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Swedish Agency for Research Cooperation
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IOC - SAREC FIELD STUDY EXERCISE ON NUTRIENTS IN TROPICAL MARINE WATERS

Mombasa, Kenya
5 - 15 April 1994

UNESCO

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1. INTRODUCTION

In the context of the regional programme agreed upon at the Third Session of the IOC Regional Committee for the Co-operative Investigation in the North and Central Western Indian Ocean, Vacoas, Mauritius, 14 - 18 December 1992, and as a follow-up to that meeting, IOC-SAREC organized a Nutrient Intercalibration exercise, the third in a series of nutrient training activities which began in 1991. The Exercise took place in Zanzibar, Tanzania, between 5 and 15 April 1993.

The goal of the nutrient training series is to build capacity to a core of East African nutrient chemists and to foster interregional co-operation and co-ordination through the standardization of sampling and analytical methods.

Three previous workshops concerning nutrient analysis in tropical waters have been conducted over the past three years. In summary these had the following objectives:

Workshop 1	To provide a theoretical background to the subjects of nutrient chemistry, dynamics and analysis in marine systems. This workshop was given in three different countries and was attended by both practicing marine scientists, other scientists and administrators. The venues were the Institute of Marine Sciences in Zanzibar (IMS), Eduardo Mondlane University, Maputo, Mozambique and Kenya Institute for Marine and Fisheries Research, Mombasa (KMFRI).
Workshop 2	To provide practical training in nutrient analysis for those scientists actively interested/involved in nutrient studies. Held at IMS Zanzibar.
Workshop 3	To further develop analytical skills by holding an intercalibration exercise for the scientists who attended the second workshop.

The natural progression in this series led to the objectives for the fourth workshop being identified as the application of the known techniques to a field situation so that different groups working within the region could be sure that they were using both the same laboratory and field techniques, and the present exercise was therefore entitled "Nutrients in Tropical Marine Waters: Field Study Exercise" and the selected venue was KMFRI, Mombasa. A secondary objective that was introduced at the request of IOC on behalf of IOCINCWIO was to give consideration to the establishment of guidelines for the introduction of a number of baseline stations for water quality to be established within the region as part of the IOCINCWIO-III Implementation plan for 94/95.

In the event, problems in the first few days when we were testing methods made us realize that the basics of laboratory techniques were not as well established as we had assumed and, although two different types of field exercise were conducted, a somewhat greater emphasis than had been originally planned was given to laboratory work.

Financial support for this workshop was provided by the Swedish Agency for Research Cooperation with Developing Countries (SAREC).

2. PARTICIPANTS

Participants from five countries attended the course, namely from Kenya, Tanzania (both mainland and Zanzibar), Seychelles, Madagascar, and Mauritius attended. Unfortunately, although invited, there was no representation from Mozambique. Full details of the delegates are given in Annex II.

The two lecturers were Dr. Ron Johnstone of the Zoology Institute, University of Stockholm, Sweden,

and Dr. Martin Preston of the Oceanography Laboratories, University of Liverpool, United Kingdom. For the past fifteen years they have been engaged in nutrient analysis in tropical marine waters.

3. CONDUCT OF THE WORKSHOP

3.1 OPENING

The Training course was opened at the Kenya Marine and Fisheries Research Institute (KMFRI), Mombasa, Kenya, at 09.30 hours on 5 April 1994, by Dr. Ezekiel Okemwa, Director of KMFRI. In his opening address, Dr. Okemwa welcomed the participants, expressed his appreciation to the IOC Secretary, Dr. Gunnar Kullenberg, for his efforts in organizing this Training course, emphasized the importance of nutrient analysis in tropical marine waters in the IOCINCWIO region and stressed that the course provided a good opportunity not only for the study of coastal chemical oceanography, but also for establishing friendly contacts among scientists and institutions in different countries.

Dr. Okemwa further said that the Ecosystems of the margin between land and water are of intense interest to man as sources of food, recreation and transportation as well as for historical reasons. The landscape of the coastal zone is changing in ways that appear to be largely detrimental to the health of these ecosystems. Some of the more obvious changes come from pollution by toxins that kill fish and shellfish or render them inedible. Other changes result from human activities, including increases in nutrient and organic matter, caused by sewage or agricultural fertilizer and nitrogen. Nutrient and organic matter overloading lead to increases in photosynthesis and respiration in estuaries. The end result of this overstimulation of metabolic activity, which we term eutrophication, is depletion of dissolved oxygen, leading to massive kills of shellfish and finfish.

Some aspects of eutrophication are still poorly understood. For example, we do not understand how the quantity and quality of changes in organic matter loading interact with nitrogen availability to produce different responses or degrees of eutrophication in estuaries or different yields of fisheries. Since human disturbance in watersheds usually changes both nutrient and organic matter loading but in different degrees, we are currently unable to predict impacts of these changes on estuaries. Developing a basic understanding of the way cycles of organic matter and nutrients especially nitrogen, interact is an important goal of our future program in the coastal zone.

We are drawing on several existing coastal and wetland research efforts to begin a coordinated coastal zone program. For example, under EEC mangrove ecology project we are studying controls of primary production and decomposition of Gazi Bay. We are also investigating the structure of the food web in the same bay.

Dr. Okemwa said that the government of the Republic of Kenya is very pleased to have the opportunity to host this very important training course. In this regard, he thanked SAREC, the Intergovernmental Oceanographic Commission (IOC) and the Kenya Marine and Fisheries Research Institute for the sponsorship and support for this course.

Dr. Ron Johnstone of Stockholm University thanked the Government of the Republic of Kenya for allowing the workshop to take place and Dr. Okemwa for providing the laboratory facilities and canoes to go out in the sea. Dr. Johnstone further said that the workshop is the latest in a series on water chemistry and nutrient dynamics and is part of the overall training programme being conducted in the East African region by IOC-SAREC. These workshops have the objective of training scientists in internationally recognized scientific techniques and encouraging their participation in the gathering of high quality data. This information is essential to an understanding of the state of health of the marine environment in East Africa and the Western Indian Ocean region. He further said that the benefit of these workshops is to encourage communication between the scientific communities in the whole region and this objective is supported by the Western Indian

Ocean Marine Science Association (WIOMSA) which acts as an advisory body. He welcomed the participants and wished the Training Course all success.

3.2 OUTLINE OF THE PROGRAMME

The programme, developed by Dr. Ron Johnstone of the Zoology Institute, University of Stockholm, Sweden, and Dr. Martin Preston of the Oceanography Laboratories, University of Liverpool, United Kingdom was aimed at providing recommendations to East African nutrient chemists with regard to possible methods for nutrient analysis in tropical waters. The course time table is attached as Annex I.

The following topics were covered during the Training Course:

(i) Introduction and Background
(ii) Safety and Laboratory Practices
  * General Safety Matters
  * General principles of laboratory safety
(iii) General points about nutrient analysis
  * Design of sampling programmes.
  * Sample handling
  * Sample storage
  * Problems relating particularly to the tropics
  * Standardization of methods
  * Blanks
  * Quality control
(iv) Preparation of phosphate reagents
(v) Presentation of some of the data obtained
  * Discussion of results produced and reasons for the variance obtained
  * Result of discussions and investigation of the problems encountered by participants
(vi) Preparation of reagents/glassware equipment for nitrate testing of reduction columns etc.
(vii) Sampling exercise to sea
(viii) Preparation of written considerations for baseline studies
(ix) Sampling exercise to sea
(x) Laboratory analyses Nitrate + phosphate
(xi) Preparation of reagents/equipment for ammonia
(xii) Second field exercise tidal study for ammonia
(xiii) Review of the results of the tidal cycle study. Presentations by participants of thoughts and written material
(xiv) Discussions relating to guidelines for the setting up of such stations, practicalities and resources required

3.3 PRACTICAL IMPLEMENTATION OF THE COURSE

Local support and infrastructure

The support and cooperation received from KMFRI was very good, however, some relatively minor problems were encountered with shortages in glassware and chemicals. In part these were due to problems of outside suppliers not meeting delivery dates. These problems did not represent a major hinderance but highlight the need to maximise the preparation period for these activities so that such problems can be resolved prior to the given activity.

4. RESULTS

4.1 RESULTS OF THE PRACTICAL EXERCISES

As mentioned in the Introduction above, the initial testing of methods in the laboratory revealed that due to lack of practical implementation of the techniques acquired during previous workshops quality of work was not evenly distributed among the participants.This lead to erroneous results. An example of the type of data obtained is presented in Figure 1 (See Annex III).

After discussion of these results, it became apparent that the problems stemmed from a number of different causes. In some cases it was simply a matter of discipline in the laboratory. In other cases the lack of co-workers within some laboratories to work together and/or to communicate with each other effectively seemed to be the problem. In virtually all cases, discussion of results when they appeared abnormal was limited and tended to focus on outside factors (reagents, glassware, equipment etc.) rather than identifying the operators as cause.

A further cause of difficulties was the fact that some laboratories still lack certain items of equipment which are essential and vital for the analytical work. The Seychelles, for example, still lack a spectrophotometer capable of such colorimetric analyses. The representative from the Seychelles although keen and competent was therefore unable to utilize the relevant techniques at home. This particular issue is addressed later in this report.

Having discussed the nature and breadth of these problems, it was finally considered appropriate that the workshop be modified slightly to increase the amount of time in the laboratory working with standard and more controllable sample material with some field work to supplement this activity.

The results from the ensuing activities showed significant improvement in analytical skills among the participants although it should be noted that those who, from the beginning, were already well versed in the methods were a little unhappy that the amount of field work was reduced. Examples of the results from the field and later laboratory work are given in Figures 2 and 3 (See Annex III).

Overall, by the end of the workshop all participants were at a similar level of expertise and the data obtained from different analyses reflected this.

4.2 FUTURE ACTIVITIES

As presented in the results, it seems appropriate and necessary that some type of activity be maintained in the region to ensure that analytical skills are held at an acceptable level. In accordance with our experience in the region, and in the light of limiting budgets for such activities, it is proposed that consideration be given to a slightly different approach to the problem as we have experienced it. Specifically, we propose that some small amount of funds be initially granted (approx. US$1,000) to test the idea of sending standard samples by mail to the various laboratories. If this system works, then it could be expanded and built into a regular practice in the region as part of IOC-SAREC activities and possibly augmented by a workshop every other year, for example. This would probably provide a much cheaper way of helping to maintain analytical standards and, given its greater frequency, would provide a more effective way of doing this.

It is envisaged that either the laboratory of Preston or Johnstone could be used for the trial of standard materials and, if functional, one of these laboratories could then serve as the dispatch/reception centre for future sample distribution.

Recommendations

Given the problems discussed above, a number of recommendations can be made with regard to any similar future exercises:

(i) That when inviting participants, we place a stronger request that the participants be those people actually involved in "hands on" analysis in their institution. Whilst it is realized that this was the original idea and request at the beginning of the workshop series, it has become increasingly obvious that this objective is not being met in all cases. Thus the problem should be readdressed. This would probably also apply to any other such scientific workshops to be conducted in the region and the present experience could serve as a good precedent.

(ii) That IOC-SAREC should endeavour to help the different institutions acquire the basic equipment which is still lacking in some instances. From the discussions, this may well be facilitated by helping to make the respective authorities in each institution more aware of the need and necessity of such items. The major missing item is a spectrophotometer in the Seychelles laboratory and we strongly support a recommendation that appropriate funds be made available for the purchase of an appropriate instrument.

(iii) That a more low key but regular intercalibration exercise be conducted in the region to maintain analytical skills and standards. One idea we propose here is the possible distribution of "unknown" samples via mail every 4 to 6 months which are analysed by each laboratory under local conditions and constraints. The samples could be compiled and compared in a reference laboratory and comments made accordingly. This could then be augmented with a more elaborate field exercise every two years, for example. There are a number of technical difficulties associated with this exercise, particularly regarding the stability of supplied samples, but we believe that a strategy of supplying concentrated standards with a prescribed dilution regime might circumvent the problem, at least for nitrate, nitrite and phosphate. This idea needs to be tested and we would be prepared to undertake this in one or the other of our two laboratories. This would be done in cooperation with the two Groups of Experts of GIPME (Global Investigation of Pollution in the Marine Environment): GEMSI (Group of Experts on Methods, Standards and Intercalibration) and GESREM (Group of Experts on Standards and Reference Materials).

4.3 THE DEVELOPMENT OF BASELINE MONITORING STATIONS IN THE IOCINCWIO REGION

In accordance with the recommendations made at IOCINCWIO-III, time was spent during the workshop discussing the potential and probable limitations on the establishment of baseline monitoring stations in each of the participating countries. Accordingly, participants were given the following outline and set of questions as a prompt for discussion:

" ***Baseline Stations - Outline and issues to be addressed***

The IOCINCWIO action plan includes an action on the establishment of Baseline Stations (water quality) under the GIPME/MARPOLMON programme. IOC-SAREC have agreed to consider combine the monitoring of water quality and nutrients into a single plan which will be initiated in 1995 with a limited quantity of funds available to support the initiative.

Each country that wishes to participate is asked to identify baseline stations and to outline the type and level of activity that they feel that they would be able to support.

The issues that we need to address in the present exercise are as follows:-

1) What is the purpose of baseline stations?
2) What should be measured?
3) Where should the station(s) be located?
4) How many stations should there be?
5) How often should samples be collected and analysed?
6) How often is it actually possible to visit station(s) and analyse samples?
7) What staff/equipment/chemicals/other resources would be required to support each level of activity?"

Both written and verbal responses were obtained to this document and we have attempted in this report to summarise these ideas together with our own experiences from the region.

Purpose of baseline stations

In line with perceptions of acute pollution problems in their home countries, all except one respondent proposed baseline monitoring stations oriented at examining concentrations of pollutants in "local" waters; i.e. harbours and recipients/estuaries. Clearly, there is a need for such monitoring but no mention was made of the establishment of stations directed at a more regional perspective such as offshore waters or in particular "typical" water bodies such as over coral reefs or in lagoons.

Parameters to be Measured

The items listed below represent the summation of suggestions by participants at the workshop:

1. Metals
1. Pesticides
2. Hydrocarbons and persistent organic toxins
3. Dissolved oxygen
4. Nutrients including nitrogen species, phosphorous, and silica
5. Water sediment load and turbidity
6. Temperature
7. Salinity

Of the parameters listed, nutrients, metals and hydrocarbons were widely considered as the most necessary with regard to pollution, and salinity, temperature and turbidity as background parameters.

Location & Number of Stations

Whilst only two respondents were very specific about location and number of stations, the majority of people proposed the selection of water bodies which were recognised as being under direct influence from human activities. Those who were specific about site location again oriented the stations toward "effected" areas but suggested that more than one type of water body should be considered eg., estuary, harbour, and coral reef lagoon.

Timing of Sampling

As discussed further below, it was widely thought that this aspect would be limited by different factors of which available personnel was probably the major one; ie. aside from the scientific considerations. Otherwise, it was widely proposed that sampling times be in the order of weekly to monthly and aspects to be highlighted within the sampling strategy were the wet and dry seasons as well as the tidal regimes. Also, some respondents proposed a varied sampling strategy for different locations/parameters so that some were sampled more frequently than others. For example, parameters such as salinity, temperature and turbidity could be monitored daily but nutrients, chlorophyll, and perhaps the different pollutants, could be sampled monthly or only several times a year.

Present Potential and Limitations for Monitoring

Timing

Most respondents proposed that it would be possible for weekly sampling of some parameters but this varied between institutions. One group proposed that monitoring happen only several times a year but that this be very intensive in terms of parameters measured and frequency over, for example, one week.

Field sampling

The greatest limits here were almost unanimously boat availability and the number of available, qualified staff. More secondary limitations were certain equipment items such as field refrigeration, water samplers, and sampling flasks etc.

Analysis

As has been the case for previously, the greatest limitations to conducting the necessary analyses are the availability of some of the chemicals and certain equipment items such as spectrophotometers, and reduction columns.

When the workshop participants were asked what the present capability of their respective institutions was to conduct monitoring, we constructed the following table. The y-axis gives the range of parameters agreed to as those to be measured. The upper x-axis lists each institution below which a cross indicates a present capability

	Institution					
Parameter	**KMFRI**	**IMS**	**UDSM**	**SEYCH.**	**MADAG.**	**MAURIT.**
T (^oC)	X	X	X	X	X	X
Salinity	X		X	X	X	X
dO_2	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X
Secchi	X	X	X		X	
Nutrients	X	X	X		X	X
Chl a	X	X	X		X	X
BOD	X	X	X			X

Key: **KMFRI** - Kenya Marine & Fisheries Research Inst., Mombasa, Kenya.
IMS - Institute of Marine Sciences, Zanzibar, Tanzania.
UDSM - University of Dar es Salaam, Dar es Salaam, Tanzania.
SEYCH. - Technical Support Services division, The Seychelles,
MADAG. National Centre for Research, Antananarivo, Madagascar.
MAURIT. - Dept. of Env. Sciences, University of Mauritius, Mauritius.

Summary

In summary, whilst there was total agreement amongst the participants that the establishment of baseline monitoring stations was both desirable and probably manageable, there were clearly different ideas about what they should be aimed at achieving. This question in itself is obviously the main one to also be addressed from the point of view of IOCINCWIO. From the discussions entered into here, it was apparent that most participants had a strong desire to use such a facility to monitor locally interesting areas which were under stress of some type but which might not necessarily fall into a more regional monitoring "picture". Given the probable budgetary limitations for this exercise, it is unlikely that both aspects can be adequately addressed and so it is necessary that one approach be taken from the beginning. This could possibly form the first step of further discussions concerning the establishment of these baseline stations.

From the practical point of view it seems to us to be most desirable that the various institutions develop a routine of collecting and archiving relevant data. This will serve not only to provide a data base for future reference but will also encourage a degree of motivation and purpose amongst participating scientists. It is clear that an elaborate programme involving offshore stations will probably founder because of the lack of indigenous resources. It therefore seems much more practicable to establish the baseline stations at points close to institutions where access is easy and the cost implications are low.

Of the parameters identified in the table above (which represent the parameters that the authors regard as realistic), the indication of a capability does not necessarily indicate that the resources necessary to perform the work are actually present. In particular, a number of chemicals are in short supply and/or difficult to obtain and nearly all chemicals are expensive. It would be feasible for the sponsoring bodies to identify the parameters that they think are of greatest importance and then to supply those organisations that express an interest with 'kits' containing small but adequate quantities of the relevant materials. Advice on the contents and costs of the kits could be supplied by the authors but, as an approximate figure, $750-1000/year/ institution would probable permit a reasonable number of nutrient and dissolved oxygen (Winkler) measurements to be performed. Temperature, Secchi disk depths and the like are essentially zero cost once the necessary hardware is supplied.

5. CLOSURE OF THE WORKSHOP

The Intercalibration workshop for nutrient analysis in tropical waters was closed on 15th April, 1994. Dr. Okemwa congratulated the participants for the successful completion of the course and thanked IOC for helping organizing and supporting it. He also expressed his sincere thanks to all the lecturers and all supporting staff for their work, and to all the trainees for their friendly co-operation. He requested the lecturers to introduce nutrient analyses exercises by post to the trainees. He hoped that the knowledge they had acquired during this course would be useful and helpful in their future work at home.

6. CONCLUSION

The Intercalibration workshop for nutrient analysis in tropical waters was well organized, smoothly run and successfully conducted in a friendly atmosphere and its goals were achieved. The spirit of co-operation, enthusiasm and hard work displayed by the trainees were highly commendable. The length of the course was considered to be adequate, the facilities sufficient, and teaching material theoretical and practical in the laboratory and field at sea was satisfactory.

ANNEX I

TIMETABLE

Saturday 2nd April	Martin Preston arrival
Sunday 3rd April	Ron Johnston arrival
Monday 4th April	Participants arrive
Tuesday 5th April	Welcome, Introduction to workshop and familiarisation with facilities. Preparation of phosphate reagents.
Wednesday 6th April	Standard run - discussion of results (which were poor).
Thursday 7th April	Repeat of phosphate standards including complete remake of reagents including local marine samples (better results)
Friday 8th April	Preparation of reagents/glassware equipment for nitrate Testing of reduction columns etc. a.m First sampling exercise to sea (inside reef) p.m. Laboratory analyses continued until 9.30 p.m Discussion of results - identification of problems
Saturday 9th April	Preparation of written considerations for baseline studies
Sunday 10th April	Free day
Monday 11th April	a.m First sampling exercise to sea (inside reef) p.m. Laboratory analyses Nitrate + phosphate
Tuesday 12th April	Discussion of Monday's results Preparation of reagents/equipment for ammonia
Wednesday 13th April	Second field exercise tidal study for ammonia (all day) sampling in the morning and analysis in the afternoon.
Thursday 14th April	Review of the results of the tidal cycle study. Presentations by delegates of thoughts and written material regarding baseline studies. Discussions relating to guidelines for the setting up of such stations, practicalities and resources required.
Friday 15th April	a.m Final discussions and close of workshop p.m. Participants depart
Saturday 16th April	Martin Preston departs
Sunday 17th April	Ron Johnstone departs

ANNEX II

LIST OF PARTICIPANTS

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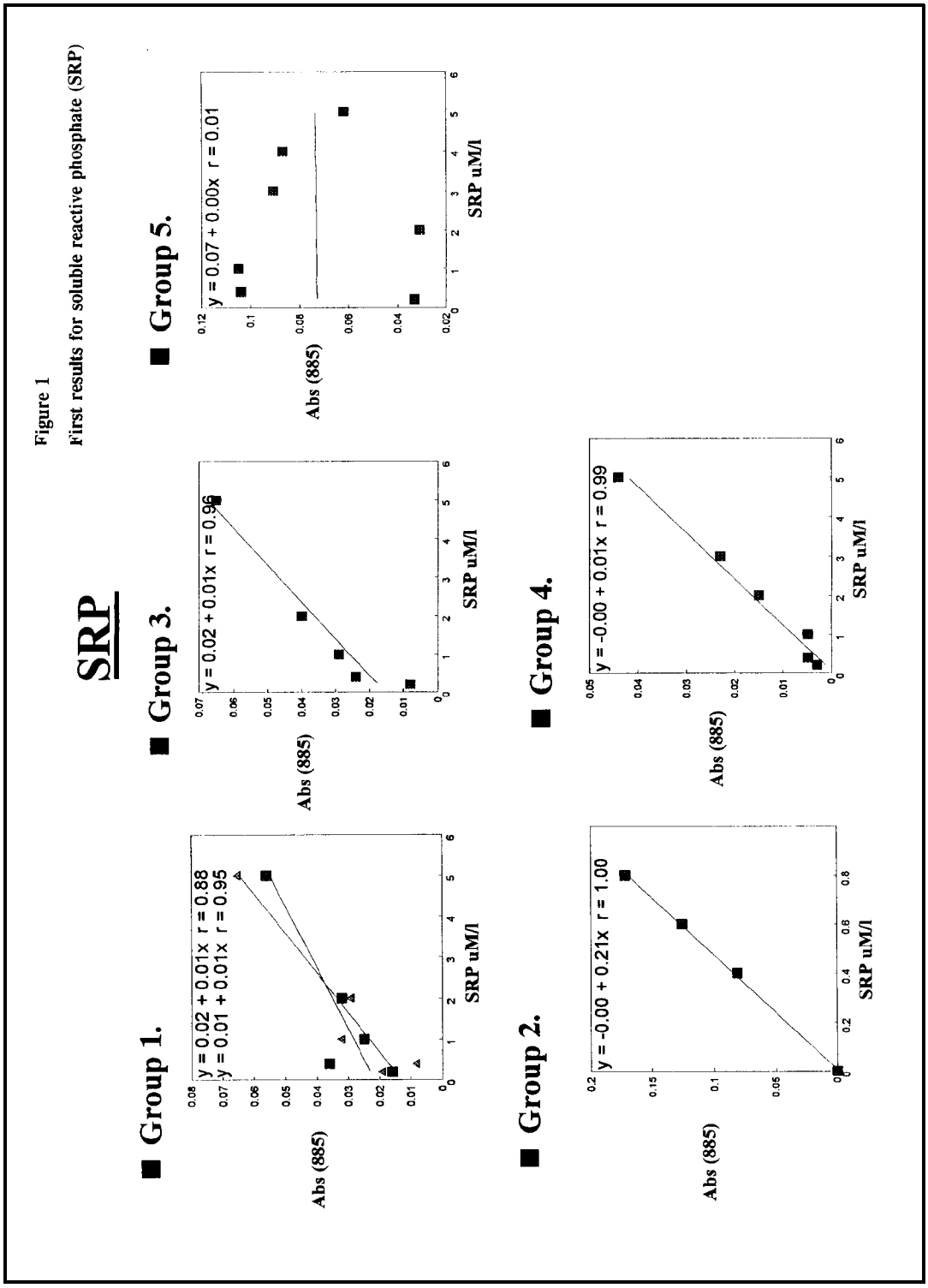
ANNEX III

ANALYTIC RESULTS

Figure 1
First results for soluble reactive phosphate (SRP)



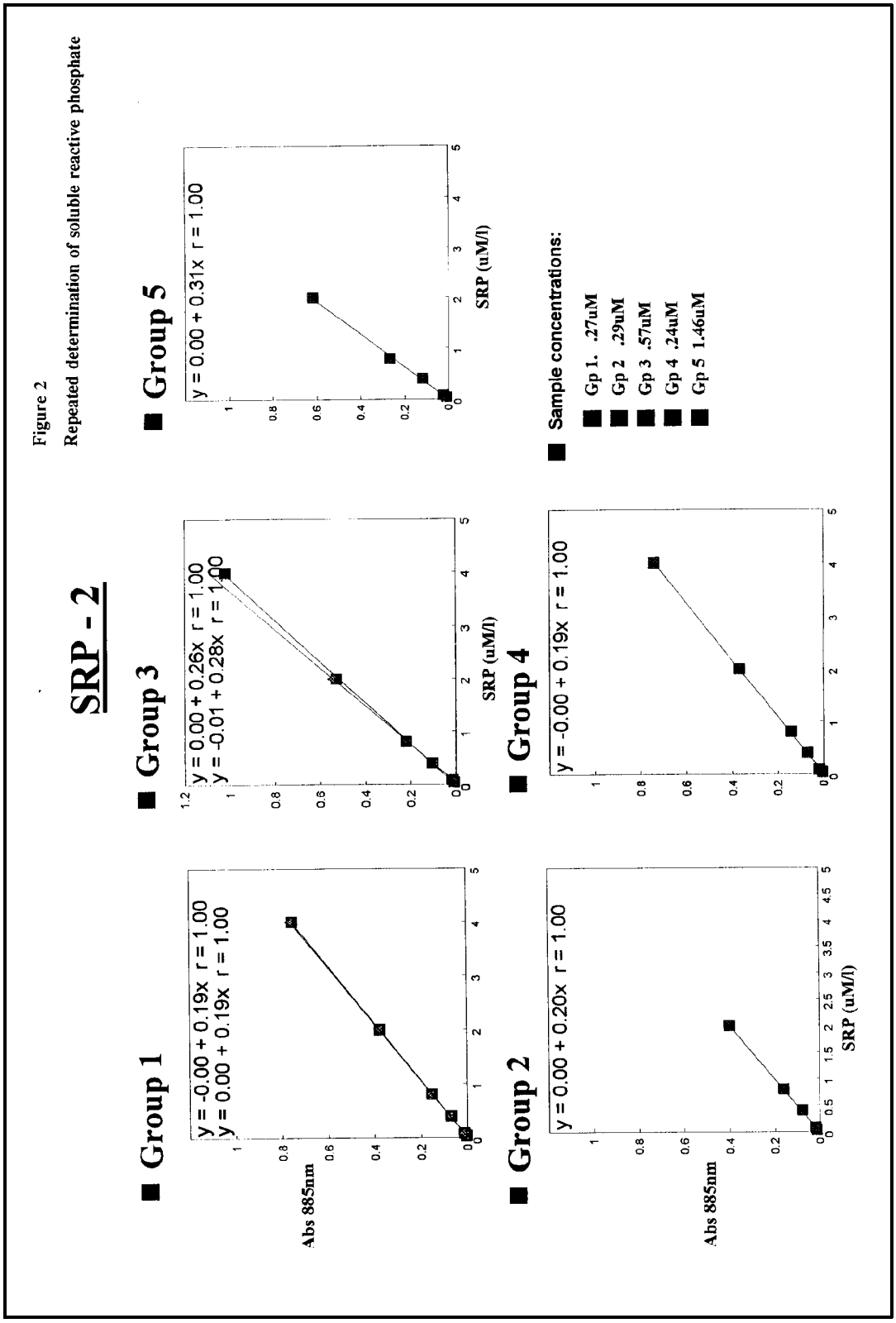


Figure 2
Repeated determination of soluble reactive phosphate

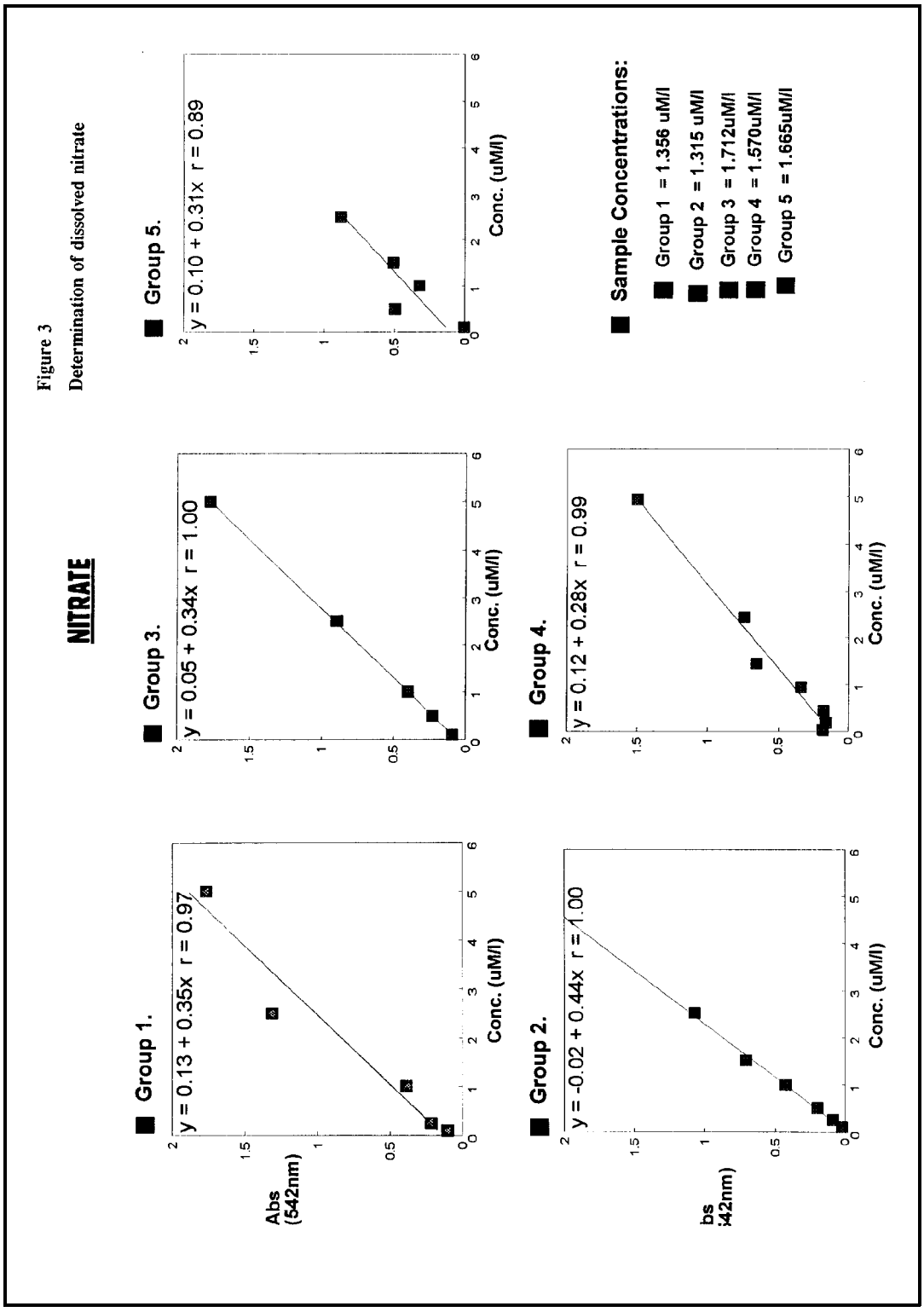


Figure 3
Determination of dissolved nitrate

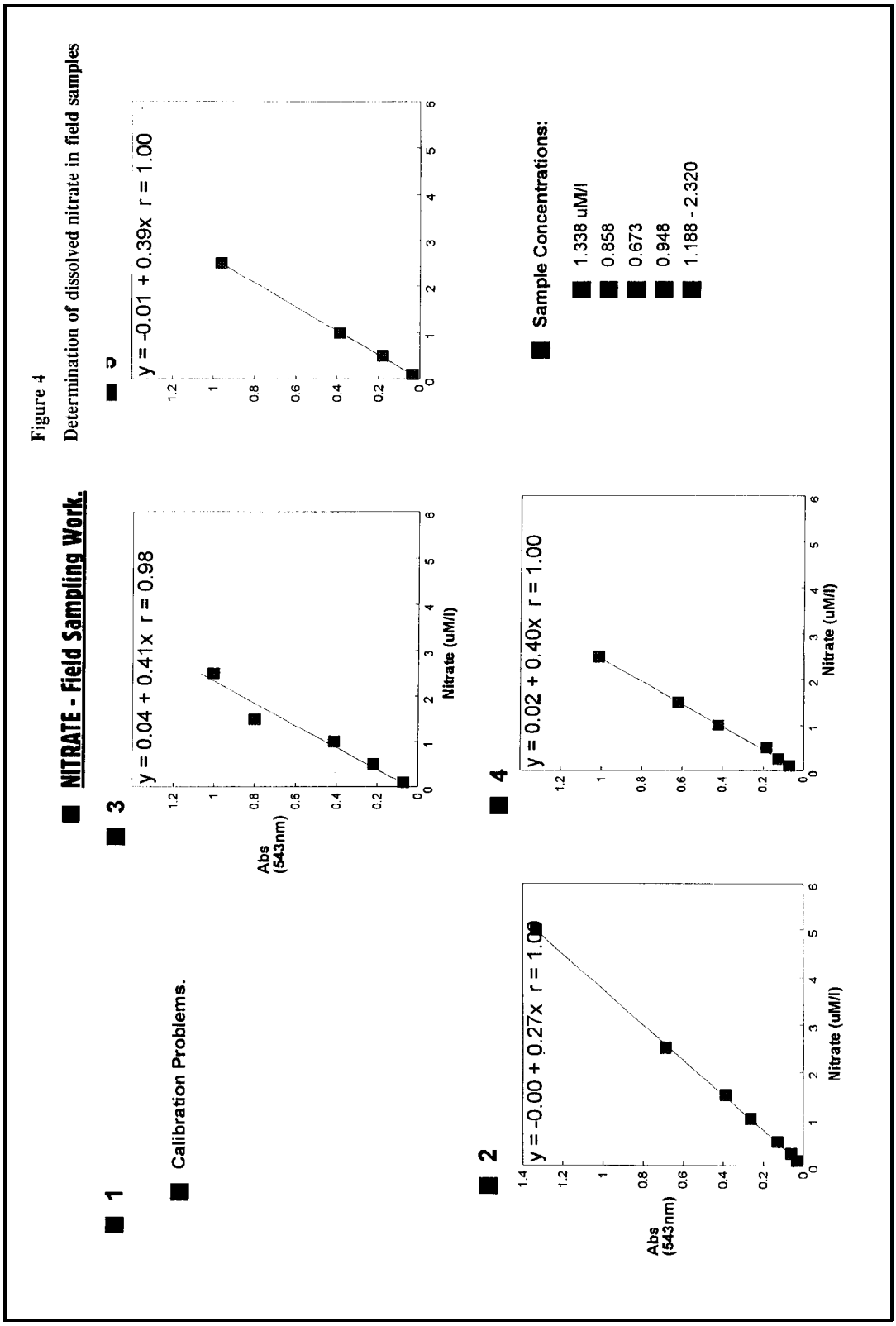


Figure 4
Determination of dissolved nitrate in field samples

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