																					
	NAD-XXXX	2015	02	26	40	13.97	0.03	2	13.31	0.04	2	0.66	0	2	0.454	0.007	2				
	NAE-XXXX				40	11.46	0.05	2	11.32	0.05	2	0.14	0	2	0.777	0.001	2				
	NAF-XXXX																				
	NAG-XXXX																				

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
87																					
	NAD-1503	2015	01	22	21	13.32		2	12.75		2	0.57		2	0.459		2	13.49		2	
	NAE-0884	2015	01	22	21	6.38		2	5.42		2	0.96		2	0.229		2	8.62		2	
	NAF-0874	2015	01	22	21	20.61		2	20.02		2	0.59		2	1.709		2	78.29		2	
	NAG-0886	2015	01	22	21	11.08		2	10.9		2	0.18		2	0.794		2	38.66		3	
88																					
	NAD-1360	2015	01	20	21	13.25		2							0.461		2	14.58		2	
	NAE-0827	2015	01	20	21	6.68		2							0.14		2	9.32		2	
	NAF-0766	2015	01	20	21	19.05		2							1.739		2	80.08		2	
	NAG-0878	2015	01	20	21	10.91		2							0.791		2	40.55		3	
89																					
	NAD-1535				21	13.12	0.12	2				0.6	0	2	0.716	0.002	2	13.27	0.04	2	
	NAE-0862				21	6.15	0.08	2				1.01	0.01	2	0.421	0.006	2	8.59	0.19	2	
	NAF-0860				21	19.9	0.22	2				0.62	0	2	3.164	0.011	2	76.38	0.12	2	
	NAG-0874				21	11.01	0.05	2				0.22	0	2	1.569	0.001	2	38.48	0.04	3	
92																					
	NAD-1401/1402	2015	02	23	18	13.27	0.05	2	13.21	0.05	2	0.57	0	2	0.461	0.006	2	14.07	0.05	2	
	NAE-0811/0871	2015	01	07	18	6.48	0.05	2	5.51	0.05	2	0.96	0	2	0.185	0.01	2	9.05	0.05	2	
	NAF-0840/0891	2015	01	08	18	20.05	0.05	2	19.45	0.05	2	0.6	0	2	1.669	0.01	2	77.35	0.05	2	
	NAG-0838/0892	2015	01	08	18	11.14	0.05	2	10.94	0.05	2	0.2	0	2	0.79	0.01	2	39.55	0.05	3	
98																					
	NAD-1398	2015	02	26	22.4	12.36	0.98	2	11.82		2	0.54		2				7.66	0.98	2	
	NAE-0803	2015	02	26	22.4	5.73	0.29	2	4.85		2	0.89		2				4.07	0.39	2	
	NAF-0850	2015	02	26	22.4	18.91	0.98	2	18.22		2	0.68		2	2.629	0.489	2	39.72	2.93	2	
	NAG-0805	2015	02	26																	
101																					
	NAD-1545	2015	02	04	21.5	12.92	0.27	2	12.33		2	0.6	0.02	2	0.449	0.017	2	13.25	0.88	2	
	NAE-0744	2015	02	04	21.5	6.16	0.13	2	5.18		2	0.99	0.03	2	0.21	0.017	2	8.61	0.88	2	
	NAF-0854	2015	02	04	21.5	20.31	0.42	2	19.68		2	0.63	0.02	2	1.635	0.037	2	74.63	1.66	2	
	NAG-0880	2015	02	04	21.5	10.96	0.23	2	10.77		2	0.19	0.02	2	0.773	0.021	2	37.91	1.05	3	

2015 IC results reported by the participants

in micro moles per kilogram

Lab	Sample	Year	Month	Day	Temperature	NOX	ERR	Flag	Nitrate	ERR	Flag	Nitrite	ERR	Flag	Phosphate	ERR	Flag	Silicate	ERR	Flag	REDUCT
102																					
	NAD-1411																				
	NAD-1412				20																
	NAD-1416				20															2	
	NAE-0848	2015	02	26	20	6.57		2	5.55		2	1.01		2	0.247		2	8.94		2	
	NAE-0872	2015	02	26	20	6.57		2	5.57		2	1		2	0.223		2	8.99		2	
	NAE-0886	2015	02	26	20															2	
	NAF-0829	2015	02	26	20	21.71		2	21.445		2	0.79		2	1.655		2	81.758		2	
	NAF-0839	2015	02	26	20	21.02		2	20.21		2	0.81		2	1.917		2	77.93		2	
	NAF-0863	2015	02	26	20	21.31		2	20.56		2	0.75		2	1.881		2	77.86		2	
	NAG-0872	2015	02	26	21	11.41		2	11.12		2	0.29		2	0.9		2	39.55		3	
	NAG-0881	2015	02	26	21	11.69		2	11.649		2	0.318		2	0.887		2	39.42		3	
	NAG-0899	2015	02	26	21	11.71		2	11.43		2	0.29		2	0.88		2	39.93		3	
112																					
	NAD 1527	2015	02	13	23.3	13.61	0.14	2	n/a	n/a	9	0.57	0.01	2	0.452	0.01	2	13.13	0.26	2	
	NAE 0866	2015	02	13	23.3	6.37	0.14	2	n/a	n/a	9	0.99	0.01	2	0.205	0.01	2	8.15	0.25	2	
	NAF 0834	2015	02	13	23.3	21.06	0.14	2	n/a	n/a	9	0.79	0.01	2	1.671	0.01	2	77.71	0.25	2	
	NAG 0844	2015	02	13	23.3	11.39	0.14	2	n/a	n/a	9	0.2	0.01	2	0.801	0.01	2	38.84	0.25	3	

Table KIOST-A3. Ammonia results reported by the participants

Lab#	Sample	AMMONIA	ERR	NO2	ERR	NO3	ERR	NOX	ERR
23									
	NAD-350	3.53		0.78		12.54		13.31	
	NAE-0142	1.41		0.97		5.32		6.29	
	NAF-0070	0.86		0.63		20.02		20.65	
	NAG-0100	0.94		0.21		11.08		11.28	
28									
	NAD-1359	7.37	0.1	0.71	0	13.47	0.2	14.18	0.2
	NAE-0817	1.5	0.1	0.93	0	5.58	0.2	6.51	0.2
	NAF-0704	0.7	0.1	0.6	0	20.35	0.24	20.95	0.24
	NAG-0816	0.83	0.1	0.21	0	11.51	0.2	11.71	0.2
50									
	NAD-1557+1565	5.99	0.04	0.58	0	12.75	0	13.33	0
	NAE-0706+0756	1.49	0.04	0.95	0.01	5.41	0.03	6.36	0.03
	NAF-0810+0822	1.61	0	0.52	0	21.24	0.02	20.72	0.02
	NAG-0857+0876	0.84	0.04	0.2	0	11.01	0.02	11.22	0.02
51									
	NAE-XXXX	1.7	0.1	0.93	0.1			6.09	0.98
	NAF-XXXX	0.87	0.1						
	NAG-XXXX	0.88	0.1	0.17	0.1			10.73	0.98
56									
	NAD-1560	6.62		0.74	0.01	12.32	0.18	13.05	0.18
	NAE-0748	1.45		0.98	0.01	4.96	0.18	5.94	0.18
	NAF-0883	4.35		1.17	0.01	20	0.18	21.17	0.18
	NAG-0875	0.81		0.2	0.01	10.7	0.18	10.89	0.18
86									
	NAD-XXXX	6.14	0.01	0.66	0	13.31	0.04	13.97	0.03
	NAE-XXXX	0.64	0.01	0.14	0	11.32	0.05	11.46	0.05
87									
	NAD-1503	6.13		0.57		12.75		13.32	
	NAE-0884	1.91		0.96		5.42		6.38	
	NAF-0874	1.11		0.59		20.02		20.61	
	NAG-0886	1.12		0.18		10.9		11.08	
89									
	NAD-1535	5.92	0.03	0.6	0			13.12	0.12
	NAE-0862	1.55	0.01	1.01	0.01			6.15	0.08
	NAF-0860	1.11	0	0.62	0			19.9	0.22
	NAG-0874	0.99	0.01	0.22	0			11.01	0.05

Lab#	Sample	AMMONIA	ERR	NO2	ERR	NO3	ERR	NOX	ERR
101									
	NAD-1545	6.14	0.22	0.6	0.02	12.33		12.92	0.27
	NAE-0744	1.79	0.21	0.99	0.03	5.18		6.16	0.13
	NAF-0854	1.24	0.21	0.63	0.02	19.68		20.31	0.42
	NAG-0880	1.17	0.21	0.19	0.02	10.77		10.96	0.23
102									
	NAE-0848	1.56		1.01		5.55		6.57	
	NAE-0872	1.64		1		5.57		6.57	
	NAF-0829	2.415		0.79		21.445		21.71	
	NAF-0839	1.89		0.81		20.21		21.02	
	NAF-0863	2.27		0.75		20.56		21.31	
	NAG-0872	2.94		0.29		11.12		11.41	
	NAG-0881	2.892		0.318		11.649		11.69	
	NAG-0899	1.37		0.29		11.43		11.71	
112									
	NAD 1527	8.34	0.02	0.57	0.01	n/a	n/a	13.61	0.14
	NAE 0866	1.46	0.02	0.99	0.01	n/a	n/a	6.37	0.14
	NAF 0834	1.85	0.02	0.79	0.01	n/a	n/a	21.06	0.14
	NAG 0844	0.89	0.02	0.2	0.01	n/a	n/a	11.39	0.14

Table KIOST-A4-1 Cross reference table of ranked order and Lab # for Figure KIOST-1

rank	Lab No.	Lab name
1	**98**	University of Tartu, Estonian Marine Institute, Estonia
2	**88**	Faroe Marine Research Institute, Faroe Islands
3	**6**	Bermuda Institute of Ocean Sciences, Bermuda
4	**89**	Scottish Environment Protection Agency, UK
5	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
6	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
7	**65**	Hawaii Ocean Time-series, USA
8	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
9	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
10	**29**	Marine Research Institute, Iceland
11	**49**	National Oceanography Centre, Southampton, UK
12	**35**	Japan Meteorological Agency, Japan
13	**5**	OD NATURE – ECOCHEM, Belgium
14	**87**	Department of Fisheries and Oceans Canada, Canada
15	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
16	**39**	Royal NIOZ, Netherlands
17	**50**	Plymouth Marine Laboratory, UK
18	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
19	**102**	Stazione Zoologica Anton Dohrn, Italy
20	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
21	**56**	Scripps Institution of Oceanography, USA
22	**57**	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, USA
23	**51**	Marine Scotland - Science, UK
24	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy

Table KIOST-A4-2 Cross reference table of ranked order and Lab # for Figure KIOST-2

rank	Lab No.	Lab name
1	**98**	University of Tartu, Estonian Marine Institute, Estonia
2	**6**	Bermuda Institute of Ocean Sciences, Bermuda
3	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
4	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
5	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
6	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
7	**49**	National Oceanography Centre, Southampton, UK
8	**5**	OD NATURE – ECOCHEM, Belgium
9	**56**	Scripps Institution of Oceanography, USA
10	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
11	**87**	Department of Fisheries and Oceans Canada, Canada
12	**39**	Royal NIOZ, Netherlands
13	**102**	Stazione Zoologica Anton Dohrn, Italy
14	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
15	**50**	Plymouth Marine Laboratory, UK
16	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy

Table KIOST-A4-3 Cross reference table of ranked order and Lab # for Figure KIOST-3

rank	Lab No.	Lab name
1	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy
2	**98**	University of Tartu, Estonian Marine Institute, Estonia
3	**49**	National Oceanography Centre, Southampton, UK
4	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
5	**51**	Marine Scotland - Science, UK
6	**5**	OD NATURE – ECOCHEM, Belgium
7	**50**	Plymouth Marine Laboratory, UK
8	**35**	Japan Meteorological Agency, Japan
9	**87**	Department of Fisheries and Oceans Canada, Canada
10	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
11	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
12	**39**	Royal NIOZ, Netherlands
13	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
14	**56**	Scripps Institution of Oceanography, USA
15	**6**	Bermuda Institute of Ocean Sciences, Bermuda
16	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
17	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
18	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
19	**29**	Marine Research Institute, Iceland
20	**80**	Instituto del Mar del Perú, Peru
21	**89**	Scottish Environment Protection Agency, UK
22	**102**	Stazione Zoologica Anton Dohrn, Italy

Table KIOST-A4-4 Cross reference table of ranked order and Lab # for Figure KIOST-4

rank	Lab No.	Lab name
1	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
2	**51**	Marine Scotland - Science, UK
3	**57**	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, USA
4	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
5	**50**	Plymouth Marine Laboratory, UK
6	**65**	Hawaii Ocean Time-series, USA
7	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
8	**35**	Japan Meteorological Agency, Japan
9	**39**	Royal NIOZ, Netherlands
10	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
11	**56**	Scripps Institution of Oceanography, USA
12	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
13	**5**	OD NATURE – ECOCHEM, Belgium
14	**87**	Department of Fisheries and Oceans Canada, Canada
15	**29**	Marine Research Institute, Iceland
16	**88**	Faroe Marine Research Institute, Faroe Islands
17	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
18	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
19	**49**	National Oceanography Centre, Southampton, UK
20	**102**	Stazione Zoologica Anton Dohrn, Italy
21	**6**	Bermuda Institute of Ocean Sciences, Bermuda
22	**98**	University of Tartu, Estonian Marine Institute, Estonia
23	**89**	Scottish Environment Protection Agency, UK
24	**80**	Instituto del Mar del Perú, Peru
25	**86**	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy

Table KIOST-A4-5 Cross reference table of ranked order and Lab # for Figure KIOST-5

rank	Lab No.	Lab name
1	**98**	University of Tartu, Estonian Marine Institute, Estonia
2	**80**	Instituto del Mar del Perú, Peru
3	**49**	National Oceanography Centre, Southampton, UK
4	**101**	Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea
5	**35**	Japan Meteorological Agency, Japan
6	**5**	OD NATURE – ECOCHEM, Belgium
7	**89**	Scottish Environment Protection Agency, UK
8	**29**	Marine Research Institute, Iceland
9	**65**	Hawaii Ocean Time-series, USA
10	**39**	Royal NIOZ, Netherlands
11	**92**	Station Biologique de Roscoff, Centre national de la recherche scientifique (CNRS) / Université Pierre et Marie Curie, France
12	**41**	Kjemilaboratoriet / Chemistry Laboratory, Havforskningsinstituttet / Institute of Marine Research, Norway
13	**57**	NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, USA
14	**112**	R/V INVESTIGATOR, CSIRO Marine and Atmospheric Research, Australia
15	**102**	Stazione Zoologica Anton Dohrn, Italy
16	**50**	Plymouth Marine Laboratory, UK
17	**87**	Department of Fisheries and Oceans Canada, Canada
18	**56**	Scripps Institution of Oceanography, USA
19	**28**	Alfred-Wegener-Institute; Helmholtz Centre for Polar and Marine Research, Germany
20	**10**	University of British Columbia, Department of Earth, Ocean & Atmospheric Sciences, Canada
21	**88**	Faroe Marine Research Institute, Faroe Islands
22	**23**	Mediterranean Institute of Oceanology (MIO) Campus de Luminy, France
23	**6**	Bermuda Institute of Ocean Sciences, Bermuda
24	**51**	Marine Scotland - Science, UK

Appendix VI

History of Inter-comparison studies

History of nutrient inter-laboratory comparison study

This history of nutrient inter-laboratory comparison study is based on several reports of previous intercomparison exercises. The histories of the first to fourth ICES exercises are derived from Aminot and Kirkwood's (1995) detailed report of the fifth ICES intercomparison, which includes histories of the first to fourth ICES exercises. Histories of the fifth ICES exercise, the first and second NOAA/NRC inter-laboratory comparison study, MRI 2003 and 2006 intercomparisons are also summarized in this appendix.

1. First ICES Exercise

The first intercalibration to include nutrients was an entirely Baltic affair in June 1965, when three research vessels met by private agreement in Copenhagen:

Aranda	Institute of Marine Research (IMR), Helsinki
Hermann Wattenberg	Institut für Meereskunde, Kiel
Skagerak	Royal Fishery Board, Gothenburg

Each ship contributed freshly collected bulk samples to the experiment, which were sub-sampled and analyzed on board each of the three participating ships on the same day. Oxygen, salinity, chlorinity, alkalinity, and phosphate were determined.

2. Second ICES Exercise

The second ICES exercise, carried out in 1966 under the auspices of the newly formed ICES Working Group on the Intercalibration of Chemical Methods, was still predominantly a Baltic initiative and consisted of two parts: Part I, Leningrad, during the 5th Conference of Baltic Oceanographers; and Part II, Copenhagen, at the 54th ICES Statutory Meeting.

Part I, Leningrad (May 1966)

The participating research vessels were

Alkor	Institut für Meereskunde, Kiel
Okeanograf	Institute of Marine Research, Leningrad
Prof Otto Krammel	Institut für Meereskunde, Warnemünde
Skagerak	Fisheries Board of Sweden, Gothenburg

The research vessels delivered bulk samples, which were subsampled and analyzed almost immediately for oxygen, salinity, chlorinity, pH, and phosphate.

Part II, Copenhagen (September 1966)

The list of interested parties continued to grow and, in addition to Baltic countries, Norway and the UK were represented. Research vessels delivered bulk samples and the various participants analyzed samples simultaneously in Copenhagen. The determinants of primary interest included not only oxygen, salinity, chlorinity, and phosphate, as in Part I (Leningrad) and the previous year's exercise (Copenhagen, 1965), but also nitrate, nitrite, and silicate.

The final report, edited by Grasshoff (UNESCO, 1966), makes no mention of nitrate or nitrite but some of those who were present confessed that these results were "too terrible to be included"! To be fair to those involved, 1966 was an early time in the development of heterogeneous cadmium-based nitrate/nitrite reduction techniques and some of the associated problems were presumably not fully appreciated at the time.

Evidently nitrate analysis had some way to go to achieve the reliability and ease of operation of the Murphy and Riley (1962) phosphate technique, but it is worth noting that intercomparison work on phosphate so far had consisted of simultaneous analysis of freshly obtained subsamples by a small number of highly competent workers, in close contact with each other, exchanging calibration solutions, ideas, technical details, etc. Subsequent to the Copenhagen trial, Jones and Folkard (ICES, 1966) undertook a detailed laboratory examination of the individual methods used by the participants and, in their contribution to Grasshoff's report, they announced, "There seems to be no need for any further intercalibration in the determination of inorganic phosphate by this method."

Clearly this happy state of affairs could and did not last. Along came the autoanalyzer!

3. Third ICES Exercise

The third ICES exercise was organized by the ICES Working Group on Chemical Analysis of Sea Water under the joint auspices of ICES and SCOR and its official title, "The International Intercalibration Exercise for Nutrient Methods2", shows that it set out to be an ambitious project.

Samples were distributed in 1969–1970 and 45 laboratories from 20 countries submitted results, but the final report on the results of the exercise was not published for several years (ICES, 1977).

The time had come to study "nutrients" separately from oxygen, salinity, chlorinity, and pH, but with the awareness of problems arising from the instability of natural seawater samples, the organizers chose to use standard solutions that were prepared and distributed by the Sagami Chemical Research Center, Japan. [*Note added by Aoyama*: The standard solutions used in this exercise were Cooperative Survey of Kuroshio(CSK) standards, which are solutions in artificial seawater for nitrate, phosphate, and silicate and in pure water for nitrite.]

In this exercise, participants performed the analyses in their own laboratories but, despite being supplied (knowingly) with appropriate blank solutions for each determination, the overall accuracy, particularly for phosphate and nitrate, was disappointing.

The report concludes, "As methods did not diverge much, it is clear that variations must be sought primarily in the standardization procedures. The results will also aid participants in re-evaluating their analytical procedures by comparison of their methods with those that appear most satisfactory from this exercise".

The names of the participating laboratories were listed, as were the tables of results, but it was not possible to link them together. Hindsight suggests that this may have been counterproductive; we now suspect that there is no greater incentive for a laboratory to improve its performance than the knowledge that peer laboratories throughout the world are aware that it is producing poor quality data.

4. Fourth ICES Exercise

Various "workshop" and multi-ship events following the ICES/SCOR exercise including nutrient studies, but it was many years later (1988) before the ICES Marine Chemistry Working Group produced volunteers (Don Kirkwood, Alain Aminot, and Matti Perttilä) to organize the next large-scale intercalibration exercise, designated "NUTS I/C 4". This exercise did not set out to be worldwide, beginning only with laboratories in ICES Member Countries, but other laboratories who were interested in participating were not turned away.

The fourth exercise differed from the third exercise in three important respects.

1) The test samples were natural or near-natural seawater rather than standard solutions. (Strictly speaking, this made the exercise an intercomparison rather than an intercalibration.)

2) Participants were unaware that "blank" samples were included.

3) Anonymity was abolished. Participants were made aware from the outset that the final report would list identities of laboratories, results, and a means for any reader to contact them.

Sixty-nine laboratories from 22 countries submitted results and, thanks in some measure to the telefax machine, the final 83-page report (Kirkwood *et al.*, 1991) was in the hands of participants within two years of the distribution of samples. Statistical treatment identified 58 laboratories consistent in phosphate analyses, 51 consistent in nitrate analyses, and 48 consistent in both phosphate and nitrate analyses, including a group of 12 whose results were especially close to the consensus concentrations.

5. Fifth ICES Exercise

Due to the generally perceived need for more and better quality control in analytical measurement, a fifth ICES intercomparison exercise was carried out in 1993. A total of 142 sets of samples were distributed in 31 countries. Results were returned by 132 laboratories, 61 of which had participated in the fourth intercomparison and 56 of which were participating in QUASIMEME (Quality Assurance of Information for Marine Environmental Monitoring in Europe).

The distribution of laboratories was as follows:

UK (22), Germany (18), Sweden (13), France (11), Spain (8), USA (7), Norway(5), Ireland(5), Australia(4) Canada(4), Netherlands(4), Denmark(3), Greece(3), Portugal(3), Belgium(2), Estonia(2), Finland(2), Italy(2), Poland(2), Argentina(1), Bermuda(1), China(1), Faroe Islands(1), Iceland(1), Japan(1), Latvia(1), Lithuania(1), New Zealand(1), Qatar(1), South Africa(1), Turkey(1).

The method of sample preparation, autoclaving, for the fifth intercomparison imposed constraints that resulted in there being only two relevant determinants per sample (nitrate and nitrite in one series, and phosphate and ammonia in the other series).

A large volume of low-nutrient natural seawater was spiked with known concentrations of nutrient salt. Although the concentrations in the distributed samples covered a greater concentration range than that in the fourth intercomparison, the concentration levels were representative of the Atlantic Ocean, 1–26 μmol L^{-1} for nitrate and 0.08–1.85 μmol L^{-1} for phosphate.

There have been no further ICES intercomparison exercises since 1993.

6. QUASIMEME

The European Union (EU) supported the QUASIMEME project between 1993 and 1995. Its aim was to develop a holistic quality assurance programme for marine environmental monitoring information in Europe. As a result of this pioneering project a marine network and laboratory performance studies have been established for most of the determinants measured in the marine environmental programmes for both monitoring and research purposes. The nutrient part of QUASIMEME was entirely based on the groundbreaking work of ICES experts and the principles and methodology described above were used. The project proved that laboratories which followed on a regular basis the learning programmes and the laboratory testing schemes improved the quality of their data. (Should some results i.e. interlaboratory variability be added?)

After the end of the EU funding in 1995, the QUASIMEME scheme continued on subscription basis. Now it is possible for any laboratory worldwide to participate (should numbers of participants be added?). QUASIMEME results have been used to assess the quality of data submitted to the marine conventions for the purpose of assessing the quality status of the marine environment.

7. 2000 NOAA/NRC Intercomparison

The test material distributed in this intercomparison was MOOS-1, a proposed certified reference material for nutrients in seawater (Clancy and Willie, 2004). The sample material was intended to be a certified reference material for silicate, phosphate, nitrite, and nitrate + nitrite. Participating laboratories were each sent two bottles of MOOS-1 and requested to perform duplicate analyses on each of the bottles. The prepared samples were sent to 36 participating laboratories. Thirty sets of results were returned.

The results of this intercomparison may, in several respects, have been compromised by sample homogeneity problems. The target standard deviation for measuring *p*-scores is too broad and does not reflect the measurement precision that can be attained.

8. 2002 NOAA/NRC Intercomparison

A further intercomparison exercise was undertaken to assess the current capabilities of a group of laboratories to quantitate orthophosphate, silicate, nitrite, and nitrite + nitrate in a seawater sample. This was the second such exercise sponsored by the NOAA Center for Coastal Monitoring and Assessment (CCMA) and coordinated by the Institute for National Measurement Standards of the National Research Council of Canada. Two seawater samples — one from Pensacola Sound, FL, and a proposed certified reference material for nutrients in seawater (MOOS-1) — were distributed to 31 laboratories.

Twenty-four laboratories submitted data. Methodologies were not prescribed to the participants; however, all reported results were obtained using traditional colorimetric procedures. Generally, satisfactory agreement among participants was achieved, with results within 10% of the assigned mean values.

The results from this exercise suggest that the homogeneity problem identified in the first NOAA/NRC intercomparison exercise was overcome, although the orthophosphate data indicate a larger inter-laboratory spread of results than expected.

Results for silicate, nitrite, and nitrite + nitrate in the distributed seawater samples were acceptable for the majority of the participants and generally deviated $<\pm 10\%$ from the assigned mean. All laboratories used methodology based on colorimetric principles.

9. 2003 MRI Intercomparison

Autoclaved natural seawater was prepared for inter-laboratory comparison study samples. Sample homogeneity was confirmed by repeatability of measurement. Sets of 6 samples covering a concentration range greater than that in previous inter-laboratory comparison study were distributed. The concentrations were 0–38 μmol kg^{-1} for nitrate, 0–0.9 μmol kg^{-1} for nitrite, 0–2.7 μmol kg^{-1} for phosphate, and 0–136 μmol kg^{-1} for silicate. A total of 18 sets of samples were distributed to 18 laboratories in 5 countries. Results were returned by 17 laboratories in 5 countries. Although consensus

concentrations were obtained for the 6 samples, the standard deviations were 4.5 times and more than 10 times greater than those of the homogeneities for phosphate and silicate, respectively. For nitrate, the standard deviations were only about double the homogeneities. These results indicate that variability in in-house standards of the participating laboratories – rather than analytical precision – is the primary source of inter-laboratory discrepancy. Therefore use of a certified RMNS is essential for establishing nutrient data sets that can be compared across laboratories, especially for silicate and phosphate.

10. 2006 MRI Intercomparison

Autoclaved natural seawater was used for an inter-laboratory comparison study for a reference material for nutrients in seawater in 2006, similar to the 2003 intercomparison exercise. Sample homogeneity was confirmed by repeatability of measurement and those for nitrate, phosphate and silicate were 0.2%, 0.3% and 0.2%, respectively. Sets of 6 samples covering a concentration range of 0.1–42.4 μmol kg^{-1} for nitrate, 0.0–0.6 μmol kg^{-1} for nitrite, 0.0–3.0 μmol kg^{-1} for phosphate, and 1.7–156.1 μmol kg^{-1} for silicate were prepared. A total of 55 sets of samples were distributed to 55 laboratories in 20 countries. Results were returned by 52 laboratories from 19 countries.

11. 2008 MRI Intercomparison

Autoclaved natural seawater was used for the next inter-laboratory comparison study for a reference material for nutrients in seawater in 2008, just as in 2003 and 2006. A total of 58 sets of samples were distributed to 58 laboratories in 20 countries. Results were returned by 52 laboratories from 19 countries.

Two of 6 samples used in 2008 I/C study were the same lots as used in the 2006 I/C study, therefore we can see internal comparability at each laboratory who participated both in the 2006 and 2008 studies as well as the international comparability of the nutrients data among the participating laboratories.

12. 2012 MRI Intercomparison

Autoclaved natural seawater was used for the next inter-laboratory comparison study for a reference material for nutrients in seawater in 2008, just as in 2003 and 2006. A total of 69 sets of samples were distributed to 69 laboratories in 28 countries. Results were returned by 67 laboratories in 28 countries.

Sample #1 used in 2012 I/C study were the same lots as used in the 2006 and 2008I/C study. Sample #2 used in 2012 I/C study were the same lots as used in the 2006 I/C study and sample #3 used in 2012 I/C study were the same lots as used in the 2008 I/C study, respectively. Therefore we can see internal comparability at each laboratory who participated in the previous I/C studies as well as the international comparability of the nutrients data among the participating laboratories.

Results of internal comparability showed that our community have good internal comparability, but less external comparability.

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