Waterquality of the coastal zone of Bonaire

Results field monitoring 2011-2013

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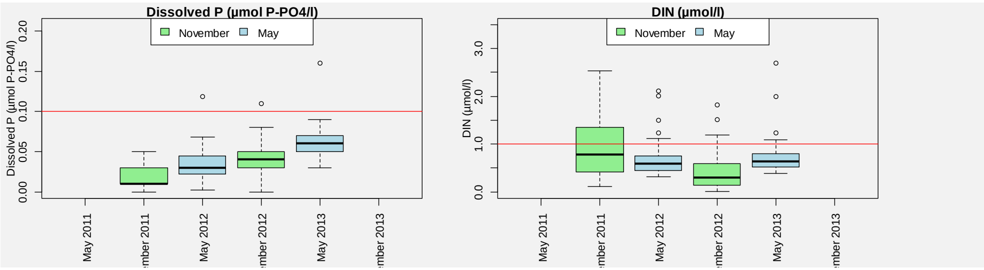

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Summary

Introduction and approach

Eutrophication is a common threat to the integrity of coral reefs as it can cause altered balance and integrity of the reef ecosystem. On the island Bonaire the former waste water treatment is limited which is a point of concern to the quality of the marine park. The reef of Bonaire faces nutrient input by various sources, of which enriched groundwater outflow from land is considered to be a substantial one. It is assumed that groundwater is enriched with nutrients e.g. due to leaking septic tanks.

In order to reduce the input of nutrients on the reef via enriched groundwater, a water treatment plant is being built on Bonaire. The treatment of sewage water is extended in 2012 with a sewage system covering the so called sensitive zone, the urbanised area from Hato to Punt Vierkant, including Kralendijk, the islands largest town. Based on the dimensions of the treatment plant and estimated connections to the plant, it is estimated that a total of 17.5 to 35 tonnes of nitrogen a year will be removed from the sensitive zone, and will not leach out to the sea. No estimates are known of the contribution of other sources to the total nitrogen load.

Limited information was available about concentrations of nutrients in the marine local environment and its eutrophic state. Therefore, Rijkswaterstaat asked IMARES to conduct a study on water quality aspects. The goal of this coastal monitoring study was to collect baseline water quality data to be able to study the impact of the water treatment plant in coming years. The following research questions are discussed based on the results:

- Are environmental safe threshold levels of water quality exceeded?
- Is temporal (over the years), or seasonal variation (November-May) of water quality observed?
- Does water quality vary among locations or regions in Bonaire?
- Based on experience and results, what are recommendations for future monitoring of water quality?

The study area was the west coast of Bonaire, and included 12 field locations. Water was sampled during early morning field trips at each location twice a year (May and November) starting November 2011 till May 2013. Indicators for water quality related to the nutrient status on the reef were selected and analyzed.

Based on their relevance to general water quality aspects and steering primary production, their relevance to the outflow of enriched (polluted) groundwater (and thus possible impact of the treatment plant in future) the following indicators were included:

- Inorganic nutrients
    - NO2, NO3, NH4, PO4
    - DIN (calculated based on NO2+ NO3+ NH4)
- Organic nutrients
    - Total nitrogen, ureum and total phosphorus
- General water parameters
- Chlorophyll-a
- Fecal bacteria

Concentrations were assessed against environmental threshold values from peer reviewed literature or (inter)national standards. If not available, outlying concentrations were highlighted taking the 80th percentile as a representative level.

Results and discussion

Water quality indicators measured at the west coast of Bonaire show signals of eutrophic conditions. Spatial and temporal variation in water quality is however observed. At some locations and certain moments environmental safe levels of nutrients are exceeded (see overview of data in Figure 1- Figure *4*). Especially at locations in the south and in the sensitive zone concentrations of nitrogen and phosphorus exceed the threshold levels. Southern locations are probably affected by the salt pans, and locations in the sensitive zone by outflow of sewage water.

Furthermore, an increase of phosphorus and chlorophyll-a is observed in the last 2 years, whereas nitrogen (DIN) decreases slightly over the years. However, despite the decrease of nitrogen, its threshold levels are exceeded at Red Slave, Tori's reef, Angel City, 18^{th} Palm, Cliff. Phosphorus and chlorophyll-a do not yet exceed environmental threshold levels, but if the increase continues, this might be relevant in near future.

The risk of higher nutrient levels is that algal growth can outcompete corals, and can change the structure of the ecosystem. Furthermore, increased levels of nutrients affect the coral reefs integrity due to decreased stability of the skeleton.

The increase of bioavailable phosphate alters the nutrient ratio (DIN:SRP ratio) and species composition can evolve from this change in relative nutrient availability. Relating these data with observations in benthic composition and chlorophyll-a trends is advised to support this hypothesis.

Fecal bacteria numbers exceed several standards for human health safety. High fecal bacteria numbers are more frequently found in the south and in the sensitive area, and are likely to be related to rainfall events. Bacteria are found in surface samples as well; indicating surface run off as a possible source.

Actual rainfall, especially just before or during sampling is an important steering factor in the concentrations measured. Rainfall is very scattered during the rainy season, and we believe so is the outflow of nutrients to the reef.

In short it is recommended to continue the monitoring of water quality over several years at the same frequency and locations. Next to the regular program, make sure that interval sampling during heavy rains are included as these moments indicate point source discharges which can be missed when rainy season is shifted. No locations should be discarded from the program. In order to prepare the monitoring program for future measures taken outside the current zone (Hato- Punt Vierkant) additional locations just north and south of the sensitive zone are advised to be included. The set of indicators can remain the same, with some slight adaptations such as the addition of coprostanol (measure of faecal discharge) and discard of ureum.

As nutrient levels are in a constant flux, data should be considered in an ecosystem context. Benthic surveys focusing on macro algae, turf algae and cyanobacteria, were not included in this study, but add largely to a whole ecosystem assessment on eutrophication issues.

Monitoring of water quality in the coastal zone <u>alone</u> will not provide satisfactory indication of the impact of the treatment plant in reducing emissions to the marine environment. To monitor the impact of the treatment plant, several factors should be considered. These are related to the treatment plant itself, groundwater quality, coastal water quality, benthic coverage and benthic quality. Actual reduction of emissions to the marine environment can be retrieved from monitoring and reporting of the efficiency of the treatment plant. Monitoring of groundwater wells provides knowledge on the groundwater quality that outflows to the reef. Water quality monitoring in the coastal zone gives knowledge on conditions contributing to environmental health. It is advised to synchronize the monitoring programs, and to analyze the datasets in a coherent way.

In the end, eutrophication is not the only pressure potentially affecting a reef. Besides the focus on the research related to the treatment plant it is advised to consider additional research on a "whole ecosystem basis" in which the contribution of other pressures as well, such as run off via canals and overflows of salinas with nutrients and sediments (in rainy season), fisheries impact and the impact of climate change/acidification on the reef are included.

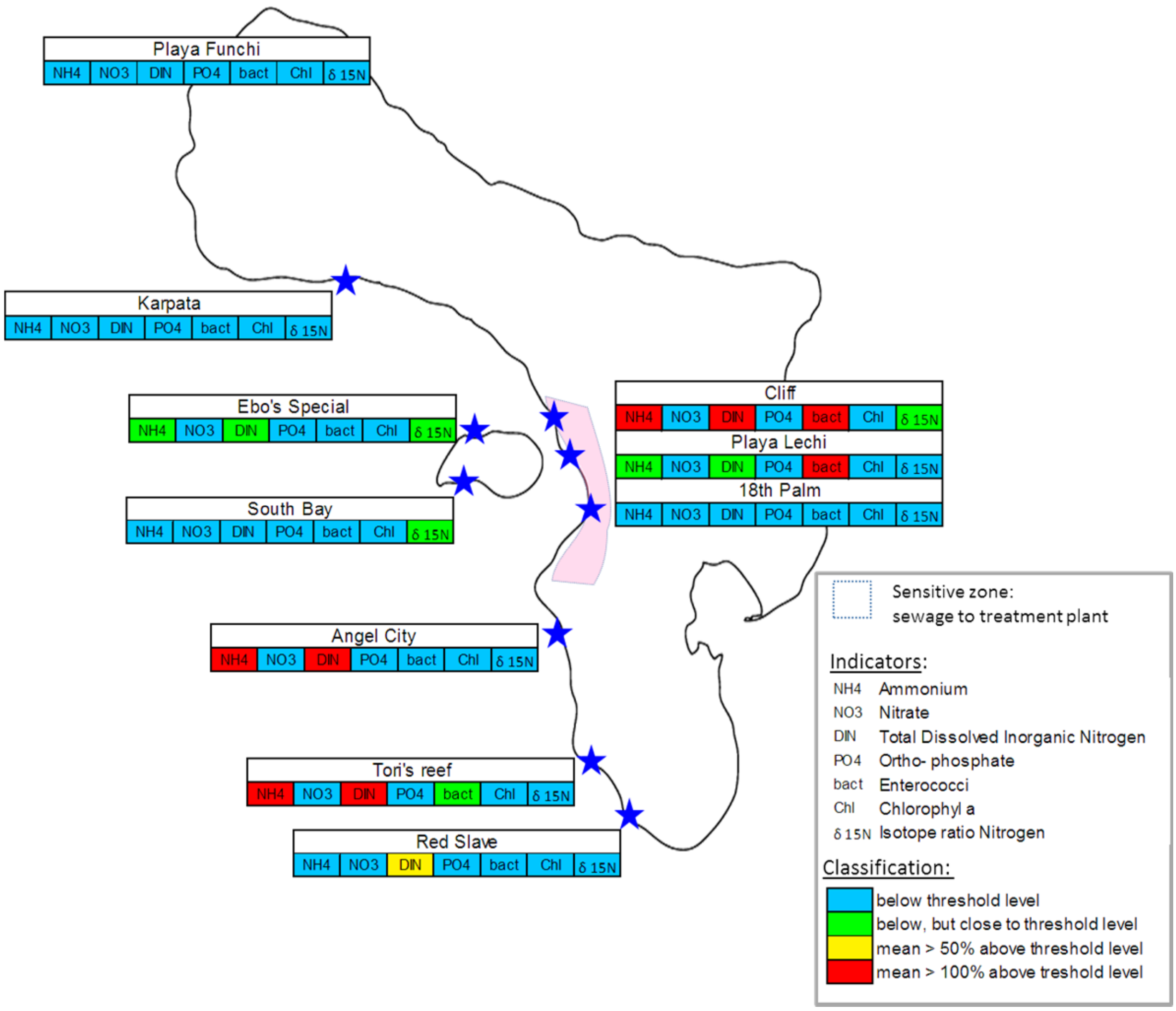

Figure 1 Summary of results November 2011 (slightly other indicator set then other sampling moments, see report for more details).

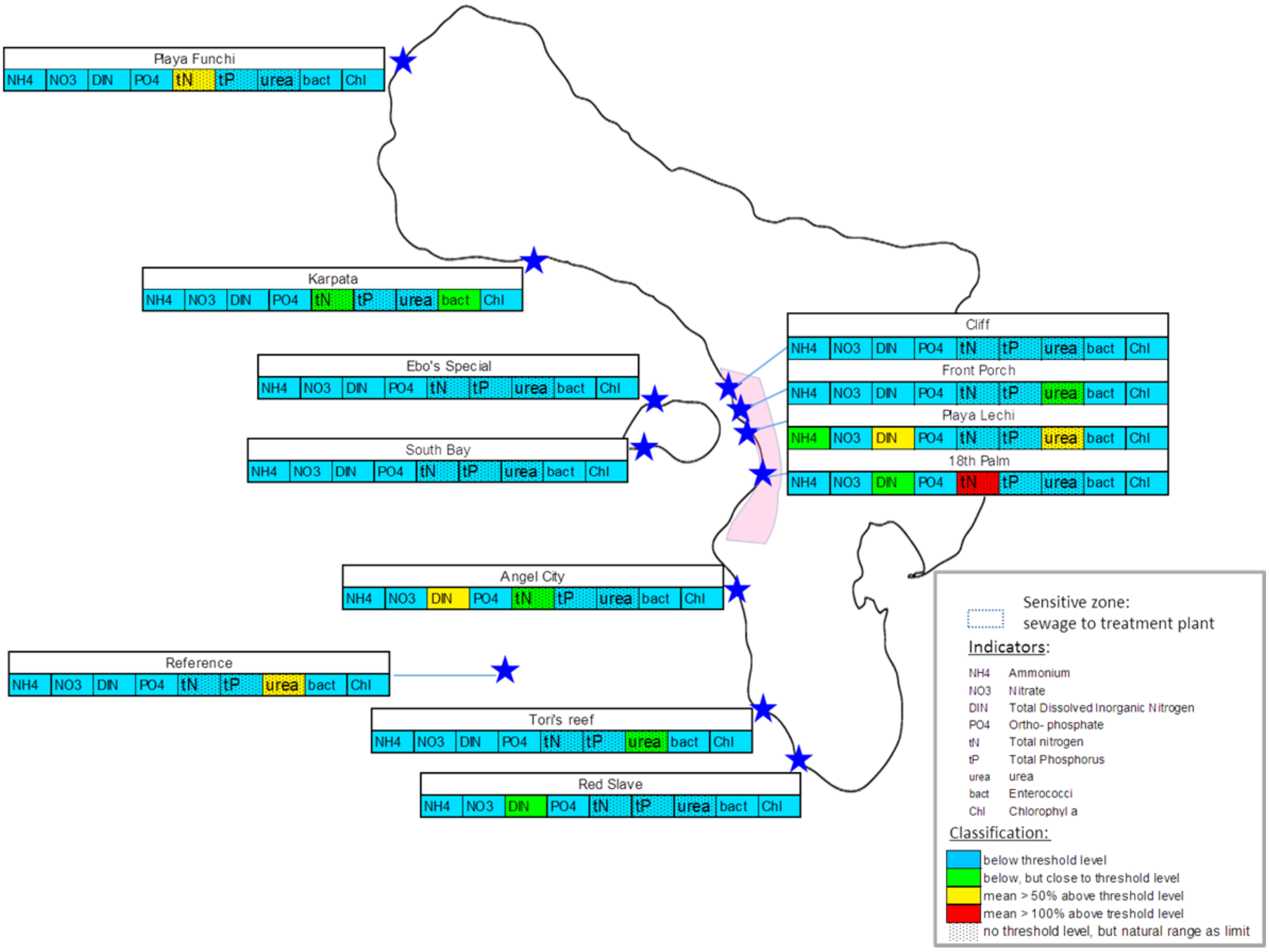

Figure 2 Summary of results May 2012

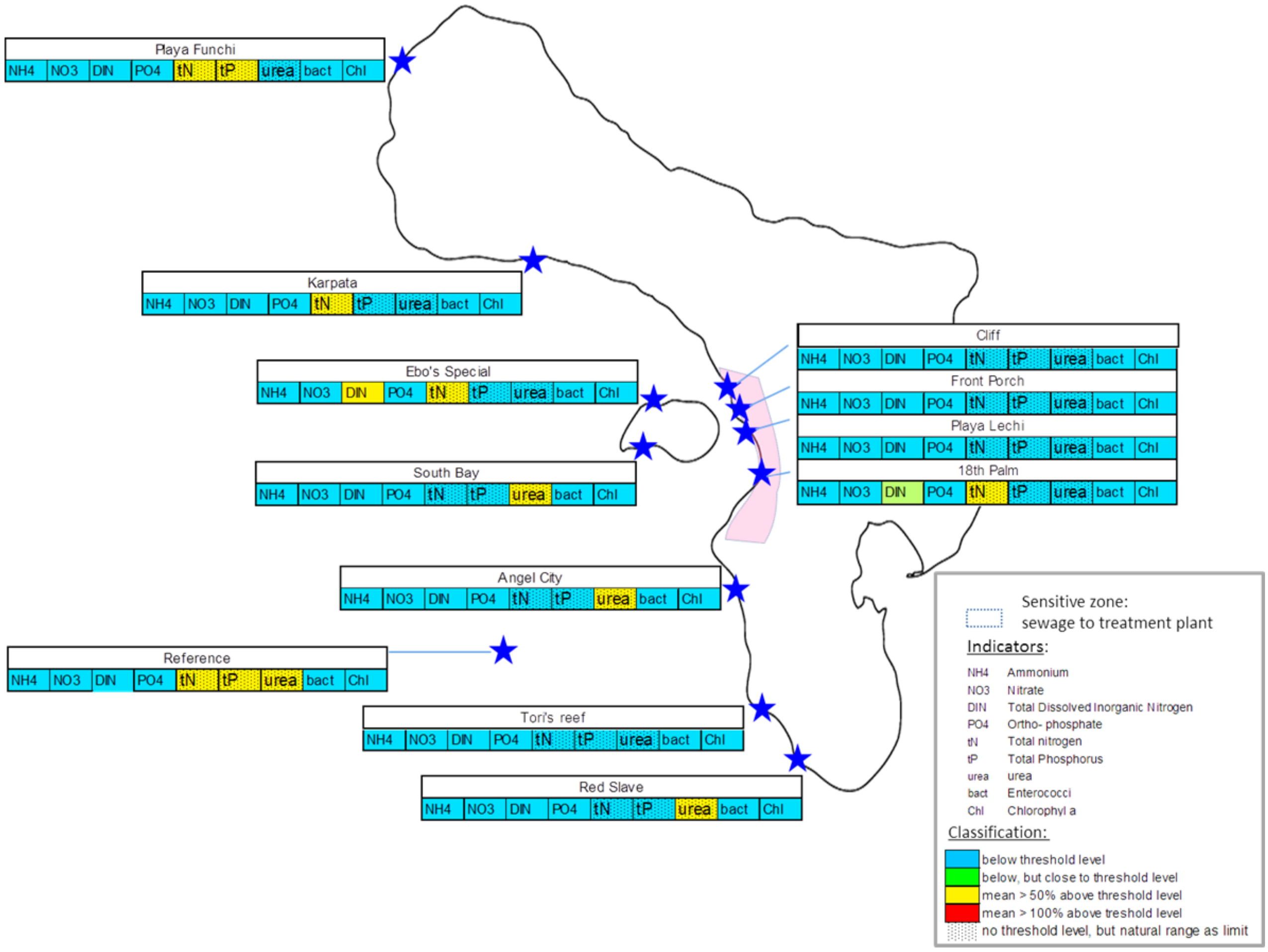

Figure 3 Summary of results November 2012

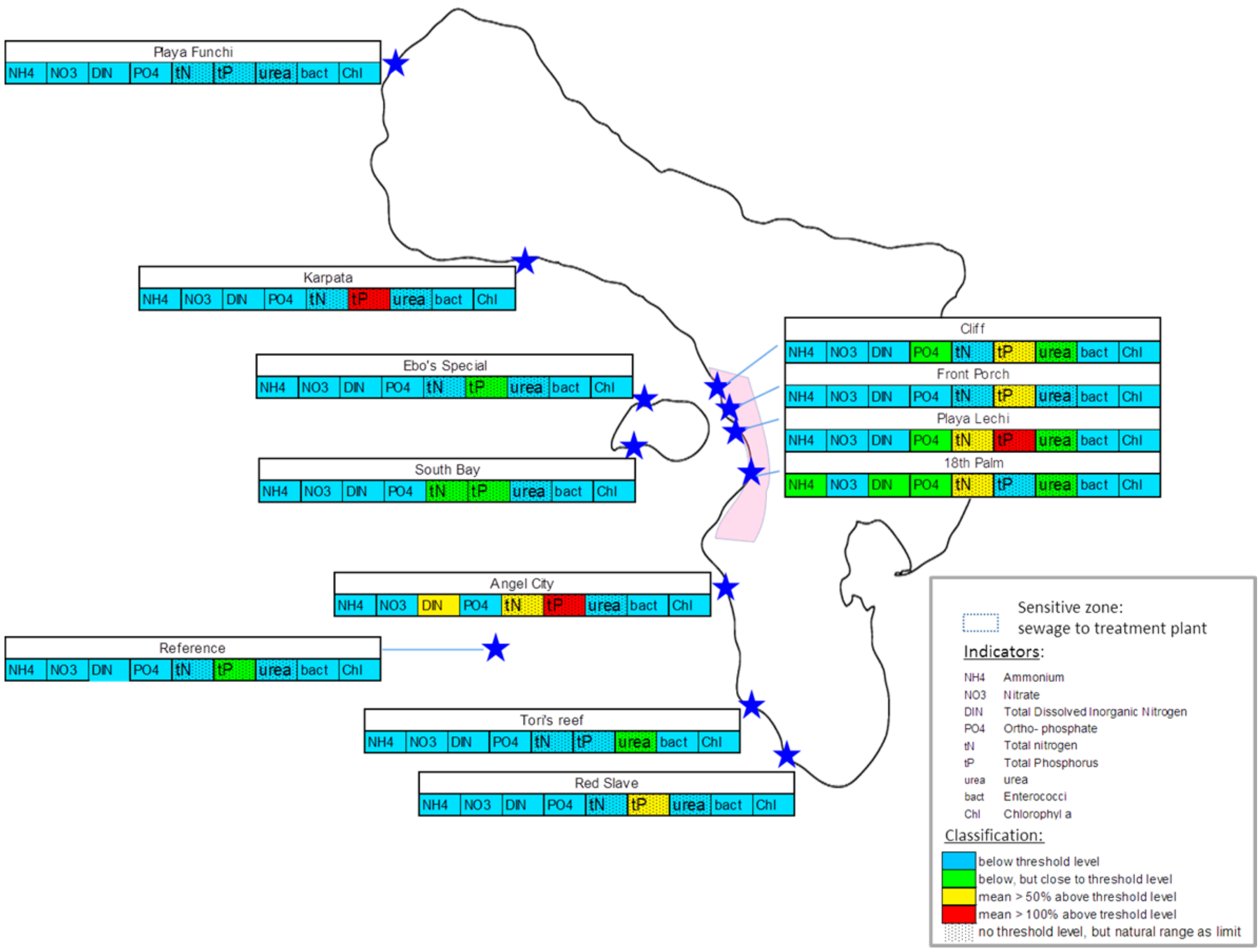

Figure 4 Summary of results May 2013

Acknowlegdements

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Contents

1 Introduction

1.1 Situation sketch

On the island Bonaire, eutrophication is a serious point of concern, affecting the coral reefs in the marine park. Eutrophication can cause altered balance of the reef system because algae shall outcompete corals, eventually leading to a disturbed composition of the reef.

The only known study on water quality of Bonaire (reported in draft) is executed by Lapointe and Mallin in 2006-2008. This study revealed that Bonaire suffers eutrophic stress induced by land based nutrient discharge. Both nitrogen and phosphorus were exceeding environmental safe threshold values at various locations along the west coast of Bonaire. Furthermore, benthic study showed algal turf cover to be associated with the elevated nutrient levels, indicating bottom up eutrophic conditions (Lapointe and Mallin, in prep).

The reef of Bonaire faces nutrient input by various sources:

- Enriched groundwater outflow to the reef. Enrichment of groundwater is caused by:
    - Discharge of untreated sewage water collected from resorts, households and companies.
    - Sewage leaking from septic tanks. Estimated is that a total of 118.275 m^3/year[1] flows into the reef ecosystem, from hotels only. Residential properties and businesses are not taken into account in this number (Anonymous, 2008).
    - Fertilizers in resort gardens
- Run off via salinas and storm water
- Illegal discharge and overflows of septic tanks
- Discharge of yachts + 1 cruise ship permit (Freewinds)
- Industrial discharge (e.g. salt company and WEB)

No information is available about the total amount of nutrients in the marine environment, and the contribution per source.

In order to reduce the input of nutrients via sewage water, a program was established to build a water treatment plant on Bonaire. A preliminary treatment plant is built treating 200 m^3 a day (73000 m^3 a year). The treatment of sewage water will be extended in near future with a sewage system covering the so called sensitive zone, from Hato to Punt Vierkant. This treatment plant, located at LVV near Lagun at the east coast, is capable of treating 1200 m^3 a day (438000 m^3 a year), and Van Kekem et al. 2006 estimated that the total nitrogen balance shows a total reduction of nitrogen input due to the foreseen connections of septic tanks to the treatment plant (with 2006 specifications) about 70% (6.5 tonnes per year) in the sensitive zone (by the year 2017 compared to 2005). In practise this estimation will be lower, as the sewage plan was adapted. No exact figures are available for this report.
The connections between houses, hotels and other buildings to the treatment plant are currently (2013) being executed and expected to be finalised by the end of 2013. In February 2013, hotels in the Hato region were connected, and sequential other hotels, tourist accommodations, houses and companies will follow.

Based on MIC (2011) average influent conditions in practice are however assumed to be different then estimated by Van Kekum (2006) (Table 1). Based on the details in table 1, it can be assumed that a total of 17520-35040 kg of Nitrogen is removed from the sensitive zone, and will not leach out to the sea at the western coast of Bonaire. The effluent will be discharged at the LVV area or used as irrigation water for

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[1] This equals roughly to 21 m3/hour (in case of constant flow, which is not the case due to variable outflow).

agriculture. Part of the treated sewage might discharge to the sea at the east coast, or infiltrates into the groundwater. The groundwater flows and its quality are unknown.

Table 1 Assumed influent and effluent conditions (MIC, 2011)

Aspect	**Specification**	**Equals to**
Average flow rate	480 m3/day	175200 m3/year
Influent Total Nitrogen	100-200 mg/l	17520-35040 kg/year
Influent total Phosphorus	75-200 mg/l	13140-35040 kg/year
Effluent Total Nitrogen	46 mg/l	8059 kg/year
Effluent total Phosphorus	65 mg/l	11388 kg/year

Figure 5 Map of Bonaire. Balloons indicate the boundaries of the sensitive zone between Hato (north) and Punt Vierkant (south)

1.2 Assignment

Rijkswaterstaat Waterdienst asked IMARES to conduct a monitoring study on the water quality status of the coastal zone of Bonaire, and to collect baseline water quality data, taking into account the relation with the treatment plant. In 2011 the monitoring started, and the results and background information is documented in Slijkerman et al., 2012a and Slijkerman et al., 2012b. Based on the results, advice was given on a monitoring program for upcoming years. In 2012 and 2013 additional sampling was conducted (three times).

This report describes the results from the monitoring performed 2011 (November), 2012 (May and November) and 2013 (May).

The following research questions were discussed based on the results:

- Are environmental safe threshold levels of water quality exceeded?
- Is temporal (over the years), or seasonal variation (November-May) of water quality observed?
- Does water quality vary among locations or regions in Bonaire?
- Based on experience and results, what are recommendations for future monitoring of water quality?

2 Methods

In Slijkerman et al. (2012a) and Slijkerman et al. (2012b), a thorough overview is provided of the locations and indicators chosen. The locations were selected as a representation of different areas of Bonaire along the west coast. This selection includes locations where sewage water via the groundwater outflows to the reef, and where in future improvement of the water quality is expected due to the installation of the treatment plant. Furthermore, there are some historical data available for most of these locations and indicators, both on nutrient concentrations, and benthic coverage which allows comparison with the new data collected.

2.1 Locations

In 2011 10 locations were sampled. Two locations were added in 2012 and 2013: Front Porch (an added location in the sensitive zone) and an offshore reference location. In Table 2 the specifications of the locations in terms of relevance to enriched groundwater with sewage from septic tanks are given, as well as other influences. The number of sampling events are also given.

Table 2 Overview of locations sampled and their specifications. Green shaded locations are located in the sensitive zone (sewage→ treatment plant). The locations are ordered geographically; from north to south, except for Klein Bonaire and the offshore reference. See Figure 6 for the geographical map.

Location	**Outflow sewage in groundwater**	**Other influence by nutrients**	**Sampling**
Playa Funchi (PF)	No	Indirect via currents, and salina	4
Karpata (KAR)	No	Indirect via currents from the south	4
Cliff (CF)*	Yes	Yes (fertilisers, brine)	4
Front Porch (FP)	Yes	Yes (yachts)	3 (- 2011)
Playa Lechi (PL)	Yes	Yes (yachts)	4
18th Palm (18P)	Yes	Yes (yachts, fertilisers)	4
Angel City (AC)	No	Yes (salt pans)	4
Tori's reef** (TR)	No	Yes (salt pans, brine effluent in harvest season)	4
Red Slave (RS)	No	Yes (salt pans)	4
Ebo's Special (EBO) (Klein Bonaire)	No	Limited, Indirect via currents and salina	4
South Bay (SB) (Klein Bonaire)	No	Limited, Indirect via currents and salina	4
Offshore reference (REF)	No	Not expected	3 (- 2011)

*: formerly known as Habitat.

**: formerly known as Cargill

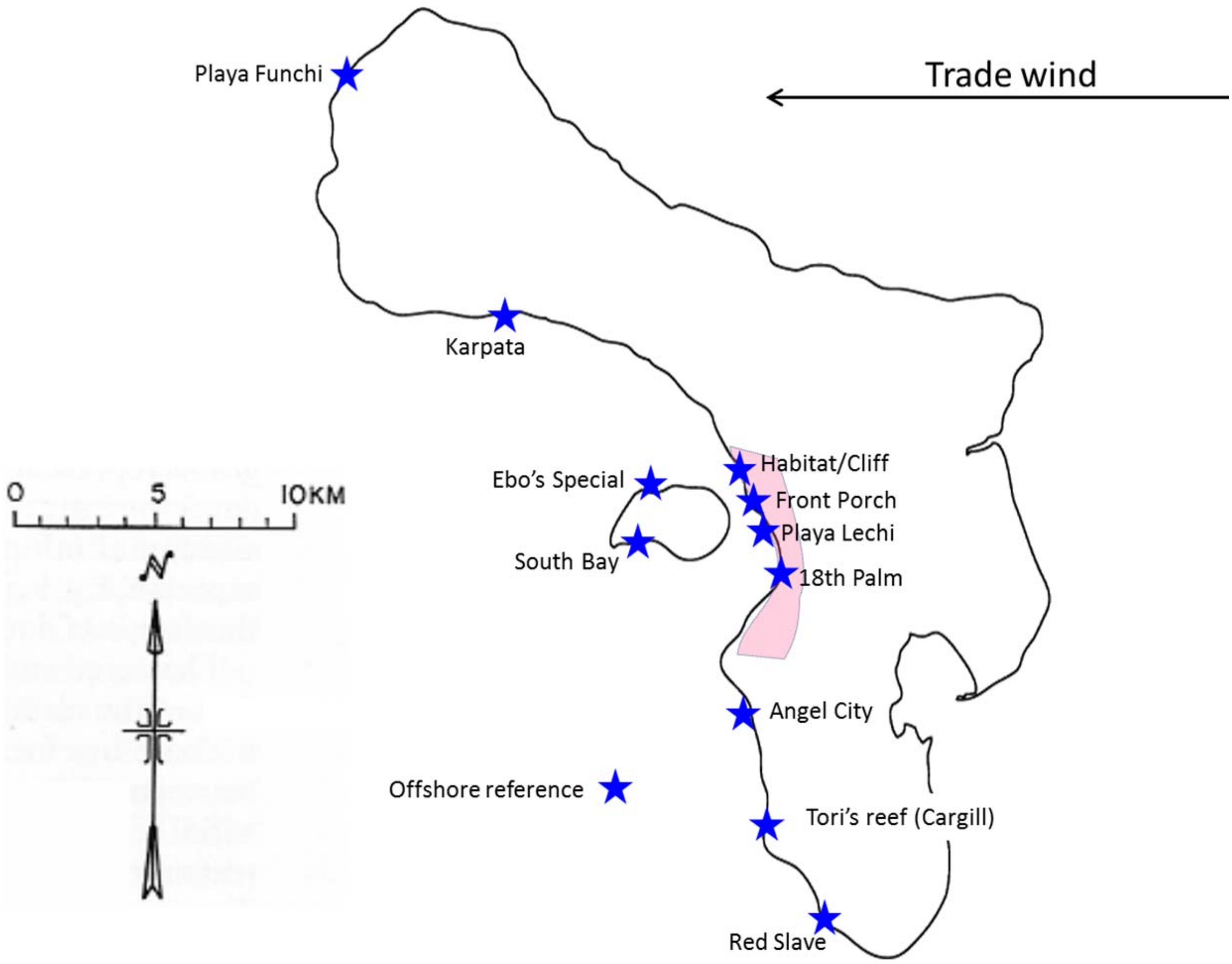

Figure 6 Geographical overview of locations sampled.

2.2 Indicators

Based on their relevance to general water quality aspects and steering primary production, their relevance to the outflow of enriched (polluted) groundwater (and thus impact of the treatment plant in future) the following indicators were included in the monitoring program:

- Inorganic nutrients
    - NH_4, NO_2, NO_3, PO_4^{3-},
    - DIN is calculated based on NH_4, NO_2, NO_3,
- Organic nutrients
    - Total nitrogen, total phosphorus and ureum
- General water parameters, including dissolved oxygen, pH, salinity, temperature
- Chlorophyll-a
- Fecal Bacteria (using Enterolert test kit, measuring enterococci)

2.3 Sampling and analysis

Fieldwork took place in dry (May) and rainy (November) seasons during 2011-2013, under coordination by IMARES. Ramón de León (Marine park manager STINAPA) conducted the water sampling by means of scuba, going from the shore. Diana Slijkerman (IMARES) coordinated and assisted in the field. The preparation of field samples and analysis of entero-bacteria was conducted in the laboratory of CIEE by Diana Slijkerman. In 2012 and 2013 technical assistance was provided by respectively Meetdienst Zeeland (Geert den Hartog) and CIEE (Graham Epstein, Ryan Patrylak, Katy Correia). STINAPA rangers assisted with offshore sampling by boat, at Klein Bonaire (Ebo's Special, South Bay) and at the offshore reference.

Each day, 2 or 3 field locations were sampled in the morning. In 2011 the sampling took place at two depths: Shallow (being the start of the reef, variable depths <15 m) and deep (~20 m at the reef). Since the results of 2011 showed no significant differences between deep and shallow concentrations, it was decided that sampling in 2012 and 2013 was conducted only at the shallow depth, being variable in depth as the beginning of the reef varies among the locations. For comparison within years, in this report only data from the shallow sampling in 2011 is taken into account.

In Table 3 an overview is provided when sampling took place, and which parameters were analysed. In Table 4 an overview of replication is given. Sampling in 2011 deviates to some extent from the 2012 and 2013 samplings in the number of locations and numbers of indicators.

*Table 3 Details of sampling period and analysis. * DIN is calculated based on NO2+NO3+ NH_4*

Sampling	Year	Month	Analyses
1	2011	November 11, 13-17	NH_4, NO_2, NO_3, DIN, PO_4^{3-}, enterococci, Chlorophyll a
2	2012	May 24 – 27	NH_4, NO_2, NO_3, DIN, PO_4^{3-}, total nitrogen, total phosphorus, ureum, enterococci, Chlorophyll a
3	2012	November 19-22	NH_4, NO_2, NO_3, DIN, PO_4^{3-}, total nitrogen, total phosphorus, ureum, enterococci, Chlorophyll a
4	2013	May 27-30	NH_4, NO_2, NO_3, DIN, PO_4^{3-}, total nitrogen, total phosphorus, ureum, enterococci, Chlorophyll a

Table 4 Replicate details per sampling moment and parameter. The sample for total N, P and ureum is taken from replicate A corresponding the Nh4 (etc) bottle. Enterococci and chlorophyll-a were sampled in the same bottles and subsamples were taken in the laboratory.

Sampling	NH_4, NO_2, NO_3^-, DIN, PO4	Total N, total P, ureum	Enterococci	Chlorophyll a
1	3	0	3	3 500 ml
2	3	1	2 (+ 1 surface)	3 500 ml
3	3	1	2 (+ 1 surface)	3 1000 ml
4	3	1	2 (+ 1 surface)	3 1000 ml

At each sampling point, 3 sample bottles of 500 ml were filled for nutrient analysis, three dark bottles of 1 L for chlorophyll a and bacteria analysis. The replicate numbers for each of the parameters is scheduled in Table 4.

General water quality parameters were analyzed in the field. Measurements were conducted in the lab of CIEE immediately after returning if technical errors in the field occurred. However, the multimeter available, showed various errors over the 4 sampling moments, and data for pH, dissolved oxygen, and salinity could not be used as co-variables since most data are unreliable. Only at sampling May 2012, these data were properly measured using YSI 6600 type multiparameter analyser.

After sampling, the samples were prepared in the CIEE laboratory according to established protocols (Slijkerman et al. 2012a).
Nutrient samples were prepared in 20 ml jars, and solid frozen in the freezer until transport to the Netherlands. Transport was conducted using a cooler, fully packed with ice packs and extra isolation material. Samples arrived solid frozen in the Netherlands, after which they were stored in the lab until frozen transport to the laboratory in NIOZ, Yerseke. The only deviation was in May 2012. Samples were collected in jars of 6 ml, and these did not have enough capacity to arrive solid frozen into the laboratory. These samples were analyzed the same day to prevent any deterioration of the sample. All other samples were analyzed within 4 weeks after sampling. Methods are described in Slijkerman et al. (2012b).

For chlorophyll a, during the first two sampling moments, 500 ml of seawater was filtered by hand using a syringe. A larger volume could not be handled due to capacity constraints, and since the detection limit could be met, this was judged as sufficient. The concentrations are however at such low levels, that even lower concentrations would be hard to measure. During sampling events 3 and 4, more capacity was built into the program using a vacuum pump, and 1000 ml was filtered instead of 500 ml. Chlorophyll a was filtered on a fiber-glass filter, which was stored in alu-foil in the freezer until transport in a Bio-bottle to keep the samples frozen. In the IMARES laboratory the samples were stored frozen until analyses within 2 weeks after sampling.

For enterococci analyses via Enterolert©, a quality control test did not exist during sampling events 1 and 2. Therefore, triplicate seawater samples (from the dark bottles) were analyzed, plus a negative control (sterile water) at the lab. In 2012, a quality control test became available, and was used since then. Instead of triplicate, duplicate samples were analyzed. Surface water analysis for enterococci was formally not included in the research program, but during field sampling additional samples were taken from the surface (~40 cm) to get a first impression of surface water bacterial quality.

2.4 Water quality standards

For soluble nitrogen and phosphorus, chlorophyll a and fecal bacteria, environmental threshold values or standards exist (Table 5).

Table 5 Water quality standards for applied indicators

	indicative for		**environmental threshold**	**reference**
Indicator	**Treatment plant**	**other pressures**		
General (Temperature, pH, dissolved oxygen, salinity,)	indirect	yes (biotic, abiotic)		
Nutrients (NH_4, NO_2, NO_3, PO_4^{3-},)	Yes	yes (biotic, abiotic)	DIN: 1 µmol/L, PO_4^{3-},: 0.1 µmol/L	Werkgroep Milieunormering Nederlandse Antillen, (2007), which is based on various peer reviewed literature (e.g. Bell 1992, Bell et al, 2007)
Chlorophyll a	indirect	yes (biotic, abiotic)	0.5 µg/L	Bell (1992)
Bacteria (enterococci)	Yes	Yes	- 185 cfu/100ml - 100 cfu/100ml - 35 cfu/100ml	- European bathing water standard (EEC, 2006) - Caribbean blue flag (UNEP, 2003) - US EPA standard (Criteria for Bathing Recreational Waters) (US EPA, 1986)

For total nitrogen, total phosphorus and ureum, no quality standards are found in literature. To derive some kind of local threshold value, the 80th percentile was taken, based on the retrieved data in this monitoring period at Bonaire for the particular indicator. This is more or less equivalent to the derivation of local water quality standards in Queensland Australia [2]where the 80th percentile of reference values was taken. In our study, all data were taken as a first attempt to say something about the variation of data. Data and retrieved standards are reported in the results section.

2.5 ANOVA analyses

For each of the measured parameters, an ANOVA (ANalysis Of VAriance) was performed. An ANOVA analyzes the significant differences between group means ($p < 0.05$). Such ANOVA analyses have been performed individually for each nutrient, bacteria, and chlorophyll-a, response variable. For the response variables, the contribution of the factor 'Location', "Season" and "Time" to the variance was tested. Season refers to the differences between wet and dry season, whereas time refers to the observed difference between 2011 and 2013 (taken as November 2011 and May 2012 vs. November 2012 and May 2013).
One of the assumptions in the ANOVA analyses is that the data is normally distributed. In order to get more normal like distributions, all data are fourth root transformed before analysis. Log transformation is not possible as our data contains zero values.
ANOVA analyses are followed by a post hoc Tukey's 'Honestly Significant Difference' test, in order to determine which groups differ significantly (remember that the ANOVA only tests whether or not all means are equal and does not compare individual groups).

In addition, some analyses have been performed not only at differences between locations, but at four "regionally" distinct groups of locations. The boundaries are more or less subjective, and based on geographical information. South includes the locations Red Slave, Tori's Reef, Angel City; Sensitive zone includes locations 18th Palm, Playa Lechi, Front Porch, Cliff; North includes Karpata and Playa Funchi, and Klein Bonaire includes South Bay, Ebo's Special and the offshore reference. These selections can be discussed, but are only used to get some impression on regional variation.

All statistical analyses have been implemented and executed in R version 2.12.2 (The R Foundation for Statistical Computing, Vienna).

2.6 Box Plots

Box plots are used to visualise data per factor (either time or location). Each box has a bold line somewhere in the middle, indicating the median value for that specific factor. The boxes indicate the first and the last quartile of the data. In other words, 50% of all observations (for the specific factor) lie within the box. Whiskers indicate the minimum and maximum values, excluding outliers. Outliers are shown as markers (◦). In the box plots, data are considered to be outliers if they deviate with more than 1.5 times the interquartile range from the first or third quartile. Box plots give a simple overview of the range of the observations.

[2] http://www.ehp.qld.gov.au/water/pdf/deriving-local-water-quality-guidelines.pdf

3 Results

In the boxplot figures, locations are plotted on the x-axes, and geographical ordered from North to South. Locations at Klein Bonaire and the offshore reference cannot be ordered properly by geographical order, and are placed last in order. Locations lying within the sensitive zone (Cliff, Front Porch, Playa Lechi and 18th Palm), and assumed to receive nutrient enriched groundwater are marked with a red colour.
If available and relevant, the environmental threshold value is plotted as a red line in the figures.
Data are described and compared with available data from the study of Lapointe and Mallin (in prep) on nutrient monitoring in Bonaire.

3.1 General water quality parameters

Water temperature ranged from 27.4-30.0 °C. November temperature is significantly higher than May temperatures ($p< 0.001$). Field observations show early morning measurements being slightly lower than late morning measurements due to influence of the sun. The lower temperatures in May correspond well with the climatological conditions in the Caribbean.

Dissolved oxygen concentrations, salinity and pH were not included in this data report as the probes were not working at 2 or more sampling moments, and when measured, data are highly insecure values.

In annex 1 and 2 overviews are presented of water depth and coordinates per location, and all available results of water quality aspects.

3.2 Nutrient concentrations

Threshold levels for soluble nitrogen and phosphorus (NH4, NO3, DIN, PO4), bacteria and chlorophyll a are available and reference can be found in Slijkerman et al (2012a). Threshold levels for urea, total nitrogen and total phosphorus are not available, and the 80th percentile is taken instead (chapter 2.).

3.2.1 Dissolved inorganic Nitrogen (DIN)

In Figure 7 and Figure 8 DIN concentrations are presented as boxplots. DIN ranged from 0.01 µM (offshore ref) till 2.69 µM (18th Palm). One extreme high value was reported for Red Slave, being 10.91 µM. DIN concentration is depended on the location and shows seasonal differences, average November concentrations (0.79 µM) being slightly higher than concentrations in May (0.73 µM), ($p< 0.05$). In general, DIN concentrations decrease when 2011-2012 is compared with 2012-2013 data, indicating a decreasing trend over time ($p<0.001$).
DIN environmental threshold level of 1 µM is exceeded at some locations (Red Slave, Tori's reef, Angel City, 18th Palm, Cliff) and is observed in all sampling moments. When comparing the 4 regions in the coastal zone, northern locations have significantly lower DIN concentrations than locations in the sensitive area and the south ($p<0.05$). In 24 out of 137 samples the threshold level is exceeded. Six of these samples were taken in the northern and offshore locations (begin dominated by Cliff and Ebo's Special), and 18 in the south and sensitive area (being dominated by Playa Lechi, 18th Palm, Angel City, Tori's Reef and Red Slave). These were mostly November 2011 samples (except for 2).

DIN concentrations vary over the locations, of which 18th Palm and Angel City have significant higher concentrations than Playa Funchi and the offshore reference ($p= 0.01$ and $p= 0.05$ respectively).

However, the large variation between the two November samplings could distort the drawn conclusion. November 2011 had considerably higher concentrations than the other sampling moments and November

2012 considerably lower concentrations, steering the statistical analysis. More data points in time are needed to confirm the observations in trend and seasonality (November).

Lapointe and Mallin (in prep) reported DIN concentrations ranging from 0.56-9.82 µmol/l in 2006-2008, the lowest being higher concentrations than observed in this study.

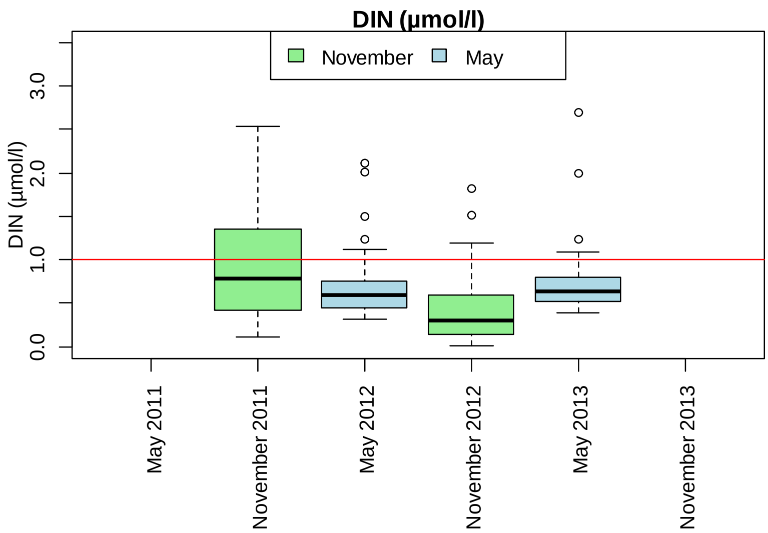

Figure 7 *Dissolved Inorganic Nitrogen (DIN) in µmol/l in time, reported for months November and May, based on all locations (n=12, except for 2011 n=10). Red line represents the environmental threshold concentration for nitrogen, being 1 µmol/l.*

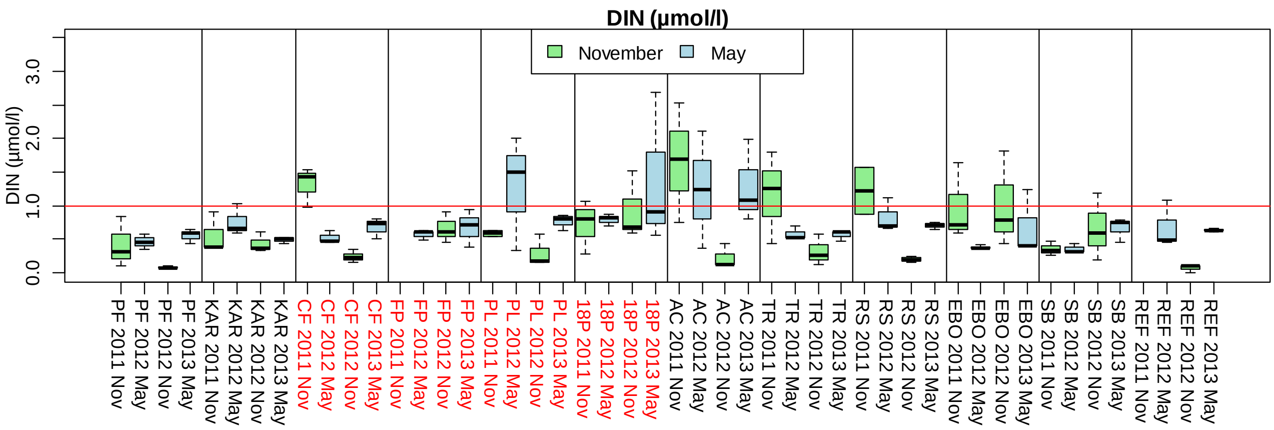

Figure 8 *DIN concentrations (µmol/l) at four different sampling moments in 2011-2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's special, South Bay and the offshore reference (coming last). Red line represents the environmental threshold concentration for nitrogen, being 1 µmol/l. Red labelled locations are in the sensitive zone.*

DIN consists of NOX (NO_3 and NO_2) and NH_4. These individual compounds are described in the following sections. The contribution of either ammonium or nitrate to DIN varies on the location and season. Data are presented in Figure 9. The offshore reference clearly differs from all the other sites, with over 80% of NH_4 contributing to DIN, whereas the shore locations show more contribution of nitrate.

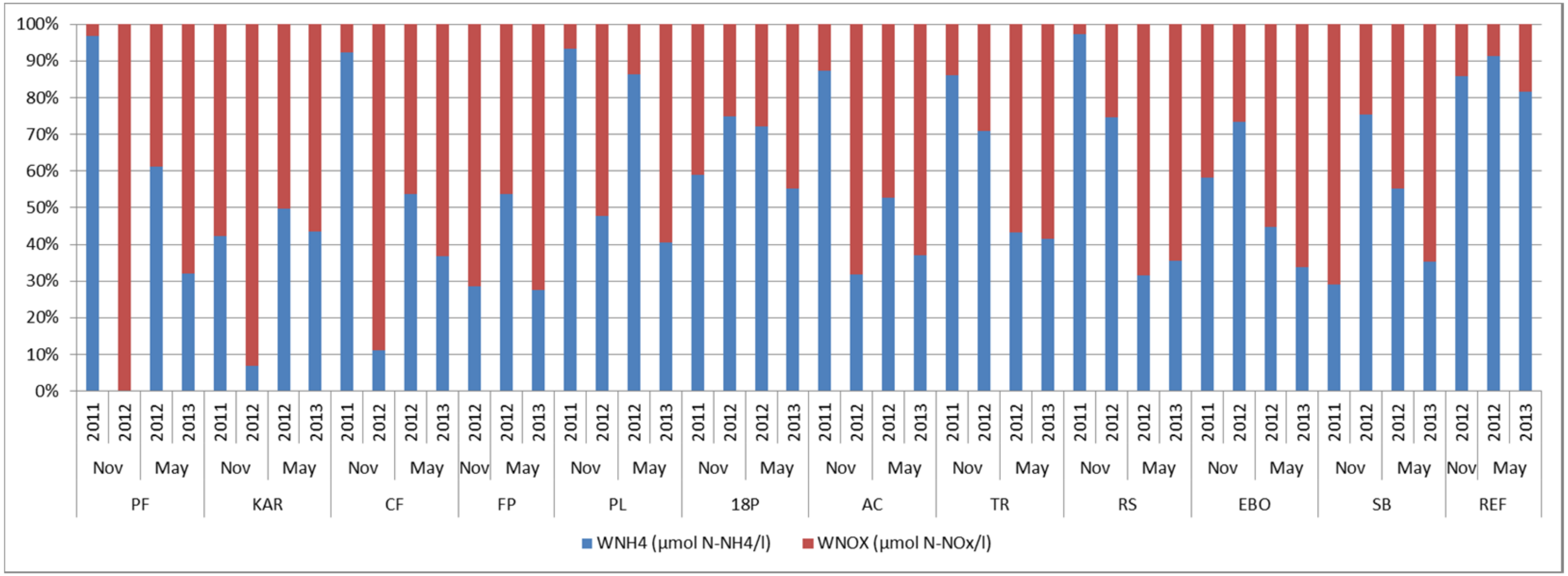

Figure 9 DIN slit into the contribution (%) of NOx and NH_4 for all samplings and locations.

3.2.2 Ammonium: N-NH4

In Figure 10 and Figure 11 ammonium concentrations are presented as boxplots. Ammonium ranged from 0 - 2.31 µmol/l, and concentration depends on the season ($p < 0.01$). 0 µmol/l means detected under detection level. Ammonium decreases over time when comparing 2011-2012 with 2012-2013 ($p < 0.001$) . November average (0.59 µmol/l) is higher than May (0.37 µmol/l), where the high average is driven by the high values of November 2011.

Ammonium exceeds the environmental threshold level in 17 samples out of 72, mostly being southern locations and locations in the sensitive zone, and being less frequent in the offshore and northern locations (4). Mostly, ammonium exceeds the threshold in November with 12 samples out of 72 (of which 9 from 2011), compared to 5 samples in May.

Location was not a significant factor in differences in NH4 concentrations, but locations 18th Palm, Angel City, Tori's Reef, Red Slave, Ebo's Special, South Bay and the offshore reference tend to have higher concentrations, whereas the more northern locations (Playa Funchi, Karpata) had lower concentrations. This regional distinction between northern locations versus the southern and sensitive zone locations was statistically significant ($p<0.05$).

Lapointe and Mallin (in prep) reported for the period 2006 to 2008 no clear ranges for ammonium, only average values. An estimated range, based on reported average +/- the deviation by Lapointe and Mallin is ~ 0.1- 4.49 µmol/l, being higher than the result in this study. Lapointe and Mallin (in prep) reported the highest values at the Southern located Red Slave, Angel City and 18th Palm. At Front Porch, Playa Lechi (both sensitive zone) and Playa Funchi (north) the lowest concentrations were found. This relative ranking is in line with our observations.

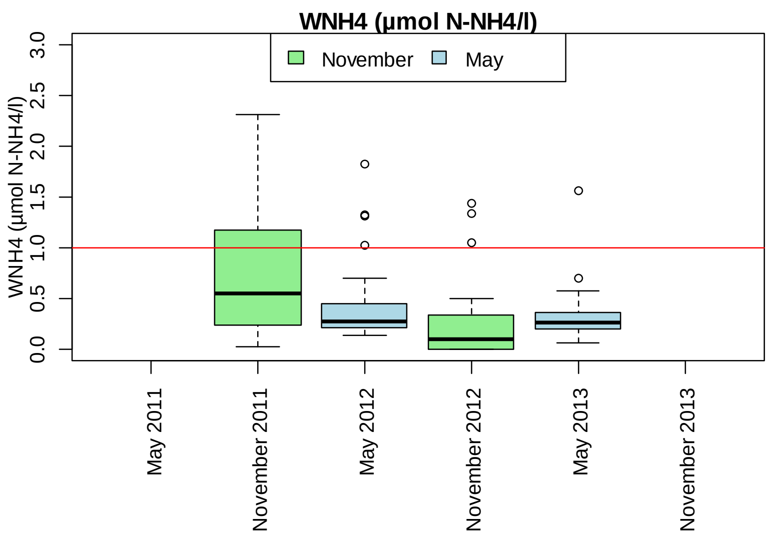

Figure 10 Ammonium concentration (µmol/l) in time, reported for months November and May, based on all locations (n=12, except for 2011 n=10).

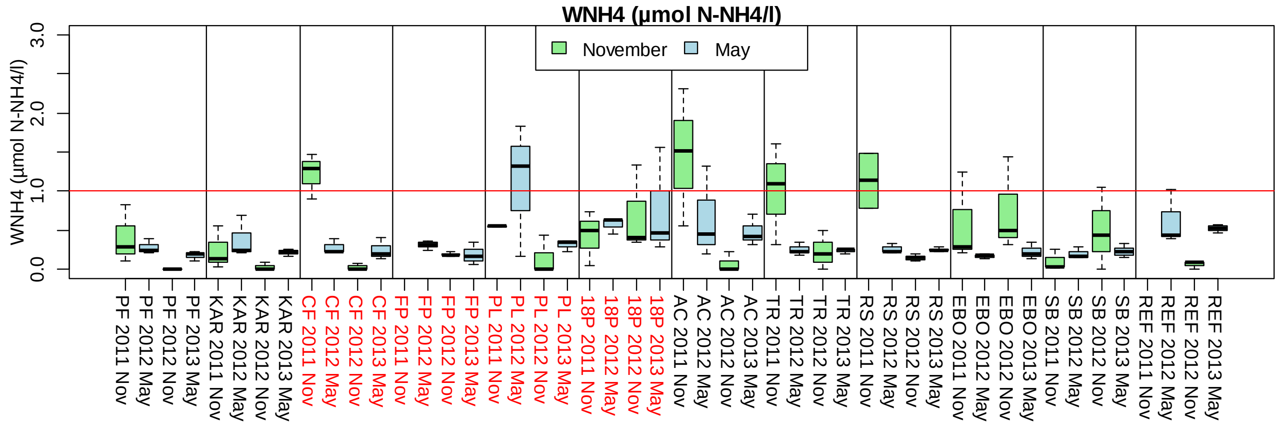

Figure 11 Ammonium concentrations (µmol/l) at four different sampling moments in 2011, 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's special, South Bay and the offshore reference (coming last). Red line represents the environmental threshold concentration for nitrogen, being 1 µmol/l. Red labelled locations are in the sensitive zone.

3.2.3 Nitrate: N-NO_3

In Figure 12 and Figure 13 the nitrate concentrations are presented as boxplots. Nitrate ranged from 0 µmol/l-1.31 µmol/l and varied significantly among locations (0.001), and the season ($p < 0.001$). Nitrate doesn't show difference in concentration over time (2011-2013), which implicates that the differences in DIN are steered by the differences in NH_4 mostly.

In November the average nitrate concentration is 0.19 µmol/l, and in May the average is 0.36 µmol/l. The latter is steered by higher values in May 2013 compared to the previous 3 sampling moments. Within a location, the difference between seasons can be different, November having lower concentrations of nitrate then May.
In general Playa Funchi and the offshore reference show the lowest Nitrate concentrations. No significant differences between regions were observed. The following differences were statistically significant (varying p-values , but always < 0.05):

- Playa Funchi< Karpata, Front Porch, 18th Palm, Angel City, Ebo's Special
- Offshore ref < all locations, except Playa Funchi

Lapointe and Mallin (in prep) reported nitrate concentrations ranging from 0.45-1.57 µmol/l, which significantly varied among sites. Stations Karpata, Ebo's Special, Cliff, 18th Palm, Playa Funchi and Front Porch had significantly higher nitrate than Red Slave, Angel City, Playa Lechi and South Bay.

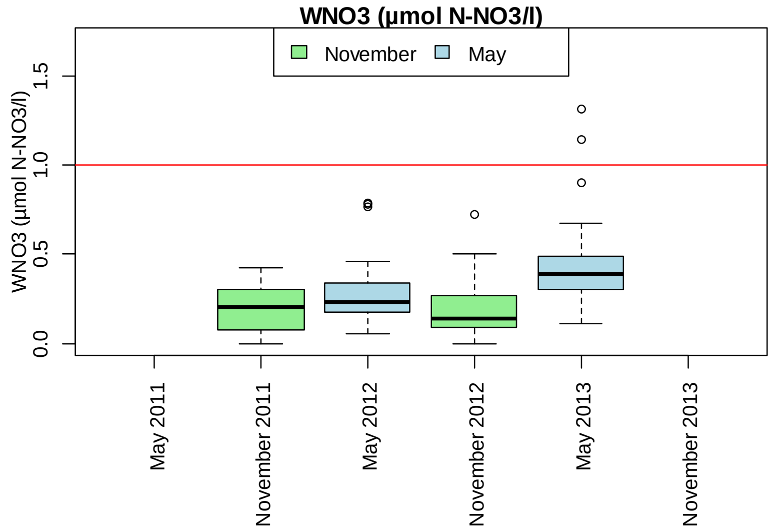

Figure 12 *Nitrate concentration (µmol/l) in time, reported for months November and May, based on all locations (n=12, except for 2011 n=10). Red line represents the environmental threshold concentration for nitrogen, being 1 µmol/l.*

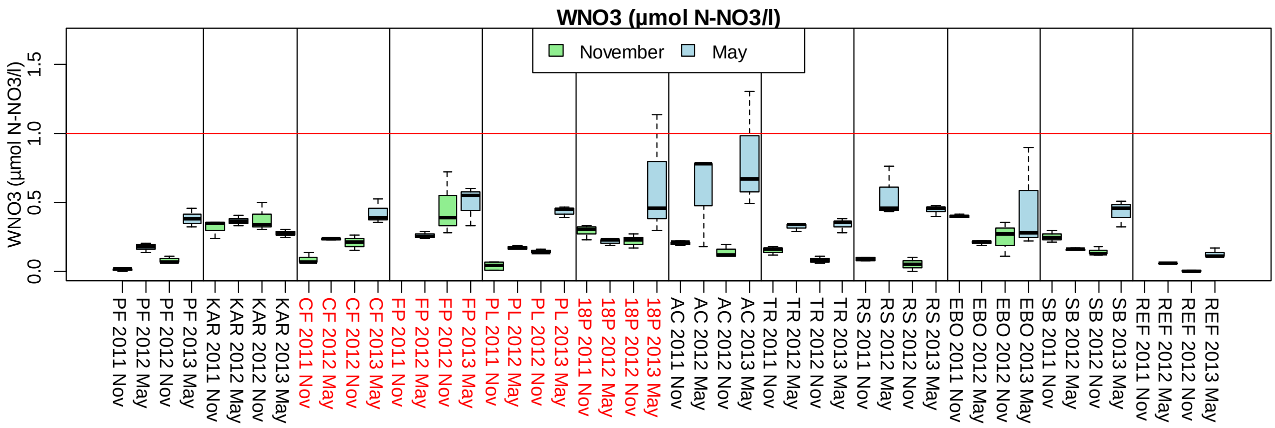

Figure 13 *Nitrate concentrations (µmol/l) at four different sampling moments in 2011, 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's special, South Bay and the offshore reference (coming last). Red line represents the environmental threshold concentration for nitrogen, being 1 µmol/l. Red labelled locations are in the sensitive zone.*

3.2.4 Nitrite: N-NO2

Nitrite data are not shown separately as NO2 was measured as part of NOx. Furthermore, NO2 was analysed at or below detection. No differences among locations, month and season were observed.

3.2.5 Total N

In Figure 15 the results for total nitrogen are presented. Total Nitrogen ranged from 0.41-21.06 µmol/l, with an average concentration of 7.6 µmol/l. No threshold values for total Nitrogen exist, and the 80th percentile was taken instead. Seasonal differences could not be tested as only 1 sampling took place in November (2012, not done in 2011). Differences among locations were observed, South Bay being significantly lower value of total nitrogen in May 2012 compared to all other locations. This is however only observed at that moment. Lapointe and Mallin (in prep) reported ranges from 6.05-65.28 µmol/l (in 2006-2008), being much higher than the values reported in this study.

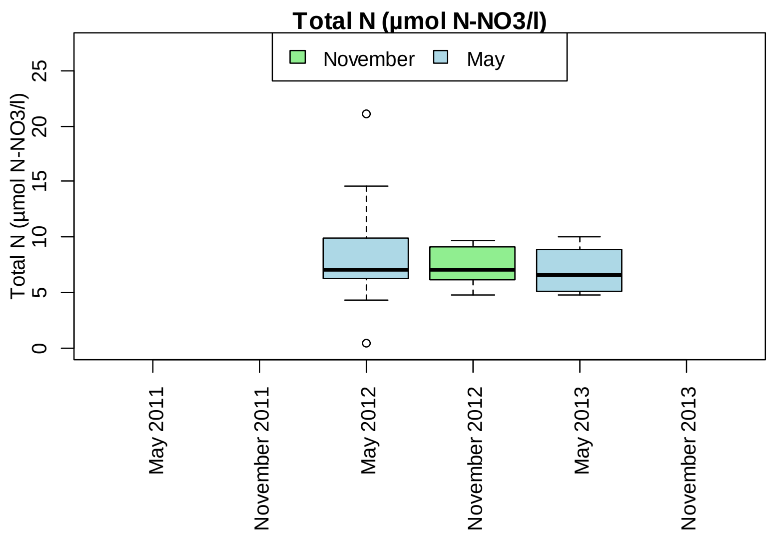

Figure 14 *Total Nitrogen concentration (µmol/l) reported for months November and May, based on all locations (n=12, except for 2011 n=10). Red line represents the environmental threshold concentration for phosphate, being 1 µmol/l.*

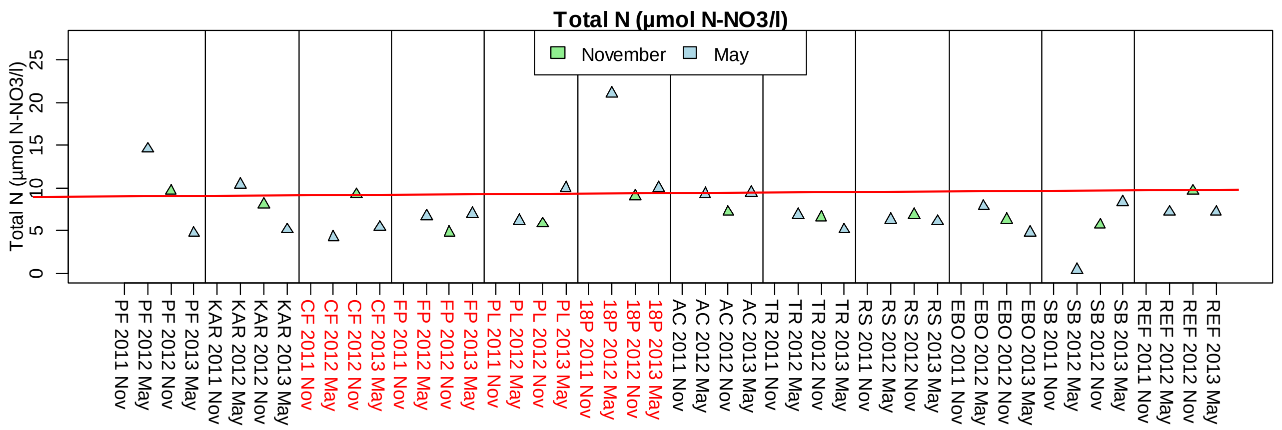

Figure 15 *Total nitrogen concentrations (µmol/l) at three different sampling moments in 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's special, South Bay and the offshore reference (coming last).*

In Table 6 the 70, 80 and 90 percentile concentrations for total nitrogen are given, and the number of samples that correspond to this group. 8 samples exceed the 80th-percentiel concentration, an indication of deviation of local reference values. Although location is no significant factor for variation in total nitrogen, data show that all the 90th-% samples were taken in the sensitive area or in northern locations.

Table 6 *Percentiles (70-80-90) given for total nitrogen (tN), total phosphorus (tP) and ureum concentrations, including the percentage of samples that lay above this concentration.*

	Concentration (µmol/l)			Number of samples		
percentile	tN	tP	ureum	tN	tP	ureum
70%	8.71	0.21	1.45	31%	31%	31%
80%	9.44	0.23	1.60	22%	22%	22%
90%	10.00	0.37	1.88	14%	11%	11%

3.2.6 Ureum

In Figure 15 the ureum concentrations are presented as boxplots. Ureum concentrations in this study ranged from 0.76-2.42 µmol/l. No significant differences among locations, season and time were observed. Urea concentrations in reef environments vary from below 0.2 µmol/l (Wafar et al. 1986) to 2.0 µmol/l (Beauregard 2004) and are generally below 0.7 µmol/l in the open ocean (Painter et al. 2008). No environmental threshold exists, and the 80th percentile is taken to indicate higher levels. The 80 percentile is 1.60 µM, and 8 out of 36 samples were above this concentration. No clear allocation to location was observed.

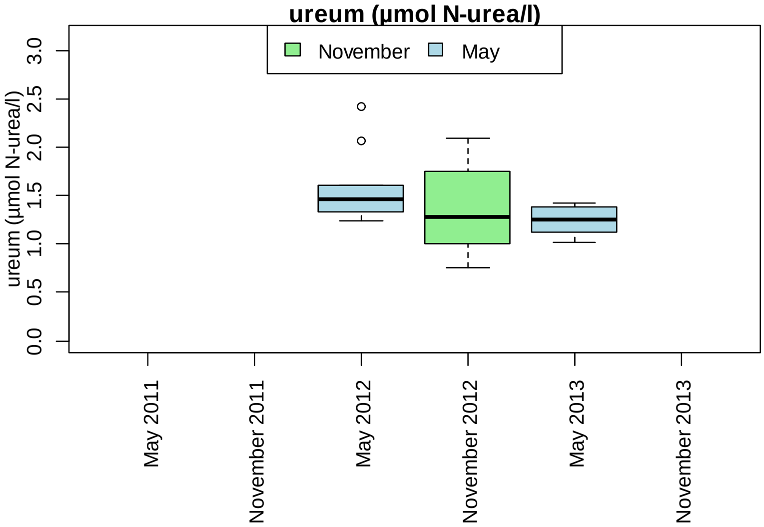

Figure 16 Ureum concentration (µmol/l) reported for months November and May, based on all locations (n=12, except for 2011 n=10).

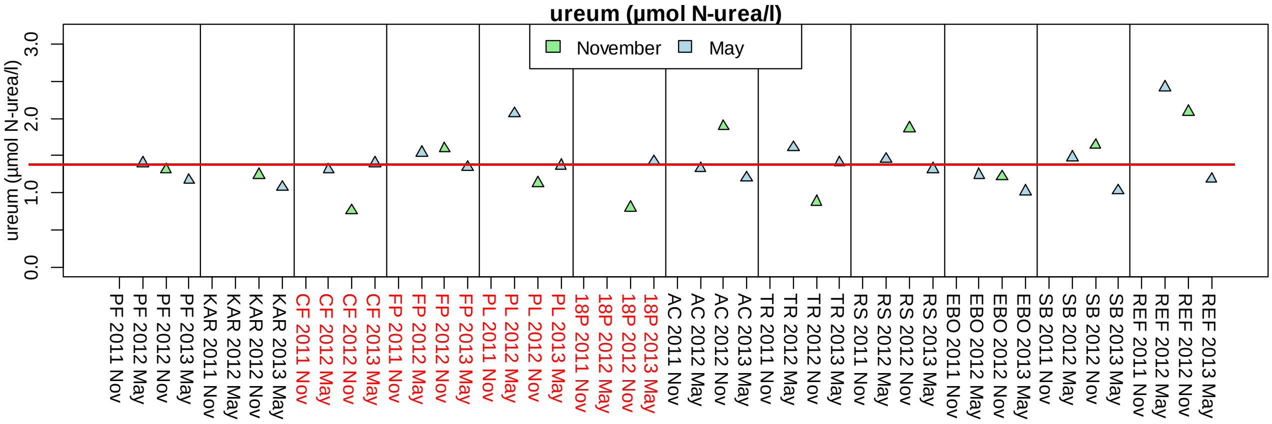

Figure 17 Ureum concentrations (µmol/l) at three different sampling moments in 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's Special, South Bay and the offshore reference (coming last).

3.2.7 Phosphate: P-PO4

In Figure 18 and Figure 19the phosphate concentrations are presented as boxplots. Phosphate ranged from 0-0.16 µmol/l (except for 1.48 umol/l). Phosphate varies significantly among locations ($p < 0.001$), among the season ($p < 0.001$), as in time ($p < 0.001$). PO_4 concentration increases over time (Figure 18) and if this increase continues threshold values will be exceeded in near future. However, between 2006 and 2008 Lapointe and Mallin found phosphate in ranges of 0.04-0.21 µmol/l, thus slightly higher than the ranges found in this study.
Concentrations in May tend to be higher than in November. Locations with lowest PO_4 are located in the north (Playa Funchi) and at Klein Bonaire (Ebo's Special). Related to these low concentrations, locations such as Front Porch and 18th Palm showed at some moments significantly higher concentrations, but this was not a structural observation.
The environmental threshold value of 0.1 µmol/l was only exceeded in few samples, which are not attributed to a specific season or specific location.

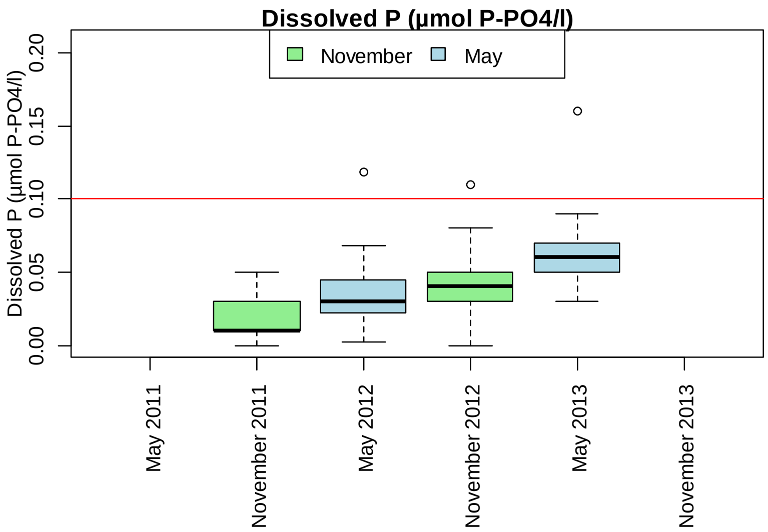

Figure 18 Dissolved phosphate concentration (µmol/l) in time, reported for months November and May, based on all locations (n=12, except for 2011 n=10). Red line represents the environmental threshold concentration for phosphate, being 0.1 µmol/l.

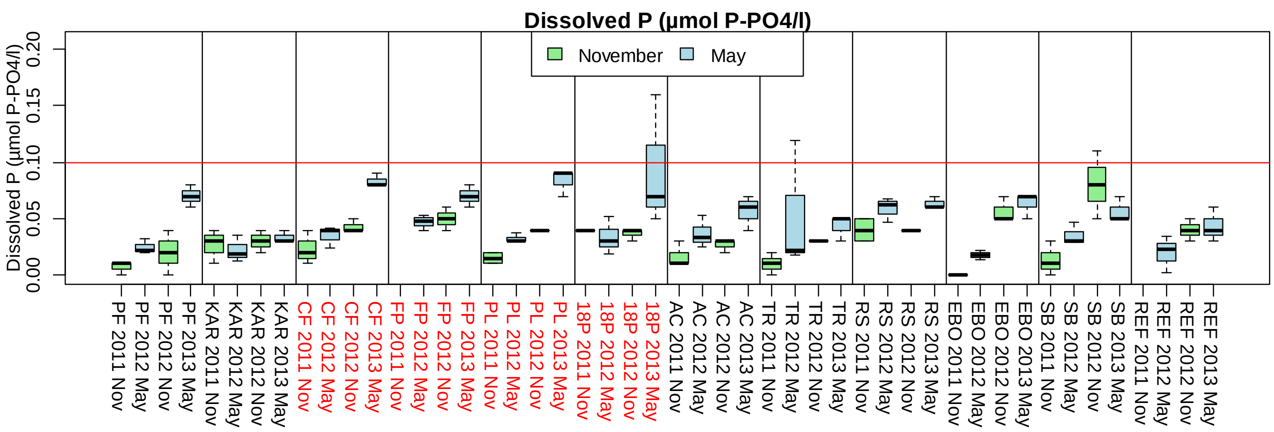

Figure 19 Dissolved phosphate (PO_4) concentrations (µmol/l) at three different sampling moments in 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's Special, South Bay and the offshore reference (coming last). Red line represents the environmental threshold concentration for phosphate, being 0.1 µmol/l.

3.2.8 Total P

In Figure 20 and Figure 21 the total P concentrations are presented as boxplots. Total phosphorus concentration ranged from 0.066-0.61 µmol/l. The concentration varies among the season (p =0.03) and shows an increase in the time (p=0.002). The concentrations don't vary among the locations, or among the regional areas. Average concentration in November is 0.17 µmol/l, in May this is 0.22 µmol/l.
No threshold values for total phosphorus exist. If total phosphorus is regarded as organic phosphorus, the environmental threshold level of 0.1 µmol/l can be applied. In that case, PO4 has to be added, and most samples exceed the threshold value, indicating eutrophic conditions.

Lapointe and Mallin (in prep) reported ranges from 0.11-1.41 µmol/l, being much higher than in this study. In Table 6 various percentiles are given, and 8 samples have concentrations above the 80 percentile of 0.23 µmol/l, of which 7 were taken in May 2013.

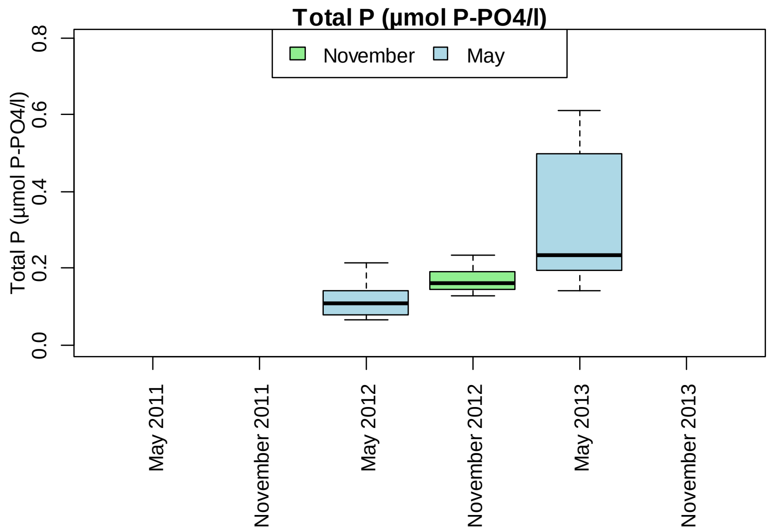

Figure 20 Total phosphate concentration (µmol/l) in time, reported for months November and May, based on all locations (n=12, except for 2011 n=10).

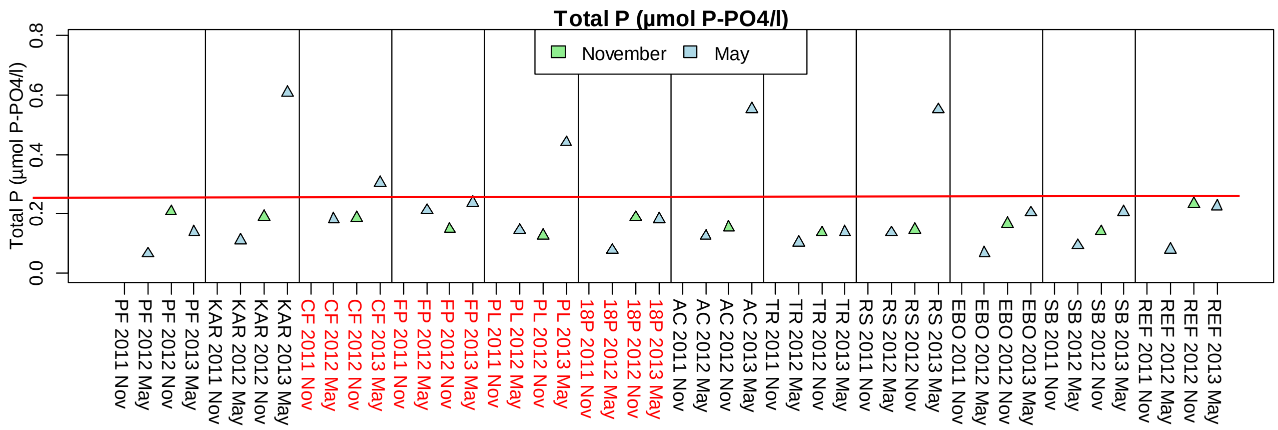

Figure 21 Total phosphate concentrations (µmol/l) at three different sampling moments in 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's Special, South Bay and the offshore reference (coming last).

3.2.9 Ratio DIN:SRP

DIN:SRP ratios, based on DIN and PO4, ranged from 1.6-192 (Figure 22). Ratios seem not related with season or location. However, at many locations a trend in time can be observed, with lower values in 2012-2013 than in 2011-2012. November values were on average 58.7 (sd 46) in 2011 and 9.9 (sd 6.6) in 2012. May values were on average 37.3 (sd 49) in 2012 and 12.4 (sd 4) in 2013. Lapointe and Mallin (in prep) reported ratios ranging from 4.6-114, and mean values of 14.4. Although this seems a bit lower than the finding in this study, values are within the same range.

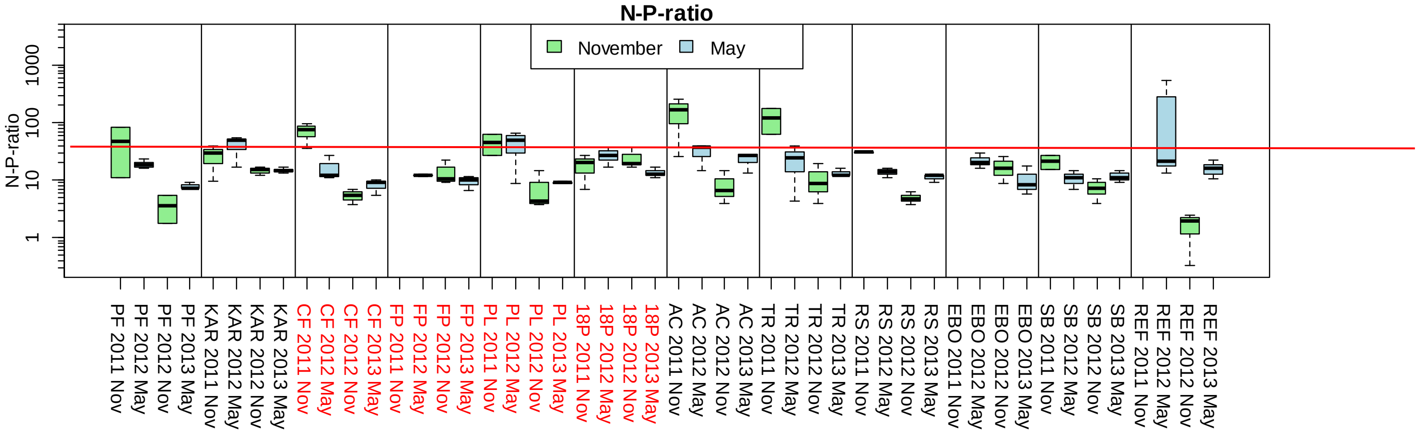

Figure 22 DIN:SRP ratio at four different sampling moments in 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's Special, South Bay and the offshore reference (coming last). Y-axes is in a log 10 scale. Solid red line represents ratio 30:1 at which below nitrogen limitation occurs.

3.2.10 Faecal bacteria (enterobacteria)

In Figure 23 data on enterobacteria numbers are given. Enterobacteria numbers ranged from 0- 324 cells/100 ml for the samples taken at the reef slope. Numbers vary among locations significantly, (p=0.01), but this depends on the sampling moment. Not all samplings had this dependency, only in 2011 being a specific observation, which was statistically significant interaction.

Cliff had highest numbers, and other locations with elevated entero's are mostly located in the south (angel city, Tori's reef), or in the sensitive area (Cliff, Playa Lechi). There seems to be a clear relation with rainfall. In the discussion section more information is provided.

In total 5 samples (from 3 different locations) exceeded the US EPA standard (35 cell/100ml), and 3 samples, all from 1 location (Cliff) in 2011 exceeded both the Caribbean Blue Flag (100 cells per 100ml) and EU bathing water standard (185 cells/100ml).

Samples taken at the water surface ranged from 0-429 cells/100 ml, and exceed the US EPA standards in 7 samples out of 68 samples. Locations exceeding the standard are Playa Lechi, Tori's reef, Karpata, and Angel City.

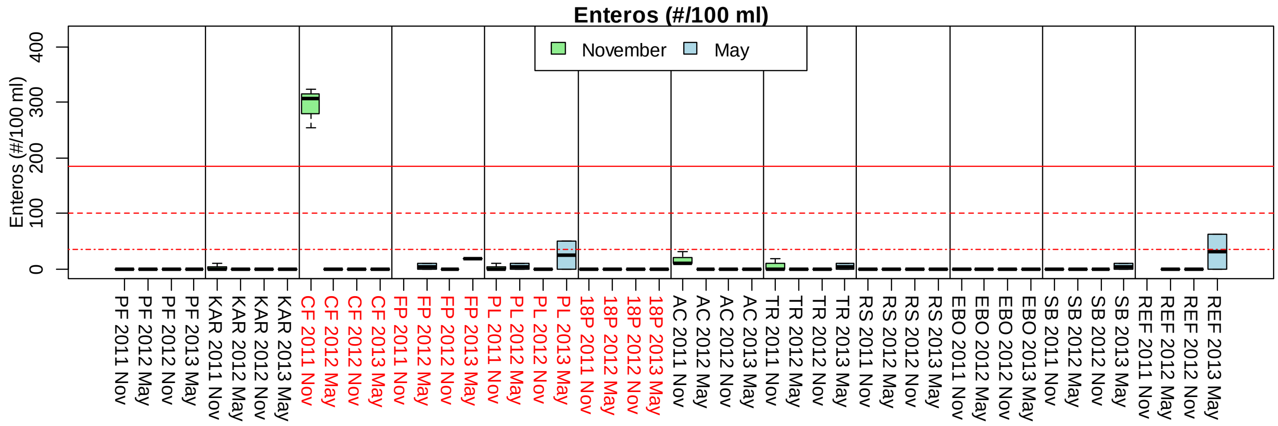

Figure 23 *Enterococci numbers per location (number of samples=2 or 3). Red line represents the EU bathing water standard (185 cells per 100 ml). Dashed red line represents the (UNEP, 2003) Caribbean blue flag criterion (< 100 cells/ 100 ml). Course dashed line represents the US EPA standard of 35 cells/100 ml.*

3.2.11 Chlorophyll a

In Figure 24 and Figure 25 concentrations of Chlorophyll a (Chl-a) are plotted in a boxplot.
The chl-a concentration of the water column is indicative for the pelagic algal biomass. Concentrations ranged from 0.02-0.42 µg/l. Chl-a concentration varies among locations ($p < 0.001$) and in time (2011-2012 vs 2012-2013; $p<0.001$). Playa Lechi has higher concentrations compared to Angel City, Tori's reef and offshore reference.
No significant variation between seasons is found. In time, the concentration Chla-a slightly increases. Lapointe and Mallin (in prep) reported values at the same range (0.06-0.38 µg/L). The environmental threshold value for chlorophyll a is set at 0.5 µg/l, and is not exceeded in 2011-2013 during our monitoring moments.

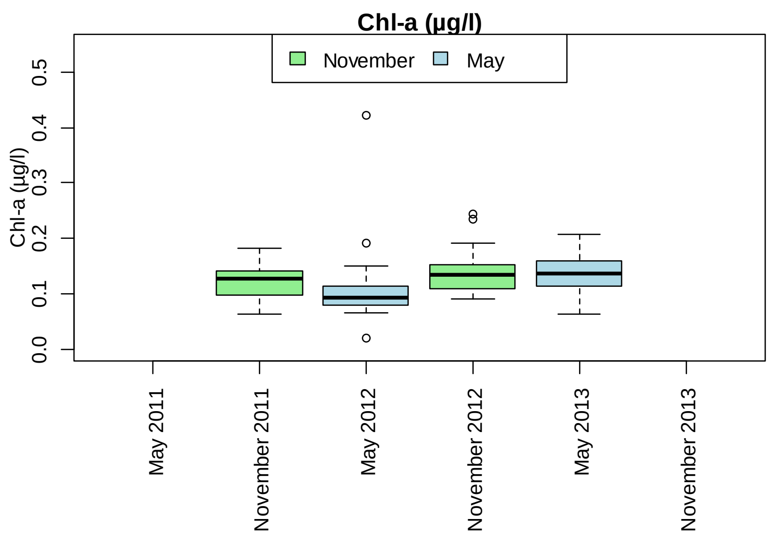

Figure 24 *Boxplot of chlorophyll a data (µg/L) in time at different sampling months (November-May).*

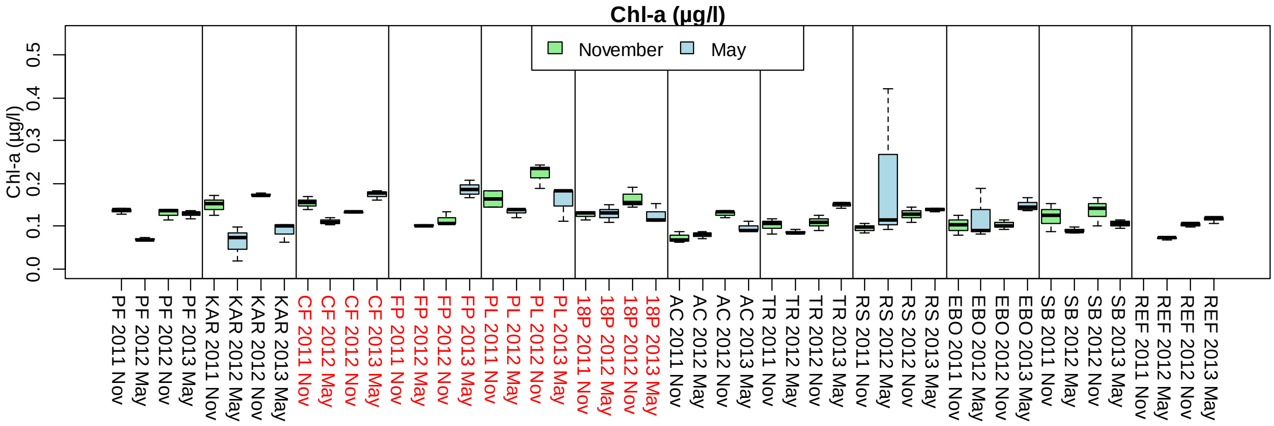

Figure 25 *Chlorophyl a concentrations (µg/L) at four different sampling moments in 2012 and 2013 in two months (November and May) at 12 locations. Locations are North-south ordered, except for Ebo's Special, South Bay and the offshore reference (coming last).*

4 Discussion, conclusions and recommendations

In this section research questions will be answered and discussed. Furthermore, an advice is given on how to continue a water quality monitoring program.

4.1 General comments

The goal of the coastal monitoring study in 2011-2013 was to collect water quality data in order to assess the impact of the water treatment facility on general water quality at the west coast of Bonaire.

The water treatment plant will treat water collected from the sensitive area, which is the urbanized area between Punt Vierkant and Hato (Van Kekem et al., 2006). Based on its capacity characteristics (MIC, 2011) the treatment plant should result in a decrease of 17520 to 35040 kg (17.5-35 tonnes) of nitrogen from septic tanks to the reef. However, due to adaptation of the original plan (pers. comm. Van Slobbe) these numbers are an overestimation.

When monitoring started, the treatment plant facilities were planned to be operational in December 2011. This schedule is adjusted and for now it seems that the plant will be fully operational in 2014. In the meantime, new sewerage systems were installed, and sewage was collected by trucks at some locations (merely tourist resorts) and transported to the plant. Information indicating when, where, or in what volumes sewage was collected and treated in this way is not available for this study. Therefore water quality data cannot be related to the amount of sewage collected and the efficiency of the sewage treatment plant cannot be evaluated yet. For that reason, in this report water quality data are evaluated in terms of environmental threshold levels in general.

In addition to the sampling program of the coastal water reported here, Directie R&O and the Waterdienst commissioned groundwater monitoring. This monitoring was conducted in November 2012 at various locations at the west coast by MICC. The selection of indicators was similar to the water quality monitoring in the coastal zone. Data will be reported in coming months by ProeS, and future monitoring is planned. These data might reveal relations between the quality of the coastal and groundwater.

4.2 Water quality and threshold levels

4.2.1 Are environmental safe threshold levels exceeded?

Yes, occasionally some environmental threshold levels are exceeded, and might indicate eutrophic signs.

Especially nitrogen expressed as DIN- Dissolved Inorganic Nitrogen, a sum of NH4, NO2 andNO3, exceeds the environmental “safe” limit for coral reef environments of 1 µmol/l in 18% of the samples taken. However, if the observed decrease in time continues DIN concentrations will become below the threshold levels within the next years or decades.
For ureum no environmental threshold values exist. Ureum is an important part of the nitrogen cycle at the reef and can be derived from anthropogenic input as well as processes on the reef (excretion by various organisms an generation in the system (Crandall and Teece, 2012). Increased ureum concentrations by anthropogenic sources can steer algal blooms (e.g. Painter et al., 2008). In this study, we cannot relate the elevated ureum concentrations to specific locations or regions in the coastal zone of Bonaire nor to sources.

The measured ortho phosphorus concentrations did not exceed the environmental threshold level of 0.1 µmol/l. However, an increasing trend over time was observed at many locations. If this continues, the concentration could exceed the levels in near future (~2 years). Total phosphorus concentrations show an increase as well, and this includes forms that can become available for primary production rapidly. Associated with the increase of phosphorus, an increase of the pelagic chlorophyll-a concentration is observed, indicating increasing biomass of phytoplankton. This observation indicates a bottom up steered process by nutrients stimulating phytoplankton growth. At this moment chlorophyll-a threshold levels are not exceeded, but if the increase continues as observed in these 2 years of monitoring, within some years the threshold level will be exceeded.

Fecal bacteria numbers, indicated by measuring enterococci, exceed several standards for human health safety. High fecal bacteria numbers are more frequent in the south and in the sensitive area. Bacteria are found in surface samples as well; indicating surface run off as a possible source.

4.2.2 Is temporal (over the years), or seasonal variation (November-May) of water quality observed?

Yes, water quality shows structural changes over the 4 sampling moments for some of the indicators. Seasonal variation depends on the indicator.

For DIN, measured concentrations were considerably higher in November 2011, and considerably lower in November 2012 than the other sampling moments. The November data of 2011 deviates from the other (has higher concentrations) which might steer the statistical analysis, resulting in a slight decrease in time. Compared to the study of Lapointe and Mallin (in prep), in general all indicators in our study have lower concentrations (20-30%). This might suggest that water quality has slightly improved in the last five years, or that methodology of sampling and/or laboratory differences affected results.
Another explanation could be that the ecosystem has changed, and that now more primary producers (cyanobacteria, macro algae, coral) are present. Primary producers consume more nutrients (continues flux) and lower the ambient nutrient concentration. On the other hand, reef systems are complex, in which nitriphication is an on-going process, resulting in elevated NO_3 levels compared to offshore waters. Finally it is possible that the outlying DIN concentrations in the November 2011 and 2012 samples are influenced by differences in rainfall around the sampling moments. In that case it is questionable if the observed trend of decreasing DIN concentrations is representative for the actual situation. More data points in time are needed to underpin the observations in trend and variation in rainy season (November). The same holds for the observed variation between seasons (PO4 higher in May, DIN higher in November), which are statistically present, but needs more observations to be underpinned.

Our dataset shows increasing phosphate (total and soluble) concentrations between 2011 and 2013, and slight increasing chlorophyll-a concentrations. This observation might be explained by release of phosphorus by decomposition of organic material, e.g. from algal and cyanobacteria blooms which allocate locked in phosphorus from the sediment. Cyanobacteria are observed more frequent in recent years, even at deep (-70 m) locations (pers. communication. F. Van Duyl and E. Meesters). In turn, an increase of bioavailable phosphate alters the DIN:SRP ratio and species composition can evolve from this change in nutrient availability.

Ratios between nitrogen and phosphorus are used to indicate the steering conditions of the ecosystem towards certain primary producers. The Redfield ratio (16N:1P) indicates optimum conditions for phytoplankton growth (Redfield et al., 1963), whereas the Atkinson ratio of 30N:1P indicates these conditions for macro algae (Atkinson and Smith, 1983). Marine cyanobacteria are found when N:P ratios occur above 20 (Bertilsson et al. 2003, Heldal et al.2003). The ratio can be used as well to indicate which element is limiting growth. DIN:SRP ratios > 30:1 indicate phosphorus limitation for marine algae while ratios below 30:1 indicate nitrogen limitation (Rhee 1978;Lapointe 1997). According to these ratios nitrogen is the limiting nutrient in the studied area, but internal concentrations within species measured over time should be included to fully understand the situation. The observed decrease of the ratio in time in this study can be explained by the increase of PO_4, and the slight decrease of nitrogen although the representativeness of the latter is not clear, as indicated below.

The lower N:P ratios might indicate steering conditions for phytoplankton growth over macro-algae and cyanobacteria which in turn might be favourable for settling coral recruits.
To compare the two seasons (rainy season-November vs. dry season in May) actual rainfall, especially just before or during sampling is an important steering factor. In November 2011 lots of rain fell before and during the sampling week, while in November 2012, hardly any rain fell. Rainfall is likely to steer the groundwater outflow, directly affecting water quality at the reef. This is illustrated by the observation that the numbers of enterobacteria in water samples seem to be positively correlated with rainfall during the sampling period. This is confirmed by observations of CIEE who collected data on entero-bacteria a few weeks before our sampling in November 2012, at various moments, with and without heavy rains (see Box 1) at the reef.

The observation for elevated bacteria numbers due to rain is most probably valid for elevated nutrient concentrations as well. Lower concentrations in November 2012 compared to November 2011, probably relates to the scattered rain events during the rainy season. This observation means that planning of water quality monitoring and the evaluation of retrieved data should be carefully done, in order to prevent missing point sources, and misjudgement of data. As an example: it is possible that the observed decreasing trend in DIN concentrations that was driven by the high concentrations measured in November 2011, and the low concentrations measured in November 2012, was caused by differences in rainfall around the sampling moments in November 2011 and 2012.

4.2.3 Does water quality vary among locations or regions in Bonaire and what is the impact?

Yes, water quality varies among locations at least for some indicators.

Specifically in the sensitive zone (Playa Lechi, 18th Palm, Angel City, Tori's Reef, Red Slave) and the southern part of Bonaire threshold values of DIN are sometimes exceeded. Phosphate (PO_4) shows spatial variance, locations with lowest PO_4 concentrations are Playa Funchi and Ebo's Special. Locations such as Front Porch and 18th Palm showed at some moments significantly higher concentrations compared to other locations, but this was not at each sampling moment. Mean values of total nitrogen, phosphate and total P in the sensitive zone in May 2013 are of some concern: phosphate values are increasing and near or already above threshold value (or above the 80th percentile for tP).

The southern locations are most probably affected by the salt ponds in terms of elevated nitrogen. Locations in the sensitive zone might be affected by the salt ponds via the current (coming from the south), but effects of saltpans are more likely to be local. Locations in the sensitive zone can be enriched via groundwater due to leaking or overflowing sewerage system and canals (roois) discharging water.

The offshore reference has lower nitrate and higher ammonium concentrations (as part of DIN) than observed at most other locations. This is explained by the fact that the offshore reference sampling took place in the open ocean and no at the reef. Reef organisms excrete nitrate could in this way affect the DIN composition.

The ecological impact of these concentrations has to be discussed in an ecosystem context. As mentioned by many, and described by Slijkerman et al. (2012b), nutrient levels are in flux, and the environmental threshold levels as such could only be used as a serious warning. Concentrations measured below this level should therefore be interpreted with care. Nutrients are allocated quickly into primary producers (turf algae, macro algae, phytoplankton) (Szmant, 2002, Fabricius, 2005) or affect the integrity of corals due to their effect on growth and calcification (Fabricius 2005), which in turn affects the reefs resilience to storms and huricanes. Based on this study we can say that locations at which threshold levels are exceeded show signs of eutrophication. Concentrations measured which are below the environmental threshold are however of important value as a changing trend serves as early warning of ecosystem change. In general, additional information is required on the ecosystem level via benthic surveys, including cyanobacteria observations, to set the water quality data in broader context. .

BOX 1

CIEE study by Elizabeth Davis in 2012

Three sample stations were selected. Station 1 (Marina) is adjacent to the mouth of Kralendijks marina, which houses boats, restaurants, and resorts. Station 2 (Playa Lechi) is 250 m south along the coast from the marina, across from Kaya Playa Lechi. There are few boats anchored, but little traffic. Station 3 (Yellow Sub) is 250 m south of the second site, and is adjacent to a residential area and the Yellow Submarine dive shop. Here there is noticeable dive and boat traffic, but less activity than at Marina.

Water and sediment samples were taken weekly at each station for five weeks during September 2012 and October 2012. The sample number allowed small temporal trends in water quality to be analysed, and prevented single-event rainfall or runoff from skewing the overall analysis of water quality. The water samples were evaluated for E. coli and enterococci colony presence using IDEXX Colilert-18TM and EnterolertTM test kits.

Average coliform levels were calculated for each station (Figure A). No differences between stations could be detected due to the large variation within the stations. The standard deviation of the average of the Marina surface samples was 1233.5 MPN/100 mL, while all of the other standard deviations of the averages varied between 255.9 and 430.4 MPN/100 mL.)

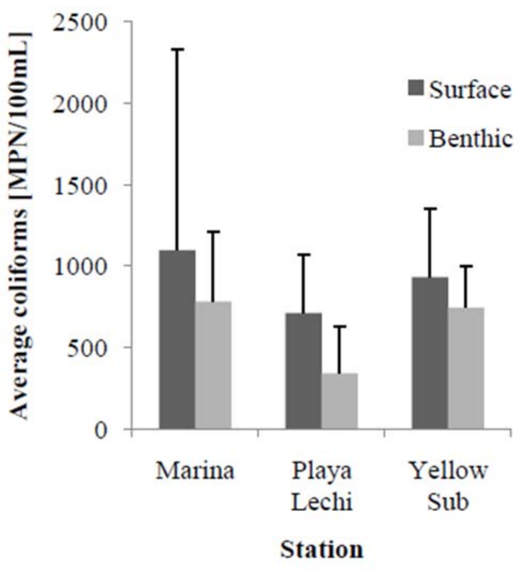

Figure A. Most probable number of coliform bacteria colonies for a 100 mL sample taken from the Marina, Playa Lechi, and Yellow Sub stations. Colony counts were averaged over six water samples. Error bars indicate standard deviation. Dark grey represents surface samples and light grey represents benthic samples (CIEE, 2012)

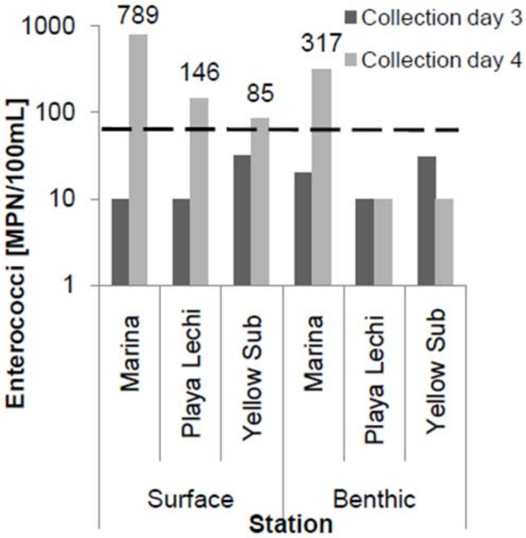

Figure B Most probable number of enterococci colonies per 100mL measured from all stations on collection days 3 and 4. Enterococci levels on all other days were insignificant. The U.S. EPA recommends that enterococci levels in bathing water not exceed 33 colonies per 100 mL (dashed horizontal line). Dark grey represents collection day 3. Light grey represents collection day 4

Enterococci levels were found to be below detection levels (<10 colonies/100 mL) in all samples in collections at day 1, 2 and 5, but not in samples of collection days 3 and 4. Collection day 3 occurred during a large public festival that increased boat traffic. Significant enterococci levels were found in both the surface and benthic samples at Yellow Sub (31 and 30 colonies/100 mL, respectively), and in the benthic sample taken from the Marina (20 colonies/100 mL) (Figure B). On collection day 4, which took place directly after a large rainstorm, the enterococci levels measured at several stations were higher than its EPA limit. The highest levels were measured at the surface Marina station (789 colonies/100 mL), followed by the benthic Marina station (317 colonies/100 mL), the surface at Playa Lechi (146 colonies/100 mL), and the surface at Yellow Sub (85 colonies/100mL).

4.3 Recommendations for future monitoring of water quality

This study leads to the following recommendations:

- Nutrients levels are in a constant flux, and data should be considered in an ecosystem context. This is not new in nutrient research, many -e.g. Szmant 1997, Steneck et al 1999-, describe the complex feedback mechanisms on the reef between nutrient (addition), reef productivity including algal growth, grazing, and fish stocks. Benthic surveys focusing on macro algae, turf algae and cyanobacteria, fish and reef coverage were not included in this study, and add largely to a whole ecosystem assessment on actual eutrophication. In upcoming research benthic surveys should be included and analyzed together with the nutrient concentrations in water and species.
- To detect temporal changes of water quality in the coastal zone in relation to the impact of the sewage treatment plant on the reef, long term monitoring over several years should be conducted, two times a year. Next to the regular program, make sure that interval sampling during heavy rains are included as these moments indicate point source discharges which can be missed when rainy season is shifted.
- The spatial coverage of the sampling program as presented in this report is at its minimum to detect regional variation and to locate locations (potentially) at risk. No locations should be discarded from the program. In order to prepare the monitoring program for future measures taken outside the current zone (Hato- Punt Vierkant) additional locations just north and south of the sensitive zone are advised to be included. This can then provide a thorough baseline, which makes it possible to detect changes in water quality in the future.
- Indicators to include are:
    - Nutrients: NH4- NOx- DIN, PO4, total N, total P. Consider to include dissolved organic forms of nutrients and carbon to cover all potential sources for primary producers.
    - Discard urea from the set of parameters, and include coprostanol. This compound is linked to cholesterol which is part of faeces (and thus sewage)
    - General water quality parameters (rationale see Slijkerman et al 2012a): make sure proper devices are available to ensure long term datasets
    - Bacteria: enterococci
    - Chlorophyll-a
    - Benthic surveys to monitor turf algae and macro algae in relation to coral cover and top down controlling fish assemblages.
- Monitoring of water quality in the coastal zone <u>alone</u> will not provide satisfactory indication of the impact of the treatment plant in reducing emissions to the marine environment (due to flux). Monitoring in the coastal zone is effective to detect areas at risk, and to detect long term changes in overall water quality (= so called "surveillance monitoring").
- Monitoring of water quality in the coastal zone should be supported by additional so called "investigative monitoring" directed at the sources to quantify the relative contribution of each of these sources. Groundwater enriched with nutrients from sewage is not the only nutrient source in the area. Nutrients from the salt pans in the south and from brine effluent near Cliff probably add to the eutrophic status at these locations. Furthermore percolation and surface run-off from Salinas and stormwater via roois (local canals) are probably a source of nutrients and bacteria. Additional research on the contribution of each of the sources and the spatial and temporal scale of their influence is recommended.
- To monitor the impact of the treatment plant, several factors should be considered. These are related to the treatment plant itself, groundwater quality, coastal water quality, and benthic coverage and quality. Actual reduction of emissions to the marine environment can be retrieved from monitoring and reporting of the efficiency of the treatment plant in (including details on influent and effluent volumes and quality aspects, and the number of pollution equivalents being treated actually and planned). Monitoring of groundwater wells is needed to get knowledge about the groundwater quality that outflows to the reef. Water quality monitoring in the coastal zone gives insight in conditions

contributing to environmental health. It is advised to synchronize the monitoring programs, and to analyze the datasets in a coherent way.

- Eutrophication is not the only pressure affecting a reef. Besides the focus on the research related to the treatment plant it is advised to consider additional research on a “whole ecosystem basis” in which the contribution of other pressures as well, such as run off via roois and overflows of Salinas with nutrients and sediments (in rainy season), fisheries impact and the impact of climate change/acidification on the reef are included.

5 Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

Report number: C158/13
Project number: 4305202701

The scientific quality of this report has been peer reviewed by a colleague scientist and the head of the department of IMARES.

Approved: Dr. Edwin M. Foekema
Sr. researcher

Signature:

Date: October 9, 2013

Approved: Drs. Floris Groenendijk
Head of department Maritiem

Signature:

Date: October 9, 2013

Appendix A. Sampling details of locations

	location	laditude	longitude	depth reef slope	tide			
					november 2011	May 2012	november 2012	May 2013
PF	Playa Funchi	12°16'56.54"N	68°24'50.28"W	~10 m	low--> high	high--> low	high--> low	high--> low
KAR	Karpata	12°13'9.14"N	68°21'6.42"W	~5-6 m	low--> high	high--> low	high--> low	high--> low
CF	Cliff	12°10'27.76"N	68°17'24.66"W	~6-7 m	low--> high	high--> low	high--> low	high--> low
FP	Front Porch	12°10'1.13"N	68°17'13.81"W	~7 m	low--> high	high--> low	low--> high	high--> low
PL	Playa Lechi	12° 9'27.20"N	68°16'48.04"W	~8-9 m	low--> high	high--> low	low--> high	high--> low
EP	18th Palm	12° 8'18.85"N	68°16'34.82"W	~7 m	low--> high	high--> low	high--> low	high--> low
AC	Angel City	12° 6'11.20"N	68°17'13.64"W	~5-6 m	low--> high	high--> low	high--> low	high--> low
TR	Tori's Reef	12° 4'13.98"N	68°16'50.14"W	~8 m	low--> high	high--> low	slack, high--> low	high--> low
RS	Red Slave	12° 1'34.67"N	68°15'3.67"W	~15-17 m	low--> high	high--> low	slack, high--> low	high--> low
SB	South Bay	12° 8'58.58"N	68°19'13.27"W	~8-9 m	low--> high	high--> low	high--> low	high--> low
ES	Ebo's special	12° 9'56.36"N	68°19'9.57"W	~8 m	low--> high	high--> low	high--> low	high--> low
REF*	offshore reference	12° 4'48.79"N	68°18'59.33"W	~5 m	low--> high	high--> low	high--> low	high--> low

* exact location varies in practise due to current

Appendix B. Statistical summary of all parameters

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
18th Palm	D	Chl-a (µg/l)	2011	November	0.137	0.155	0.046	-0.822	0.123	3
18th Palm	D	DIN (µmol/l)	2011	November	0.410	0.407	0.065	-0.395	0.071	3
18th Palm	D	Dissolved P (µmol P-PO4/l)	2011	November	0.020	0.060	0.078	-1.508	0.611	3
18th Palm	D	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
18th Palm	D	N-P-ratio	2011	November	17.000	20.378	19.158	1.113	0.568	3
18th Palm	D	Temperature	2011	November	29.000	29.000		1.462		1
18th Palm	D	Temperature	2012	November	29.500	29.500		1.470		1
18th Palm	D	Temperature	2013	May	28.080	28.080		1.448		1
18th Palm	D	WNH4 (µmol N-NH4/l)	2011	November	0.130	0.137	0.040	-0.877	0.128	3
18th Palm	D	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.007	0.006	#NAME?		3
18th Palm	D	WNO3 (µmol N-NO3/l)	2011	November	0.280	0.270	0.026	-0.570	0.044	3
18th Palm	D	WNOX (µmol N-NOx/l)	2011	November	0.290	0.277	0.032	-0.560	0.052	3
18th Palm	S	Chl-a (µg/l)	2011	November	0.131	0.127	0.010	-0.896	0.035	3
18th Palm	S	Chl-a (µg/l)	2012	May	0.130	0.130	0.020	-0.890	0.067	3
18th Palm	S	Chl-a (µg/l)	2012	November	0.156	0.165	0.024	-0.786	0.061	3
18th Palm	S	Chl-a (µg/l)	2013	May	0.114	0.127	0.023	-0.902	0.074	3
18th Palm	S	DIN (µmol/l)	2011	November	0.810	0.720	0.403	-0.205	0.307	3
18th Palm	S	DIN (µmol/l)	2012	May	0.813	0.793	0.085	-0.103	0.048	3
18th Palm	S	DIN (µmol/l)	2012	November	0.690	0.930	0.505	-0.070	0.219	3
18th Palm	S	DIN (µmol/l)	2013	May	0.910	1.387	1.142	0.046	0.349	3
18th Palm	S	Dissolved P (µmol P-PO4/l)	2011	November	0.040	0.040	0.000	-1.398	0.000	3
18th Palm	S	Dissolved P (µmol P-PO4/l)	2012	May	0.030	0.034	0.017	-1.509	0.219	3
18th Palm	S	Dissolved P (µmol P-PO4/l)	2012	November	0.040	0.037	0.006	-1.440	0.072	3
18th Palm	S	Dissolved P (µmol P-PO4/l)	2013	May	0.070	0.093	0.059	-1.084	0.260	3
18th Palm	S	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
18th Palm	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
18th Palm	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
18th Palm	S	Enteros (#/100 ml)	2013	May	0.000	0.000	0.000	#NAME?		2
18th Palm	S	N-P-ratio	2011	November	20.250	18.000	10.065	1.193	0.307	3
18th Palm	S	N-P-ratio	2012	May	27.100	26.848	10.070	1.407	0.174	3
18th Palm	S	N-P-ratio	2012	November	19.667	24.889	11.203	1.369	0.182	3
18th Palm	S	N-P-ratio	2013	May	13.000	13.671	2.866	1.130	0.089	3
18th Palm	S	Temperature	2011	November	29.000	29.000		1.462		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
18th Palm	S	Temperature	2012	May	27.440	27.440		1.438		1
18th Palm	S	Temperature	2012	November	29.700	29.700		1.473		1
18th Palm	S	Temperature	2013	May	28.320	28.320		1.452		1
18th Palm	S	TN-TP-ratio	2012	May	270.000	270.000		2.431		1
18th Palm	S	TN-TP-ratio	2012	November	47.831	47.831		1.680		1
18th Palm	S	TN-TP-ratio	2013	May	54.627	54.627		1.737		1
18th Palm	S	Total N (µmol N-NO3/l)	2012	May	21.060	21.060		1.323		1
18th Palm	S	Total N (µmol N-NO3/l)	2012	November	9.040	9.040		0.956		1
18th Palm	S	Total N (µmol N-NO3/l)	2013	May	9.997	9.997		1.000		1
18th Palm	S	Total P (µmol P-PO4/l)	2012	May	0.078	0.078		-1.108		1
18th Palm	S	Total P (µmol P-PO4/l)	2012	November	0.189	0.189		-0.724		1
18th Palm	S	Total P (µmol P-PO4/l)	2013	May	0.183	0.183		-0.738		1
18th Palm	S	ureum (µmol N-urea/l)	2012	November	0.800	0.800		-0.097		1
18th Palm	S	ureum (µmol N-urea/l)	2013	May	1.420	1.420		0.152		1
18th Palm	S	WNH4 (µmol N-NH4/l)	2011	November	0.500	0.430	0.350	-0.578	0.632	3
18th Palm	S	WNH4 (µmol N-NH4/l)	2012	May	0.629	0.572	0.102	-0.248	0.083	3
18th Palm	S	WNH4 (µmol N-NH4/l)	2012	November	0.410	0.697	0.549	-0.240	0.317	3
18th Palm	S	WNH4 (µmol N-NH4/l)	2013	May	0.460	0.767	0.693	-0.232	0.384	3
18th Palm	S	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.010	0.000	-2.000	0.000	3
18th Palm	S	WNO2 (µmol N-NO2/l)	2012	May	0.004	0.004	0.004	#NAME?		3
18th Palm	S	WNO2 (µmol N-NO2/l)	2012	November	0.010	0.010	0.000	-2.000	0.000	3
18th Palm	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
18th Palm	S	WNO3 (µmol N-NO3/l)	2011	November	0.310	0.290	0.053	-0.543	0.084	3
18th Palm	S	WNO3 (µmol N-NO3/l)	2012	May	0.229	0.217	0.029	-0.666	0.060	3
18th Palm	S	WNO3 (µmol N-NO3/l)	2012	November	0.230	0.223	0.050	-0.659	0.102	3
18th Palm	S	WNO3 (µmol N-NO3/l)	2013	May	0.460	0.633	0.446	-0.268	0.296	3
18th Palm	S	WNOX (µmol N-NOx/l)	2011	November	0.320	0.300	0.053	-0.528	0.081	3
18th Palm	S	WNOX (µmol N-NOx/l)	2012	May	0.233	0.221	0.032	-0.660	0.066	3
18th Palm	S	WNOX (µmol N-NOx/l)	2012	November	0.240	0.233	0.050	-0.639	0.097	3
18th Palm	S	WNOX (µmol N-NOx/l)	2013	May	0.450	0.620	0.450	-0.282	0.308	3
18th Palm	S	WSi (µmol Si-SiO2/l)	2012	November	1.510	1.520	0.125	0.181	0.036	3
18th Palm	S	WSi (µmol Si-SiO2/l)	2013	May	0.520	0.577	0.116	-0.245	0.083	3
18th Palm	SUR	Enteros (#/100 ml)	2011	November	5.000	5.000	7.071	#NAME?		2
18th Palm	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
18th Palm	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
18th Palm	SUR	Enteros (#/100 ml)	2013	May	0.000	0.000		#NAME?		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
18th Palm	SUR	Temperature	2011	November	28.500	28.500		1.455		1
Angel City	D	Chl-a (µg/l)	2011	November	0.085	0.084	0.017	-1.079	0.088	3
Angel City	D	DIN (µmol/l)	2011	November	1.860	1.827	0.581	0.246	0.146	3
Angel City	D	Dissolved P (µmol P-PO4/l)	2011	November	0.060	0.063	0.025	-1.222	0.176	3
Angel City	D	Enteros (#/100 ml)	2011	November	10.000	13.333	5.774	1.100	0.174	3
Angel City	D	N-P-ratio	2011	November	39.833	33.333	17.355	1.468	0.290	3
Angel City	D	Temperature	2011	November	28.900	28.900		1.461		1
Angel City	D	Temperature	2012	November	29.600	29.600		1.471		1
Angel City	D	Temperature	2013	May	27.860	27.860		1.445		1
Angel City	D	WNH4 (µmol N-NH4/l)	2011	November	1.460	1.433	0.531	0.135	0.172	3
Angel City	D	WNO2 (µmol N-NO2/l)	2011	November	0.030	0.023	0.012	-1.682	0.275	3
Angel City	D	WNO3 (µmol N-NO3/l)	2011	November	0.400	0.393	0.050	-0.408	0.057	3
Angel City	D	WNOX (µmol N-NOx/l)	2011	November	0.410	0.417	0.050	-0.382	0.052	3
Angel City	S	Chl-a (µg/l)	2011	November	0.067	0.073	0.014	-1.143	0.082	3
Angel City	S	Chl-a (µg/l)	2012	May	0.082	0.080	0.009	-1.097	0.051	3
Angel City	S	Chl-a (µg/l)	2012	November	0.133	0.130	0.008	-0.886	0.028	3
Angel City	S	Chl-a (µg/l)	2013	May	0.089	0.097	0.014	-1.016	0.059	3
Angel City	S	DIN (µmol/l)	2011	November	1.700	1.663	0.886	0.171	0.266	3
Angel City	S	DIN (µmol/l)	2012	May	1.231	1.237	0.871	-0.006	0.387	3
Angel City	S	DIN (µmol/l)	2012	November	0.130	0.230	0.182	-0.721	0.316	3
Angel City	S	DIN (µmol/l)	2013	May	1.090	1.297	0.617	0.082	0.199	3
Angel City	S	Dissolved P (µmol P-PO4/l)	2011	November	0.010	0.017	0.012	-1.841	0.275	3
Angel City	S	Dissolved P (µmol P-PO4/l)	2012	May	0.033	0.037	0.014	-1.453	0.165	3
Angel City	S	Dissolved P (µmol P-PO4/l)	2012	November	0.030	0.027	0.006	-1.582	0.102	3
Angel City	S	Dissolved P (µmol P-PO4/l)	2013	May	0.060	0.057	0.015	-1.258	0.126	3
Angel City	S	Enteros (#/100 ml)	2011	November	10.000	17.000	12.124	1.164	0.284	3
Angel City	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Angel City	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Angel City	S	Enteros (#/100 ml)	2013	May	0.000	0.000	0.000	#NAME?		2
Angel City	S	N-P-ratio	2011	November	170.000	149.444	115.217	2.012	0.534	3
Angel City	S	N-P-ratio	2012	May	37.303	30.644	13.780	1.447	0.240	3
Angel City	S	N-P-ratio	2012	November	6.500	8.389	5.579	0.860	0.285	3
Angel City	S	N-P-ratio	2013	May	27.250	23.060	8.300	1.340	0.182	3
Angel City	S	Temperature	2011	November	29.000	29.000		1.462		1
Angel City	S	Temperature	2012	May	27.700	27.700		1.442		1
Angel City	S	Temperature	2012	November	29.300	29.300		1.467		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Angel City	S	Temperature	2013	May	27.790	27.790		1.444		1
Angel City	S	TN-TP-ratio	2012	May	75.161	75.161		1.876		1
Angel City	S	TN-TP-ratio	2012	November	46.688	46.688		1.669		1
Angel City	S	TN-TP-ratio	2013	May	17.064	17.064		1.232		1
Angel City	S	Total N (µmol N-NO3/l)	2012	May	9.320	9.320		0.969		1
Angel City	S	Total N (µmol N-NO3/l)	2012	November	7.190	7.190		0.857		1
Angel City	S	Total N (µmol N-NO3/l)	2013	May	9.437	9.437		0.975		1
Angel City	S	Total P (µmol P-PO4/l)	2012	May	0.124	0.124		-0.907		1
Angel City	S	Total P (µmol P-PO4/l)	2012	November	0.154	0.154		-0.812		1
Angel City	S	Total P (µmol P-PO4/l)	2013	May	0.553	0.553		-0.257		1
Angel City	S	ureum (µmol N-urea/l)	2012	May	1.330	1.330		0.124		1
Angel City	S	ureum (µmol N-urea/l)	2012	November	1.890	1.890		0.276		1
Angel City	S	ureum (µmol N-urea/l)	2013	May	1.200	1.200		0.079		1
Angel City	S	WNH4 (µmol N-NH4/l)	2011	November	1.510	1.457	0.881	0.094	0.320	3
Angel City	S	WNH4 (µmol N-NH4/l)	2012	May	0.447	0.651	0.591	-0.318	0.422	3
Angel City	S	WNH4 (µmol N-NH4/l)	2012	November	0.000	0.073	0.127	#NAME?		3
Angel City	S	WNH4 (µmol N-NH4/l)	2013	May	0.420	0.480	0.197	-0.342	0.173	3
Angel City	S	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.007	0.006	#NAME?		3
Angel City	S	WNO2 (µmol N-NO2/l)	2012	May	0.004	0.005	0.002	-2.359	0.187	3
Angel City	S	WNO2 (µmol N-NO2/l)	2012	November	0.010	0.013	0.006	-1.900	0.174	3
Angel City	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Angel City	S	WNO3 (µmol N-NO3/l)	2011	November	0.210	0.207	0.015	-0.686	0.033	3
Angel City	S	WNO3 (µmol N-NO3/l)	2012	May	0.781	0.582	0.350	-0.321	0.373	3
Angel City	S	WNO3 (µmol N-NO3/l)	2012	November	0.120	0.143	0.049	-0.859	0.140	3
Angel City	S	WNO3 (µmol N-NO3/l)	2013	May	0.670	0.823	0.431	-0.122	0.218	3
Angel City	S	WNOX (µmol N-NOx/l)	2011	November	0.210	0.213	0.015	-0.672	0.031	3
Angel City	S	WNOX (µmol N-NOx/l)	2012	May	0.784	0.586	0.351	-0.316	0.369	3
Angel City	S	WNOX (µmol N-NOx/l)	2012	November	0.130	0.157	0.055	-0.821	0.143	3
Angel City	S	WNOX (µmol N-NOx/l)	2013	May	0.670	0.817	0.420	-0.124	0.215	3
Angel City	S	WSi (µmol Si-SiO2/l)	2012	November	1.430	1.360	0.157	0.132	0.052	3
Angel City	S	WSi (µmol Si-SiO2/l)	2013	May	0.930	0.933	0.195	-0.036	0.092	3
Angel City	SUR	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		2
Angel City	SUR	Enteros (#/100 ml)	2012	May	21.000	21.000	29.698	#NAME?		2
Angel City	SUR	Enteros (#/100 ml)	2012	November	1.000	1.000		0.000		1
Angel City	SUR	Enteros (#/100 ml)	2013	May	0.000	0.000		#NAME?		1
Angel City	SUR	Temperature	2011	November	28.800	28.800		1.459		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Cliff	D	Chl-a (µg/l)	2011	November	0.150	0.150	0.028	-0.828	0.082	3
Cliff	D	DIN (µmol/l)	2011	November	1.510	2.250	1.549	0.289	0.278	3
Cliff	D	Dissolved P (µmol P-PO4/l)	2011	November	0.040	0.047	0.021	-1.359	0.187	3
Cliff	D	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
Cliff	D	N-P-ratio	2011	November	50.333	46.052	14.155	1.648	0.147	3
Cliff	D	Temperature	2012	November	29.800	29.800		1.474		1
Cliff	D	WNH4 (µmol N-NH4/l)	2011	November	1.210	1.833	1.440	0.178	0.327	3
Cliff	D	WNO2 (µmol N-NO2/l)	2011	November	0.030	0.023	0.012	-1.682	0.275	3
Cliff	D	WNO3 (µmol N-NO3/l)	2011	November	0.400	0.417	0.126	-0.393	0.132	3
Cliff	D	WNOX (µmol N-NOx/l)	2011	November	0.410	0.440	0.128	-0.368	0.124	3
Cliff	S	Chl-a (µg/l)	2011	November	0.156	0.155	0.015	-0.812	0.043	3
Cliff	S	Chl-a (µg/l)	2012	May	0.110	0.111	0.008	-0.954	0.031	3
Cliff	S	Chl-a (µg/l)	2012	November	0.134	0.133	0.003	-0.875	0.009	3
Cliff	S	Chl-a (µg/l)	2013	May	0.179	0.175	0.011	-0.758	0.027	3
Cliff	S	DIN (µmol/l)	2011	November	1.430	1.313	0.302	0.110	0.108	3
Cliff	S	DIN (µmol/l)	2012	May	0.474	0.524	0.098	-0.286	0.077	3
Cliff	S	DIN (µmol/l)	2012	November	0.220	0.240	0.101	-0.646	0.184	3
Cliff	S	DIN (µmol/l)	2013	May	0.740	0.680	0.159	-0.176	0.109	3
Cliff	S	Dissolved P (µmol P-PO4/l)	2011	November	0.020	0.023	0.015	-1.699	0.301	3
Cliff	S	Dissolved P (µmol P-PO4/l)	2012	May	0.039	0.035	0.010	-1.468	0.132	3
Cliff	S	Dissolved P (µmol P-PO4/l)	2012	November	0.040	0.043	0.006	-1.366	0.056	3
Cliff	S	Dissolved P (µmol P-PO4/l)	2013	May	0.080	0.083	0.006	-1.080	0.030	3
Cliff	S	Enteros (#/100 ml)	2011	November	306.000	294.667	36.350	2.467	0.055	3
Cliff	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Cliff	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Cliff	S	Enteros (#/100 ml)	2013	May	0.000	0.000	0.000	#NAME?		2
Cliff	S	N-P-ratio	2011	November	77.000	69.917	31.233	1.809	0.227	3
Cliff	S	N-P-ratio	2012	May	12.154	16.543	8.643	1.183	0.209	3
Cliff	S	N-P-ratio	2012	November	5.500	5.417	1.627	0.720	0.137	3
Cliff	S	N-P-ratio	2013	May	9.250	8.269	2.379	0.904	0.139	3
Cliff	S	Temperature	2012	May	27.720	27.720		1.443		1
Cliff	S	Temperature	2012	November	30.000	30.000		1.477		1
Cliff	S	TN-TP-ratio	2012	May	23.352	23.352		1.368		1
Cliff	S	TN-TP-ratio	2012	November	49.731	49.731		1.697		1
Cliff	S	TN-TP-ratio	2013	May	17.719	17.719		1.248		1
Cliff	S	Total N (µmol N-NO3/l)	2012	May	4.250	4.250		0.628		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Cliff	S	Total N (µmol N-NO3/l)	2012	November	9.250	9.250		0.966		1
Cliff	S	Total N (µmol N-NO3/l)	2013	May	5.387	5.387		0.731		1
Cliff	S	Total P (µmol P-PO4/l)	2012	May	0.182	0.182		-0.740		1
Cliff	S	Total P (µmol P-PO4/l)	2012	November	0.186	0.186		-0.730		1
Cliff	S	Total P (µmol P-PO4/l)	2013	May	0.304	0.304		-0.517		1
Cliff	S	ureum (µmol N-urea/l)	2012	May	1.310	1.310		0.117		1
Cliff	S	ureum (µmol N-urea/l)	2012	November	0.760	0.760		-0.119		1
Cliff	S	ureum (µmol N-urea/l)	2013	May	1.400	1.400		0.146		1
Cliff	S	WNH4 (µmol N-NH4/l)	2011	November	1.290	1.220	0.291	0.077	0.110	3
Cliff	S	WNH4 (µmol N-NH4/l)	2012	May	0.228	0.281	0.094	-0.566	0.136	3
Cliff	S	WNH4 (µmol N-NH4/l)	2012	November	0.000	0.027	0.046	#NAME?		3
Cliff	S	WNH4 (µmol N-NH4/l)	2013	May	0.200	0.250	0.142	-0.647	0.238	3
Cliff	S	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.007	0.006	#NAME?		3
Cliff	S	WNO2 (µmol N-NO2/l)	2012	May	0.008	0.007	0.002	-2.197	0.174	3
Cliff	S	WNO2 (µmol N-NO2/l)	2012	November	0.010	0.007	0.006	#NAME?		3
Cliff	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Cliff	S	WNO3 (µmol N-NO3/l)	2011	November	0.070	0.093	0.040	-1.055	0.174	3
Cliff	S	WNO3 (µmol N-NO3/l)	2012	May	0.238	0.236	0.007	-0.627	0.013	3
Cliff	S	WNO3 (µmol N-NO3/l)	2012	November	0.210	0.207	0.055	-0.696	0.120	3
Cliff	S	WNO3 (µmol N-NO3/l)	2013	May	0.390	0.427	0.091	-0.376	0.089	3
Cliff	S	WNOX (µmol N-NOx/l)	2011	November	0.080	0.100	0.044	-1.025	0.177	3
Cliff	S	WNOX (µmol N-NOx/l)	2012	May	0.246	0.243	0.006	-0.615	0.010	3
Cliff	S	WNOX (µmol N-NOx/l)	2012	November	0.220	0.213	0.060	-0.683	0.130	3
Cliff	S	WNOX (µmol N-NOx/l)	2013	May	0.390	0.430	0.096	-0.373	0.093	3
Cliff	S	WSi (µmol Si-SiO2/l)	2012	November	1.770	1.767	0.065	0.247	0.016	3
Cliff	S	WSi (µmol Si-SiO2/l)	2013	May	0.970	1.140	0.450	0.036	0.163	3
Cliff	SUR	Enteros (#/100 ml)	2011	November	25.500	25.500	7.778	1.396	0.135	2
Cliff	SUR	Enteros (#/100 ml)	2012	May	10.000	10.000	14.142	#NAME?		2
Cliff	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Cliff	SUR	Enteros (#/100 ml)	2013	May	20.000	20.000		1.301		1
Ebo's Special	D	Chl-a (µg/l)	2011	November	0.127	0.130	0.012	-0.888	0.039	3
Ebo's Special	D	DIN (µmol/l)	2011	November	1.170	1.010	0.480	-0.039	0.253	3
Ebo's Special	D	Dissolved P (µmol P-PO4/l)	2011	November	0.000	0.003	0.006	#NAME?		3
Ebo's Special	D	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
Ebo's Special	D	N-P-ratio	2011	November	117.000	117.000		2.068		1
Ebo's Special	D	Temperature	2011	November	29.000	29.000		1.462		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Ebo's Special	D	Temperature	2012	November	28.900	28.900		1.461		1
Ebo's Special	D	Temperature	2013	May	27.670	27.670		1.442		1
Ebo's Special	D	WNH4 (µmol N-NH4/l)	2011	November	0.960	0.780	0.476	-0.194	0.371	3
Ebo's Special	D	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.010	0.000	-2.000	0.000	3
Ebo's Special	D	WNO3 (µmol N-NO3/l)	2011	November	0.230	0.230	0.020	-0.639	0.038	3
Ebo's Special	D	WNOX (µmol N-NOx/l)	2011	November	0.240	0.240	0.020	-0.621	0.036	3
Ebo's Special	S	Chl-a (µg/l)	2011	November	0.103	0.103	0.023	-0.993	0.099	3
Ebo's Special	S	Chl-a (µg/l)	2012	May	0.089	0.121	0.060	-0.949	0.198	3
Ebo's Special	S	Chl-a (µg/l)	2012	November	0.102	0.104	0.011	-0.986	0.047	3
Ebo's Special	S	Chl-a (µg/l)	2013	May	0.144	0.150	0.016	-0.826	0.045	3
Ebo's Special	S	DIN (µmol/l)	2011	November	0.710	0.983	0.571	-0.052	0.234	3
Ebo's Special	S	DIN (µmol/l)	2012	May	0.367	0.381	0.030	-0.420	0.033	3
Ebo's Special	S	DIN (µmol/l)	2012	November	0.790	1.017	0.717	-0.066	0.310	3
Ebo's Special	S	DIN (µmol/l)	2013	May	0.410	0.683	0.482	-0.231	0.281	3
Ebo's Special	S	Dissolved P (µmol P-PO4/l)	2011	November	0.000	0.000	0.000	#NAME?		3
Ebo's Special	S	Dissolved P (µmol P-PO4/l)	2012	May	0.018	0.018	0.004	-1.752	0.098	3
Ebo's Special	S	Dissolved P (µmol P-PO4/l)	2012	November	0.050	0.057	0.012	-1.252	0.084	3
Ebo's Special	S	Dissolved P (µmol P-PO4/l)	2013	May	0.070	0.063	0.012	-1.204	0.084	3
Ebo's Special	S	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
Ebo's Special	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Ebo's Special	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Ebo's Special	S	Enteros (#/100 ml)	2013	May	0.000	0.000	0.000	#NAME?		2
Ebo's Special	S	N-P-ratio	2012	May	20.389	22.147	6.790	1.332	0.130	3
Ebo's Special	S	N-P-ratio	2012	November	15.800	16.867	8.649	1.186	0.235	3
Ebo's Special	S	N-P-ratio	2013	May	8.200	10.543	6.334	0.973	0.251	3
Ebo's Special	S	Temperature	2011	November	29.000	29.000		1.462		1
Ebo's Special	S	Temperature	2012	May	27.640	27.640		1.442		1
Ebo's Special	S	Temperature	2012	November	29.000	29.000		1.462		1
Ebo's Special	S	Temperature	2013	May	27.630	27.630		1.441		1
Ebo's Special	S	TN-TP-ratio	2012	May	116.324	116.324		2.066		1
Ebo's Special	S	TN-TP-ratio	2012	November	38.133	38.133		1.581		1
Ebo's Special	S	TN-TP-ratio	2013	May	23.611	23.611		1.373		1
Ebo's Special	S	Total N (µmol N-NO3/l)	2012	May	7.910	7.910		0.898		1
Ebo's Special	S	Total N (µmol N-NO3/l)	2012	November	6.330	6.330		0.801		1
Ebo's Special	S	Total N (µmol N-NO3/l)	2013	May	4.817	4.817		0.683		1
Ebo's Special	S	Total P (µmol P-PO4/l)	2012	May	0.068	0.068		-1.167		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Ebo's Special	S	Total P (µmol P-PO4/l)	2012	November	0.166	0.166		-0.780		1
Ebo's Special	S	Total P (µmol P-PO4/l)	2013	May	0.204	0.204		-0.690		1
Ebo's Special	S	ureum (µmol N-urea/l)	2012	May	1.240	1.240		0.093		1
Ebo's Special	S	ureum (µmol N-urea/l)	2012	November	1.220	1.220		0.086		1
Ebo's Special	S	ureum (µmol N-urea/l)	2013	May	1.020	1.020		0.009		1
Ebo's Special	S	WNH4 (µmol N-NH4/l)	2011	November	0.290	0.580	0.573	-0.374	0.411	3
Ebo's Special	S	WNH4 (µmol N-NH4/l)	2012	May	0.179	0.170	0.031	-0.775	0.084	3
Ebo's Special	S	WNH4 (µmol N-NH4/l)	2012	November	0.490	0.747	0.607	-0.220	0.342	3
Ebo's Special	S	WNH4 (µmol N-NH4/l)	2013	May	0.200	0.230	0.108	-0.670	0.201	3
Ebo's Special	S	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.013	0.006	-1.900	0.174	3
Ebo's Special	S	WNO2 (µmol N-NO2/l)	2012	May	0.001	0.001	0.002	#NAME?		3
Ebo's Special	S	WNO2 (µmol N-NO2/l)	2012	November	0.020	0.023	0.006	-1.640	0.102	3
Ebo's Special	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Ebo's Special	S	WNO3 (µmol N-NO3/l)	2011	November	0.400	0.403	0.015	-0.395	0.016	3
Ebo's Special	S	WNO3 (µmol N-NO3/l)	2012	May	0.216	0.210	0.019	-0.680	0.041	3
Ebo's Special	S	WNO3 (µmol N-NO3/l)	2012	November	0.270	0.247	0.127	-0.657	0.269	3
Ebo's Special	S	WNO3 (µmol N-NO3/l)	2013	May	0.280	0.467	0.376	-0.419	0.327	3
Ebo's Special	S	WNOX (µmol N-NOx/l)	2011	November	0.410	0.417	0.021	-0.381	0.021	3
Ebo's Special	S	WNOX (µmol N-NOx/l)	2012	May	0.219	0.211	0.020	-0.677	0.043	3
Ebo's Special	S	WNOX (µmol N-NOx/l)	2012	November	0.300	0.270	0.128	-0.610	0.245	3
Ebo's Special	S	WNOX (µmol N-NOx/l)	2013	May	0.270	0.453	0.380	-0.439	0.343	3
Ebo's Special	S	WSi (µmol Si-SiO2/l)	2012	November	1.430	1.423	0.250	0.149	0.077	3
Ebo's Special	S	WSi (µmol Si-SiO2/l)	2013	May	0.780	0.770	0.036	-0.114	0.021	3
Ebo's Special	SUR	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		2
Ebo's Special	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Ebo's Special	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Ebo's Special	SUR	Enteros (#/100 ml)	2013	May	0.000	0.000		#NAME?		1
Ebo's Special	SUR	Temperature	2011	November	28.900	28.900		1.461		1
Front Porch	D	Temperature	2013	May	27.900	27.900		1.446		1
Front Porch	S	Chl-a (µg/l)	2012	May	0.102	0.103	0.001	-0.988	0.004	3
Front Porch	S	Chl-a (µg/l)	2012	November	0.107	0.116	0.015	-0.939	0.054	3
Front Porch	S	Chl-a (µg/l)	2013	May	0.186	0.187	0.020	-0.730	0.047	3
Front Porch	S	DIN (µmol/l)	2012	May	0.611	0.572	0.079	-0.246	0.063	3
Front Porch	S	DIN (µmol/l)	2012	November	0.620	0.663	0.228	-0.195	0.149	3
Front Porch	S	DIN (µmol/l)	2013	May	0.710	0.680	0.276	-0.195	0.195	3
Front Porch	S	Dissolved P (µmol P-PO4/l)	2012	May	0.048	0.047	0.007	-1.331	0.062	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Front Porch	S	Dissolved P (µmol P-PO4/l)	2012	November	0.050	0.050	0.010	-1.307	0.088	3
Front Porch	S	Dissolved P (µmol P-PO4/l)	2013	May	0.070	0.070	0.010	-1.158	0.063	3
Front Porch	S	Enteros (#/100 ml)	2012	May	5.000	5.000	7.071	#NAME?		2
Front Porch	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Front Porch	S	Enteros (#/100 ml)	2013	May	20.000	20.000	0.000	1.301	0.000	2
Front Porch	S	N-P-ratio	2012	May	12.025	12.170	0.503	1.085	0.018	3
Front Porch	S	N-P-ratio	2012	November	10.333	14.094	7.517	1.112	0.214	3
Front Porch	S	N-P-ratio	2013	May	10.143	9.464	2.690	0.963	0.134	3
Front Porch	S	Temperature	2012	May	27.590	27.590		1.441		1
Front Porch	S	Temperature	2012	November	29.600	29.600		1.471		1
Front Porch	S	Temperature	2013	May	27.900	27.900		1.446		1
Front Porch	S	TN-TP-ratio	2012	May	31.604	31.604		1.500		1
Front Porch	S	TN-TP-ratio	2012	November	32.432	32.432		1.511		1
Front Porch	S	TN-TP-ratio	2013	May	29.398	29.398		1.468		1
Front Porch	S	Total N (µmol N-NO3/l)	2012	May	6.700	6.700		0.826		1
Front Porch	S	Total N (µmol N-NO3/l)	2012	November	4.800	4.800		0.681		1
Front Porch	S	Total N (µmol N-NO3/l)	2013	May	6.997	6.997		0.845		1
Front Porch	S	Total P (µmol P-PO4/l)	2012	May	0.212	0.212		-0.674		1
Front Porch	S	Total P (µmol P-PO4/l)	2012	November	0.148	0.148		-0.830		1
Front Porch	S	Total P (µmol P-PO4/l)	2013	May	0.238	0.238		-0.623		1
Front Porch	S	ureum (µmol N-urea/l)	2012	May	1.540	1.540		0.188		1
Front Porch	S	ureum (µmol N-urea/l)	2012	November	1.600	1.600		0.204		1
Front Porch	S	ureum (µmol N-urea/l)	2013	May	1.340	1.340		0.127		1
Front Porch	S	WNH4 (µmol N-NH4/l)	2012	May	0.317	0.307	0.062	-0.520	0.092	3
Front Porch	S	WNH4 (µmol N-NH4/l)	2012	November	0.180	0.190	0.026	-0.724	0.059	3
Front Porch	S	WNH4 (µmol N-NH4/l)	2013	May	0.160	0.187	0.142	-0.829	0.378	3
Front Porch	S	WNO2 (µmol N-NO2/l)	2012	May	0.001	0.003	0.004	#NAME?		3
Front Porch	S	WNO2 (µmol N-NO2/l)	2012	November	0.010	0.010	0.000	-2.000	0.000	3
Front Porch	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Front Porch	S	WNO3 (µmol N-NO3/l)	2012	May	0.259	0.262	0.023	-0.582	0.038	3
Front Porch	S	WNO3 (µmol N-NO3/l)	2012	November	0.390	0.463	0.229	-0.368	0.208	3
Front Porch	S	WNO3 (µmol N-NO3/l)	2013	May	0.550	0.493	0.144	-0.321	0.140	3
Front Porch	S	WNOX (µmol N-NOx/l)	2012	May	0.260	0.265	0.027	-0.578	0.044	3
Front Porch	S	WNOX (µmol N-NOx/l)	2012	November	0.400	0.473	0.229	-0.357	0.204	3
Front Porch	S	WNOX (µmol N-NOx/l)	2013	May	0.550	0.493	0.144	-0.321	0.140	3
Front Porch	S	WSi (µmol Si-SiO2/l)	2012	November	1.580	1.550	0.089	0.190	0.025	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Front Porch	S	WSi (µmol Si-SiO2/l)	2013	May	1.310	1.270	0.125	0.102	0.044	3
Front Porch	SUR	Enteros (#/100 ml)	2012	May	5.000	5.000	7.071	#NAME?		2
Front Porch	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Front Porch	SUR	Enteros (#/100 ml)	2013	May	10.000	10.000		1.000		1
Karpata	D	Chl-a (µg/l)	2011	November	0.179	0.169	0.018	-0.773	0.047	3
Karpata	D	DIN (µmol/l)	2011	November	1.110	1.067	0.150	0.025	0.063	3
Karpata	D	Dissolved P (µmol P-PO4/l)	2011	November	0.020	0.023	0.006	-1.640	0.102	3
Karpata	D	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
Karpata	D	N-P-ratio	2011	November	45.000	46.722	8.056	1.665	0.074	3
Karpata	D	Temperature	2011	November	29.000	29.000		1.462		1
Karpata	D	Temperature	2012	November	29.100	29.100		1.464		1
Karpata	D	Temperature	2013	May	28.490	28.490		1.455		1
Karpata	D	WNH4 (µmol N-NH4/l)	2011	November	0.670	0.597	0.154	-0.235	0.123	3
Karpata	D	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.010	0.000	-2.000	0.000	3
Karpata	D	WNO3 (µmol N-NO3/l)	2011	November	0.480	0.470	0.026	-0.328	0.025	3
Karpata	D	WNOX (µmol N-NOx/l)	2011	November	0.490	0.480	0.026	-0.319	0.024	3
Karpata	S	Chl-a (µg/l)	2011	November	0.152	0.150	0.023	-0.826	0.067	3
Karpata	S	Chl-a (µg/l)	2012	May	0.074	0.064	0.040	-1.282	0.370	3
Karpata	S	Chl-a (µg/l)	2012	November	0.172	0.173	0.003	-0.762	0.008	3
Karpata	S	Chl-a (µg/l)	2013	May	0.102	0.090	0.022	-1.057	0.119	3
Karpata	S	DIN (µmol/l)	2011	November	0.390	0.557	0.297	-0.292	0.213	3
Karpata	S	DIN (µmol/l)	2012	May	0.659	0.761	0.240	-0.132	0.129	3
Karpata	S	DIN (µmol/l)	2012	November	0.360	0.433	0.154	-0.380	0.144	3
Karpata	S	DIN (µmol/l)	2013	May	0.510	0.490	0.053	-0.312	0.048	3
Karpata	S	Dissolved P (µmol P-PO4/l)	2011	November	0.030	0.027	0.015	-1.640	0.318	3
Karpata	S	Dissolved P (µmol P-PO4/l)	2012	May	0.019	0.022	0.011	-1.688	0.217	3
Karpata	S	Dissolved P (µmol P-PO4/l)	2012	November	0.030	0.030	0.010	-1.540	0.151	3
Karpata	S	Dissolved P (µmol P-PO4/l)	2013	May	0.030	0.033	0.006	-1.481	0.072	3
Karpata	S	Enteros (#/100 ml)	2011	November	0.000	3.333	5.774	#NAME?		3
Karpata	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Karpata	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Karpata	S	Enteros (#/100 ml)	2013	May	0.000	0.000	0.000	#NAME?		2
Karpata	S	N-P-ratio	2011	November	30.000	26.167	15.119	1.349	0.326	3
Karpata	S	N-P-ratio	2012	May	50.692	40.674	20.713	1.556	0.286	3
Karpata	S	N-P-ratio	2012	November	15.250	14.583	2.323	1.160	0.072	3
Karpata	S	N-P-ratio	2013	May	14.333	14.861	1.930	1.170	0.055	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Karpata	S	Temperature	2011	November	29.000	29.000		1.462		1
Karpata	S	Temperature	2012	May	27.780	27.780		1.444		1
Karpata	S	Temperature	2012	November	29.100	29.100		1.464		1
Karpata	S	Temperature	2013	May	28.260	28.260		1.451		1
Karpata	S	TN-TP-ratio	2012	May	92.857	92.857		1.968		1
Karpata	S	TN-TP-ratio	2012	November	42.356	42.356		1.627		1
Karpata	S	TN-TP-ratio	2013	May	8.451	8.451		0.927		1
Karpata	S	Total N (µmol N-NO3/l)	2012	May	10.400	10.400		1.017		1
Karpata	S	Total N (µmol N-NO3/l)	2012	November	8.090	8.090		0.908		1
Karpata	S	Total N (µmol N-NO3/l)	2013	May	5.147	5.147		0.712		1
Karpata	S	Total P (µmol P-PO4/l)	2012	May	0.112	0.112		-0.951		1
Karpata	S	Total P (µmol P-PO4/l)	2012	November	0.191	0.191		-0.719		1
Karpata	S	Total P (µmol P-PO4/l)	2013	May	0.609	0.609		-0.215		1
Karpata	S	ureum (µmol N-urea/l)	2012	November	1.240	1.240		0.093		1
Karpata	S	ureum (µmol N-urea/l)	2013	May	1.080	1.080		0.033		1
Karpata	S	WNH4 (µmol N-NH4/l)	2011	November	0.140	0.240	0.274	-0.879	0.632	3
Karpata	S	WNH4 (µmol N-NH4/l)	2012	May	0.234	0.379	0.272	-0.489	0.287	3
Karpata	S	WNH4 (µmol N-NH4/l)	2012	November	0.000	0.030	0.052	#NAME?		3
Karpata	S	WNH4 (µmol N-NH4/l)	2013	May	0.220	0.213	0.050	-0.679	0.107	3
Karpata	S	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.010	0.010	#NAME?		3
Karpata	S	WNO2 (µmol N-NO2/l)	2012	May	0.015	0.014	0.003	-1.873	0.111	3
Karpata	S	WNO2 (µmol N-NO2/l)	2012	November	0.020	0.020	0.000	-1.699	0.000	3
Karpata	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Karpata	S	WNO3 (µmol N-NO3/l)	2011	November	0.350	0.317	0.067	-0.506	0.098	3
Karpata	S	WNO3 (µmol N-NO3/l)	2012	May	0.365	0.369	0.039	-0.435	0.045	3
Karpata	S	WNO3 (µmol N-NO3/l)	2012	November	0.340	0.383	0.102	-0.426	0.110	3
Karpata	S	WNO3 (µmol N-NO3/l)	2013	May	0.270	0.277	0.031	-0.560	0.047	3
Karpata	S	WNOX (µmol N-NOx/l)	2011	November	0.370	0.327	0.075	-0.494	0.109	3
Karpata	S	WNOX (µmol N-NOx/l)	2012	May	0.380	0.382	0.042	-0.419	0.047	3
Karpata	S	WNOX (µmol N-NOx/l)	2012	November	0.360	0.403	0.102	-0.403	0.105	3
Karpata	S	WNOX (µmol N-NOx/l)	2013	May	0.270	0.277	0.031	-0.560	0.047	3
Karpata	S	WSi (µmol Si-SiO2/l)	2012	November	1.690	1.707	0.029	0.232	0.007	3
Karpata	S	WSi (µmol Si-SiO2/l)	2013	May	1.340	1.257	0.362	0.086	0.135	3
Karpata	SUR	Enteros (#/100 ml)	2011	November	5.000	5.000	7.071	#NAME?		2
Karpata	SUR	Enteros (#/100 ml)	2012	May	64.000	64.000	15.556	1.800	0.107	2
Karpata	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Karpata	SUR	Enteros (#/100 ml)	2013	May	10.000	10.000		1.000		1
Karpata	SUR	Temperature	2011	November	29.000	29.000		1.462		1
Offshore ref	D	Temperature	2013	May	27.720	27.720		1.443		1
Offshore ref	S	Chl-a (µg/l)	2012	May	0.073	0.072	0.003	-1.143	0.018	3
Offshore ref	S	Chl-a (µg/l)	2012	November	0.107	0.104	0.005	-0.983	0.023	3
Offshore ref	S	Chl-a (µg/l)	2013	May	0.120	0.116	0.007	-0.937	0.028	3
Offshore ref	S	DIN (µmol/l)	2012	May	0.495	0.678	0.352	-0.204	0.208	3
Offshore ref	S	DIN (µmol/l)	2012	November	0.100	0.070	0.052	-1.333	0.577	3
Offshore ref	S	DIN (µmol/l)	2013	May	0.630	0.637	0.021	-0.196	0.014	3
Offshore ref	S	Dissolved P (µmol P-PO4/l)	2012	May	0.023	0.020	0.016	-1.935	0.667	3
Offshore ref	S	Dissolved P (µmol P-PO4/l)	2012	November	0.040	0.040	0.010	-1.407	0.111	3
Offshore ref	S	Dissolved P (µmol P-PO4/l)	2013	May	0.040	0.043	0.015	-1.381	0.151	3
Offshore ref	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Offshore ref	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Offshore ref	S	Enteros (#/100 ml)	2013	May	31.500	31.500	44.548	#NAME?		2
Offshore ref	S	N-P-ratio	2012	May	21.522	192.292	302.884	1.731	0.875	3
Offshore ref	S	N-P-ratio	2012	November	2.000	1.611	1.134	0.074	0.480	3
Offshore ref	S	N-P-ratio	2013	May	15.750	16.028	5.838	1.185	0.164	3
Offshore ref	S	Temperature	2012	May	27.730	27.730		1.443		1
Offshore ref	S	Temperature	2012	November	29.000	29.000		1.462		1
Offshore ref	S	Temperature	2013	May	27.800	27.800		1.444		1
Offshore ref	S	TN-TP-ratio	2012	May	90.375	90.375		1.956		1
Offshore ref	S	TN-TP-ratio	2012	November	41.459	41.459		1.618		1
Offshore ref	S	TN-TP-ratio	2013	May	31.755	31.755		1.502		1
Offshore ref	S	Total N (µmol N-NO3/l)	2012	May	7.230	7.230		0.859		1
Offshore ref	S	Total N (µmol N-NO3/l)	2012	November	9.660	9.660		0.985		1
Offshore ref	S	Total N (µmol N-NO3/l)	2013	May	7.177	7.177		0.856		1
Offshore ref	S	Total P (µmol P-PO4/l)	2012	May	0.080	0.080		-1.097		1
Offshore ref	S	Total P (µmol P-PO4/l)	2012	November	0.233	0.233		-0.633		1
Offshore ref	S	Total P (µmol P-PO4/l)	2013	May	0.226	0.226		-0.646		1
Offshore ref	S	ureum (µmol N-urea/l)	2012	May	2.420	2.420		0.384		1
Offshore ref	S	ureum (µmol N-urea/l)	2012	November	2.090	2.090		0.320		1
Offshore ref	S	ureum (µmol N-urea/l)	2013	May	1.190	1.190		0.076		1
Offshore ref	S	WNH4 (µmol N-NH4/l)	2012	May	0.433	0.618	0.353	-0.251	0.228	3
Offshore ref	S	WNH4 (µmol N-NH4/l)	2012	November	0.090	0.060	0.052	#NAME?		3
Offshore ref	S	WNH4 (µmol N-NH4/l)	2013	May	0.530	0.520	0.056	-0.286	0.047	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Offshore ref	S	WNO2 (µmol N-NO2/l)	2012	May	0.000	0.000	0.000	#NAME?		3
Offshore ref	S	WNO2 (µmol N-NO2/l)	2012	November	0.010	0.007	0.006	#NAME?		3
Offshore ref	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Offshore ref	S	WNO3 (µmol N-NO3/l)	2012	May	0.059	0.059	0.003	-1.227	0.018	3
Offshore ref	S	WNO3 (µmol N-NO3/l)	2012	November	0.000	0.003	0.006	#NAME?		3
Offshore ref	S	WNO3 (µmol N-NO3/l)	2013	May	0.110	0.130	0.035	-0.896	0.109	3
Offshore ref	S	WNOX (µmol N-NOx/l)	2012	May	0.059	0.059	0.003	-1.227	0.018	3
Offshore ref	S	WNOX (µmol N-NOx/l)	2012	November	0.010	0.010	0.000	-2.000	0.000	3
Offshore ref	S	WNOX (µmol N-NOx/l)	2013	May	0.100	0.117	0.038	-0.947	0.133	3
Offshore ref	S	WSi (µmol Si-SiO2/l)	2012	November	1.190	1.233	0.179	0.088	0.062	3
Offshore ref	S	WSi (µmol Si-SiO2/l)	2013	May	0.920	0.853	0.257	-0.084	0.143	3
Offshore ref	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Offshore ref	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Offshore ref	SUR	Enteros (#/100 ml)	2013	May	0.000	0.000		#NAME?		1
Playa Funchi	D	Chl-a (µg/l)	2011	November	0.143	0.143	0.002	-0.844	0.005	3
Playa Funchi	D	DIN (µmol/l)	2011	November	0.870	1.173	0.587	0.037	0.201	3
Playa Funchi	D	Dissolved P (µmol P-PO4/l)	2011	November	0.030	0.033	0.006	-1.481	0.072	3
Playa Funchi	D	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
Playa Funchi	D	N-P-ratio	2011	November	26.667	36.694	21.766	1.518	0.240	3
Playa Funchi	D	Temperature	2011	November	29.000	29.000		1.462		1
Playa Funchi	D	Temperature	2012	November	29.100	29.100		1.464		1
Playa Funchi	D	Temperature	2013	May	28.000	28.000		1.447		1
Playa Funchi	D	WNH4 (µmol N-NH4/l)	2011	November	0.620	0.937	0.610	-0.084	0.260	3
Playa Funchi	D	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.007	0.006	#NAME?		3
Playa Funchi	D	WNO3 (µmol N-NO3/l)	2011	November	0.250	0.237	0.023	-0.627	0.044	3
Playa Funchi	D	WNOX (µmol N-NOx/l)	2011	November	0.260	0.243	0.029	-0.616	0.054	3
Playa Funchi	S	Chl-a (µg/l)	2011	November	0.139	0.137	0.006	-0.865	0.020	3
Playa Funchi	S	Chl-a (µg/l)	2012	May	0.069	0.069	0.004	-1.161	0.025	3
Playa Funchi	S	Chl-a (µg/l)	2012	November	0.136	0.131	0.014	-0.885	0.046	3
Playa Funchi	S	Chl-a (µg/l)	2013	May	0.130	0.129	0.009	-0.891	0.032	3
Playa Funchi	S	DIN (µmol/l)	2011	November	0.310	0.420	0.377	-0.514	0.441	3
Playa Funchi	S	DIN (µmol/l)	2012	May	0.458	0.462	0.116	-0.345	0.111	3
Playa Funchi	S	DIN (µmol/l)	2012	November	0.070	0.080	0.026	-1.112	0.137	3
Playa Funchi	S	DIN (µmol/l)	2013	May	0.590	0.553	0.110	-0.263	0.091	3
Playa Funchi	S	Dissolved P (µmol P-PO4/l)	2011	November	0.010	0.007	0.006	#NAME?		3
Playa Funchi	S	Dissolved P (µmol P-PO4/l)	2012	May	0.022	0.025	0.006	-1.617	0.108	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Playa Funchi	S	Dissolved P (µmol P-PO4/l)	2012	November	0.020	0.020	0.020	#NAME?		3
Playa Funchi	S	Dissolved P (µmol P-PO4/l)	2013	May	0.070	0.070	0.010	-1.158	0.063	3
Playa Funchi	S	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
Playa Funchi	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Playa Funchi	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Playa Funchi	S	Enteros (#/100 ml)	2013	May	0.000	0.000	0.000	#NAME?		2
Playa Funchi	S	N-P-ratio	2011	November	47.500	47.500	51.619	1.483	0.624	2
Playa Funchi	S	N-P-ratio	2012	May	18.125	18.948	3.612	1.272	0.081	3
Playa Funchi	S	N-P-ratio	2012	November	3.625	3.625	2.652	0.492	0.352	2
Playa Funchi	S	N-P-ratio	2013	May	7.375	7.895	1.086	0.895	0.058	3
Playa Funchi	S	Temperature	2011	November	29.500	29.500		1.470		1
Playa Funchi	S	Temperature	2012	May	27.650	27.650		1.442		1
Playa Funchi	S	Temperature	2012	November	29.100	29.100		1.464		1
Playa Funchi	S	Temperature	2013	May	27.800	27.800		1.444		1
Playa Funchi	S	TN-TP-ratio	2012	May	220.455	220.455		2.343		1
Playa Funchi	S	TN-TP-ratio	2012	November	46.570	46.570		1.668		1
Playa Funchi	S	TN-TP-ratio	2013	May	33.789	33.789		1.529		1
Playa Funchi	S	Total N (µmol N-NO3/l)	2012	May	14.550	14.550		1.163		1
Playa Funchi	S	Total N (µmol N-NO3/l)	2012	November	9.640	9.640		0.984		1
Playa Funchi	S	Total N (µmol N-NO3/l)	2013	May	4.697	4.697		0.672		1
Playa Funchi	S	Total P (µmol P-PO4/l)	2012	May	0.066	0.066		-1.180		1
Playa Funchi	S	Total P (µmol P-PO4/l)	2012	November	0.207	0.207		-0.684		1
Playa Funchi	S	Total P (µmol P-PO4/l)	2013	May	0.139	0.139		-0.857		1
Playa Funchi	S	ureum (µmol N-urea/l)	2012	May	1.400	1.400		0.146		1
Playa Funchi	S	ureum (µmol N-urea/l)	2012	November	1.310	1.310		0.117		1
Playa Funchi	S	ureum (µmol N-urea/l)	2013	May	1.170	1.170		0.068		1
Playa Funchi	S	WNH4 (µmol N-NH4/l)	2011	November	0.290	0.407	0.369	-0.527	0.436	3
Playa Funchi	S	WNH4 (µmol N-NH4/l)	2012	May	0.247	0.283	0.097	-0.564	0.142	3
Playa Funchi	S	WNH4 (µmol N-NH4/l)	2012	November	0.000	0.000	0.000	#NAME?		3
Playa Funchi	S	WNH4 (µmol N-NH4/l)	2013	May	0.190	0.177	0.061	-0.773	0.166	3
Playa Funchi	S	WNO2 (µmol N-NO2/l)	2011	November	0.000	0.000	0.000	#NAME?		3
Playa Funchi	S	WNO2 (µmol N-NO2/l)	2012	May	0.005	0.004	0.003	#NAME?		3
Playa Funchi	S	WNO2 (µmol N-NO2/l)	2012	November	0.000	0.000	0.000	#NAME?		3
Playa Funchi	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Playa Funchi	S	WNO3 (µmol N-NO3/l)	2011	November	0.020	0.013	0.012	#NAME?		3
Playa Funchi	S	WNO3 (µmol N-NO3/l)	2012	May	0.182	0.175	0.034	-0.762	0.086	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Playa Funchi	S	WNO3 (µmol N-NO3/l)	2012	November	0.070	0.080	0.026	-1.112	0.137	3
Playa Funchi	S	WNO3 (µmol N-NO3/l)	2013	May	0.380	0.387	0.070	-0.417	0.079	3
Playa Funchi	S	WNOX (µmol N-NOx/l)	2011	November	0.020	0.013	0.012	#NAME?		3
Playa Funchi	S	WNOX (µmol N-NOx/l)	2012	May	0.187	0.179	0.037	-0.754	0.093	3
Playa Funchi	S	WNOX (µmol N-NOx/l)	2012	November	0.070	0.080	0.026	-1.112	0.137	3
Playa Funchi	S	WNOX (µmol N-NOx/l)	2013	May	0.360	0.377	0.067	-0.428	0.075	3
Playa Funchi	S	WSi (µmol Si-SiO2/l)	2012	November	1.680	1.643	0.257	0.212	0.070	3
Playa Funchi	S	WSi (µmol Si-SiO2/l)	2013	May	1.410	1.310	0.557	0.086	0.210	3
Playa Funchi	SUR	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		2
Playa Funchi	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Playa Funchi	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Playa Funchi	SUR	Enteros (#/100 ml)	2013	May	0.000	0.000		#NAME?		1
Playa Funchi	SUR	Temperature	2011	November	28.800	28.800		1.459		1
Playa Lechi	D	Chl-a (µg/l)	2011	November	0.128	0.125	0.034	-0.913	0.122	3
Playa Lechi	D	DIN (µmol/l)	2011	November	0.650	1.637	2.166	-0.142	0.735	3
Playa Lechi	D	Dissolved P (µmol P-PO4/l)	2011	November	0.010	0.007	0.006	#NAME?		3
Playa Lechi	D	Enteros (#/100 ml)	2011	November	0.000	6.667	11.547	#NAME?		3
Playa Lechi	D	N-P-ratio	2011	November	39.500	39.500	36.062	1.480	0.471	2
Playa Lechi	D	Temperature	2011	November	29.000	29.000		1.462		1
Playa Lechi	D	Temperature	2013	May	27.800	27.800		1.444		1
Playa Lechi	D	WNH4 (µmol N-NH4/l)	2011	November	0.590	1.570	2.145	-0.223	0.826	3
Playa Lechi	D	WNO2 (µmol N-NO2/l)	2011	November	0.000	0.000	0.000	#NAME?		3
Playa Lechi	D	WNO3 (µmol N-NO3/l)	2011	November	0.060	0.067	0.021	-1.190	0.131	3
Playa Lechi	D	WNOX (µmol N-NOx/l)	2011	November	0.060	0.067	0.021	-1.190	0.131	3
Playa Lechi	S	Chl-a (µg/l)	2011	November	0.164	0.164	0.025	-0.788	0.067	2
Playa Lechi	S	Chl-a (µg/l)	2012	May	0.140	0.133	0.012	-0.876	0.039	3
Playa Lechi	S	Chl-a (µg/l)	2012	November	0.235	0.223	0.029	-0.655	0.058	3
Playa Lechi	S	Chl-a (µg/l)	2013	May	0.183	0.160	0.041	-0.807	0.122	3
Playa Lechi	S	DIN (µmol/l)	2011	November	0.590	0.590	0.057	-0.230	0.042	2
Playa Lechi	S	DIN (µmol/l)	2012	May	1.494	1.278	0.862	-0.002	0.422	3
Playa Lechi	S	DIN (µmol/l)	2012	November	0.170	0.300	0.243	-0.610	0.325	3
Playa Lechi	S	DIN (µmol/l)	2013	May	0.800	0.763	0.119	-0.121	0.071	3
Playa Lechi	S	Dissolved P (µmol P-PO4/l)	2011	November	0.015	0.015	0.007	-1.849	0.213	2
Playa Lechi	S	Dissolved P (µmol P-PO4/l)	2012	May	0.030	0.032	0.004	-1.493	0.053	3
Playa Lechi	S	Dissolved P (µmol P-PO4/l)	2012	November	0.040	0.040	0.000	-1.398	0.000	3
Playa Lechi	S	Dissolved P (µmol P-PO4/l)	2013	May	0.090	0.083	0.012	-1.082	0.063	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Playa Lechi	S	Enteros (#/100 ml)	2011	November	0.000	3.333	5.774	#NAME?		3
Playa Lechi	S	Enteros (#/100 ml)	2012	May	5.000	5.000	7.071	#NAME?		2
Playa Lechi	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Playa Lechi	S	Enteros (#/100 ml)	2013	May	25.500	25.500	36.062	#NAME?		2
Playa Lechi	S	N-P-ratio	2011	November	45.250	45.250	25.102	1.619	0.255	2
Playa Lechi	S	N-P-ratio	2012	May	49.800	41.920	29.877	1.491	0.474	3
Playa Lechi	S	N-P-ratio	2012	November	4.250	7.500	6.067	0.788	0.325	3
Playa Lechi	S	N-P-ratio	2013	May	9.000	9.148	0.357	0.961	0.017	3
Playa Lechi	S	Temperature	2011	November	29.000	29.000		1.462		1
Playa Lechi	S	Temperature	2012	May	27.540	27.540		1.440		1
Playa Lechi	S	Temperature	2012	November	29.500	29.500		1.470		1
Playa Lechi	S	Temperature	2013	May	27.600	27.600		1.441		1
Playa Lechi	S	TN-TP-ratio	2012	May	42.708	42.708		1.631		1
Playa Lechi	S	TN-TP-ratio	2012	November	46.142	46.142		1.664		1
Playa Lechi	S	TN-TP-ratio	2013	May	22.640	22.640		1.355		1
Playa Lechi	S	Total N (µmol N-NO3/l)	2012	May	6.150	6.150		0.789		1
Playa Lechi	S	Total N (µmol N-NO3/l)	2012	November	5.860	5.860		0.768		1
Playa Lechi	S	Total N (µmol N-NO3/l)	2013	May	10.007	10.007		1.000		1
Playa Lechi	S	Total P (µmol P-PO4/l)	2012	May	0.144	0.144		-0.842		1
Playa Lechi	S	Total P (µmol P-PO4/l)	2012	November	0.127	0.127		-0.896		1
Playa Lechi	S	Total P (µmol P-PO4/l)	2013	May	0.442	0.442		-0.355		1
Playa Lechi	S	ureum (µmol N-urea/l)	2012	May	2.070	2.070		0.316		1
Playa Lechi	S	ureum (µmol N-urea/l)	2012	November	1.130	1.130		0.053		1
Playa Lechi	S	ureum (µmol N-urea/l)	2013	May	1.370	1.370		0.137		1
Playa Lechi	S	WNH4 (µmol N-NH4/l)	2011	November	0.550	0.550	0.014	-0.260	0.011	2
Playa Lechi	S	WNH4 (µmol N-NH4/l)	2012	May	1.321	1.104	0.848	-0.131	0.562	3
Playa Lechi	S	WNH4 (µmol N-NH4/l)	2012	November	0.000	0.143	0.248	#NAME?		3
Playa Lechi	S	WNH4 (µmol N-NH4/l)	2013	May	0.350	0.310	0.078	-0.519	0.120	3
Playa Lechi	S	WNO2 (µmol N-NO2/l)	2011	November	0.000	0.000	0.000	#NAME?		2
Playa Lechi	S	WNO2 (µmol N-NO2/l)	2012	May	0.000	0.001	0.001	#NAME?		3
Playa Lechi	S	WNO2 (µmol N-NO2/l)	2012	November	0.010	0.010	0.000	-2.000	0.000	3
Playa Lechi	S	WNO2 (µmol N-NO2/l)	2013	May	0.020	0.017	0.015	#NAME?		3
Playa Lechi	S	WNO3 (µmol N-NO3/l)	2011	November	0.040	0.040	0.042	-1.577	0.598	2
Playa Lechi	S	WNO3 (µmol N-NO3/l)	2012	May	0.173	0.174	0.016	-0.761	0.039	3
Playa Lechi	S	WNO3 (µmol N-NO3/l)	2012	November	0.140	0.147	0.012	-0.835	0.033	3
Playa Lechi	S	WNO3 (µmol N-NO3/l)	2013	May	0.450	0.437	0.042	-0.361	0.042	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Playa Lechi	S	WNOX (µmol N-NOx/l)	2011	November	0.040	0.040	0.042	-1.577	0.598	2
Playa Lechi	S	WNOX (µmol N-NOx/l)	2012	May	0.173	0.175	0.015	-0.759	0.036	3
Playa Lechi	S	WNOX (µmol N-NOx/l)	2012	November	0.150	0.157	0.012	-0.806	0.031	3
Playa Lechi	S	WNOX (µmol N-NOx/l)	2013	May	0.450	0.453	0.045	-0.345	0.043	3
Playa Lechi	S	WSi (µmol Si-SiO2/l)	2012	November	1.720	1.643	0.187	0.214	0.051	3
Playa Lechi	S	WSi (µmol Si-SiO2/l)	2013	May	1.040	1.007	0.391	-0.022	0.184	3
Playa Lechi	SUR	Enteros (#/100 ml)	2011	November	417.500	417.500	16.263	2.620	0.017	2
Playa Lechi	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Playa Lechi	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Playa Lechi	SUR	Enteros (#/100 ml)	2013	May	50.000	50.000		1.699		1
Playa Lechi	SUR	Temperature	2011	November	28.900	28.900		1.461		1
Red Slave	D	Chl-a (µg/l)	2011	November	0.075	0.071	0.014	-1.155	0.091	3
Red Slave	D	DIN (µmol/l)	2011	November	1.040	1.080	0.164	0.030	0.065	3
Red Slave	D	Dissolved P (µmol P-PO4/l)	2011	November	0.040	0.037	0.006	-1.440	0.072	3
Red Slave	D	Enteros (#/100 ml)	2011	November	0.000	6.667	11.547	#NAME?		3
Red Slave	D	N-P-ratio	2011	November	31.333	29.611	3.128	1.470	0.047	3
Red Slave	D	Temperature	2011	November	29.000	29.000		1.462		1
Red Slave	D	Temperature	2012	November	29.000	29.000		1.462		1
Red Slave	D	Temperature	2013	May	28.100	28.100		1.449		1
Red Slave	D	WNH4 (µmol N-NH4/l)	2011	November	0.650	0.643	0.090	-0.194	0.062	3
Red Slave	D	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.010	0.000	-2.000	0.000	3
Red Slave	D	WNO3 (µmol N-NO3/l)	2011	November	0.390	0.437	0.081	-0.365	0.077	3
Red Slave	D	WNOX (µmol N-NOx/l)	2011	November	0.400	0.447	0.081	-0.354	0.075	3
Red Slave	S	Chl-a (µg/l)	2011	November	0.098	0.097	0.011	-1.017	0.051	3
Red Slave	S	Chl-a (µg/l)	2012	May	0.115	0.210	0.184	-0.782	0.355	3
Red Slave	S	Chl-a (µg/l)	2012	November	0.129	0.128	0.018	-0.896	0.061	3
Red Slave	S	Chl-a (µg/l)	2013	May	0.140	0.139	0.005	-0.858	0.016	3
Red Slave	S	DIN (µmol/l)	2011	November	1.225	1.225	0.488	0.070	0.178	2
Red Slave	S	DIN (µmol/l)	2012	May	0.693	0.823	0.251	-0.097	0.124	3
Red Slave	S	DIN (µmol/l)	2012	November	0.190	0.197	0.050	-0.716	0.111	3
Red Slave	S	DIN (µmol/l)	2013	May	0.720	0.703	0.057	-0.154	0.036	3
Red Slave	S	Dissolved P (µmol P-PO4/l)	2011	November	0.040	0.040	0.014	-1.412	0.157	2
Red Slave	S	Dissolved P (µmol P-PO4/l)	2012	May	0.062	0.059	0.011	-1.234	0.083	3
Red Slave	S	Dissolved P (µmol P-PO4/l)	2012	November	0.040	0.040	0.000	-1.398	0.000	3
Red Slave	S	Dissolved P (µmol P-PO4/l)	2013	May	0.060	0.063	0.006	-1.200	0.039	3
Red Slave	S	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Red Slave	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Red Slave	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2
Red Slave	S	Enteros (#/100 ml)	2013	May	0.000	0.000	0.000	#NAME?		2
Red Slave	S	N-P-ratio	2011	November	30.367	30.367	1.461	1.482	0.021	2
Red Slave	S	N-P-ratio	2012	May	14.128	13.886	2.596	1.137	0.083	3
Red Slave	S	N-P-ratio	2012	November	4.750	4.917	1.258	0.682	0.111	3
Red Slave	S	N-P-ratio	2013	May	12.000	11.214	1.811	1.046	0.074	3
Red Slave	S	Temperature	2012	May	27.720	27.720		1.443		1
Red Slave	S	Temperature	2012	November	28.400	28.400		1.453		1
Red Slave	S	Temperature	2013	May	27.720	27.720		1.443		1
Red Slave	S	TN-TP-ratio	2012	May	46.397	46.397		1.666		1
Red Slave	S	TN-TP-ratio	2012	November	46.667	46.667		1.669		1
Red Slave	S	TN-TP-ratio	2013	May	11.101	11.101		1.045		1
Red Slave	S	Total N (µmol N-NO3/l)	2012	May	6.310	6.310		0.800		1
Red Slave	S	Total N (µmol N-NO3/l)	2012	November	6.860	6.860		0.836		1
Red Slave	S	Total N (µmol N-NO3/l)	2013	May	6.117	6.117		0.787		1
Red Slave	S	Total P (µmol P-PO4/l)	2012	May	0.136	0.136		-0.866		1
Red Slave	S	Total P (µmol P-PO4/l)	2012	November	0.147	0.147		-0.833		1
Red Slave	S	Total P (µmol P-PO4/l)	2013	May	0.551	0.551		-0.259		1
Red Slave	S	ureum (µmol N-urea/l)	2012	May	1.450	1.450		0.161		1
Red Slave	S	ureum (µmol N-urea/l)	2012	November	1.870	1.870		0.272		1
Red Slave	S	ureum (µmol N-urea/l)	2013	May	1.320	1.320		0.121		1
Red Slave	S	WNH4 (µmol N-NH4/l)	2011	November	1.135	1.135	0.502	0.033	0.199	2
Red Slave	S	WNH4 (µmol N-NH4/l)	2012	May	0.222	0.259	0.068	-0.597	0.108	3
Red Slave	S	WNH4 (µmol N-NH4/l)	2012	November	0.150	0.147	0.045	-0.848	0.141	3
Red Slave	S	WNH4 (µmol N-NH4/l)	2013	May	0.240	0.250	0.026	-0.604	0.045	3
Red Slave	S	WNO2 (µmol N-NO2/l)	2011	November	0.015	0.015	0.007	-1.849	0.213	2
Red Slave	S	WNO2 (µmol N-NO2/l)	2012	May	0.012	0.012	0.001	-1.922	0.036	3
Red Slave	S	WNO2 (µmol N-NO2/l)	2012	November	0.000	0.000	0.000	#NAME?		3
Red Slave	S	WNO2 (µmol N-NO2/l)	2013	May	0.010	0.007	0.006	#NAME?		3
Red Slave	S	WNO3 (µmol N-NO3/l)	2011	November	0.090	0.090	0.014	-1.048	0.069	2
Red Slave	S	WNO3 (µmol N-NO3/l)	2012	May	0.459	0.552	0.184	-0.273	0.135	3
Red Slave	S	WNO3 (µmol N-NO3/l)	2012	November	0.050	0.050	0.050	#NAME?		3
Red Slave	S	WNO3 (µmol N-NO3/l)	2013	May	0.460	0.447	0.042	-0.351	0.041	3
Red Slave	S	WNOX (µmol N-NOx/l)	2011	November	0.105	0.105	0.021	-0.983	0.088	2
Red Slave	S	WNOX (µmol N-NOx/l)	2012	May	0.471	0.564	0.183	-0.262	0.132	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Red Slave	S	WNOX (µmol N-NOx/l)	2012	November	0.050	0.050	0.050	#NAME?		3
Red Slave	S	WNOX (µmol N-NOx/l)	2013	May	0.470	0.453	0.038	-0.345	0.037	3
Red Slave	S	WSi (µmol Si-SiO2/l)	2012	November	1.160	1.233	0.172	0.088	0.059	3
Red Slave	S	WSi (µmol Si-SiO2/l)	2013	May	1.280	1.297	0.206	0.109	0.069	3
Red Slave	SUR	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		2
Red Slave	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Red Slave	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Red Slave	SUR	Enteros (#/100 ml)	2013	May	10.000	10.000		1.000		1
Red Slave	SUR	Temperature	2011	November	29.900	29.900		1.476		1
South Bay	D	Chl-a (µg/l)	2011	November	0.140	0.140	0.023	-0.855	0.073	2
South Bay	D	DIN (µmol/l)	2011	November	0.300	0.390	0.182	-0.438	0.188	3
South Bay	D	Dissolved P (µmol P-PO4/l)	2011	November	0.020	0.017	0.006	-1.799	0.174	3
South Bay	D	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
South Bay	D	N-P-ratio	2011	November	27.000	24.000	7.937	1.362	0.162	3
South Bay	D	Temperature	2011	November	29.000	29.000		1.462		1
South Bay	D	Temperature	2012	November	28.000	28.000		1.447		1
South Bay	D	Temperature	2013	May	27.740	27.740		1.443		1
South Bay	D	WNH4 (µmol N-NH4/l)	2011	November	0.150	0.227	0.150	-0.703	0.266	3
South Bay	D	WNO2 (µmol N-NO2/l)	2011	November	0.000	0.000	0.000	#NAME?		3
South Bay	D	WNO3 (µmol N-NO3/l)	2011	November	0.150	0.163	0.032	-0.792	0.082	3
South Bay	D	WNOX (µmol N-NOx/l)	2011	November	0.150	0.163	0.032	-0.792	0.082	3
South Bay	S	Chl-a (µg/l)	2011	November	0.127	0.122	0.033	-0.924	0.122	3
South Bay	S	Chl-a (µg/l)	2012	May	0.089	0.091	0.008	-1.043	0.038	3
South Bay	S	Chl-a (µg/l)	2012	November	0.142	0.137	0.033	-0.874	0.111	3
South Bay	S	Chl-a (µg/l)	2013	May	0.107	0.106	0.009	-0.975	0.037	3
South Bay	S	DIN (µmol/l)	2011	November	0.330	0.357	0.103	-0.459	0.122	3
South Bay	S	DIN (µmol/l)	2012	May	0.322	0.361	0.070	-0.448	0.080	3
South Bay	S	DIN (µmol/l)	2012	November	0.590	0.660	0.499	-0.284	0.390	3
South Bay	S	DIN (µmol/l)	2013	May	0.750	0.663	0.177	-0.190	0.128	3
South Bay	S	Dissolved P (µmol P-PO4/l)	2011	November	0.010	0.013	0.015	#NAME?		3
South Bay	S	Dissolved P (µmol P-PO4/l)	2012	May	0.030	0.035	0.010	-1.463	0.117	3
South Bay	S	Dissolved P (µmol P-PO4/l)	2012	November	0.080	0.080	0.030	-1.119	0.172	3
South Bay	S	Dissolved P (µmol P-PO4/l)	2013	May	0.050	0.057	0.012	-1.252	0.084	3
South Bay	S	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
South Bay	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
South Bay	S	Enteros (#/100 ml)	2012	November	0.000	0.000	0.000	#NAME?		2

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
South Bay	S	Enteros (#/100 ml)	2013	May	5.000	5.000	7.071	#NAME?		2
South Bay	S	N-P-ratio	2011	November	21.333	21.333	8.014	1.313	0.167	2
South Bay	S	N-P-ratio	2012	May	11.000	10.850	3.927	1.015	0.167	3
South Bay	S	N-P-ratio	2012	November	7.375	7.398	3.409	0.835	0.218	3
South Bay	S	N-P-ratio	2013	May	11.143	11.781	2.952	1.062	0.107	3
South Bay	S	Temperature	2011	November	29.000	29.000		1.462		1
South Bay	S	Temperature	2012	May	27.610	27.610		1.441		1
South Bay	S	Temperature	2012	November	29.000	29.000		1.462		1
South Bay	S	Temperature	2013	May	27.830	27.830		1.445		1
South Bay	S	TN-TP-ratio	2012	May	4.362	4.362		0.640		1
South Bay	S	TN-TP-ratio	2012	November	40.643	40.643		1.609		1
South Bay	S	TN-TP-ratio	2013	May	40.663	40.663		1.609		1
South Bay	S	Total N (µmol N-NO3/l)	2012	May	0.410	0.410		-0.387		1
South Bay	S	Total N (µmol N-NO3/l)	2012	November	5.690	5.690		0.755		1
South Bay	S	Total N (µmol N-NO3/l)	2013	May	8.377	8.377		0.923		1
South Bay	S	Total P (µmol P-PO4/l)	2012	May	0.094	0.094		-1.027		1
South Bay	S	Total P (µmol P-PO4/l)	2012	November	0.140	0.140		-0.854		1
South Bay	S	Total P (µmol P-PO4/l)	2013	May	0.206	0.206		-0.686		1
South Bay	S	ureum (µmol N-urea/l)	2012	May	1.480	1.480		0.170		1
South Bay	S	ureum (µmol N-urea/l)	2012	November	1.640	1.640		0.215		1
South Bay	S	ureum (µmol N-urea/l)	2013	May	1.030	1.030		0.013		1
South Bay	S	WNH4 (µmol N-NH4/l)	2011	November	0.030	0.103	0.136	-1.269	0.599	3
South Bay	S	WNH4 (µmol N-NH4/l)	2012	May	0.160	0.199	0.075	-0.720	0.153	3
South Bay	S	WNH4 (µmol N-NH4/l)	2012	November	0.440	0.497	0.527	#NAME?		3
South Bay	S	WNH4 (µmol N-NH4/l)	2013	May	0.220	0.233	0.091	-0.654	0.171	3
South Bay	S	WNO2 (µmol N-NO2/l)	2011	November	0.000	0.000	0.000	#NAME?		3
South Bay	S	WNO2 (µmol N-NO2/l)	2012	May	0.001	0.001	0.001	#NAME?		3
South Bay	S	WNO2 (µmol N-NO2/l)	2012	November	0.020	0.020	0.000	-1.699	0.000	3
South Bay	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.007	0.012	#NAME?		3
South Bay	S	WNO3 (µmol N-NO3/l)	2011	November	0.250	0.253	0.045	-0.601	0.077	3
South Bay	S	WNO3 (µmol N-NO3/l)	2012	May	0.161	0.161	0.008	-0.794	0.020	3
South Bay	S	WNO3 (µmol N-NO3/l)	2012	November	0.130	0.143	0.032	-0.851	0.093	3
South Bay	S	WNO3 (µmol N-NO3/l)	2013	May	0.460	0.430	0.098	-0.375	0.106	3
South Bay	S	WNOX (µmol N-NOx/l)	2011	November	0.250	0.253	0.045	-0.601	0.077	3
South Bay	S	WNOX (µmol N-NOx/l)	2012	May	0.162	0.162	0.007	-0.792	0.018	3
South Bay	S	WNOX (µmol N-NOx/l)	2012	November	0.150	0.163	0.032	-0.792	0.082	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
South Bay	S	WNOX (µmol N-NOx/l)	2013	May	0.450	0.430	0.111	-0.377	0.119	3
South Bay	S	WSi (µmol Si-SiO2/l)	2012	November	1.320	1.333	0.180	0.122	0.059	3
South Bay	S	WSi (µmol Si-SiO2/l)	2013	May	0.860	0.870	0.026	-0.061	0.013	3
South Bay	SUR	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		2
South Bay	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
South Bay	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
South Bay	SUR	Enteros (#/100 ml)	2013	May	0.000	0.000		#NAME?		1
South Bay	SUR	Temperature	2011	November	28.700	28.700		1.458		1
Tori's reef	D	Chl-a (µg/l)	2011	November	0.082	0.079	0.006	-1.100	0.033	3
Tori's reef	D	DIN (µmol/l)	2011	November	1.850	1.577	0.571	0.174	0.183	3
Tori's reef	D	Dissolved P (µmol P-PO4/l)	2011	November	0.000	0.000	0.000	#NAME?		3
Tori's reef	D	Enteros (#/100 ml)	2011	November	0.000	0.000	0.000	#NAME?		3
Tori's reef	D	Temperature	2011	November	29.000	29.000		1.462		1
Tori's reef	D	Temperature	2012	November	29.400	29.400		1.468		1
Tori's reef	D	Temperature	2013	May	27.590	27.590		1.441		1
Tori's reef	D	WNH4 (µmol N-NH4/l)	2011	November	1.530	1.227	0.587	0.043	0.262	3
Tori's reef	D	WNO2 (µmol N-NO2/l)	2011	November	0.010	0.010	0.000	-2.000	0.000	3
Tori's reef	D	WNO3 (µmol N-NO3/l)	2011	November	0.360	0.350	0.026	-0.457	0.034	3
Tori's reef	D	WNOX (µmol N-NOx/l)	2011	November	0.370	0.360	0.026	-0.445	0.033	3
Tori's reef	S	Chl-a (µg/l)	2011	November	0.106	0.102	0.018	-0.994	0.079	3
Tori's reef	S	Chl-a (µg/l)	2012	May	0.086	0.087	0.005	-1.062	0.025	3
Tori's reef	S	Chl-a (µg/l)	2012	November	0.110	0.109	0.017	-0.968	0.071	3
Tori's reef	S	Chl-a (µg/l)	2013	May	0.153	0.151	0.006	-0.822	0.019	3
Tori's reef	S	DIN (µmol/l)	2011	November	1.260	1.160	0.685	-0.004	0.323	3
Tori's reef	S	DIN (µmol/l)	2012	May	0.532	0.582	0.098	-0.239	0.070	3
Tori's reef	S	DIN (µmol/l)	2012	November	0.260	0.320	0.236	-0.581	0.342	3
Tori's reef	S	DIN (µmol/l)	2013	May	0.610	0.570	0.078	-0.247	0.062	3
Tori's reef	S	Dissolved P (µmol P-PO4/l)	2011	November	0.010	0.010	0.010	#NAME?		3
Tori's reef	S	Dissolved P (µmol P-PO4/l)	2012	May	0.022	0.053	0.057	-1.442	0.451	3
Tori's reef	S	Dissolved P (µmol P-PO4/l)	2012	November	0.030	0.030	0.000	-1.523	0.000	3
Tori's reef	S	Dissolved P (µmol P-PO4/l)	2013	May	0.050	0.043	0.012	-1.375	0.128	3
Tori's reef	S	Enteros (#/100 ml)	2011	November	0.000	6.667	11.547	#NAME?		3
Tori's reef	S	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Tori's reef	S	Enteros (#/100 ml)	2012	November	0.500	0.500	0.707	#NAME?		2
Tori's reef	S	Enteros (#/100 ml)	2013	May	5.000	5.000	7.071	#NAME?		2
Tori's reef	S	N-P-ratio	2011	November	121.000	121.000	82.024	2.026	0.321	2

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Tori's reef	S	N-P-ratio	2012	May	24.182	22.388	17.191	1.204	0.498	3
Tori's reef	S	N-P-ratio	2012	November	8.667	10.667	7.860	0.942	0.342	3
Tori's reef	S	N-P-ratio	2013	May	12.400	13.533	2.139	1.128	0.066	3
Tori's reef	S	Temperature	2011	November	28.000	28.000		1.447		1
Tori's reef	S	Temperature	2012	May	27.690	27.690		1.442		1
Tori's reef	S	Temperature	2012	November	28.900	28.900		1.461		1
Tori's reef	S	Temperature	2013	May	27.630	27.630		1.441		1
Tori's reef	S	TN-TP-ratio	2012	May	66.058	66.058		1.820		1
Tori's reef	S	TN-TP-ratio	2012	November	48.529	48.529		1.686		1
Tori's reef	S	TN-TP-ratio	2013	May	36.954	36.954		1.568		1
Tori's reef	S	Total N (µmol N-NO3/l)	2012	May	6.870	6.870		0.837		1
Tori's reef	S	Total N (µmol N-NO3/l)	2012	November	6.600	6.600		0.820		1
Tori's reef	S	Total N (µmol N-NO3/l)	2013	May	5.137	5.137		0.711		1
Tori's reef	S	Total P (µmol P-PO4/l)	2012	May	0.104	0.104		-0.983		1
Tori's reef	S	Total P (µmol P-PO4/l)	2012	November	0.136	0.136		-0.866		1
Tori's reef	S	Total P (µmol P-PO4/l)	2013	May	0.139	0.139		-0.857		1
Tori's reef	S	ureum (µmol N-urea/l)	2012	May	1.610	1.610		0.207		1
Tori's reef	S	ureum (µmol N-urea/l)	2012	November	0.880	0.880		-0.056		1
Tori's reef	S	ureum (µmol N-urea/l)	2013	May	1.410	1.410		0.149		1
Tori's reef	S	WNH4 (µmol N-NH4/l)	2011	November	1.100	1.007	0.655	-0.087	0.375	3
Tori's reef	S	WNH4 (µmol N-NH4/l)	2012	May	0.230	0.252	0.085	-0.614	0.142	3
Tori's reef	S	WNH4 (µmol N-NH4/l)	2012	November	0.190	0.227	0.247	#NAME?		3
Tori's reef	S	WNH4 (µmol N-NH4/l)	2013	May	0.250	0.237	0.032	-0.629	0.061	3
Tori's reef	S	WNO2 (µmol N-NO2/l)	2011	November	0.000	0.010	0.017	#NAME?		3
Tori's reef	S	WNO2 (µmol N-NO2/l)	2012	May	0.009	0.006	0.005	#NAME?		3
Tori's reef	S	WNO2 (µmol N-NO2/l)	2012	November	0.010	0.010	0.000	-2.000	0.000	3
Tori's reef	S	WNO2 (µmol N-NO2/l)	2013	May	0.000	0.000	0.000	#NAME?		3
Tori's reef	S	WNO3 (µmol N-NO3/l)	2011	November	0.160	0.153	0.031	-0.820	0.091	3
Tori's reef	S	WNO3 (µmol N-NO3/l)	2012	May	0.339	0.324	0.027	-0.490	0.037	3
Tori's reef	S	WNO3 (µmol N-NO3/l)	2012	November	0.080	0.083	0.025	-1.092	0.132	3
Tori's reef	S	WNO3 (µmol N-NO3/l)	2013	May	0.360	0.340	0.053	-0.472	0.071	3
Tori's reef	S	WNOX (µmol N-NOx/l)	2011	November	0.160	0.163	0.045	-0.798	0.122	3
Tori's reef	S	WNOX (µmol N-NOx/l)	2012	May	0.339	0.330	0.025	-0.482	0.033	3
Tori's reef	S	WNOX (µmol N-NOx/l)	2012	November	0.090	0.093	0.025	-1.040	0.117	3
Tori's reef	S	WNOX (µmol N-NOx/l)	2013	May	0.350	0.333	0.047	-0.480	0.064	3
Tori's reef	S	WSi (µmol Si-SiO2/l)	2012	November	1.350	1.353	0.105	0.131	0.034	3

Location	Depth code	Parameter	Year	Month	median_value	mean_value	stdev_value	means_of_log10_value	stdev_of_log10_value	Replicates
Tori's reef	S	WSi (µmol Si-SiO2/l)	2013	May	1.010	1.120	0.387	0.033	0.146	3
Tori's reef	SUR	Enteros (#/100 ml)	2011	November	60.300	60.300	51.336	1.683	0.428	2
Tori's reef	SUR	Enteros (#/100 ml)	2012	May	0.000	0.000	0.000	#NAME?		2
Tori's reef	SUR	Enteros (#/100 ml)	2012	November	0.000	0.000		#NAME?		1
Tori's reef	SUR	Enteros (#/100 ml)	2013	May	0.000	0.000		#NAME?		1
Tori's reef	SUR	Temperature	2011	November	28.200	28.200		1.450		1