Cruise report RV Pelagia 64PE430

Bottom topography, groundwater discharge and cyanobacterial mats of mesophotic reefs

25 January - 2 February 2018

Curaçao-Bonaire-Aruba (*NICO expedition leg 3*)

Scientific party NICO expedition Leg 3

Petra M. Visser, Erik H. Meesters, Fleur C. van Duyl (Eds.)

Participants of the NICO expedition Leg 3. Insets: Mark Vermeij (l) and Karel Buizer (r) embarked at Curaçao after the Pelagia returned from Bonaire

Contents

Introduction

The Caribbean is well known for its tropical islands fringed by beautiful coral reefs. However, reefs nowadays shift from coral dominance to dominance by algae and cyanobacteria, probably due to eutrophication and overfishing. This is known for shallow reefs on the leeward side of islands. The deep (mesophotic, > 30 m deep) reefs are considered to be important as providers of offspring to shallow reef communities that are arguably more affected by climate change, overfishing and unsustainable coastal development. Mesophotic reefs are probably also important on the wind ward side of islands: due to high wave exposure benthic communities are largely confined to the mesophotic region. These mesophotic reefs are still mostly unexplored because of their remoteness or inaccessibility. Incidental deep dives and submarine dives have established sites where well developed reef communities have been found (Curaçao), but also where large areas with cyanobacterial mats (Bonaire) were observed. Cyanobacteria are known to proliferate under eutrophied conditions and to be stimulated by global warming. We hypothesize that submarine groundwater discharge (SGD) is a main and continuous nutrient transport route from land to sea on Caribbean islands and cause proliferation of cyanobacterial mats. Understanding its role in the onshore-offshore hydro(geo)logy of the island is a prerequisite for cost-effective waste (water) management on the island and consequently improved health of the coral reefs.

Aim and Background.

This research expedition in the Caribbean Sea was one of the NICO expeditions (Netherlands Initiative Changing Oceans) funded by NWO and coordinated by NIOZ-NMF in 2018. One of the aims was to accommodate research proposals of Dutch research institutes and Universities to study various aspects in the Caribbean from the RV Pelagia. During our 9-day cruise five different projects were accommodated with the originally submitted titles:

- *Land-sea interactions reflected in salinity, temperature, nutrient concentrations and hydrodynamics of the coastal waters of Bonaire (WUR, Victor Bense)*
- *Inventarisation of bottom topography around Curacao (UvA/Carmabi, Mark Vermeij)*

- *Deep cyanobacterial mats off the coast of Bonaire: what causes their proliferation and what is their impact on the reef ecosystem? (UvA, Petra Visser)*
- *Windward reefs of Dutch Caribbean (WUR, Erik Meesters)*
- *Sources and gradients of nutrients from land and sea around the Dutch Caribbean Islands and possible effects on corals , algae and cyanobacteria (Han Lindeboom, WUR)*

During the South Caribbean expedition of the Pelagia, we have investigated the mesophotic reefs and water characteristics of Curaçao, Bonaire and Aruba. We investigated 1) the bathymetry on both the leeward and windward side of the islands of Curaçao and Bonaire, 2) Water column characteristics in depth profiles along the ABC islands and in the benthic boundary layer overlying deep benthic cyanobacterial mats along Bonaire, 3) seepage of nutrients from ground water along Bonaire, and 3) functioning of cyanobacterial mats on the mesophotic reefs along Bonaire.

Scientific party

Petra M. Visser	UvA	Chief Scientist/Exp. Leader
Fleur C. van Duyl	NIOZ-MMB	Co-chief Scientist, Coral reef microbial ecology
Erik H. Meesters	WMR	Scientist, Coral reef ecology
Victor Bense	WUR	Scientist, Geohydrology
Boris van Breukelen	TU	Scientist, Geohydrology
Vincent Post	BGR	Scientist, Geohydrology
Bob Koster	NIOZ-OCS	Technician
Yvo Witte	NIOZ-NMF	SeaTechnician
Bas van Beusekom	UVA	Technician
Henk de Haas	NIOZ-NMF	Data scientist, Acoustics
Karel Bakker	NIOZ	Chemical Analyst
Willem Peter Oosthoek	NTR	Camera operator
Elisabeth van Nimwegen	NTR	Presenter
Saskia van Leeuwen	NTR	Film director
From Curaçao		
Mark Vermeij	Carmabi/UvA	Scientist, Coral biology
Karel Buizer	Royal Netherlands Navy	Searider REA Hydrography

Acknowledgements

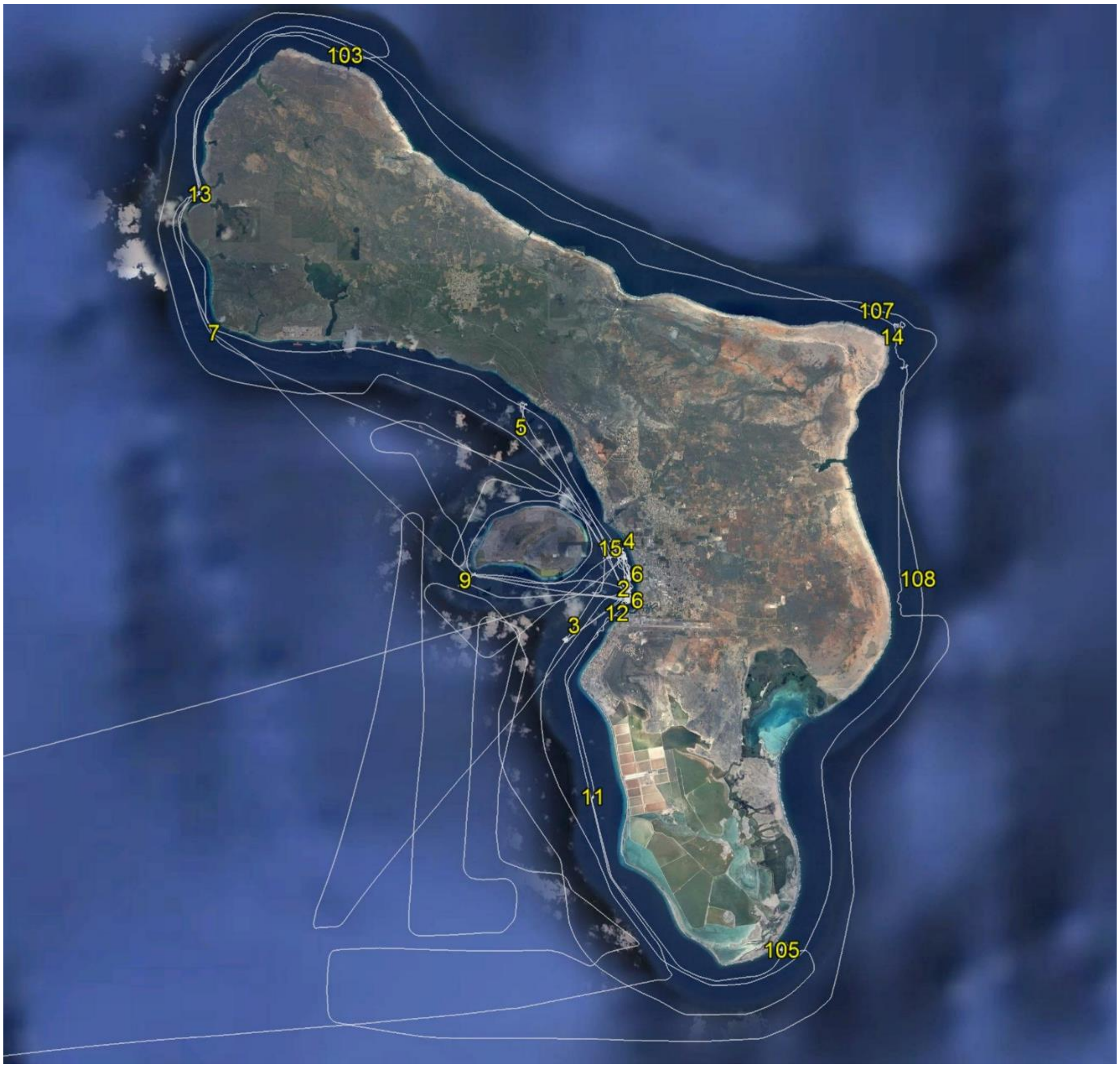
We are grateful for the solid and dedicated support of the crew of the RV Pelagia.

John Ellen, Captain	Cor Stevens, Bosun
Joep van Haaren, 1st Officer	Martin de Vries, Sailor
Peter Lucassen, 2nd Officer	Patrick Gunn, Sailor
Bert Hogewerf, Chief Engineer	Peter van Maurik, Sailor
Fred Hiemstra, 2nd Engineer	Iwan den Breejen, Cook
	Alexandr Popov, Steward

We thank NIOZ National Marine Facilities (NMF) for logistic support from the home base on Texel, i.e. Erica Koning, Henk de Haas, Joep van Haaren and Mildred Jourdan. Without the financial support of NWO this NICO cruise would not have been possible.

Itinerary of cruise

Ship trajectory (white) with station locations (yellow) along the ABC islands



Sampling locations and ship trajectory around Bonaire. Numbers refer to station numbers. Numbers larger than 100 are the start of a hopper frame transect. Note that multibeam tracks are along the ship trajectory.

Sampling locations and ship trajectory around Kralendijk. Numbers refer to station numbers. Numbers larger than 100 are the start of a hopper frame transect. Note that multibeam tracks are along the ship trajectory.

Sampling locations and ship trajectory around Curaçao and Klein Curaçao. Numbers refer to station numbers. Numbers larger than 100 are the start of a hopper frame transect. Note that multibeam tracks are along the ship trajectory.

Sampling locations around Aruba. Numbers refer to station numbers. Numbers larger than 100 are the start of a hopper frame transect.

Equipment for sea survey

Most important sea survey devices used during this cruise were the

a. **Multibeam** to survey the bathymetry of the deeper reefs and missing parts of the reefs along the coasts of Bonaire and Curaçao (in cooperation with the Dutch Hydrographic Service)

b. **CTD rosette** to obtain profiles of salinity, temperature, density, oxygen concentrations, fluorescence, underwater light measurements (PAR) and collect water samples with Niskin bottles.

c. **Hopper** frame equipped with HR video, two Nikon D800 camera's, a GoPro camera, laser and sonar for online recording of benthic communities (see pg 17).

d. **Bottom water gradient sampler**, called **PUMPY**. The PUMPY lander consists of a tripod carrying six 10L bags which are filled with water by six electric pumps connected to a battery pack with timer starting to pump 45min after deployment of the lander. On the bottom water is pumped simultaneously into the bags for 30 min. Water was taken from 6 different depths above the bottom (10, 20, 40, 80, 160, 300cm ab). The lander carried a Nortek Aquadopp Profiler (2MHz) positioned horizontally on the tail with sensors looking upwards at the far end (ca 40 cm above the bottom). On the opposite side a SB37 Microcat CTD plus dissolved oxygen sensor (optode) was connected. On the 3m pole sticking upwards from the middle of the lander a GoPro camera was attached to record the actual benthic community Pumpy has landed in. PUMPY was deployed 2 times per day for up to 2 hrs (between 6:00 and 7:00h and between 14:00 and 15:20h) in front of Kralendijk. It was moored each time with its own 2-step anchoring device and floats (including pick up line).

f. **Multicorer** to take multiple cores from the sediment

e. Large **Boxcore** (50 cm diam) equipped with as well as without online camera in sandy areas.

g. **Hydrolab DS5 Sonde** (OTT Messtechnik Gmbh & Co, Kempten, Germany) to obtain profiles of salinity, temperature, oxygen concentrations, pH, fluorescence, and underwater light measurements (PAR).

h. **RAMSES** ACC-VIS spectroradiometer (TriOS, Oldenburg, Germany) to obtain profiles of underwater light measurements at different wavelengths.

Scientific reports

Multibeam Cruise Report

Henk de Haas[1] and Karel Buizer[2]
[1]Royal Netherlands Institute for Sea Research (NIOZ), [2]Royal Netherlands Navy

Technical description

The Kongsberg EM 302 multibeam echosounder as presently installed on board of the Pelagia is a 30 kHz echo sounder with a one degree opening angle for the transmitter and a two degree angle for the receiver. It uses 288 beams with 1-2 depth measurements per beam. The system is equipped with a dual swath, resulting in a maximum number of depth measurements of 864 per ping (only at deeper water). The maximum swath opening angle is 150°. Under favourable conditions this can result in a swath width in the order of 5 times the water depth. Under favourable conditions a reasonable swath width can be reached at depths of over 8 km. The transmit fan is split into at maximum 9 individual sectors that can be steered independently to compensate for ships roll, pitch and yaw to get a best fit of the ensonified line perpendicular to the ships track and thus a uniform coverage of the sea bed. The transducers are mounted in a gondola which is placed at the port site of the vessel at about one quarter to one third of the ships length from the bow. The motion of the vessel is registered by a Kongsberg MRU-5 motion reference unit. Ships position and heading is determined with two GPS antennas. The motion and position information is combined in a Seapath 200 ships attitude processing unit and send to the Transmit and Receiver Unit (TRU). The system is synchronized by means of a 1 pulse per second (1PPS) signal produced by the Seapath 200 which is send to the TRU. The data from the receiver transducer and the ships attitude are sent through an ethernet connection to the acquisition computer. Data acquisition is done using the Kongsberg SIS (Seafloor Information System) software. The sound velocity profile is calculated from salinity, pressure and temperature data recorded by a Seabird CTD system. During the cruise the Reson SVP 70 sound velocity probe that is normally mounted on the gondola containing the transducers and measures the sound velocity near the transducers was not available. The near-transducer sound velocity was taken from the calculated velocity profile. The processing PC is connected to a display on the bridge of the Pelagia through a KVM switch and an ethernet connection allowing operation of the system from the bridge if desired. Data can be processed on board using SISQA and Fledermaus (installed on the on board processing computer) or other user owned software.

Results

In total about 90 hours of multibeam echosounding has been carried out, resulting in about 550 nautical miles of survey lines. The initial focus of the multibeam activity was on the coastal waters with a water depth of 60-200 m. Unfortunately the extremely steep slopes of the seabed near the coasts of the islands of Aruba, Bonaire and Curaçao made it too dangerous for the vessel to always reach the shallower parts of the targeted water depth. The ship had to stay in deeper waters to avoid to hit the rocky coast.

The islands of Curaçao and Bonaire were (almost) encircled twice. Near Aruba the limited amount of time allowed only for a small survey. In addition to the 60-200 m waters around the first two islands, here also deeper waters were surveyed. Especially near Bonaire there was time for an additional survey of the sea bed at the southwest of the island.

Large parts of the steep slopes of Bonaire and Curaçao are characterised by smaller and larger channels, canyons and slides. These indicate (periods of) regular and intense sediment transport and slope failure. The sea bed southwest of Bonaire is marked by the presence of canyons that can reach a depth of three to four metres and a width of about 1 km at their base.

The EM302 multibeam echosounder not only measured water depth, it also registers the backscatter strength of the returned sea bed echo. This backscatter can be used as an indicator for the type of sediment that is present at the sea floor. Backscatter strength analysis in combination with seabed video and photography information might be used for sea bed sediment classification/habitat mapping. Some limited tests were performed during the cruise, but no definitive results have been reached at the time this cruise report is written.

Figures:

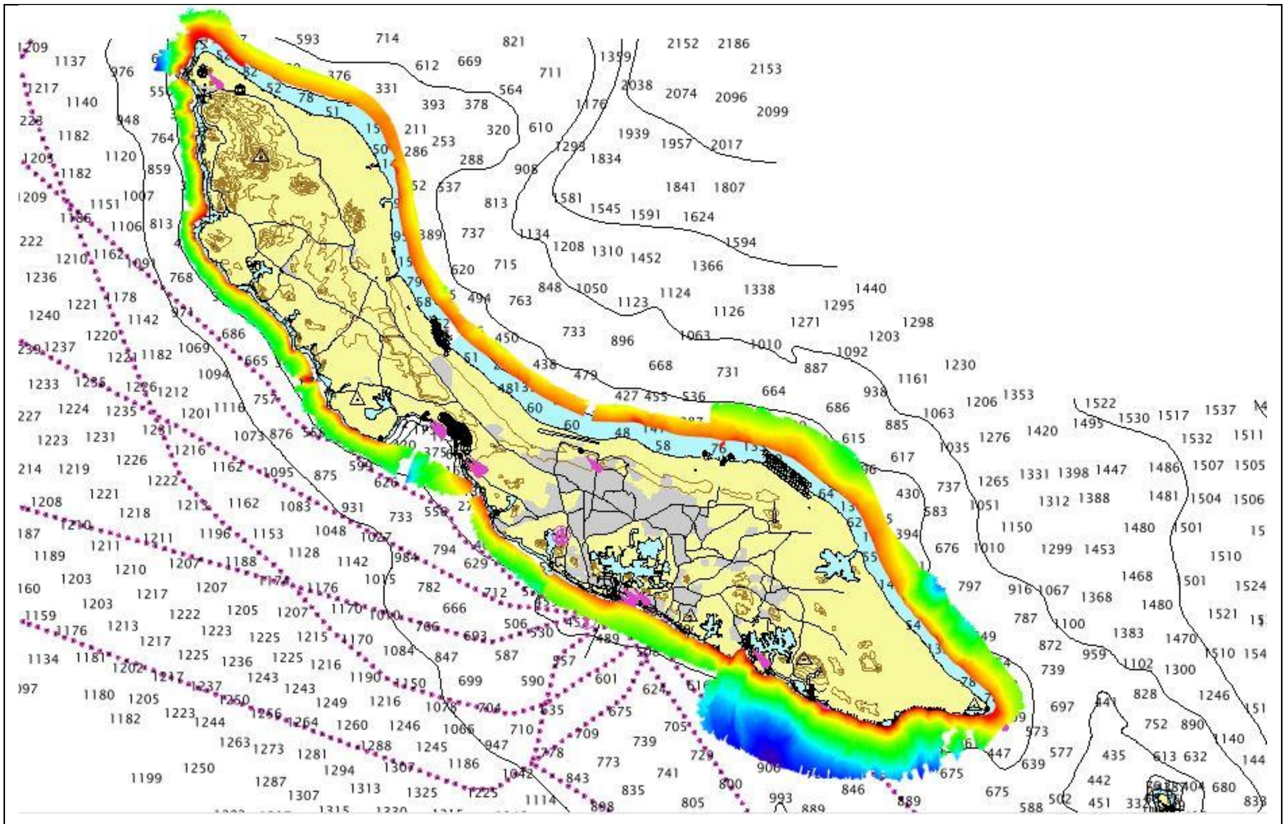


Figure 1. Multibeam map of Curaçao

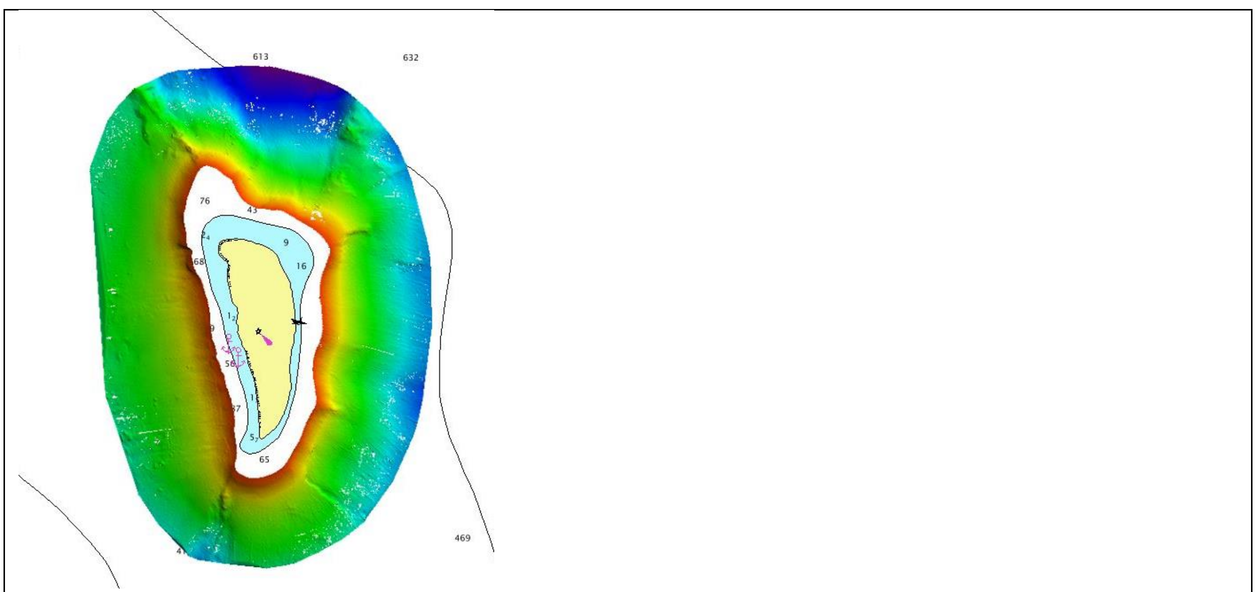


Figure 2. Multibeam map of Klein Curaçao

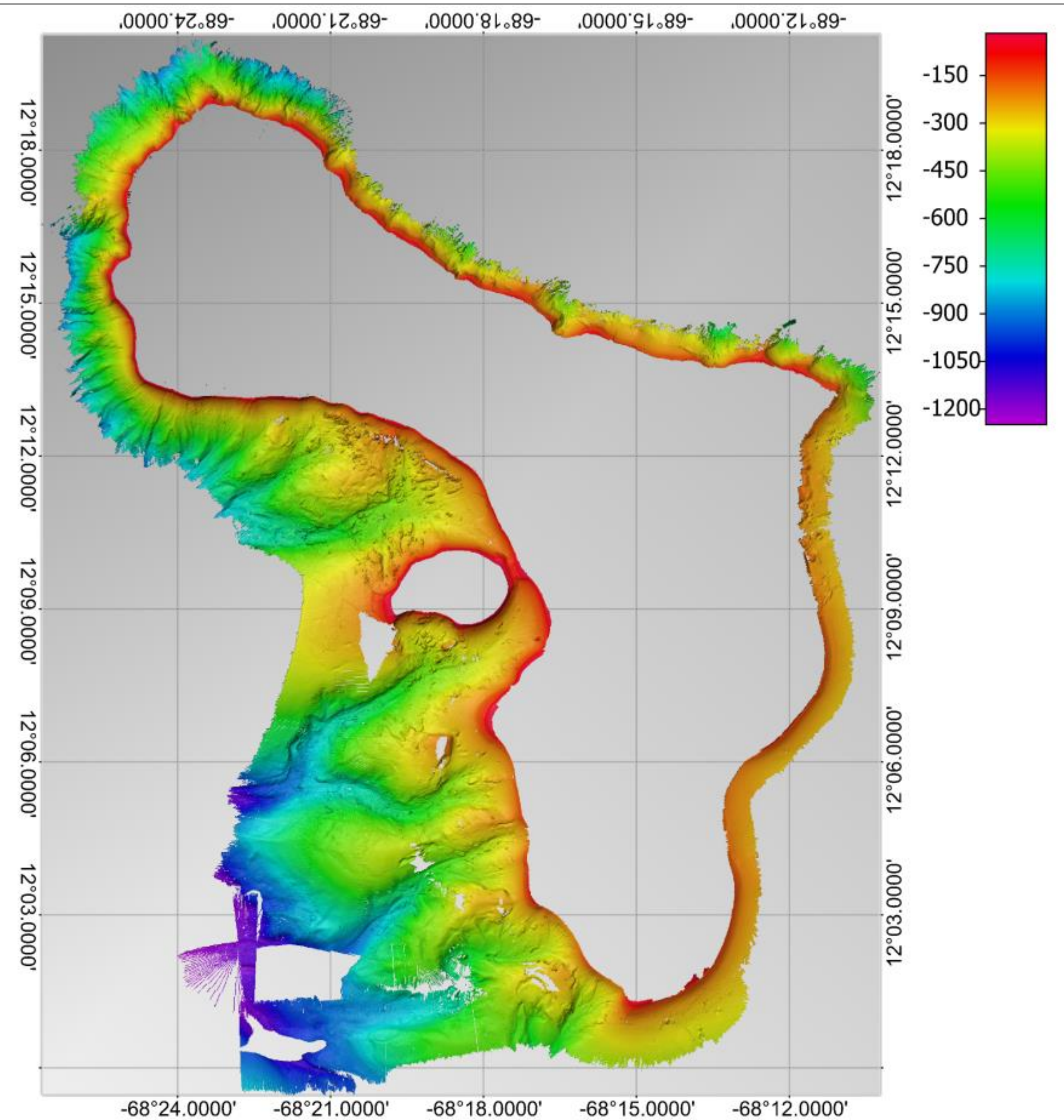


Figure 3. Multibeam map of Bonaire, depth in m)

Benthic mapping

Erik Meesters

Wageningen Marine Research-NIOZ

Introduction

Leg 3 of the NICO program contains explorations and experiments of mesophotic areas on the windward and leeward sides of the islands Curaçao, Bonaire, and Aruba. On Bonaire extensive explorations on the leeward were made to investigate benthic cyanobacterial mats.

Materials and results

The 'hopper' frame (Figure) consists of a steel frame which houses several cameras, lights and sonars. The frame is pulled beside the ship and video and images are collected. The frame was used to collect images on cyanobacterial mats on Bonaire (leeward side) and to study mesophotic ecosystems on Bonaire and Curaçao. Specifics of the hopper frame: one downward looking HD cam, Sony FCB-EH4300, 1/3" CMOS, 2MP, 1080i resolution, HD-SDI interface, shutter 1/100s, manual focus; one forward looking SD cam: Sony FCB-EX20, 1/3"CCD, PAL 520Lines resolution, analog Y/C interface, shutter 1/50s, manual focus; two Lasers: 300mm distance, 532nm (green), 5mW each; power/ Fiber-Optic interface: energy transfer max 500W over 10km sea-cable, data/video over single-mode 9/125um fiber-optic; dual sonar head: Kongsberg 675kHz 1071 Series sonar head, horizontal and vertical scanning; Video recording: HD video on Atomos NINJA recorder in Apple ProRes format; Depth specification for entire HD video frame including dual sonar heads is 6000m. In addition the frame was provided with two bottom facing Nikon D800 cameras with 20mm lens in a stereo configuration with a depth rating to 100m.

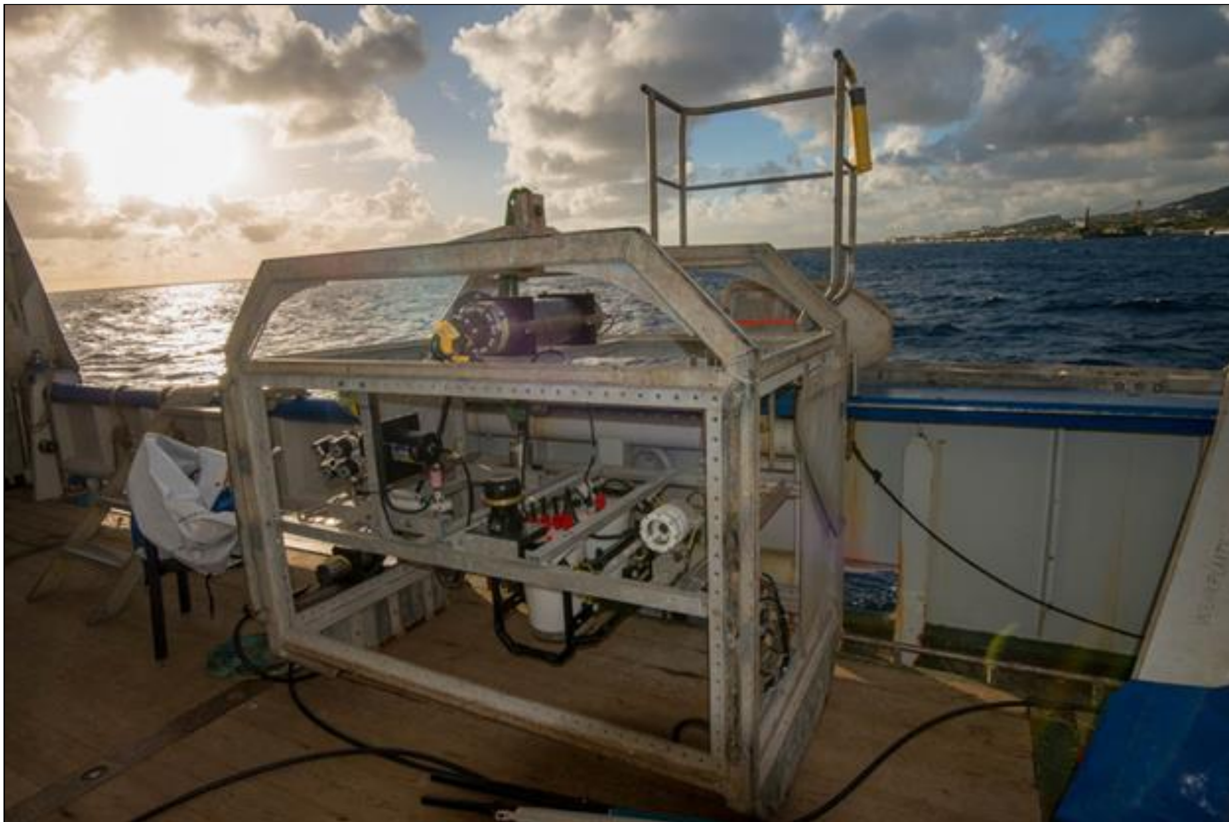


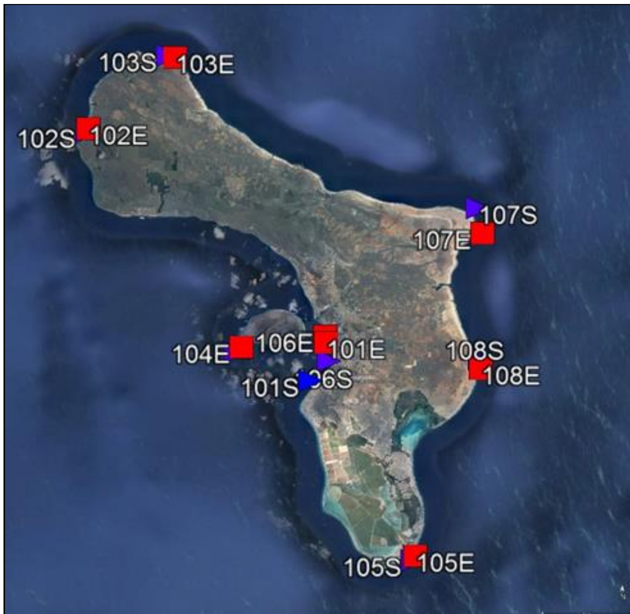
Figure 1. The 'Hopper' frame with mounted cameras, video lights, and sonars.

All photos were imported into Adobe Lightroom and approximate position of the photo derived from a GPS on board of the research vessel (*Figure 2*).

Figure 2. Picture from Adobe Lightroom showing the position of the taken photos (Station 101). Each number refers to the number of pictures taken at that position. Blue line indicates the track of the ship.

During leg 3 of the expedition the islands Bonaire, Curaçao and Aruba were visited. On both sides of the islands transects were run with the hopper frame recording images when the scenery changed. On Bonaire's leeward side our interest was mostly on the occurrence of cyanobacterial mats.

Bonaire



Aruba

Curaçao

Figure 3. Location of hopper stations Blue triangle marks start of transect; red square its end.

An overview of the sites that were investigated by the hopper frame is given in Table 1. Each site will be shortly described.

Table 1. Overview of hopper stations.

Date	Time (UTC)	Latitude	Longitude	Station #	Name	Depth (m)
26-Jan-18	11:30:54	N 12° 7.74642'	W 68° 17.3409'	101	Kralendijk	92.02
26-Jan-18	13:54:11	N 12° 9.02256'	W 68° 16.82988'	101	Kralendijk	57.02
28-Jan-18	00:59:21	N 12° 16.03206'	W 68° 24.96042'	102	Slagbaai	71.83
28-Jan-18	01:43:48	N 12° 16.1403'	W 68° 24.93078'	102	Slagbaai	45.02
28-Jan-18	03:07:02	N 12° 18.5805'	W 68° 22.19052'	103	Windzijde Noord	67.89
28-Jan-18	03:30:59	N 12° 18.51894'	W 68° 21.96744'	103	Windzijde Noord	73.41
28-Jan-18	17:35:49	N 12° 8.66958'	W 68° 19.89198'	104	SW corner Klein Bonaire	102.49
28-Jan-18	18:24:39	N 12° 8.86566'	W 68° 19.7043'	104	SW corner Klein Bonaire	94,66
29-Jan-18	00:28:22	N 12° 1.75356'	W 68° 13.84602'	105	Willemstoren	67.11
29-Jan-18	01:30:51	N 12° 1.90554'	W 68° 13.7721'	105	Willemstoren	45.69
29-Jan-18	11:16:14	N 12° 8.40696'	W 68° 16.72638'	106	Kralendijk	63.17
29-Jan-18	13:03:39	N 12° 9.23538'	W 68° 16.8561'	106	Kralendijk	60.01
29-Jan-18	22:52:37	N 12° 13.4982'	W 68° 11.6325'	107	Oostpunt Bonaire	71.05
30-Jan-18	00:07:02	N 12° 12.66396'	W 68° 11.47692'	107	Oostpunt Bonaire	148.74
30-Jan-18	01:10:21	N 12° 8.46426'	W 68° 11.55996'	108	Noord van Lac	61.59
30-Jan-18	01:49:07	N 12° 8.14512'	W 68° 11.53758'	108	Noord van Lac	56.78
31-Jan-18	00:22:42	N 12° 4.56714'	W 68° 53.05806'	109	Jan Thiel Curacao	61.48
31-Jan-18	00:43:36	N 12° 4.57608'	W 68° 53.04306'	109	Jan Thiel Curacao	40.29
31-Jan-18	01:11:10	N 12° 4.21656'	W 68° 52.49886'	110	Lijkhoek Curacao	58.43
31-Jan-18	01:28:02	N 12° 4.37856'	W 68° 52.24572'	110	Lijkhoek Curacao	30.82
31-Jan-18	02:25:07	N 12° 2.17764'	W 68° 48.2976'	111	Awa Blancu	58.2
31-Jan-18	02:54:14	N 12° 2.14584'	W 68° 47.98326'	111	Awa Blancu	52.91
31-Jan-18	12:26:49	N 12° 23.10954'	W 69° 8.08338'	112	Windzijde Noord Curacao	65.53
31-Jan-18	13:15:42	N 12° 23.04396'	W 69° 7.88334'	112	Windzijde Noord Curacao	83.65
31-Jan-18	14:02:01	N 12° 22.97388'	W 69° 9.8082'	113	Westpunt	62.38
31-Jan-18	14:52:29	N 12° 22.69656'	W 69° 9.83424'	113	Westpunt	57.62
31-Jan-18	18:41:29	N 12° 11.7573'	W 69° 4.80606'	114	Coral Estate	76.56
31-Jan-18	19:03:08	N 12° 11.63286'	W 69° 4.7778'	114	Coral Estate	122.91
31-Jan-18	20:40:03	N 12° 9.7635'	W 69° 0.62304'	115	Vaersenbaai	68.67
31-Jan-18	21:22:08	N 12° 9.51468'	W 69° 0.41766'	115	Vaersenbaai	77.19
1-Feb-18	00:55:04	N 12° 2.51796'	W 68° 46.78074'	116	Awa Blancu	52.12
1-Feb-18	01:07:31	N 12° 2.5824'	W 68° 46.5786'	116	Awa Blancu	62.38
1-Feb-18	01:44:17	N 12° 2.44896'	W 68° 46.92108'	117	Awa Blancu	42.65
1-Feb-18	02:26:08	N 12° 2.55894'	W 68° 46.25952'	117	Awa Blancu	78.14
1-Feb-18	12:16:16	N 12° 10.8504'	W 68° 52.7826'	118	Boka Playa Kanoa	63.9
1-Feb-18	13:59:15	N 12° 10.87746'	W 68° 51.79464'	118	Boka Playa Kanoa	80.5
1-Feb-18	16:04:56	N 12° 6.52704'	W 68° 47.43798'	119	South of Sint Jorisbay	83.65
1-Feb-18	16:24:39	N 12° 6.47904'	W 68° 47.39406'	119	South of Sint Jorisbay	89.15
1-Feb-18	18:13:07	N 12° 2.3061'	W 68° 44.34048'	120	Awa di Oostpunt	87.58
1-Feb-18	18:33:19	N 12° 2.4039'	W 68° 44.23464'	120	Awa di Oostpunt	66.67
2-Feb-18	12:15:11	N 12° 26.54976'	W 69° 51.3153'	121	Aruba Boka Grandi	86.01
2-Feb-18	12:18:57	N 12° 26.51322'	W 69° 51.30474'	121	Aruba Boka Grandi	82.07

Preliminary station descriptions

Below a short description is given for some of the stations. All stations will be extensively described elsewhere. Interesting pictures from presented stations are given in the appendix 3.

Station 101

Purpose	Cyanobacteria fields (220 pictures)
Location	Kralendijk, Bonaire
Average depth	74m
Bottom description	The bottom is sandy with the occasional patch of boulders, cemented sand or eroded beachrock. Presumably, these are remains of previous sea level stands. The hard structures are often colonized by sponges, calcareous algae and in the shallower parts sometimes by corals. In the sandy parts sometimes soft corals can be found. At the bottom of the reef around 50m reef fish species can be observed as well as macro algae (*Lobophora variegata*). The most obvious fish species are lionfish (*Pterois volitans*) that appear to be hiding here. On videos they can be seen hunting in this area. Often the lionfish hover above sand tile fish (*Malacanthus plumieri*) burrows consisting of piles of rock, often hovering near the entrance. It is not known whether the lionfish hinder the tile fish or whether they are just hunting on small fish that also hide within the stones making up the burrows the tile fish. The transect runs south to north and where cyanobacteria are thinly spread over the deep sandy terrace, they become more dense to very dense later on when the more central area of Kralendijk is approached.

Station 102

Purpose	Mesophotic reefs (240 pictures)
Location	North of Slagbaai, in front of Salina Wayaka, Bonaire
Average depth	58m
Bottom description	At the start of the transect there are vertical cliffs covered by crustose coralline algae, black corals, and sand. Sponges are also a conspicuous part of the fauna here. When the slope becomes less steep there are rocky outcrops that are occupied by branching soft corals, but much of the bottom is covered by sediment. There are several steep cliffs and terraces probably previous sea level stands. Sand tile fish burrows with many crustose coralline algae covered stones occur here as well. Many soft corals are actually black corals (Antipatharia). Shallower, the slope become more coral reef like with stony corals and coralline algae. Between the cliffs are sometimes sand channels. On the top of the rocky outcrops, looking somewhat like buttresses sheetlike corals of the genus Agaricia can cover the bottom to a very large degree, however, the scenery seems to be largely governed by sand flowing down the slope with the occasional outcrop of coral or large *Xestospongia muta* sponges.

Figure 4. Picture track off Slagbaai.

Station 103

Purpose	Mesophotic reefs (290 pictures)
Location	Northern wind side of Bonaire
Average depth	70m
Bottom description	At first the bottom appears to be largely covered by coarse sediment with a faint colorization of algae, however, after a relatively short distance irregular shaped rhodoliths, round stones of coralline algae become very common, sometimes interspersed with *Halimeda*, a green macroalgae that also creates calcified segments, and sargassum. Rhodoliths can be as big as 20cm and are the dominant bottom cover halfway down the transect. Among the rhodoliths encrusting and small sponges can be seen. At shallower depths other algae such as *Lobophora variegata* are more clearly visible. Large sponges are not very common, but occasionally large *Xestospongia muta* sponges are encountered within the rhodoliths fields.

Figure 5. Picture track northern wind side of Bonaire.

Station 104

Purpose	Mesophotic reefs (495 pictures)
Location	Off the south-west point of Klein Bonaire
Average depth	74m
Bottom description	This track starts at approximately 75m depth where the bottom is mainly covered by sand and rather steep hard bottom with soft corals. The hard bottom parts are often covered by encrusting coralline algae which at places have developed into rhodoliths. In places either soft corals, sand or rhodoliths can be the dominant bottom category. Sponges are also an important part, but in the beginning they are rather inconspicuous. Only later and shallower do they become larger and more visible. Lionfish are often present at outcrops and places where rhodoliths have rolled together to creat small hills. At the end of the transect cyanobacteria appear and become the dominant bottom cover. In the sand there are many holes that are probably from garden eels or worms.

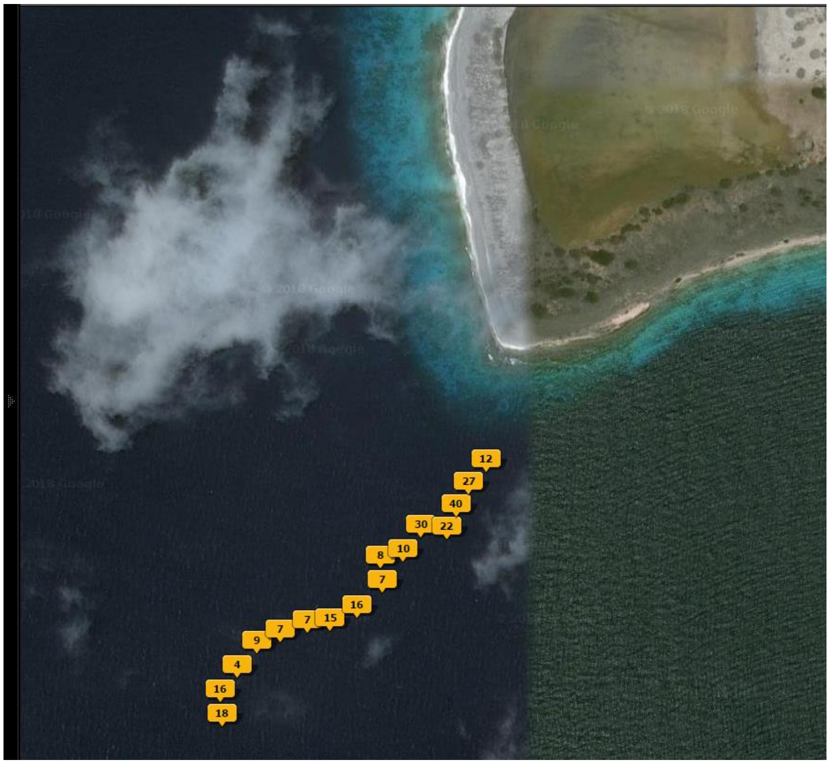


Figure 6. Picture track off Klein Bonaire.

Nutrients

Karel Bakker

Royal Netherlands Institute for Sea Research (NIOZ), Texel

Summary

Nutrients were analysed in a temperature controlled lab container equipped with a QuAAtro Gas Segmented Continuous Flow Analyser, measuring approximately 200 samples for the different parameters. Samples were collected from the CTD-Rosette bottles and a Gradient Sampler equipped with 6 sample bottles. Measurements were made simultaneously on four channels for Phosphate, Ammonium, Nitrate with Nitrite together and Nitrite separate. At some stations approximately 100 sub-samples were collected and preserved for Dissolved Inorganic Carbon (DIC), Total Alkalinity (Talk) and Total Phosphorous and Total Nitrogen. All measurements were calibrated with stock-standards diluted in low nutrient seawater (LNSW) in the same salinity range as the stations.

Equipment and Methods

Sample Handling. The samples were collected in 60ml high-density polyethylene syringes with a three way valve to make it possible to sample air free water from the Niskin bottles of the Rosette and Gradient Sampler. The syringes with a three way valve were first rinsed three times with a small amount of sample before being completely filled up.

After sampling on deck, the samples were processed immediately in the lab; samples were filtered over a combined 0.8/0.2µm filter and instantly sub-sampled for DIC in a glass vial already containing 15µl saturated $HgCl_2$ and filled with a round meniscus before being capped and stored upside down in a refrigerator. TAlk was sampled as the second sub-sample in the same way as DIC, however in a high density polyethylene HDPE tube, also known as 'pony-vials' containing 15µl saturated $HgCl_2$ and stored in the dark at 4°C. Two more pony-vials, were used for storing PO_4, NH_4 and NO_3 plus NO_2 for direct analysis as one sample, and the other stored at -20°C for Total Nitrogen and Total Phosphorous analysis in the home lab after the cruise.

PO_4, NH_4 and NO_3 plus NO_2 samples were simultaneously measured in the lab container within 12 hours after sampling. All sampling vials were including caps were pre-rinsed three times with sample before use.

To avoid NH_4 contamination from the air during analysis, all vials including the calibration standards were covered with 'parafilm' when placed into the auto-sampler to keep gas exchange to a minimum. The sharpened sample needle of the sampler easily penetrated through the film under tension leaving only a small hole. Gas segmentation on the QuAAtro in the continuous flow for mixing reagent and samples and keeping dispersion as low as possible was done using NH_4 free Nitrogen gas.

A sampler rate of 60 samples per hour was used. Calibration standards were diluted from stock standards of the different nutrients with 0.2µm filtered LNSW and were freshly prepared every day. LNSW was also used as baseline water for the analysis in-between the samples. Each run of the system had a correlation coefficient of at least 0.9999 for 10 calibration points, but typical 1.0000 for linear chemistry. The samples were measured from the lowest to the highest concentration in order to keep carry-over in the flow system as small as possible, i.e. from surface to deep waters. Concentrations were recorded in 'µmol per liter' (µM/L) at the lab temperature of 22.5°C. During the cruise each run, a freshly diluted mixed internal nutrient standard (nutrient cocktail), containing, phosphate and nitrate was diluted 250 times in LNSW and measured. The cocktail sample was used to monitor independently of the standards the performance of the system.

A second control sample (LNSW from OSIL batch LNS 21) close to the method detection limits was measured direct after the baseline.

Analytical Methods

The colorimetric methods used are as follows:

Ortho-Phosphate (PO_4) reacts with ammonium molybdate at pH 1.0, and potassium antimonyltartrate is used as a catalyst. The yellow phosphate-molybdenum complex is reduced by ascorbic acid and forms a blue reduced molybdophosphate-complex which is measured at 880nm (Murphy & Riley, 1962).

Ammonium (NH_4) reacts with phenol and sodiumhypochlorite at pH 10.5 to form an indo-phenolblue complex. Citrate is used as a buffer and complexant for calcium and magnesium at this pH. The blue color is measured at 630nm. (Helder and de Vries, 1979).

Nitrate plus Nitrite (NO_3+NO_2) is mixed with an imidazol buffer at pH 7.5 and reduced by a copperized cadmium column to Nitrite. The Nitrite is diazotized with sulphanyl-amide and naphtyl-ethylene-diamine to a pink colored complex and measured at 550nm. Nitrate is calculated by subtracting the Nitrite value of the Nitrite channel from the 'NO3+NO2' value. (Grasshoff et al, 1983)

Nitrite (NO_2) is diazotized with sulphanyl-amide and naphtyl-ethylene-diamine to form a pink colored complex and measured at 550nm. (Grasshoff et al, 1983)

Calibration and Standards

Nutrient primary stock standards were prepared in deionised water (18.2MΩ) at the NIOZ as follows:

- Phosphate: by weighing Potassium dihydrogen phosphate in a calibrated volumetric PP flask to make 1mM PO4 stock solution.
- Ammonium: by weighing Ammonium Chloride in a calibrated volumetric PP flask to make 1mM NH4 stock solution.
- Nitrate: by weighing Potassium nitrate in a calibrated volumetric PP flask set to make a 10mM NO_3 stock solution.
- Nitrite: by weighing Sodium nitrite in a calibrated volumetric PP flask set to make a 0.5mM NO_2 stock solution.
- The cocktail standard, a mixture of Phosphate and Nitrate preserved with addition of 1ml saturated $HgCl_2$

All stock-standards were stored at room temperature in a 100% humidified box. The calibration standards were prepared daily by diluting the separate stock standards, using three electronic pipettes, into four 100ml PP volumetric flasks (pre-calibrated at the NIOZ) filled with diluted LNSW. The background values of the diluted LNSW were measured on-board and added up to the standard values to compute the final calibration-point values.

Statistics

Quality Control. Our standards have already been proven by inter-calibration exercises from ICES and Quasimeme, and since 2006 by the Inter Comparison exercises organised by MRI, Japan.

Our cocktail standard was measured every run for all nutrients during the cruise.

To obtain international comparable results, two KANSO CRM's produced by The General Environmental Technos Co., Ltd. Japan were analysed three times in three consecutive run.

Method Detection Limits

The method detection limit M.D.L was calculated during the cruise using the standard deviation of ten samples containing 2% of the highest standard used for the calibration curve and multiplied with the student's value for n=10, thus being 2.82. (M.D.L = std. dev. of 10 samples x 2.82 E.P.A. procedure). Values below are the average values of two measurements at rough sea and calm sea state.

	M.D.L. µM/l	At applied measuring range µM/l:
PO4	0.02	1.5
NH4	0.04	2
NO3	0.015	20
NO2	0.000	0.5

Precision at concentration levels.

Used concentration level µM/l and *c.v.* % (triplicate analysis):

	µM/l	*c.v.* %	µM/l	*c.v.* %	µM/l	*c.v.* %
PO4	0.3	*0.5*	0.6	*0.7*	1.0	*0.4*
NH4	0.4	*0.6*	0.8	*0.4*	1.4	*0.5*
NO3	4	*0.7*	8	*0.5*	14	*0.5*
NO2	0.1	*1.2*	0.2	*0.3*	0.35	*0.3*

Control sample close to the M.D.L.

As an independent control on near baseline values from in-between analytical runs, LNSW from OSIL batch LNS 21 was measured every day n=8:

OSIL batch LNS21	µM/l	st. dev. µM/l
PO4	0.019	0.010
NH4	0.059	0.015
NO3	0.018	0.020
NO2	0.016	0.004

From the day to day variation no trends over time was observed concluding the baseline water LNSW used was stable during the time of the cruise.

Cocktail statistics.

The average value of 8 triplicates was 0.93uM for PO4 and 13.84uM for NO3 with a coefficient of variation being respectively 1.7 and 1.0% as an indication of in-between analytical runs precision. From the cocktail measurements no trends were observed concluding that the calibration standards were stable during the cruise.

Obtained CRM values

The average value of 3 triplicate measurements of **CRM "BY"** are:

	µM/l	converted to µM/kg: 22.5°C	assigned *KANSO* in µM/kg:
PO4	0.036	0.035	*0.039**
NO3	0.071	0.070	*0.024**
NO2	0.024	0.024	*0.019**

* KANSO : The values for NO3, NO2 and PO4 are below quantifiable detection limit (QDL), thus use these values as a guide

The average value of 3 triplicate measurements of **CRM "BU"** are:

	µM/l	converted to µM/kg: 22.5°C	assigned *KANSO* in µM/kg:
PO4	0.363	0.354	*0.345*
NO3	4.052	3.958	*3.937*
NO2	0.085	0.083	*0.072*

The CRM values obtained are in good agreement with the assigned values, so no post cruise adjusting's are needed.

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Land Sea Water Interactions: Radon

Vincent Post[1], Boris van Breukelen[2], Victor Bense[3]

[1]DRG, Germany, [2]TU, Delft, [3]Wageningen UR

Radon Isotope (^{222}Rn)

The radon isotope ^{222}Rn is a frequently used tracer to detect groundwater inputs into the ocean (Stieglitz, 2010). It occurs in groundwater at an activity that is 2 to 3 orders higher than in seawater, and as a noble gas is chemically inert, which makes it an ideal tracer to detect submarine groundwater discharge. It was decided to measure ^{222}Rn activities during Leg 3 of the cruise to assess the possible contribution of groundwater to the near-shore seawater near Bonaire. Unfortunately the instrument to measure ^{222}Rn on board was not available for the part of the leg near Curaçao. In what follows ^{222}Rn will be referred to as 'radon'.

A seawater sample was obtained by placing a glass sample bottle inside a container which was overflowing with water from the Niskin bottle on the Rosette sampler. The bottle was capped underwater to prevent radon loss to the atmosphere. The radon activities were measured using a SARAD EQF3220 instrument. The measurement principle for measuring radon in seawater is that a known volume of seawater sample is equilibrated with a known volume of air in a closed loop system. The time for the air to equilibrate with the seawater sample is 30 minutes. Once equilibration is achieved the radon activity is determined using alpha-spectroscopy.

Radon is determined in the instrument's measurement chamber by counting the alpha particles that are emitted during the decay of ^{222}Rn to ^{218}Po. The half-life of ^{218}Po (which decays to ^{214}Po) is 3.05 minutes, which means that secular equilibrium is reached after circa 15 minutes. The measurement period was subdivided into 3 30 minute periods per sample. Each complete measurement cycle therefore consisted of a 30 minute air-water equilibration step followed by a 90 minute measurement step. In between measurements the instrument has to be flushed with air for 15 minutes to empty the contents of the measurement chamber several times to prevent memory effects that carry over radon to the next sample. This limited the number of radon measurements that could be conducted. The pre-set protocol of the instrument for water samples (3 x 5 minutes) turned out to be too short so that some of the early samples could not be measured.

The radon activity in seawater is between 0 and 25 Bq/m^3, (Stieglitz et al., 2010) which is close to the detection limit of the instrument (4.9 Bq/m^3). The number of detected decays therefore varied in an irregular way over the measurement time interval. An overview of the samples that were taken is presented in table 1. A total of 17 samples were taken during the cruise and one post-cruise at the Carmabi research institute. The latter represents seawater from a small bay and was characterized by a higher number of counts than the other samples, and a ^{222}Rn concentration of 20 +/- 10 Bq/m^3. This could be an indication for groundwater discharge but it may also be due to tide-or wave induced seawater recirculation through the seabed sediments. The seawater pouring from the box core brought to the deck of the Pelagia at station 4 also had slightly higher ^{222}Rn concentration of 15 +/- 9 Bq/m^3. All other samples were very close to the instrument detection limit.

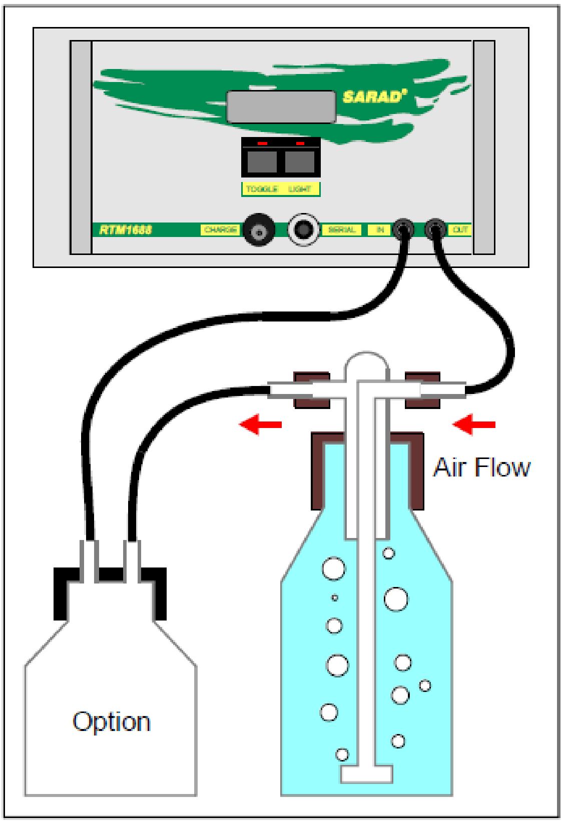

Figure 1. Schematic diagram showing the measurement setup. A ~500 mL flask was filled to the rim (yielding a volume of 597 mL of seawater) and equilibrated with air in a closed-loop system.

Figure 2. Instrument setup on lab bench in Pelagia laboratory.

Table 1. Results of the ^{222}Rn analyses. N.D. means no detection of ^{222}Rn.

Station	*Cast*	*Sample*	*Time sampled*	*Lat*	*Long*	*Depth*	*Sample type*	*^{222}Rn (Bq/m^3)*
1	1	1	2018-01-25 23:23:47	12.121	-68.974	237	Niskin bottle	N.D.[1]
2	6		2018-01-26 15:43:52	12.146	-68.279	Seafloor	Discarded water box core	N.D. [1]
2	7		2018-01-26 20:19:28	12.145	-68.279	60 cm above seafloor	Lander	N.D. [1]
2	9	1	2018-01-26 19:31:24	12.147	-68.279	65	Niskin bottle	N.D. [1]
RHIB003						Surface	Glass sample bottle	N.D. [1]
5	1	1	2018-01-27 18:06:16	12.223	-68.412	250	Niskin bottle	N.D. [1]
4	2	1	2018-01-27 11:22:19	12.153	-68.281	78	Niskin bottle	N.D. [1]
4	8		2018-01-27 15:24:24	12.153	-68.280		Discarded water box core	15 (9) [2]
7	1	1	2018-01-27 23:59:01	12.223	-68.412	280	Niskin bottle	N.D.
RHIB-3-1			2018-01-28 13:00:00			Surface	Glass sample bottle	N.D.
RHIB-3-1			2018-01-28 13:30:00			Surface	Glass sample bottle	N.D.
8	2	1	2018-01-28 10:36:41	12.140	-68.279	61	Niskin bottle	N.D.
10	4	1	2018-01-28 21:04:51	12.140	-68.279	69	Niskin bottle	N.D.
12	2	1	2018-01-29 10:41:47	12.140	-68.279	64	Niskin bottle	N.D.
13	3	1	2018-01-29 17:41:08	12.266	-68.417	139	Niskin bottle	N.D.
14	1	1	2018-01-29 21:20:25	12.225	-68.191	110	Niskin bottle	N.D.
15	1	1	2018-01-30 12:45:22	12.155	-68.281	5 cm above seafloor	Lander	N.D.
Carmabi Seawater[3]			02.02.2018 15:20	12.122	-68.969	Surface	Glass sample bottle	20 (10) [2]

[1] Used 5 min measurement interval [2] Number between parentheses is standard deviation [3] Taken from diving school jetty.

Land Sea Water Interactions: Groundwater seepage

Vincent Post[1], Boris van Breukelen[2], Victor Bense[3]

[1]DRG, Germany, [2]TU, Delft, [3]Wageningen UR

Five deployments of the RHIB were made during the time that Pelagia spend in the waters around Bonaire (for locations visited “Overview of activities” in Appendix 1. A sixth planned deployment was cancelled because unexpectedly the RHIB was needed for other purposes.

Aim: The RHIB was launched from Pelagia to allow CTD casting in near coastal waters that were unreachable from Pelagia itself. The aim of RHIB deployment was to survey for evidence of sub marine groundwater discharge (SGD) through the seabed and in the near-shore environment. The RHIB deployment also gave the opportunity to visually inspect the geological formations outcropping along cliffs. This could reveal geological conditions that can favour, or be unfavourable for groundwater to reach the sea through the subsurface.

Operational Procedure: The RHIB had to be lifted from the deck into the sea where it could be entered using a ladder. Three persons and a captain could be fitted comfortably to still allow people to move around during the excursion. RHIB deployments lasted up to three hours.

The HYDROLAB sonde was used during RHIB activities to survey the shallow (e.g., upto 5-6 meters water depth) for anomalies in conductivity, temperature, pH, oxygen content, or chlorophyll as compared to background values. Such anomalies could be indicative of the presence of SGD. The HYDROLAB was used in two modes, either to make vertical profiles at one location (casts), or by carefully dragging the instrument through the water at one fixed depth (e.g., 1.5 meters). Data were read and stored at 1s intervals.

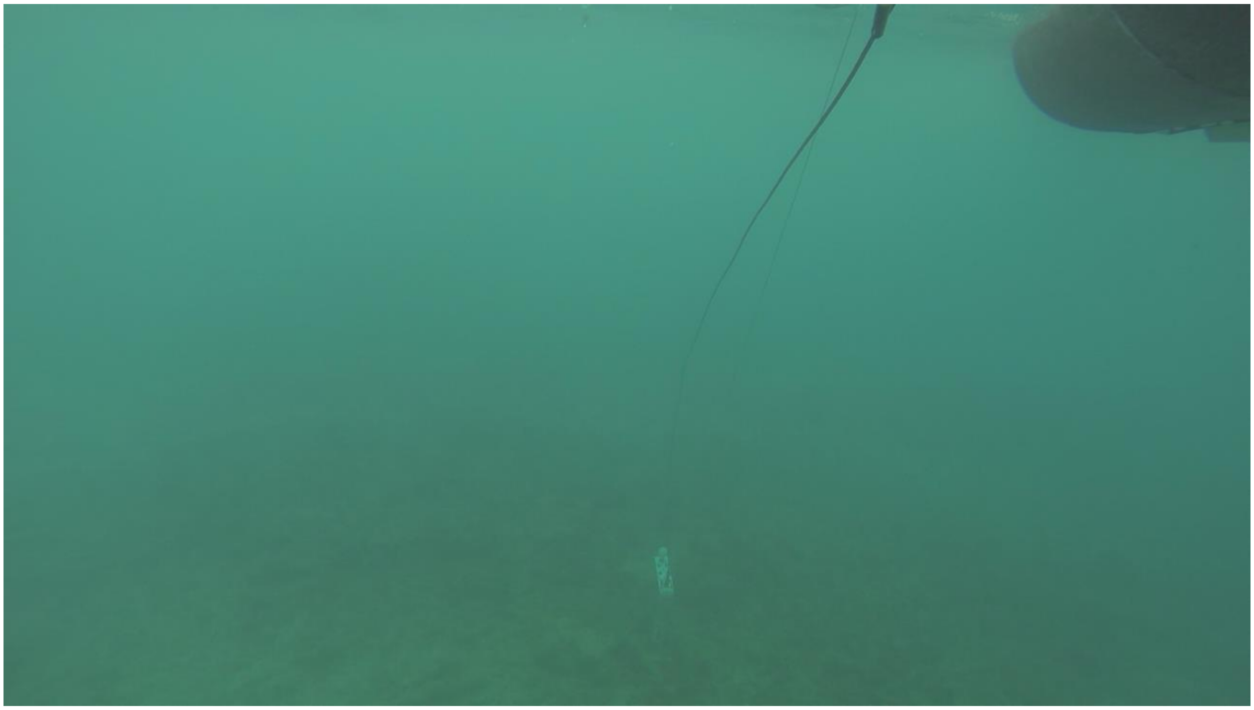

Figure 1. Hydrolab suspended from RHIB. The top of the instrument is faintly visible as it hovers just above the seafloor. It is suspended from a steel winch cable which was lowered or pulled depending on the bottom depth. The slack cable is the communications cable that enabled real-time readout of the instrument.

Results

Electrical conductivity measurements from the RHIB showed very little variability, although some spatial trends were detected, and no locations could be identified that are loci of SGD. However, geological observations provide clear evidence of fluid-rock interactions both through groundwater flow (Figure 2a) as well as via surface water runoff (Figure 2b). Sea conditions proved to be the limiting factor controlling safety and usefulness of data collection from the RHIB. Under rough sea conditions mixing of the sea water column with any inflowing groundwater from the seafloor will be more efficient, and hence the SGD signal more obscure.

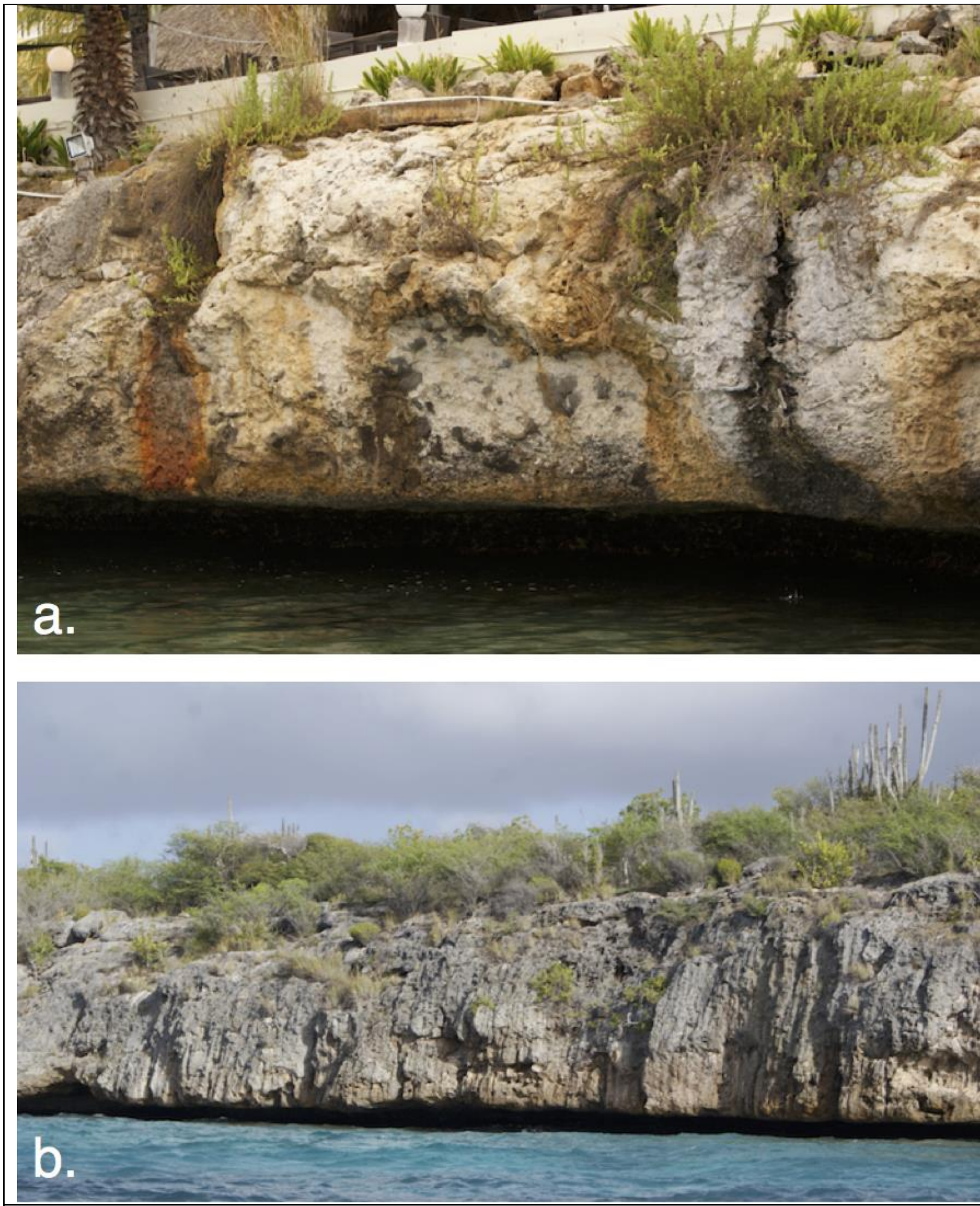

Figure 2. Limestone (a) and dolomite (b) terraces and cliff faces along the shore north west of Kralendijk as observed during RHIB deployment #3 (January 27). Here it was possible to observe distinct evidence of karstification and fracture flow (a) as well as surface water runoff caused rill erosion (b).

Hopper video imagery & WQ sensor data Water quality sensors were always logging during the deployment of the Hopper frame. The Hydrolab was used until the (third) USB to serial cable required to operate the equipment malfunctioned (Wed morning 31-1). Since then a SB Microcat salinity & DO sensor was used for the remaining hopper deployments. Unfortunately, both the Hydrolab and the Microcat could not log at a higher frequency than 30 seconds, whereas we ideally hoped to log at 1 sec intervals to detect the occurrence of fresh water seeps. First results showed that the WQ data plotted vs depth provided an additional cast at the Hopper survey location with similar outcomes as the CTD casts.

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Habitat and nutrient dynamics of deep cyanobacterial mats along Kralendijk and nutrient profiles along the ABC islands

Fleur C. van Duyl

Royal Netherlands Institute for Sea Research (NIOZ), Texel

Focus of this research was on (1) environmental conditions and nutrient dynamics of deep benthic cyanobacterial mats (50-80m depth) in front of Kralendijk, Bonaire and on (2) the trophic conditions of coastal waters along Curaçao, Bonaire and Aruba (ABC islands).

Rationale. Cyanobacterial mats appear to increase throughout the Caribbean. On shallow reefs until ca 40 m depth, cover of cyanobacterial mats increased the last 15 years (De Bakker et al. 2017) and reaches nowadays more that 20% cover on many reefs. Recently cyanobacterial mats were also found on deep sandy slopes along the leeward sides of Bonaire (e.g. Meesters & Becker pers. communication, master student reports by van Heuzen 2015, and van Zanten 2016) below shallow reefs on sandy slopes between 50 and 90 m depth. There are indications that these mats are expanding possibly due to eutrophication. Therefore indicators of eutrophication in water samples were measured along the leeward and windward sides of Curaçao, Bonaire and Aruba.

Variables measured. Nutrient concentrations, (PO_4, NH_4, NO_3, NO_2, DIC/alkalinity) particulate and dissolved organic matter, phytoplankton and bacterial and viral abundance were sampled close to the bottom with a bottom lander (bottom water gradient sampler, see Fig. 2) between 50 and 80 m in front of Kralendijk, Bonaire and a CTD equipped with a rosette water sampler until approximately 300 m bottom depth in coastal waters along the ABC islands. Sensors on the ship borne CTD measured besides conductivity, temperature, depth (pressure), also fluorescence, oxygen concentration, turbidity and light (PAR: photosynthetic active radiation). The sensors on the bottom water gradient sampler measured conductivity, temperature, depth (pressure), oxygen, current velocities and directions. Based on conductivity, pressure and temperature the salinity was calculated.

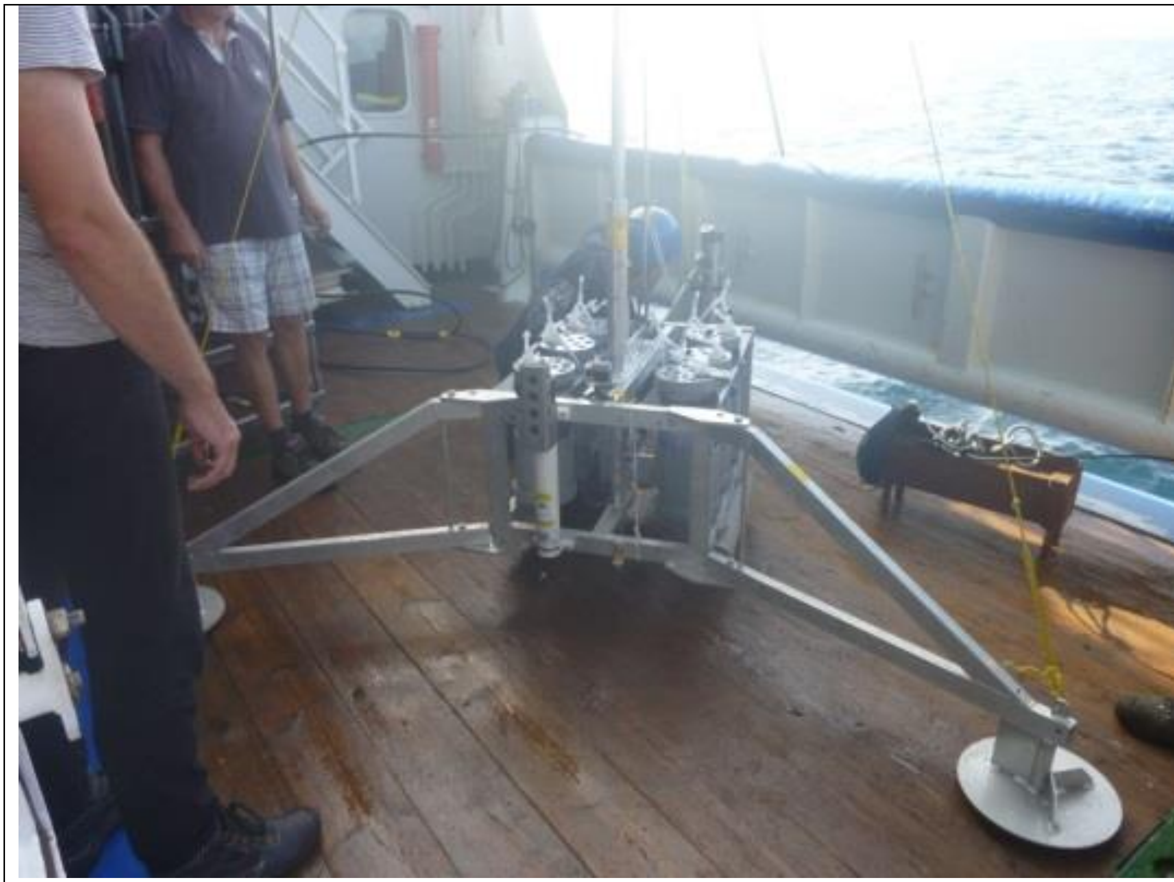

Figure 1. Bottom Water Gradient Sampler on board of the Pelagia.

Use of equipment. The bottom water gradient sampler (BWGS) was deployed seven times between 50 and 80 m bottom depth in the depth zone in which deep cyanobacterial mats occurred during the cruise in front of Kralendijk, Bonaire. Four deployments were made in the early morning (twilight) to pick up the night signal of mats and 3 were deployed in the course of the afternoon to collect the daylight signal of mats. Furthermore CTD profiles + water samples from the Pelagia were taken at several stations along the leeward and windward sides of the ABC islands. Three to ten different depths were sampled for inorganic nutrients per CTD station. Other variables (e.g. TOC, POM , bacterioplankton etc) were sampled up to 3 to 4 depths in several of these profiles. All together twenty four CTD profiles with water samples were taken from 300 to 50 m bottom depth to the surface. Fourteen along Bonaire of which seven in front of Kralendijk, which were taken during BWGS deployments, eight along Curacao and two along Aruba (see table below for the locations). The number of water samples taken at each station (inorganic nutrients mostly) with the CTD are also listed below.

Table 1. CTD casts taken with water samples

Bonaire:	*nr water samples per CTD cast*	*coordinates*	
In front of Kralendijk (n=7)	3,3,3,3,8,7,4	(N 12° 8.3'-9.0'	W 68° 17.7' -17.9’)
Just north of Punt Vierkant (n=1)	6	(N 12° 7.57926'	W 68° 17.92014')
Barcadera (n=1)	6	(N 12° 11.59068'	W 68° 18.8343')
Wecua (n=1)	4	(N 12° 13.35882'	W 68° 24.7188')
SW corner Klein Bonaire (n=1)	10	(N 12° 8.70786'	W 68° 19.8987')
Tori’s Reef (n=1)	9	(N 12° 4.6494'	W 68° 17.46348')
Slagbaai (n=1)	6	(N 12° 16.044'	W 68° 24.95988')
Oostpunt Bonaire (wind side) (n=1)	6	(N 12° 13.49844'	W 68° 11.43618')
Total 14 CTD casts			
Curaçao:			
Piscaderabaai (n=1)	3	(N 12° 7.26096'	W 68° 58.47516')
Noordpunt (n=1)	8	(N 12° 24.33528'	W 69° 9.60468')
Santa Cruz (n=1	6	(N 12° 18.40428'	W 69° 9.15252')
Vaersenbaai (n=1)	5	(N 12° 9.7239'	W 69° 0.66552')
Spaanse Water (n=1)	8	(N 12° 3.57792'	W 68° 51.59514')
Boca Play’i Kanoa (windside) (n=1)	8	(N 12° 11.52408'	W 68° 52.81746')
Oostpunt (windside) (n=1)	8	(N 12° 2.04624'	W 68° 44.1354')
Annabaai (n=1)	7	(N 12° 6.24306'	W 68° 56.85')
Total 8 CTD casts			
Aruba:			
SE corner Aruba (windside) (n=1)	7	(N 12° 23.45166'	W 69° 50.6613')
Palm Beach (n=1)	4	(N 12° 35.66178'	W 70° 6.47172')
Total 2 CTD casts			

Preliminary results

Bonaire. In all CTD profiles we saw that a well-mixed surface layer of 35-55 m thick characterized by salinities of approximately 35.7 PSU overlaid a water mass with salinities of approximately 36.7 PSU or more. In the surface layer low inorganic nutrient concentrations were found (DIN<1 μM, PO_4 <0.06 μM) and in the deeper layer enhanced concentration of nitrate and soluble reactive phosphorous. Steep inorganic nutrient gradients (nutriclines) were found just above the depth zone in which cyanobacterial mats occur along Kralendijk. Also in the water column where the depths exceed the depth of the cyanobacterial mats we found steep gradients in nutrients, temperature and salinity around 50-80 m depth with significantly higher concentrations of PO_4, NO_2 and NO_3 below the nutricline than in mixed surface water. Also the deep chlorophyll-*a* max (based on fluorescence) was present in this depth zone from 55 to 75 m depth.

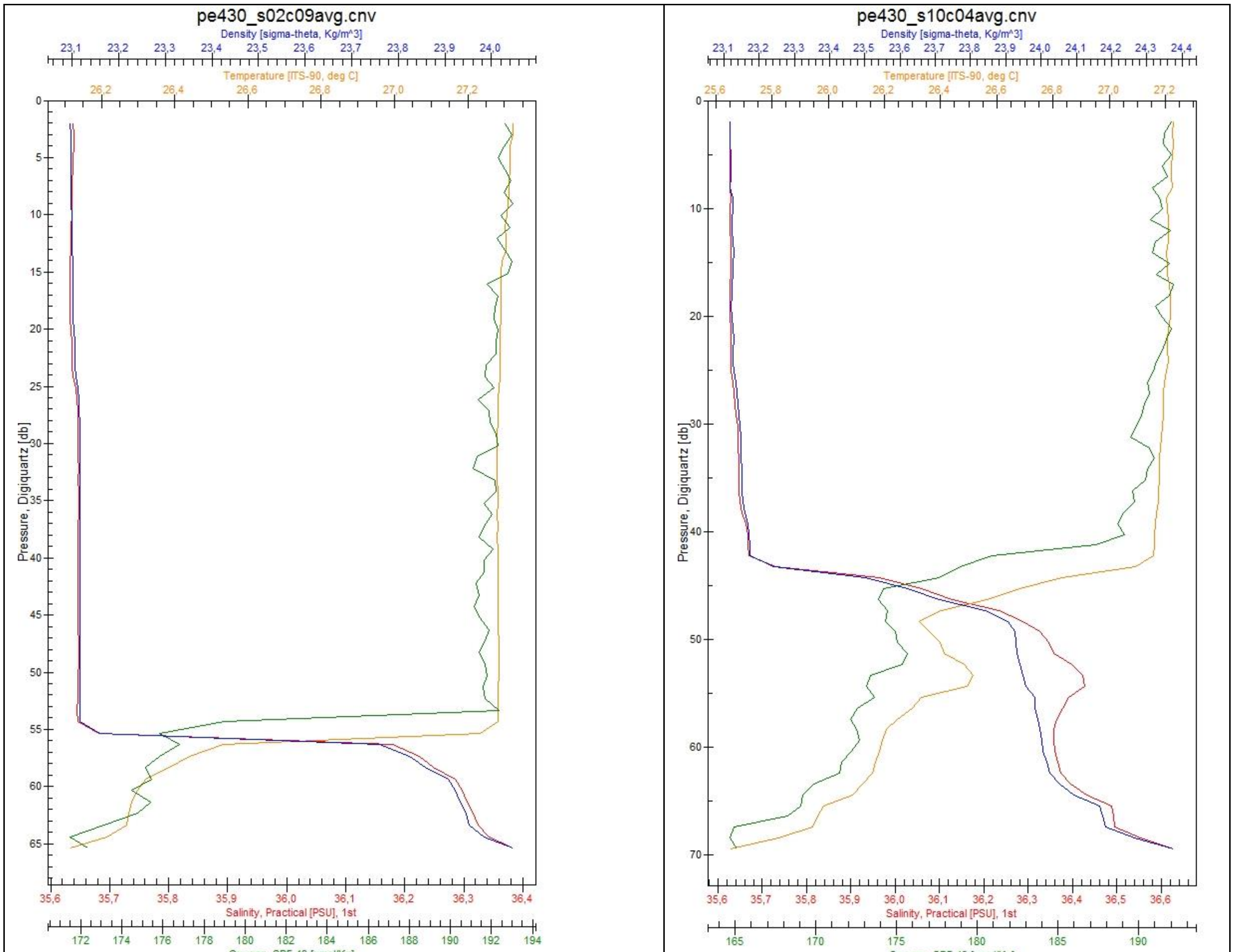

Figure 2. CTD profiles of station Kralendijk 1(St 2-9) and 5 (St 10-4) on 26 and 28 January 2018 with steep haloclines and thermoclines at approximately 56m, 43m depth respectively. Oxygen concentrations dropped 2 m above the halocline/thermocline in both profiles. Bottom depth at these sites was approximately 66m, 69m respectively.

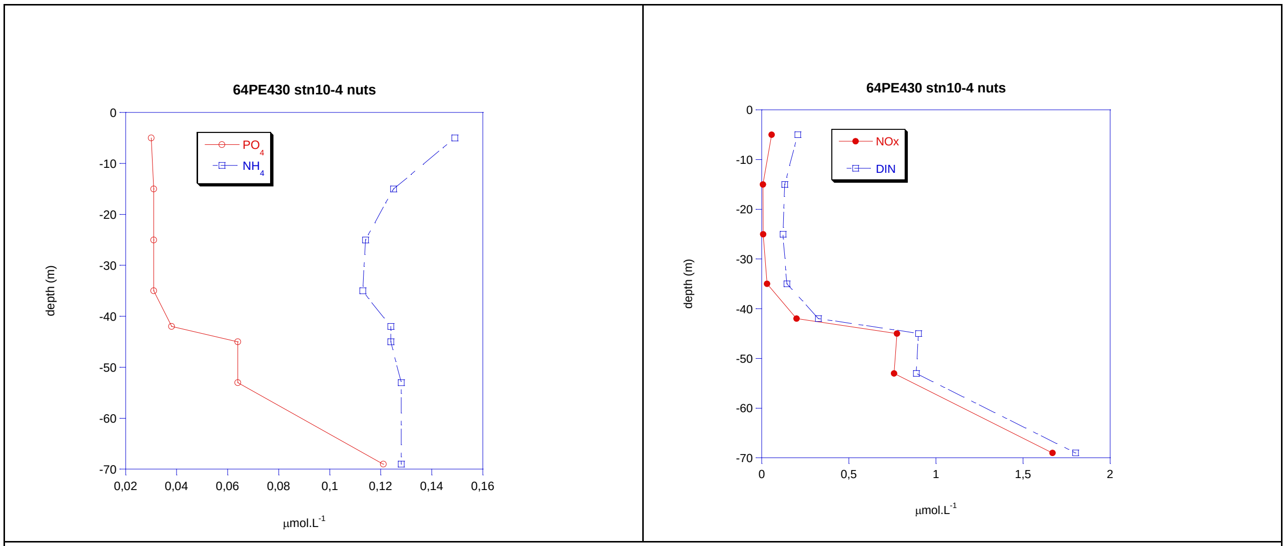

Figure 3. Inorganic nutrient profiles of PO_4 and NH_4 (l) and NO_x (=NO_2 +NO_3) and DIN (=NO_x + NH_4) (r) at stn 10-4 (Kralendijk 5, 28 Jan. 2018), 17:02h Local time.

Variations in depth of the halocline were substantial (ca 8 m) shifting upwards from 55 to 35 m depth from 27 to 30 January in front of Kralendijk. This apparently coincided with mixing between the 2 distinct water masses resulting in enhanced nutrient concentrations up to 35 m depth (Fig. 3). Deep cyanobacterial mats between 55 and 70 m might benefit of the enhanced algal concentration (measured as enhanced fluorescence), settlement of particulate organic matter, as well as higher (in)organic nutrient concentrations of NO_x and PO_4 in this interface. Only NH_4 concentrations were higher in surface waters than below the halocline at all stations along the leeward coast of Bonaire. The nutricline coincides with an increase in salinity (halocline) and a decrease in temperature (thermocline). Oxygen concentrations start decreasing a few meters above the halocline.

__Curaçao__. Along Curaçao CTD profiles were made at eight stations with bottom depths varying between 105 and 281 m. Deep Chlorophyll-*a* maxima (DCM's) were found between 51 and 100 m. Dissolved inorganic nitrogen (DIN) concentrations were below 1 µmol.L^{-1} until 50 m depth, ranging between 0.104 to 0.248 µmol.L^{-1} at 5m depth. Only in front of the Annabaai DIN concentrations of 0.443 µmol.L^{-1} were measured, dominated by NO_3. Below 50 m depth DIN concentrations increased and rose to more than 15 µmol.L^{-1} below 225 m depth. PO_4 concentrations ranging between 0 and 0.02 µmol.L^{-1} in surface water and increased below ca 40 m depth to more than 1 µmol.L^{-1} down to 200m depth.

Aruba. Along Aruba two CTD profiles with water samples were made. One at the SE corner at 204 m depth and one at the leeward side at 82 m depth (in front of Palm Beach). DCM at the deep station was at 39 m depth and at the shallower station at 16 m. From surface water to 40 m deep the DIN concentration increased from 0.27 to 0.82 $\mu mol.L^{-1}$. In front of Palm Beach the DIN concentration increased from 0.76 to 0.80 $\mu mol.L^{-1}$ DIN towards 40 m depth. DIN concentrations in surface water (ca 5 m depth) along Aruba (in front of Palm Beach in particular), were higher than along Curaçao and Bonaire on average. Below 40 m DIN concentrations rose to 15 $\mu mol.L^{-1}$ down to 200 m depth, comparable to DIN concentrations found in the deep waters along Curaçao and Bonaire. Variations in PO_4 concentrations were comparable between Bonaire and Aruba ranging between 0.014 and 0.059 $\mu mol.L^{-1}$ in surface waters. Lowest PO_4 concentrations were measured along Curaçao.

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Investigations on the physiology of benthic cyanobacterial mats

Petra M. Visser and Bas van Beusekom
University of Amsterdam

Rationale

Cyanobacterial mats at depths of 45-90 meters off the coast of Bonaire have been discovered some years ago. The mats occurred mainly on relatively flat and sandy bottoms and most were found near Kralendijk. These deep mats have never been described before and hardly anything is known about the causes of their proliferation, their species composition and physiological characteristics. Cyanobacteria are known to proliferate under eutrophied conditions and are stimulated by global warming. Furthermore, cyanobacteria can fix nitrogen, can produce dissolved organic matter (DOM) and toxic compounds. All these aspects might be harmful for coral reefs. During this cruise we have investigated the ambient light conditions of locations with mats (e.g. light quantity and quality). Samples of the mats were incubated at ambient light conditions and nitrogen fixation capacity and photosynthesis was determined. Toxicity of the cyanobacterial mats was determined using a *Thamnocephalus* assay. To get more insight in their functioning and impact on the reef ecosystem, also a metagenomics analysis will be performed on the samples.

Materials and methods.

Measuring light profiles using the Hydrolab DS5 Sonde (OTT Messtechnik Gmbh & Co, Kempten, Germany) for light quantity and RAMSES ACC-VIS spectroradiometer (TriOS, Oldenburg, Germany) for light quality on the following days and locations (see appendix 1 for coordinates):

20180126 station 2 Kralendijk

20180127 station 6 Kralendijk

20180128 station 10 Kralendijk

20180129 station 12 Kralendijk.

Sampling cyanobacterial mats was tried using the Multicore sampler but the cores did not go deep enough in the sediment or lost the sediment before the cores were closed. Several times only cores with water came up. The next step was to use the Box corer. With this sampler we were able to collect cores of the sediment but the cyanobacterial mats had disappeared from the sediment by the time the boxcorer was on board. Apparently, the corer created too much current which blew away the mats which was visible on recordings from a camera attached to the box corer. Finally, samples were taken by divers at 50 m depth using Perspex cores of 10 cm height and 10 cm diameter that were closed with a stopper.

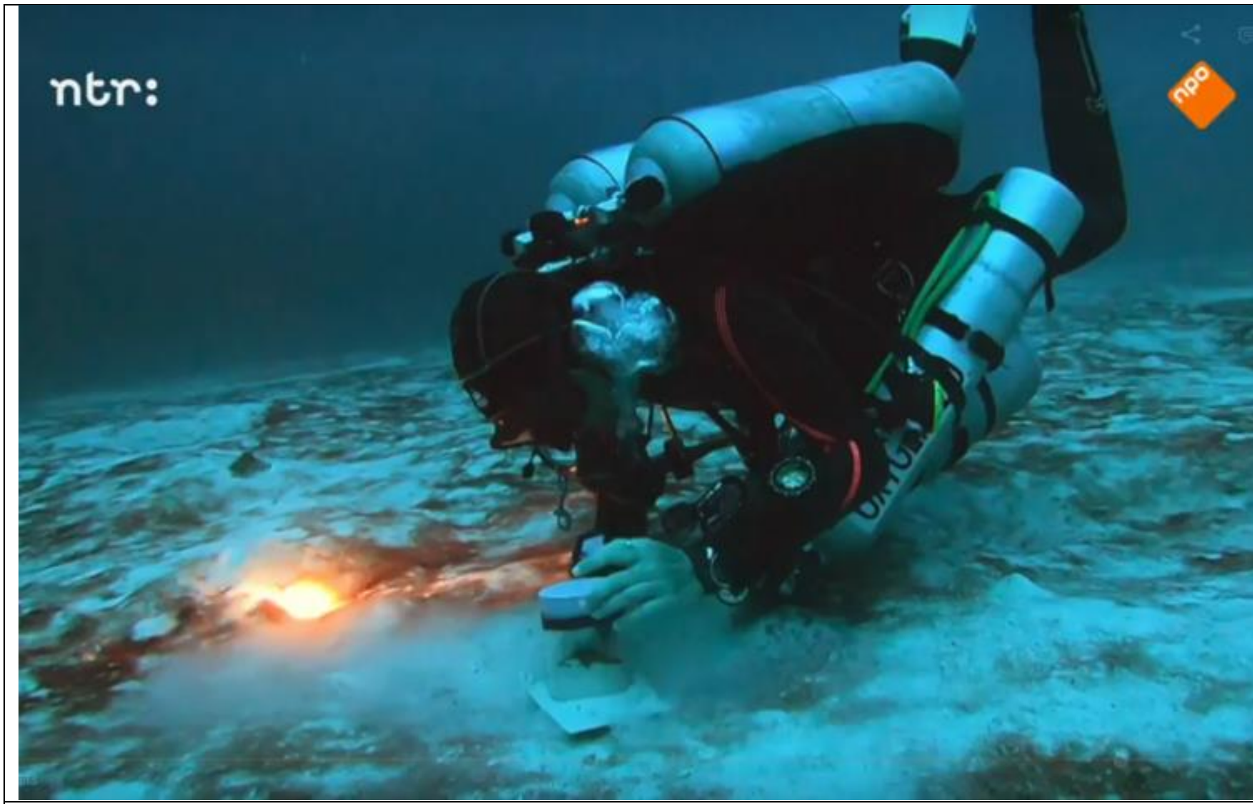


Figure 1. Diver sampling a cyanobacterial mat.

Incubations in the lab. Ambient light conditions as experienced by the cyanobacteria in the field were established in the lab on board using a Solux 4700k lamp and LEE115 Peacock Blue filters. The light intensity in the middle of the cores was approximately 9 µmol photons m^{-2} s^{-1}. Cores and vials with samples were placed in the light or were covered in aluminum foil for measuring changes in oxygen concentrations and nitrogen fixation as described below. The temperature in the lab was 26^{o}C.

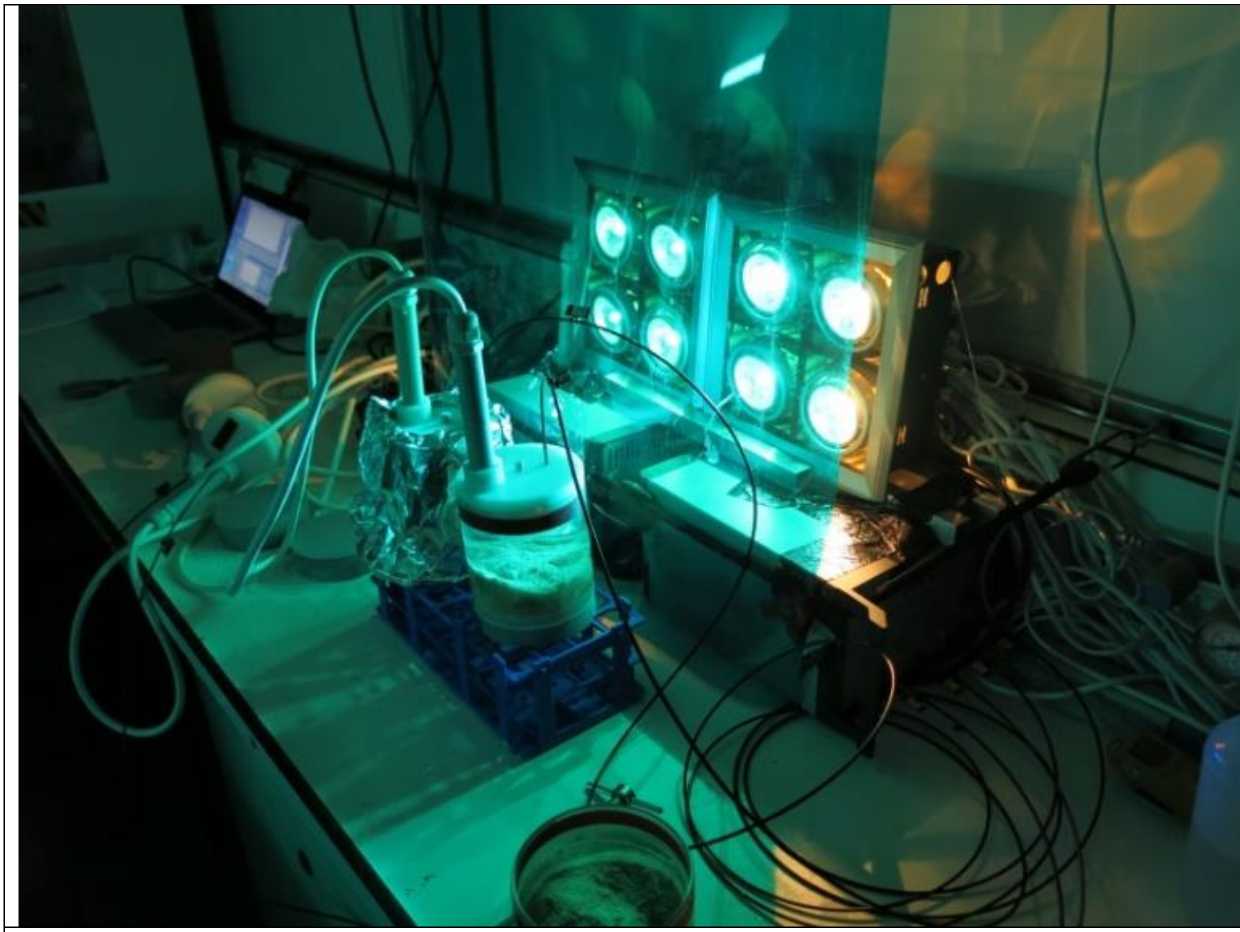


Figure 2. Incubation set up for oxygen measurements.

Filters were used to mimic the light spectrum underwater as good as possible. The light had an maximum at 510 nm and was cut off around 380 and 620 nm. The light spectrum is shown below:

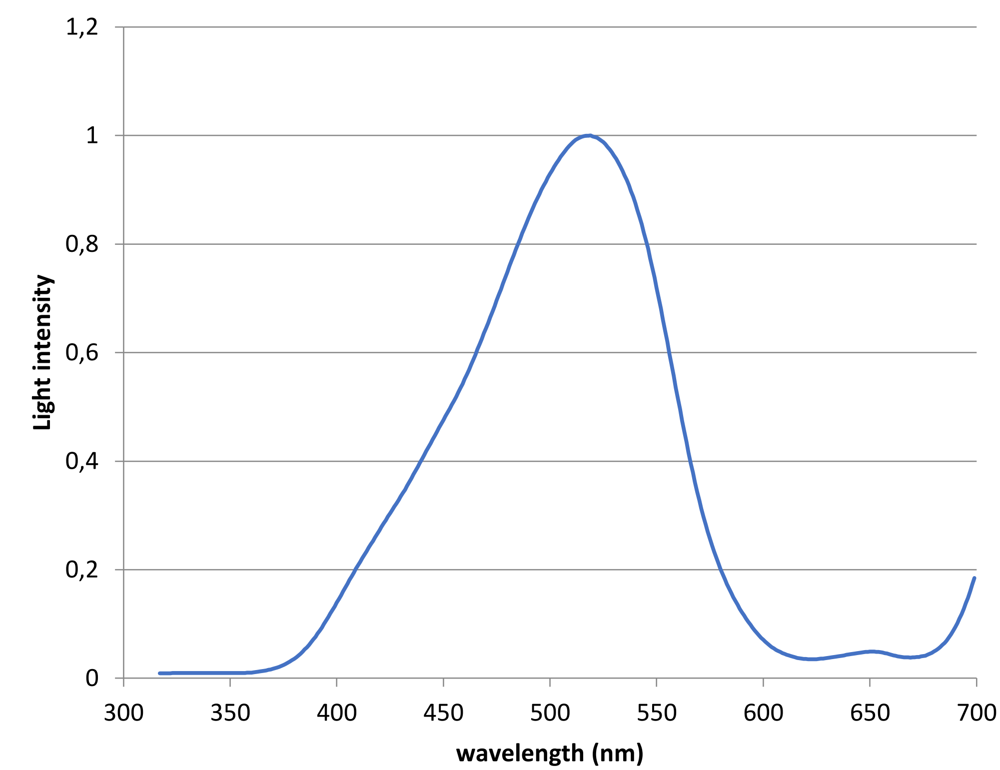


Figure 3. Light spectrum of the lamp plus filter used for lab incubations.

As comparison the light spectrum at 40, 50 and 60 m as measured by the RAMSES spectroradiometer on January 29 2018 at station 12 Kralendijk where the maximum light intensity was at around 480 nm.

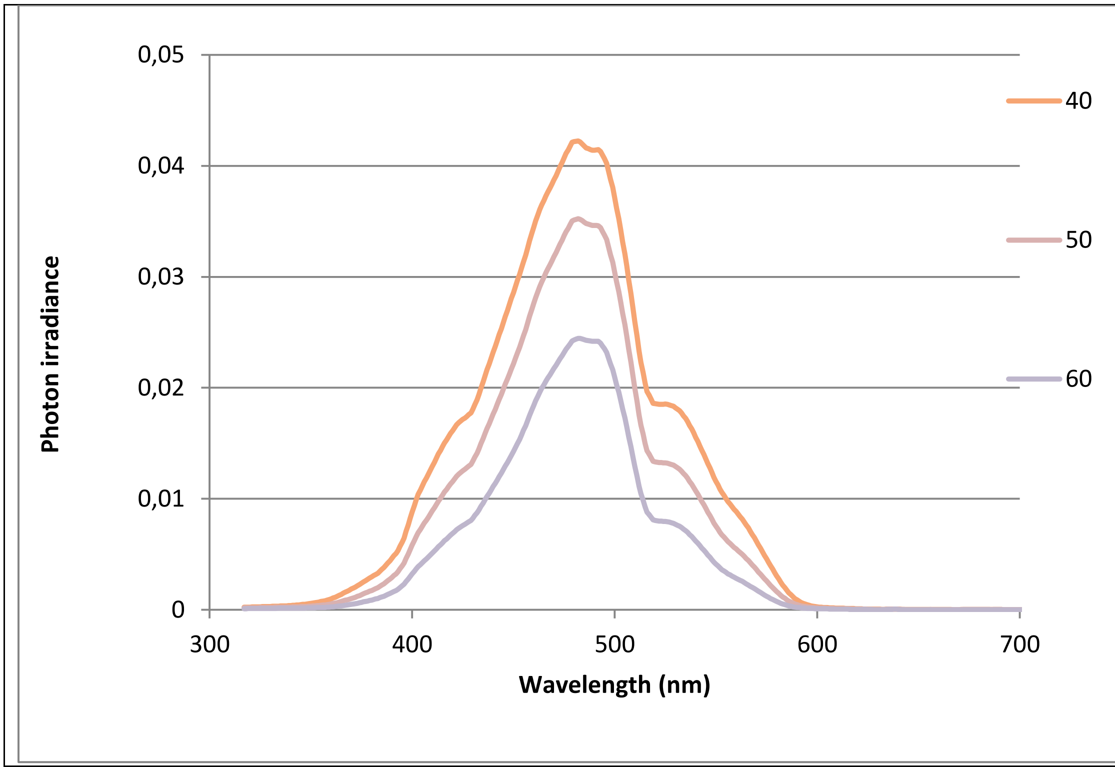


Figure 4. Underwater light spectrum at 40, 50 and 60 m depth.

Photosynthesis of the mats was determined using Oxi-4 presens optodes in the cores in the lab under ambient light conditions. The photosynthetic quantum yield was determined on top of the cyanobacterial mats using a Mini-PAM fluorometer (Walz Mess- und Regeltechnik, Effentrich, Germany).

Nitrogen fixation rate was determined using the acetylene reduction assay (Stal, 1988). Samples were taken using a small corer with a diameter of 1 cm and placed in a 20 ml vial which has been previously filled with 3 ml 0.22 µm filtered seawater (FSW) and were sealed with a serum cap. After addition of acetylene, the vials were incubated for 4 hours in the light or in the dark. Samples of the air in the vials were taken after 1 hour and 4 hours. The samples were stored in a 6 ml vial and shipped to the Netherlands. Samples were analysed on a GC for quantification of ethylene at the University of Amsterdam. Toxicity of the mats was determined using a standard bioassay (*Thamnocephalus*-kit) that is often used to detect cyanobacterial toxins (Torökne et al. 2006).

Identification of the cyanobacteria in the mats was done using a microscope. *Results* The light profile of Photosynthetic Active Radiation (PAR, 400-700 nm) as measured with the Hydrolab Profiler on January 28 2018 at station 10 Kralendijk is plotted below.

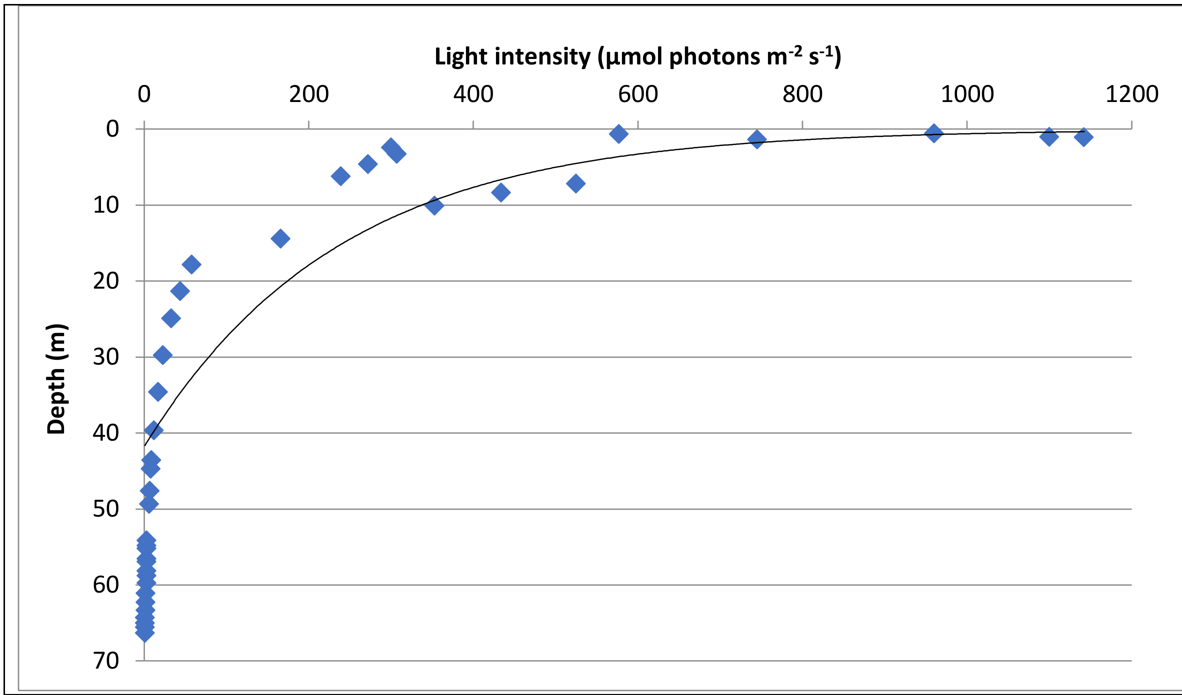


Figure 5. Photon irradiance profile. Exponentially decreasing regression line added.

The light spectrum as measured with the RAMSES on January 29 2018 at station 12 Kralendijk is plotted below

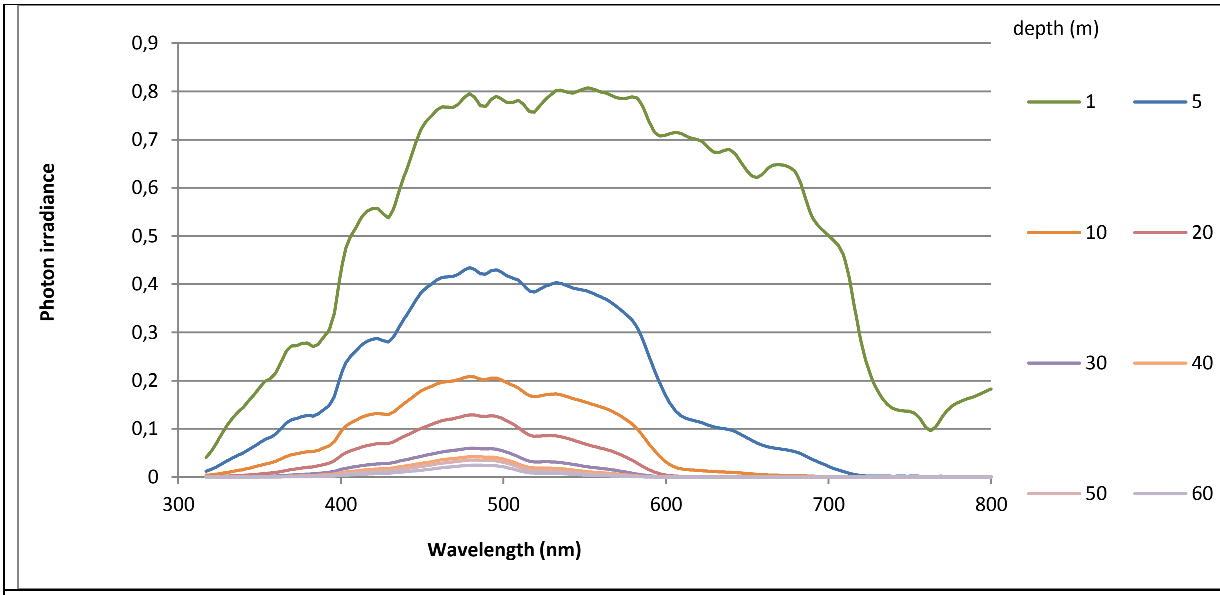


Figure 6. Underwater light spectrum at several depths.

Oxygen changes in the incubation vials were monitored during 4 hours in the light and dark. Both in the light and dark a decrease in oxygen concentrations was observed, see graph below. Photosynthesis by the cyanobacterial mats under these conditions was not high enough to compensate for the respiration of non-photosynthetic organisms in the mats and sand. Whether there will be a net oxygen consumption in the field as well cannot be concluded from these results since water flowing over the mats may change the oxygen conditions compared to the incubations vials.

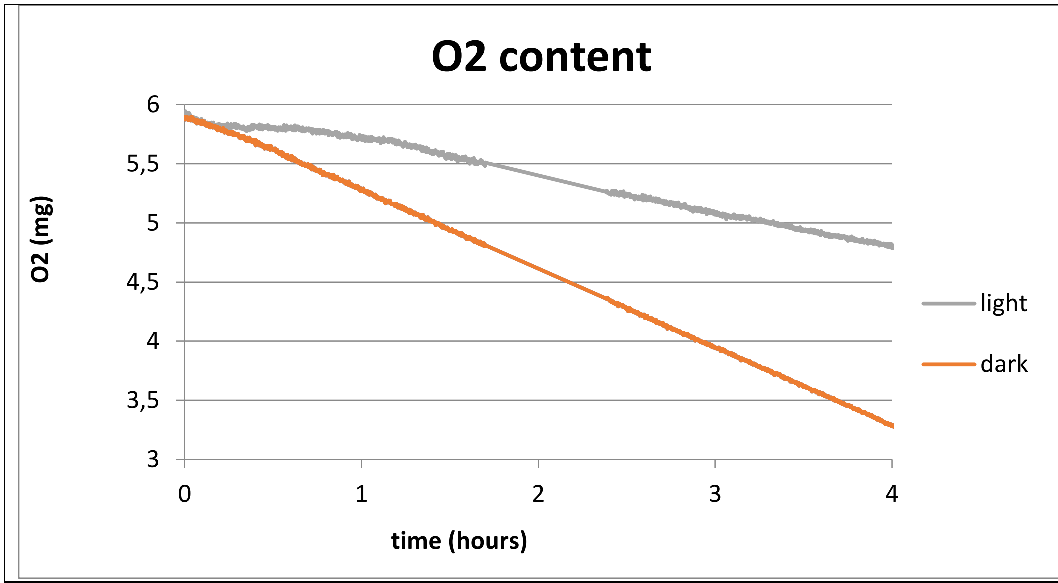


Figure 7. Changes in oxygen content in the incubation chambers with cyanobacterial mats incubated in the light and dark.

Fluorometer measurements of the quantum yield at different light intensities (PI-curves) showed an increase of the photosynthetic activity with increasing light up to a light intensity of about 220 µmol photons m^{-2} s^{-1}. Below the average relative ETR (electron transport rate) versus the light intensity is shown (n=10).

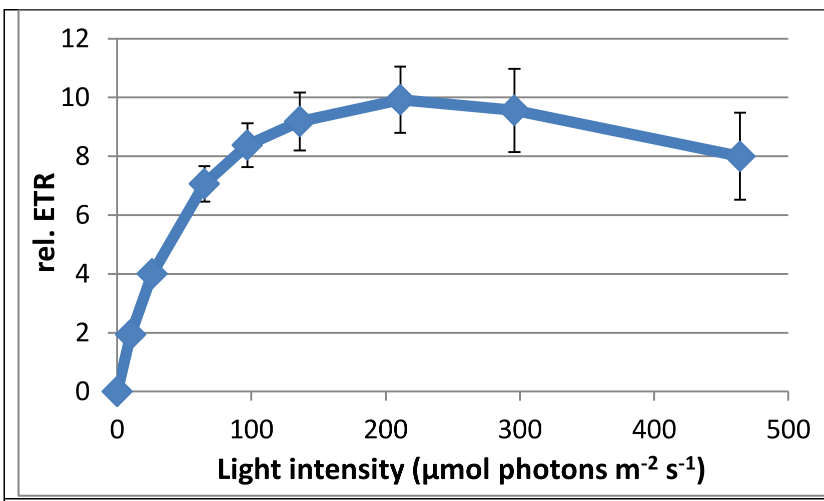


Figure 8. Relative ETR (Electron Transport Rate) vs. light intensity of a cyanobacterial mat as measured by a mini-PAM fluorometer.

No nitrogen fixing activity was detected in the mats. The toxicity tests with the fairy shrimp *Thamnocephalus* showed no toxicity of the extracts of the mats to this organism. The mats consisted of one type of filament which was identified as belonging to the genus *Oscillatoria* following the key provided by Komárek & Anagnostidis (2005). Identification up to species level was not possible as the morphology of filaments did not match with any of the species described by Komárek & Anagnostidis (2005). Sequencing of mats using Illumina Sequencing and metagenomics will hopefully provide more information about the taxonomy of the cyanobacteria. Pictures of the mats are shown below.

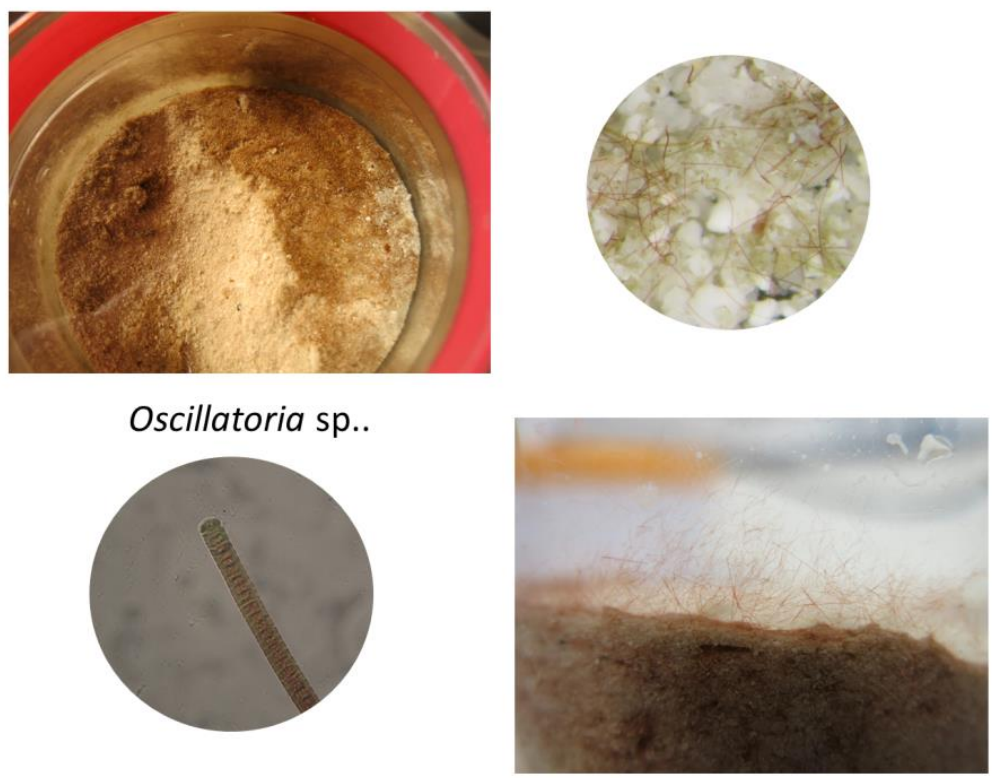


Figure 9. Pictures from cyanobacterial mats.

References

Komárek J, Anagnostidis K (2005) Süsswasserflora von Mitteleuropa. Cyanoprokaryota 2. Teil: Oscillatoriales. Elsevier Spektrum Akademischer Verlag, München.

Stal, L. J. (1988). [49] Nitrogen fixation in cyanobacterial mats. In Methods in enzymology (Vol. 167, pp. 474-484). Academic Press.

Törökné, A., Vasdinnyei, R., & Asztalos, B. M. (2007). A rapid microbiotest for the detection of cyanobacterial toxins. Environmental Toxicology: An International Journal, 22(1), 64-68.

Appendices

Appendix 1. Overview of all activities from RV Pelagia

Date	Heure UTC	Latitude(deg. min.milli)	Longitude(deg. min.milli)	Name	Device name	Device code	Action name	Station	Strate	depth (m)
25/01/2018	11:12:38PM	N 12° 7.26096'	W 68° 58.47516'	Piscaderabaai	CTD	CTD1	Begin	1	1_1	215,32
25/01/2018	11:23:47PM	N 12° 7.26564'	W 68° 58.46016'	Piscaderabaai	CTD	CTD1	Bottom	1	1_1	199,15
25/01/2018	11:55:01PM	N 12° 7.30056'	W 68° 58.4997'	Piscaderabaai	CTD	CTD1	End	1	1_1	215,26
26/01/2018	11:30:54AM	N 12° 7.74642'	W 68° 17.3409'	Kralendijk_1	Hopper Cam	HC		101		92,02
26/01/2018	1:54:11PM	N 12° 9.02256'	W 68° 16.82988'	Kralendijk_1	Hopper Cam	HC		101		57,02
26/01/2018	2:27:56 PM	N 12° 8.74758'	W 68° 16.71864'	Kralendijk_1	Multi Corer	MC12	Bottom	2	2_1	57,02
26/01/2018	2:39:07 PM	N 12° 8.74788'	W 68° 16.71402'	Kralendijk_1	Multi Corer	MC12	Bottom	2	2_2	56,08
26/01/2018	2:46:29 PM	N 12° 8.74668'	W 68° 16.72116'	Kralendijk_1	Multi Corer	MC12	Bottom	2	2_3	57,96
26/01/2018	3:03:27 PM	N 12° 8.75844'	W 68° 16.71612'	Kralendijk_1	Multi Corer	MC12	Bottom	2	2_4	56,38
26/01/2018	3:28:31 PM	N 12° 8.74554'	W 68° 16.72182'	Kralendijk_1	Boxcore	BOX125	Bottom	2	2_5	57,9
26/01/2018	3:43:52 PM	N 12° 8.7396'	W 68° 16.72044'	Kralendijk_1	Boxcore	BOX125	Bottom	2	2_6	58,78
26/01/2018	6:00:54 PM	N 12° 8.72868'	W 68° 16.72734'	Kralendijk_1	Lander	BWGS	Deployment	2	2_7	61,11
26/01/2018	6:44:13 PM	N 12° 8.81082'	W 68° 16.75434'	Kralendijk_1	Lightprofiler	RAMSES	Begin	2	2_8	66,52
26/01/2018	7:07:25 PM	N 12° 8.79438'	W 68° 16.7376'	Kralendijk_1	Lightprofiler	RAMSES	End	2	2_8	61,11
26/01/2018	7:20:07 PM	N 12° 8.80266'	W 68° 16.74342'	Kralendijk_1	CTD	CTD2	Begin	2	2_9	61,8
26/01/2018	7:23:54 PM	N 12° 8.79834'	W 68° 16.74396'	Kralendijk_1	CTD	CTD2	Bottom	2	2_9	63,43
26/01/2018	7:31:24 PM	N 12° 8.80992'	W 68° 16.7496'	Kralendijk_1	CTD	CTD2	End	2	2_9	63,87
26/01/2018	7:52:40 PM	N 12° 8.77626'	W 68° 16.76802'	Kralendijk_1	RHIB	RHIB	Deployment	2	2_10	78,89
26/01/2018	8:19:28 PM	N 12° 8.74554'	W 68° 16.73934'	Kralendijk_1	Lander	BWGS	Recovery	2	2_11	65,7
26/01/2018	8:47:42 PM	N 12° 7.57926'	W 68° 17.92014'	N Pnt Vierkant	RHIB	RHIB	Recovery			256,69
26/01/2018	10:49:02PM	N 12° 7.6338'	W 68° 17.98164'	N Pnt Vierkant	CTD	CTD3	Begin	3	3_1	276,07
26/01/2018	10:59:12PM	N 12° 7.61124'	W 68° 17.93076'	N Pnt Vierkant	CTD	CTD3	Bottom	3	3_1	260,7
26/01/2018	11:12:22PM	N 12° 7.5615'	W 68° 17.9736'	N Pnt Vierkant	CTD	CTD3	End	3	3_1	265,31
27/01/2018	10:14:43AM	N 12° 9.1353'	W 68° 16.94142'	Kralendijk_2	Lander	BWGS	Deployment	4	4_1	113,83
27/01/2018	10:20:39AM	N 12° 9.15594'	W 68° 16.91922'	Kralendijk_2	Lander	BWGS	Recovery	4	failed	102,05
27/01/2018	10:20:41AM	N 12° 9.156'	W 68° 16.91928'	Kralendijk_2	Lander	BWGS	Recovery	4	failed	102,05
27/01/2018	10:59:33AM	N 12° 9.13686'	W 68° 16.8474'	Kralendijk_2	Lander	BWGS	Deployment	4	4_1	70,38
27/01/2018	11:17:48AM	N 12° 9.17778'	W 68° 16.86714'	Kralendijk_2	CTD	CTD4	Begin	4	4_2	72,2
27/01/2018	11:22:19AM	N 12° 9.19146'	W 68° 16.85946'	Kralendijk_2	CTD	CTD4	Bottom	4	4_2	68,22

27/01/2018	11:28:11AM	N 12° 9.17868'	W 68° 16.86804'	Kralendijk_2	CTD	CTD4	End	4	4_2	75,8
27/01/2018	12:03:42PM	N 12° 9.15468'	W 68° 17.07654'	Kralendijk_2	RHIB	RHIB	Deployment	4	4_3	153,82
27/01/2018	1:23:26 PM	N 12° 9.15618'	W 68° 16.84752'	Kralendijk_2	Lander	BWGS	Recovery	4	4_1	67,86
27/01/2018	1:44:01 PM	N 12° 9.14784'	W 68° 16.80996'	Kralendijk_2	Multi Corer	MC12	Bottom	4	4_4	55,18
27/01/2018	1:50:13 PM	N 12° 9.13956'	W 68° 16.82694'	Kralendijk_2	Multi Corer	MC12	Bottom	4	4_5	62,38
27/01/2018	2:03:43 PM	N 12° 9.13464'	W 68° 16.82202'	Kralendijk_2	Multi Corer	MC12	Bottom	4	4_6	60,75
27/01/2018	2:06:57 PM	N 12° 9.135'	W 68° 16.82328'	Kralendijk_2	Multi Corer	MC12	Bottom	4	4_7	60,65
27/01/2018	3:24:24 PM	N 12° 9.17304'	W 68° 16.82226'	Kralendijk_2	Boxcore	BOX125	Bottom	4	4_8	56,85
27/01/2018	3:52:35 PM	N 12° 9.25116'	W 68° 16.95978'	Kralendijk_2	RHIB	RHIB	Recovery	4	4_3	109,58
27/01/2018	5:43:00 PM	N 12° 11.59068'	W 68° 18.8343'	Barcadera	CTD	CTD5	Begin	5	5_1	263,66
27/01/2018	5:57:23 PM	N 12° 11.58252'	W 68° 18.82158'	Barcadera	CTD	CTD5	Bottom	5	5_1	266,05
27/01/2018	6:06:16 PM	N 12° 11.57622'	W 68° 18.82164'	Barcadera	CTD	CTD5	End	5	5_1	266,18
27/01/2018	6:59:26 PM	N 12° 8.47188'	W 68° 16.713'	Kralendijk_3	Lander	BWGS	Deployment	6	6_1	62,38
27/01/2018	9:06:27PM	N 12° 8.60658'	W 68° 16.9842'	Kralendijk_3	Lander	BWGS	Recovery?			
27/01/2018	7:27:23 PM	N 12° 8.58156'	W 68° 16.7112'	Kralendijk_3	CTD	CTD6	Begin	6	6_2	61,92
27/01/2018	7:29:50 PM	N 12° 8.57388'	W 68° 16.71054'	Kralendijk_3	CTD	CTD6	Bottom	6	6_2	62,11
27/01/2018	7:37:28 PM	N 12° 8.56722'	W 68° 16.70508'	Kralendijk_3	CTD	CTD6	End	6	6_2	59,07
27/01/2018	7:53:02 PM	N 12° 8.57328'	W 68° 16.71354'	Kralendijk_3	Lightprofiler	RAMSES	Begin	6	6_3	62,37
27/01/2018	8:10:34 PM	N 12° 8.57214'	W 68° 16.71336'	Kralendijk_3	Lightprofiler	RAMSES	End	6	6_3	63,5
27/01/2018	11:45:06PM	N 12° 13.35882'	W 68° 24.7188'	Wecua	CTD	CTD7	Begin	7	7_1	229,76
27/01/2018	11:59:01PM	N 12° 13.37232'	W 68° 24.71874'	Wecua	CTD	CTD7	Bottom	7	7_1	213,46
28/01/2018	12:06:21AM	N 12° 13.36938'	W 68° 24.72126'	Wecua	CTD	CTD7	End	7	7_1	215,79
28/01/2018	12:08:34AM	N 12° 13.36944'	W 68° 24.73182'	Wecua	CTD	CTD7	End	7	7_1	225,88
28/01/2018	12:54:11AM	N 12° 16.044'	W 68° 24.95988'	Slagbaai	Hopper Cam	HC	Deployment	102	102	74,2
28/01/2018	12:59:21AM	N 12° 16.03206'	W 68° 24.96042'	Slagbaai	Hopper Cam	HC	Start Camera	102	102	71,83
28/01/2018	1:43:48 AM	N 12° 16.1403'	W 68° 24.93078'	Slagbaai	Hopper Cam	HC	End Camera	102	102	45,02
28/01/2018	1:46:15 AM	N 12° 16.13658'	W 68° 24.95028'	Slagbaai	Hopper Cam	HC	Recovery	102	102	71,05
28/01/2018	3:03:34 AM	N 12° 18.59256'	W 68° 22.22454'	Windzijde N	Hopper Cam	HC	Deployment	103	103	75,77
28/01/2018	3:07:02 AM	N 12° 18.5805'	W 68° 22.19052'	Windzijde N	Hopper Cam	HC	Start Camera	103	103	67,89
28/01/2018	3:30:59 AM	N 12° 18.51894'	W 68° 21.96744'	Windzijde N	Hopper Cam	HC	End Camera	103	103	73,41
28/01/2018	3:36:40 AM	N 12° 18.51972'	W 68° 21.96786'	Windzijde N	Hopper Cam	HC	Recovery	103	103	70,26
28/01/2018	10:12:30AM	N 12° 8.31228'	W 68° 16.7289'	Kralendijk_4	Lander	BWGS	Deployment	8	8_1	58,43
28/01/2018	10:34:56AM	N 12° 8.40402'	W 68° 16.7202'	Kralendijk_4	CTD	CTD8	Begin	8	8_2	60,8

28/01/2018	10:36:41AM	N 12° 8.40216'	W 68° 16.7229'	Kralendijk_4	CTD	CTD8	Bottom	8	8_2	61,59
28/01/2018	10:44:02AM	N 12° 8.4042'	W 68° 16.72086'	Kralendijk_4	CTD	CTD8	End	8	8_2	60,43
28/01/2018	11:44:20AM	N 12° 8.3553'	W 68° 16.79148'	Kralendijk_4	RHIB	RHIB	Deployment	8	8_3	89,14
28/01/2018	12:00:26PM	N 12° 8.32422'	W 68° 16.73298'	Kralendijk_4	Lander	BWGS	Recovery	8	8_1	60,8
28/01/2018	1:01:47 PM	N 12° 8.37972'	W 68° 16.7292'	Kralendijk_4	Boxcore	BOX125	Bottom	8	8_4	63,17
28/01/2018	1:36:14 PM	N 12° 8.3913'	W 68° 16.71324'	Kralendijk_4	Boxcore	BOX125	Bottom	8	8_5	58,43
28/01/2018	2:57:06 PM	N 12° 8.53554'	W 68° 16.72404'	Kralendijk_4	Boxcore	BOX125	Bottom	8	8_6	70,05
28/01/2018	3:17:52 PM	N 12° 8.54382'	W 68° 16.76856'	Kralendijk_4	RHIB	RHIB	Recovery	8	8_3	91,51
28/01/2018	4:02:14 PM	N 12° 8.70786'	W 68° 19.8987'	SW Kl Bon	CTD	CTD9	Begin	9	9_1	96,23
28/01/2018	4:04:44 PM	N 12° 8.71224'	W 68° 19.90284'	SW Klein Bon	CTD	CTD9	Bottom	9	9_1	97,01
28/01/2018	4:24:05 PM	N 12° 8.71542'	W 68° 19.9002'	SW Klein Bon	CTD	CTD9	End	9	9_1	95,44
28/01/2018	5:34:00 PM	N 12° 8.66592'	W 68° 19.90206'	SW Klein Bon	Hopper Cam	HC	Deployment	9	104	105,54
28/01/2018	5:35:49 PM	N 12° 8.66958'	W 68° 19.89198'	SW Klein Bon	Hopper Cam	HC	Start Camera	9	104	102,49
28/01/2018	6:24:39 PM	N 12° 8.86566'	W 68° 19.7043'	SW Klein Bon	Hopper Cam	HC	End Camera	9	104	0
28/01/2018	6:30:28 PM	N 12° 8.80818'	W 68° 19.68906'	SW Klein Bon	Hopper Cam	HC	Recovery	9	104	94,66
28/01/2018	7:17:52 PM	N 12° 8.35314'	W 68° 16.73706'	Kralendijk_5	Lander	BWGS	Deployment	10	10_1	64,74
28/01/2018	7:44:54 PM	N 12° 8.41926'	W 68° 16.77054'	Kralendijk_5	RHIB	RHIB	Deployment	10	10_2	85,56
28/01/2018	8:11:59 PM	N 12° 8.4327'	W 68° 16.73226'	Kralendijk_5	Lightprofiler	RAMSES	Begin	10	10_3	67,89
28/01/2018	8:34:21 PM	N 12° 8.41836'	W 68° 16.72182'	Kralendijk_5	Lightprofiler	RAMSES	End	10	10_3	60,9
28/01/2018	9:02:39 PM	N 12° 8.40432'	W 68° 16.74936'	Kralendijk_5	CTD	CTD10	Begin	10	10_4	77,35
28/01/2018	9:04:51 PM	N 12° 8.40756'	W 68° 16.73226'	Kralendijk_5	CTD	CTD10	Bottom	10	10_4	65,53
28/01/2018	9:21:29 PM	N 12° 8.38764'	W 68° 16.76814'	Kralendijk_5	CTD	CTD10	End	10	10_4	82,86
28/01/2018	9:21:29 PM	N 12° 8.38764'	W 68° 16.76814'	Kralendijk_5	Lander	BWGS	Recovery?			
28/01/2018	10:03:20PM	N 12° 8.1978'	W 68° 16.8879'	Kralendijk_5	RHIB	RHIB	Recovery			93,77
28/01/2018	10:54:29PM	N 12° 4.6494'	W 68° 17.46348'	Tori's Reef	CTD	CTD11	Begin	11	11_1	253
28/01/2018	10:59:13PM	N 12° 4.64334'	W 68° 17.46378'	Tori's Reef	CTD	CTD11	Bottom	11	11_1	254,52
28/01/2018	11:21:42PM	N 12° 4.63314'	W 68° 17.46534'	Tori's Reef	CTD	CTD11	End	11	11_1	259,04
29/01/2018	12:26:30AM	N 12° 1.75986'	W 68° 13.85646'	Willemstoren	Hopper Cam	HC	Deployment	105	105	60,8
29/01/2018	12:28:22AM	N 12° 1.75356'	W 68° 13.84602'	Willemstoren	Hopper Cam	HC	Start Camera	105	105	67,11
29/01/2018	1:30:51 AM	N 12° 1.90554'	W 68° 13.7721'	Willemstoren	Hopper Cam	HC	End Camera	105	105	45,69
29/01/2018	1:34:36 AM	N 12° 1.88718'	W 68° 13.75026'	Willemstoren	Hopper Cam	HC	Recovery	105	105	51,98
29/01/2018	10:18:22AM	N 12° 8.33334'	W 68° 16.73376'	Kralendijk_6	Lander	BWGS	Deployment	12	12_1	60,77
29/01/2018	10:41:42AM	N 12° 8.40396'	W 68° 16.72374'	Kralendijk_6	CTD	CTD12	Begin	12	12_2	61,59

29/01/2018	10:41:47AM	N 12° 8.40366'	W 68° 16.72308'	Kralendijk_6	CTD	CTD12	Bottom	12	12_2	61,59
29/01/2018	10:41:47AM	N 12° 8.40366'	W 68° 16.72308'	Kralendijk_6	CTD	CTD12	End	12	12_2	61,59
29/01/2018	11:08:48AM	N 12° 8.40822'	W 68° 16.74054'	Kralendijk_6	Hopper Camera	HC	Deployment	106	106	71,05
29/01/2018	11:16:14AM	N 12° 8.40696'	W 68° 16.72638'	Kralendijk_6	Hopper Camera	HC	Start Camera	106	106	63,17
29/01/2018	1:03:39 PM	N 12° 9.23538'	W 68° 16.8561'	Kralendijk_6	Hopper Camera	HC	End Camera	106	106	60,01
29/01/2018	1:06:37 PM	N 12° 9.2535'	W 68° 16.84632'	Kralendijk_6	Hopper Cam	HC	Recovery	106	106	54,07
29/01/2018	1:32:02 PM	N 12° 8.32314'	W 68° 16.72572'	Kralendijk_6	Lander	BWGS	Recovery	12	12_1	58,36
29/01/2018	1:59:18 PM	N 12° 8.3376'	W 68° 16.76196'	Kralendijk_6	Lightprofiler	RAMSES	Begin	12	12_3	-1
29/01/2018	2:24:53 PM	N 12° 8.36268'	W 68° 16.72926'	Kralendijk_6	Lightprofiler	RAMSES	End	12	12_3	61,94
29/01/2018	4:38:38 PM	N 12° 15.94938'	W 68° 25.06278'	Slagbaai	RHIB	RHIB	Deployment	13	13_1	140,94
29/01/2018	5:18:45 PM	N 12° 16.01412'	W 68° 25.00554'	Slagbaai	RHIB	RHIB	Recovery	13	13_2	117,42
29/01/2018	5:30:17 PM	N 12° 15.9957'	W 68° 24.9819'	Slagbaai	CTD	CTD13	Begin	13	13_3	83,65
29/01/2018	5:41:08 PM	N 12° 15.98214'	W 68° 24.99162'	Slagbaai	CTD	CTD13	Bottom	13	13_3	96,23
29/01/2018	5:52:13 PM	N 12° 15.98778'	W 68° 24.99336'	Slagbaai	CTD	CTD13	End	13	13_3	100,94
29/01/2018	9:15:31 PM	N 12° 13.49844'	W 68° 11.43618'	Oostpnt Bon	CTD	CTD14	Begin	14	14_1	114,17
29/01/2018	9:20:25 PM	N 12° 13.50684'	W 68° 11.44518'	Oostpnt Bon	CTD	CTD14	Bottom	14	14_1	114,59
29/01/2018	9:32:41 PM	N 12° 13.51818'	W 68° 11.45964'	Oostpnt Bon	CTD	CTD14	End	14	14_1	120,56
29/01/2018	9:48:49 PM	N 12° 13.40142'	W 68° 11.53428'	Oostpnt Bon	Grab	VEEN60	Bottom	14	14_2	67,89
29/01/2018	9:53:59 PM	N 12° 13.40412'	W 68° 11.5464'	Oostpnt Bon	Grab	VEEN60	Bottom	14	14_3	66,32
29/01/2018	10:52:35PM	N 12° 13.49832'	W 68° 11.63274'	Oostpnt Bon	Hopper Cam	HC	Deployment	107	107	70,26
29/01/2018	10:52:37PM	N 12° 13.4982'	W 68° 11.6325'	Oostpnt Bon	Hopper Cam	HC	Start Camera	107	107	71,05
30/01/2018	12:07:02AM	N 12° 12.66396'	W 68° 11.47692'	Oostpnt Bon	Hopper Cam	HC	End Camera	107	107	148,74
30/01/2018	12:11:28AM	N 12° 12.69768'	W 68° 11.51388'	Oostpnt Bon	Hopper Cam	HC	Recovery	107	107	110,36
30/01/2018	1:07:18 AM	N 12° 8.47644'	W 68° 11.53848'	N of Lac	Hopper Cam	HC	Deployment	108	108	64,74
30/01/2018	1:10:21 AM	N 12° 8.46426'	W 68° 11.55996'	N of Lac	Hopper Cam	HC	Start Camera	108	108	61,59
30/01/2018	1:49:07 AM	N 12° 8.14512'	W 68° 11.53758'	N of Lac	Hopper Cam	HC	End Camera	108	108	56,78
30/01/2018	1:54:59 AM	N 12° 8.06916'	W 68° 11.5227'	N of Lac	Hopper Cam	HC	Recovery	108	108	58,36
30/01/2018	10:20:58AM	N 12° 9.3081'	W 68° 16.8861'	Kralendijk_7	Lander	BWGS	Deployment	15	15_1	52,75
30/01/2018	10:43:07AM	N 12° 9.41376'	W 68° 16.93434'	Kralendijk_7	CTD	CTD15	Begin	15	15_2	59,22
30/01/2018	10:44:16AM	N 12° 9.41382'	W 68° 16.93668'	Kralendijk_7	CTD	CTD15	Bottom	15	15_2	59,98
30/01/2018	10:54:05AM	N 12° 9.4245'	W 68° 16.94718'	Kralendijk_7	CTD	CTD15	End	15	15_2	60,8
30/01/2018	11:46:25AM	N 12° 9.45048'	W 68° 17.109'	Kralendijk_7	RHIB	RHIB	Deployment	15	15_3	113,5
30/01/2018	12:45:22PM	N 12° 9.30126'	W 68° 16.87104'	Kralendijk_7	Lander	BWGS	Recovery	15	15_1	55,23

30/01/2018	2:58:04 PM	N 12° 9.22998'	W 68° 16.95744'	Kralendijk_7	RHIB	RHIB	Recovery	15	15_3	108,01
31/01/2018	12:20:51AM	N 12° 4.5636'	W 68° 53.06154'	Jan Thiel Cur	Hopper Cam	HC	Deployment	109	109	66,32
31/01/2018	12:22:42AM	N 12° 4.56714'	W 68° 53.05806'	Jan Thiel Cur	Hopper Cam	HC	Start Camera	109	109	61,48
31/01/2018	12:43:36AM	N 12° 4.57608'	W 68° 53.04306'	Jan Thiel Cur	Hopper Cam	HC	End Camera	109	109	40,29
31/01/2018	12:47:04AM	N 12° 4.56696'	W 68° 53.0457'	Jan Thiel Cur	Hopper Cam	HC	Recovery	109	109	53,7
31/01/2018	1:08:38 AM	N 12° 4.21302'	W 68° 52.49328'	Lijhoek Cur	Hopper Cam	HC	Deployment	110	110	58,43
31/01/2018	1:11:10 AM	N 12° 4.21656'	W 68° 52.49886'	Lijhoek Cur	Hopper Cam	HC	Start Camera	110	110	58,43
31/01/2018	1:28:02 AM	N 12° 4.37856'	W 68° 52.24572'	Lijhoek Cur	Hopper Cam	HC	End Camera	110	110	30,82
31/01/2018	1:29:53 AM	N 12° 4.39554'	W 68° 52.19886'	Lijhoek Cur	Hopper Cam	HC	Recovery	110	110	0
31/01/2018	2:25:00 AM	N 12° 2.17752'	W 68° 48.29808'	Awa Blancu	Hopper Cam	HC	Deployment	111	111	58,2
31/01/2018	2:25:07 AM	N 12° 2.17764'	W 68° 48.2976'	Awa Blancu	Hopper Cam	HC	Start Camera	111	111	58,2
31/01/2018	2:54:14 AM	N 12° 2.14584'	W 68° 47.98326'	Awa Blancu	Hopper Cam	HC	End Camera	111	111	52,91
31/01/2018	2:57:02 AM	N 12° 2.1117'	W 68° 47.97924'	Awa Blancu	Hopper Cam	HC	Recovery	111	111	88,37
31/01/2018	11:18:53AM	N 12° 24.33528'	W 69° 9.60468'	N-pnt Cur	CTD	CTD16	Begin	16	16_1	262,3
31/01/2018	11:25:01AM	N 12° 24.33426'	W 69° 9.61692'	N-pnt Cur	CTD	CTD16	Bottom	16	16_1	268,5
31/01/2018	11:45:40AM	N 12° 24.33906'	W 69° 9.6327'	N-pnt Cur	CTD	CTD16	End	16	16_1	272,37
31/01/2018	12:24:09PM	N 12° 23.07126'	W 69° 8.05566'	Windzijde N	Hopper Cam	HC	Deployment	112	112	50,54
31/01/2018	12:26:49PM	N 12° 23.10954'	W 69° 8.08338'	Windzijde N	Hopper Cam	HC	Start Camera	112	112	65,53
31/01/2018	1:15:42 PM	N 12° 23.04396'	W 69° 7.88334'	Windzijde N	Hopper Cam	HC	End Camera	112	112	83,65
31/01/2018	1:21:47 PM	N 12° 23.05806'	W 69° 7.89066'	Windzijde N	Hopper Cam	HC	Recovery	112	112	86,79
31/01/2018	1:57:41 PM	N 12° 22.9884'	W 69° 9.80286'	Westpunt	Hopper Cam	HC	Deployment	113	113	60,8
31/01/2018	2:02:01 PM	N 12° 22.97388'	W 69° 9.8082'	Westpunt	Hopper Cam	HC	Start Camera	113	113	62,38
31/01/2018	2:52:29 PM	N 12° 22.69656'	W 69° 9.83424'	Westpunt	Hopper Cam	HC	End Camera	113	113	57,62
31/01/2018	2:55:18 PM	N 12° 22.68876'	W 69° 9.84888'	Westpunt	Hopper Cam	HC	Recovery	113	113	65,41
31/01/2018	3:53:11 PM	N 12° 18.40428'	W 69° 9.15252'	Santa Cruz	CTD	CTD17	Begin	17	17_1	113,5
31/01/2018	3:55:55 PM	N 12° 18.40476'	W 69° 9.12822'	Santa Cruz	CTD	CTD17	Bottom	17	17_1	97,01
31/01/2018	4:08:25 PM	N 12° 18.38532'	W 69° 9.13206'	Santa Cruz	CTD	CTD17	End	17	17_1	94,66
31/01/2018	6:40:47 PM	N 12° 11.76318'	W 69° 4.80738'	Kap Mari	Hopper Cam	HC	Deployment	18	114	77,35
31/01/2018	6:41:29 PM	N 12° 11.7573'	W 69° 4.80606'	Coral Estate	Hopper Cam	HC	Start Camera	18	114	76,56
31/01/2018	7:03:08 PM	N 12° 11.63286'	W 69° 4.7778'	Coral Estate	Hopper Cam	HC	End Camera	18	114	122,91
31/01/2018	7:09:50 PM	N 12° 11.59278'	W 69° 4.78176'	Coral Estate	Hopper Cam	HC	Recovery	18	114	169,89
31/01/2018	8:07:43 PM	N 12° 9.7239'	W 69° 0.66552'	Vaersenbaai	CTD	CTD19	Begin	19	19_1	100,94
31/01/2018	8:14:29 PM	N 12° 9.73704'	W 69° 0.67788'	Vaersenbaai	CTD	CTD19	Bottom	19	19_1	101,73

31/01/2018	8:22:28 PM	N 12° 9.75006'	W 69° 0.6882'	Vaersenbaai	CTD	CTD19	End	19	19_1	100,15
31/01/2018	8:37:09 PM	N 12° 9.75786'	W 69° 0.64098'	Vaersenbaai	Hopper Cam	HC	Deployment Start	19	115	74,13
31/01/2018	8:40:03 PM	N 12° 9.7635'	W 69° 0.62304'	Vaersenbaai	Hopper Cam	HC	Camera	19	115	68,67
31/01/2018	9:22:08 PM	N 12° 9.51468'	W 69° 0.41766'	Vaersenbaai	Hopper Cam	HC	End Camera	19	115	77,19
31/01/2018	9:32:10 PM	N 12° 9.09018'	W 69° 0.3822'	Vaersenbaai	Hopper Cam	HC	Recovery	19	115	181,59
31/01/2018	11:16:31PM	N 12° 3.57792'	W 68° 51.59514'	Sp Water	CTD	CTD20	Begin	20	20_1	222,77
31/01/2018	11:26:10PM	N 12° 3.59616'	W 68° 51.61386'	Sp Water	CTD	CTD20	Bottom	20	20_1	215,01
31/01/2018	11:41:25PM	N 12° 3.57444'	W 68° 51.62172'	Sp Water	CTD	CTD20	End	20	20_1	234,41
01/02/2018	12:54:21AM	N 12° 2.51706'	W 68° 46.77414'	Awa Blancu	Hopper Cam	HC	Deployment Start	116	116	56,85
01/02/2018	12:55:04AM	N 12° 2.51796'	W 68° 46.78074'	Awa Blancu	Hopper Cam	HC	Camera	116	116	52,12
01/02/2018	1:07:31 AM	N 12° 2.5824'	W 68° 46.5786'	Awa Blancu	Hopper Cam	HC	End Camera	116	116	62,38
01/02/2018	1:09:25 AM	N 12° 2.56818'	W 68° 46.56816'	Awa Blancu	Hopper Cam	HC	Recovery	116	116	82,07
01/02/2018	1:42:04 AM	N 12° 2.4294'	W 68° 46.91928'	Awa Blancu	Hopper Cam	HC	Deployment Start	117	117	61,59
01/02/2018	1:44:17 AM	N 12° 2.44896'	W 68° 46.92108'	Awa Blancu	Hopper Cam	HC	Camera	117	117	42,65
01/02/2018	2:26:08 AM	N 12° 2.55894'	W 68° 46.25952'	Awa Blancu	Hopper Cam	HC	End Camera	117	117	78,14
01/02/2018	2:28:36 AM	N 12° 2.514'	W 68° 46.26192'	Awa Blancu	Hopper Cam	HC	Recovery	117	117	144,07
01/02/2018	11:07:34AM	N 12° 11.52408'	W 68° 52.81746'	Boka Play'i Kanoa	CTD	CTD21	Begin	21	21_1	252,05
01/02/2018	11:15:11AM	N 12° 11.5107'	W 68° 52.84086'	Boka Play'i Kanoa	CTD	CTD21	Bottom	21	21_1	247,48
01/02/2018	11:31:06AM	N 12° 11.5014'	W 68° 52.8705'	Boka Play'i Kanoa	CTD	CTD21	End	21	21_1	245,88
01/02/2018	12:15:45PM	N 12° 10.84842'	W 68° 52.79052'	Boka Play'i Kanoa	Hopper Cam	HC	Deployment Start	118	118	64,74
01/02/2018	12:16:16PM	N 12° 10.8504'	W 68° 52.7826'	Boka Play'i Kanoa	Hopper Cam	HC	Camera	118	118	63,9
01/02/2018	1:59:15 PM	N 12° 10.87746'	W 68° 51.79464'	Boka Play'i Kanoa	Hopper Cam	HC	End Camera	118	118	80,5
01/02/2018	2:02:25 PM	N 12° 10.90302'	W 68° 51.8658'	Boka Play'i Kanoa	Hopper Cam	HC	Recovery	118	118	80,5
01/02/2018	4:04:16 PM	N 12° 6.52344'	W 68° 47.43282'	Boka Play'i Kanoa	Hopper Cam	HC	Deployment Start	118	118	84,43
01/02/2018	4:04:56 PM	N 12° 6.52704'	W 68° 47.43798'	Boka Play'i Kanoa	Hopper Cam	HC	Camera	118	118	83,65
01/02/2018	4:24:39 PM	N 12° 6.47904'	W 68° 47.39406'	Boka Play'i Kanoa	Hopper Cam	HC	End Camera	118	118	89,15
01/02/2018	4:29:41 PM	N 12° 6.50772'	W 68° 47.3607'	Boka Play'i Kanoa	Hopper Cam	HC	Recovery	118	118	95,98
01/02/2018	6:10:05 PM	N 12° 2.2911'	W 68° 44.37426'	Awa di Oostpnt	Hopper Cam	HC	Deployment Start	22	120	105,65
01/02/2018	6:13:07 PM	N 12° 2.3061'	W 68° 44.34048'	Awa di Oostpnt	Hopper Cam	HC	Camera	22	120	87,58
01/02/2018	6:33:19 PM	N 12° 2.4039'	W 68° 44.23464'	Awa di Oostpnt	Hopper Cam	HC	End Camera	22	120	66,67
01/02/2018	6:36:53 PM	N 12° 2.35296'	W 68° 44.20794'	Awa di Oostpnt	Hopper Cam	HC	Recovery	22	120	74,65
01/02/2018	6:48:02 PM	N 12° 2.04624'	W 68° 44.1354'	Oostpunt	CTD	CTD22	Begin	22	22_1	244,49
01/02/2018	7:01:39 PM	N 12° 2.06946'	W 68° 44.1357'	Oostpunt	CTD	CTD22	Bottom	22	22_1	230,53

01/02/2018	7:15:57 PM	N 12° 2.06844'	W 68° 44.12232'	Oostpunt	CTD	CTD22	End	22	22_1	233,64
01/02/2018	8:58:46 PM	N 12° 6.24306'	W 68° 56.85'	Annabaai	CTD	CTD23	Begin	23	23_1	115,07
01/02/2018	9:03:19 PM	N 12° 6.23616'	W 68° 56.85834'	Annabaai	CTD	CTD23	Bottom	23	23_1	121,2
01/02/2018	9:18:07 PM	N 12° 6.21624'	W 68° 56.85594'	Annabaai	CTD	CTD23	End	23	23_1	139,37
02/02/2018	11:11:09AM	N 12° 23.45166'	W 69° 50.6613'	SE pnt Aruba	CTD	CTD24	Begin	24	24_1	220,45
02/02/2018	11:15:26AM	N 12° 23.4684'	W 69° 50.72352'	SE pnt Aruba	CTD	CTD24	Bottom	24	24_1	202,16
02/02/2018	11:32:22AM	N 12° 23.48538'	W 69° 50.76738'	SE pnt Aruba	CTD	CTD24	End	24	24_1	191,28
02/02/2018	12:11:49PM	N 12° 26.5521'	W 69° 51.32322'	Boka Grandi	Hopper Cam	HC	Deployment	121	121	85,22
02/02/2018	12:15:11PM	N 12° 26.54976'	W 69° 51.3153'	Boka Grandi	Hopper Cam	HC	Start Camera	121	121	86,01
02/02/2018	12:18:57PM	N 12° 26.51322'	W 69° 51.30474'	Boka Grandi	Hopper Cam	HC	End Camera	121	121	82,07
02/02/2018	12:22:12PM	N 12° 26.54898'	W 69° 51.33762'	Boka Grandi	Hopper Cam	HC	Recovery	121	121	83,65
02/02/2018	5:29:36 PM	N 12° 35.66178'	W 70° 6.47172'	Palm Beach	CTD	CTD25	Begin	25	25_1	79,61
02/02/2018	5:34:45 PM	N 12° 35.65836'	W 70° 6.50424'	Palm Beach	CTD	CTD25	Bottom	25	25_1	82,4
02/02/2018	5:45:21 PM	N 12° 35.66124'	W 70° 6.46884'	Palm Beach	CTD	CTD25	End	25	25_1	79,63

Appendix 2. CTD sampling

Cruise: 64PE430	Date: 25 Jan 2018
Station: 01 CTD Cast: 01	Start time (UTC):
CTD file name*: PE4 _ S01C01	Bottom depth CTD [m]: 207
LADCP file name**:	Altimeter at bottom [m]:
Latitude: 12° 7.261' N	CTD operator: Bob
Longitude: 68° 58.460' W	Sample: Piscaderabaai

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	237	X			X	X	X	X			X	
2	219.2										X	
3	196.5										X	
4	176.7										X	
5	162.8										X	
6	135										X	
7	100	X			X	X	X	X			X	
8	85										X	
9	71										X	
10	59										X	
11	44										X	
12	4.7	X			X	X	X	X			X	

Cruise: 64PE430	Date: 26 Jan 2018
Station: 02 CTD Cast: 09	Start time (UTC): 19:20
CTD file name*: PE430 _ 30s02c09	Bottom depth CTD [m]: 61
LADCP file name**:	Altimeter at bottom [m]: 3.5
Latitude: 12° 8.803' N	CTD operator: Bob
Longitude: 68°16.733' W	Sample: Kralendijk 1, Bon

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	65	X	X	X	X	X	X				X	
2	55	X	X	X	X	X	X				X	
3	6	X	X	X	X	X	X	X			X	

Cruise: 64PE430	Date: 26 Jan 2018
Station: 03 CTD Cast: 01	Start time (UTC): 22:49
CTD file name*: PE430 _s03c01	Bottom depth CTD [m]: 303
LADCP file name**:	Altimeter at bottom [m]:
Latitude: 12° 7.632' N	CTD operator: Bob
Longitude: 68° 17.980' W	Sample: Nabij Punt Vierkant, Bon

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	280	X		X		X	X				X	bottom
2	170	X		X							X	
3	130	X		X							X	
4	98	X		X							X	
5	67	X		X		X	X				X	Chl max
6	5	X		X		X	X				X	surface

Cruise: 64PE430	**Date: 27 Jan 2018**
Station: 04 CTD Cast: 02	**Start time (UTC): 11:15**
CTD file name*: PE430 _s04c02	**Bottom depth CTD [m]: 78**
LADCP file name:**	**Altimeter at bottom [m]: 1**
Latitude: 12° 9.190' N	**CTD operator: Bob**
Longitude: 68° 16.856' W	**Sample: Kralendijk 2, Bon**

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	78	X	X	X	X	X	X	X			X	bottom
2	59	X	X	X	X	X	X					
3	4	X	X	X	X	X	X				X	surf

Cruise: 64PE430	**Date: 27 Jan 2018**
Station: 05 CTD Cast: 01	**Start time (UTC): 17:44**
CTD file name*: PE430 _s05c01	**Bottom depth CTD [m]: 255**
LADCP file name:**	**Altimeter at bottom [m]: 5**
Latitude: 12° 11.592' N	**CTD operator: Bob**
Longitude: 68° 18.816' W	**Sample: Barcadera, Bon**

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	250	X			X			X			X	bottom
2	199	X									X	
3	165	X									X	
4	110	X									X	
5	60	X			X						X	Chl max
6	5	X			X						X	surf

Cruise: 64PE430	**Date: 27 Jan 2018**
Station: 06 CTD Cast: 02	**Start time (UTC): 19:28**
CTD file name*: PE430 _ s06c02	**Bottom depth CTD [m]: 62**
LADCP file name:**	**Altimeter at bottom [m]:**
Latitude: 12° 8.581' N	**CTD operator: Bob**
Longitude: 68° 16.704' W	**Sample: Kralendijk 3, Bon**

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	65	X	X	X	X	X	X					bottom
2	56	X	X	X	X	X	X					
3	3	X	X	X	X	X	X					surf

Cruise: 64PE430	**Date: 27 Jan 2018**
Station: 07 CTD Cast: 01	**Start time (UTC): 23:45**
CTD file name*: PE430 _ s07c01	**Bottom depth CTD [m]: 280**
LADCP file name:**	**Altimeter at bottom [m]: 3**
Latitude: 12° 13.365' N	**CTD operator: Bob**
Longitude: 68° 24.716' W	**Sample: Wecua, Bon**

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	280	X						X				bottom
2	98	X										
3	60	X										Chl max
4	5	X			X							surf

Cruise: 64PE430	**Date: 28 Jan 2018**
Station: 08 CTD Cast: 02	**Start time (UTC): 10:35**
CTD file name*: PE430 _ s08c02	**Bottom depth CTD [m]: 63**
LADCP file name:**	**Altimeter at bottom [m]:**
Latitude: 12° 8.407' N	**CTD operator: Bob**
Longitude: 68° 16.715' W	**Sample: Kralendijk 4, Bon**

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Io-nen	Isotopen H20	Remarks
1	61	X	X	X	X	X	X					bottom
2	55	X	X	X	X	X	X					
3	5	X	X	X	X	X	X					surf

Cruise: 64PE430	**Date: 28 Jan 2018**
Station: 09 CTD Cast: 01	**Start time (UTC): 16:00**
CTD file name*: PE430 _S09C01	**Bottom depth CTD [m]: 99**
LADCP file name:**	**Altimeter at bottom [m]: 3**
Latitude: 12° 8.710' N	**CTD operator: Bob**
Longitude: 68° 19.892' W	**Sample: SW corner Kl Bonaire**

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	97	X						X			X	bottom
2	73	X									X	
3	65	X									X	
4	59	X									X	
5	54	X									X	
6	46	X									X	
7	38	X									X	
8	25	X									X	
9	15	X									X	
10	5	X									X	surface

Cruise: 64PE430	**Date: 28 Jan 2018**
Station: 10 CTD Cast: 04	**Start time (UTC): 21:02**
CTD file name*: PE430 _S10C04	**Bottom depth CTD [m]: 69**
LADCP file name:**	**Altimeter at bottom [m]: 3**
Latitude: 12° 8.406' N	**CTD operator: Bob**
Longitude: 68° 16.741' W	**Sample: Kralendijk 5, Bon**

NISKIN	Sampling	NUTS	TP	DIC alk	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	69	X						X				
2	53	X	X	X	X	X	X					
3	45	X										
4	42	X	X	X	X	X	X					
5	35	X										
6	25	X										
7	15	X										
8	5	X	X	X	X	X	X					

Cruise: 64PE430	Date: 28 Jan 2018
Station: 11 CTD Cast: 01	Start time (UTC): 22:53
CTD file name*: PE430 _S11C01	Bottom depth CTD [m]: 256
LADCP file name**:	Altimeter at bottom [m]: 5
Latitude:12° 4.652’ N	CTD operator: Bob
Longitude: 68° 17.454’ W	Sample: Tori’s Reef, Bon

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	252	X										bottom
2	74	X										Chl max
3	58	X										
4	52	X										
5	46	X										
6	30	X										
7	24	X										
8	15	X										
9	5	X										

Cruise: 64PE430	Date: 29 Jan 2018
Station: 12 CTD Cast: 02	Start time (UTC): 10:40
CTD file name*: PE430 _ s12c02	Bottom depth CTD [m]: 63
LADCP file name**:	Altimeter at bottom [m]:
Latitude: 12° 8.407’ N	CTD operator: Bob
Longitude: 68° 16.718’ W	Sample: Kralendijk 6, Bon

NISKIN	Sampling depth	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	64	X						X			X	bottom
2	53	X	X	X	X	X	X				X	
3	44	X	X	X	X	X	X				X	
1	34	X									X	
2	24	X									X	
3	15	X									X	
3	5	X	X	X	X	X	X				X	surf

Cruise: 64PE430	Date: 29 Jan 2018
Station: 13 CTD Cast: 03	Start time (UTC): 17:32
CTD file name*: PE430 _ s13c03	Bottom depth CTD [m]: 141
LADCP file name**:	Altimeter at bottom [m]: 3
Latitude: 12° 15.983’ N	CTD operator: Bob
Longitude: 68° 24.986’ W	Sample: Slagbaai, Bon

* CTD file name: PE400_CTD_cc_Station_ ss (cc = CTD cast number, ss = station number from bridge)

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	139	X						X				Bottom
2	99	X										
3	65	X			X	X	X					Chl max
4	58	X			X	X	X					
5	35	X										
6	5	X			X	X	X					

Cruise: 64PE430	Date: 29 Jan 2018
Station: 14 CTD Cast: 01	Start time (UTC): 21:15
CTD file name*: PE430 _ s14c01	Bottom depth CTD [m]: 126
LADCP file name**:	Altimeter at bottom [m]: 6
Latitude: 12° 13.500’ N	CTD operator: Bob
Longitude: 68° 11.425’ W	Sample: Oostpunt, Bon

NISKIN	Sampling depth	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	110	X						X				bottom
2	84	X										Sal max
3	59	X			X	X	X					
4	40	X										
5	28	X			X	X	X					
6	5	X			X	X	X					

Cruise: 64PE430	Date: 30 Jan 2018
Station: 15 CTD Cast: 02	Start time (UTC): 10:42
CTD file name*: PE430 _ s15c02	Bottom depth CTD [m]: 60
LADCP file name**:	Altimeter at bottom [m]: 3
Latitude: 12° 9.413’ N	CTD operator: Bob
Longitude: 68° 16.927’ W	Sample: Kralendijk 7, Bon

* CTD file name: PE400_CTD_cc_Station_ ss (cc = CTD cast number, ss = station number from bridge)

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Io-nen	Isotopen H20	Remarks
1	59	X										bottom
2	50	X			X	X	X					
3	43	X			X	X	X					
4	5	X			X	X	X					

Cruise: 64PE430	Date: 31 Jan 2018
Station: 16 CTD Cast: 01	Start time (UTC): 11:18
CTD file name*: PE430 _ s16c01	Bottom depth CTD [m]: 281
LADCP file name**:	Altimeter at bottom [m]: 3
Latitude: 12° 24.336’ N	CTD operator: Bob
Longitude: 69° 9.595’ W	Sample: Noordpunt, Cur

NISKIN	Sampling depth	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	274	X							X			bottom
2	150	X							X			
3	100	X			X				X			
4	80	X							X			
5	70	X			X				X			Chl max
6	44	X							X			
7	25	X							X			
8	5	X			X				X			

Cruise: 64PE430	Date: 31 Jan 2018
Station: 17 CTD Cast: 01	Start time (UTC): 15:53
CTD file name*: PE430 _ s17c01	Bottom depth CTD [m]: 105
LADCP file name**:	Altimeter at bottom [m]: 2
Latitude: 12° 18.409’ N	CTD operator: Bob
Longitude: 69° 9.142’ W	Sample: Santa Cruz, Cur

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow cytometr	Rd	pH	Ionen	Isotopen H20	Remarks
1	110	X							X			bottom
2	72	X			X				X			
3	59	X							X			
4	52	X			X				X			Chl max
5	38	X							X			
6	4	X			X				X			

Cruise: 64PE430	Date: 31 Jan 2018
Station: 19 CTD Cast: 01	Start time (UTC): 20:06
CTD file name*: PE430 _ s19c01	Bottom depth CTD [m]: 125
LADCP file name**:	Altimeter at bottom [m]: 5
Latitude: 12° 9.721' N	CTD operator: Bob
Longitude: 69° 0.654' W	Sample: Vaersenbaai, Cur

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	123	X										bottom
2	65	X			X							
3	51	X			X							
4	38	X										
5	5	X			X							

Cruise: 64PE430	Date: 31 Jan 2018
Station: 20 CTD Cast: 01	Start time (UTC): 23:16
CTD file name*: PE430 _ s20c01	Bottom depth CTD [m]: 234
LADCP file name**:	Altimeter at bottom [m]: 3
Latitude: 12° 3.578' N	CTD operator: Bob
Longitude: 68° 51.588' W	Sample: Spaanse water, Cur

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	235	X							X			
2	200	X							X			
3	109	X							X			
4	87	X			X				X			
5	73	X							X			
6	61	X			X				X			Chl max
7	46	X							X			
8	5	X			X				X			

Cruise: 64PE430	Date: 1 Feb 2018
Station: 21 CTD Cast: 01	Start time (UTC): 11:05
CTD file name*: PE430 _ s21c01	Bottom depth CTD [m]: 252
LADCP file name**:	Altimeter at bottom [m]: 4
Latitude: 12° 11.528' N	CTD operator: Bob
Longitude: 68° 52.820' W	Sample: Boka Play'I Kanoa, Cur

NISKIN	Sampling depth	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	242	X		X					X			Bottom
2	146	X		X					X			
3	106	X		X					X			
4	81	X		X					X			
5	64	X		X	X				X			Chl max
6	40	X		X	X				X			
7	21	X		X					X			
8	5	X		X	X				X			

Cruise: 64PE430	Date: 01 Feb 2018
Station: 22 CTD Cast: 01	Start time (UTC): 18:50
CTD file name*: PE430 _S22C01	Bottom depth CTD [m]: 247
LADCP file name**:	Altimeter at bottom [m]: 3.5
Latitude: 12° 2.054' N	CTD operator: Bob
Longitude: 68° 44.126 W'	Sample: Awa di Oostpunt, Cur

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	244	X										Bottom
2	166	X										
3	112	X			X							
4	76	X										
5	62	X			X							Chl a max
6	44	X										
7	24	X										
8	5	X			X							

Cruise: 64PE430	Date: 01 Feb 2018
Station: 23 CTD Cast: 01	Start time (UTC): 20:58
CTD file name*: PE430 _S23C01	Bottom depth CTD [m]: 142
LADCP file name**:	Altimeter at bottom [m]: 2
Latitude: 12° 6.0239' N	CTD operator: Bob
Longitude: 68° 56.845' W	Sample: Annabaai, Cur

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	139	X							X			Bottom
2	100	X			X				X			
3	78	X			X				X			
4	65	X							X			
5	46	X							X			
6	25	X							X			
7	5	X			X				X			

Cruise: 64PE430	Date: 02 Feb 2018
Station: 24 CTD Cast: 01	Start time (UTC): 11:10
CTD file name*: PE430 _S24C01	Bottom depth CTD [m]: 204
LADCP file name**:	Altimeter at bottom [m]: 4
Latitude: 12° 23.453' N	CTD operator: Bob
Longitude: 68° 50.654' W	Sample: Zuidpunt, Aruba

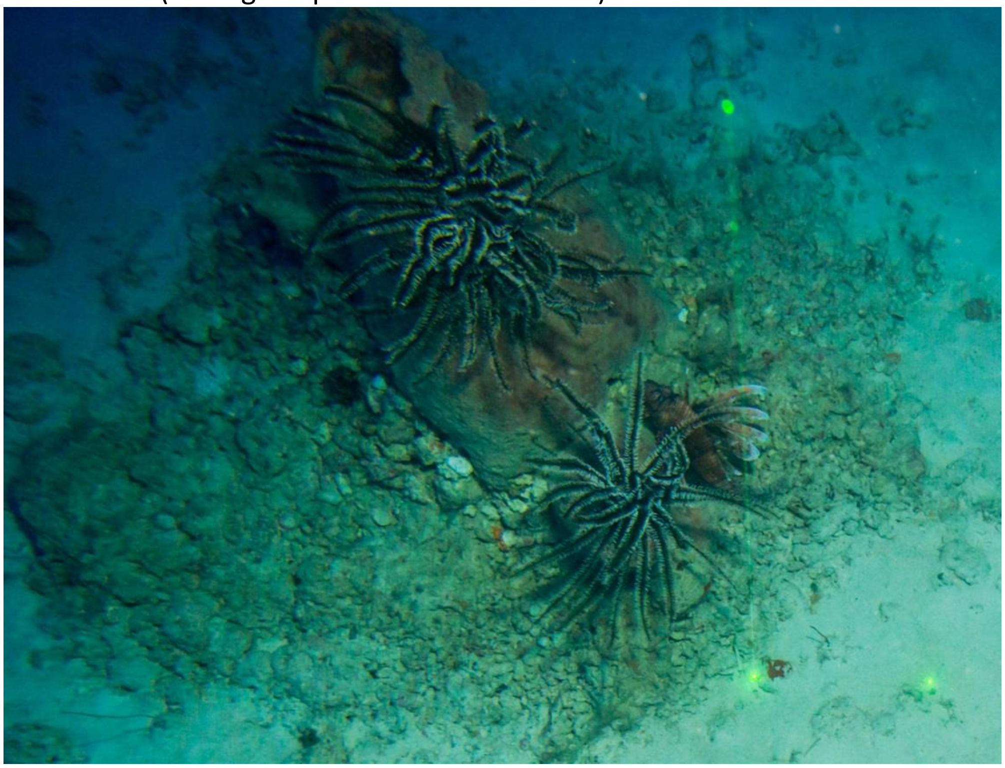
NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	197	X							X	X	X	Bottom
2	149	X			X				X	X	X	
3	100	X							X	X	X	
4	64	X			X				X	X	X	
5	39	X			X				X	X	X	Chl Max
6	19	X							X	X	X	
7	6	X			X				X	X	X	

Cruise: 64PE430	Date: 02 Feb 2018
Station: 25 CTD Cast: 01	Start time (UTC): 11:10
CTD file name*: PE430 _S25C01	Bottom depth CTD [m]: 204
LADCP file name**:	Altimeter at bottom [m]: 4
Latitude: 12° 35.675' N	CTD operator: Bob
Longitude: 70° 6.469' W	Sample: Zuidpunt, Aruba

NISKIN	Sampling	NUTS	TP	DIC	TOC TN	POM	Flow	Rd	pH	Ionen	Isotopen H20	Remarks
1	78	X			X				X	X		Bottom
2	39	X			X				X	X		
3	16	X			X				X	X		
4	5	X			X				X	X		

Appendix 3. Pictures from the hopper frame.

Station 101 (average depth of transect is 74m)

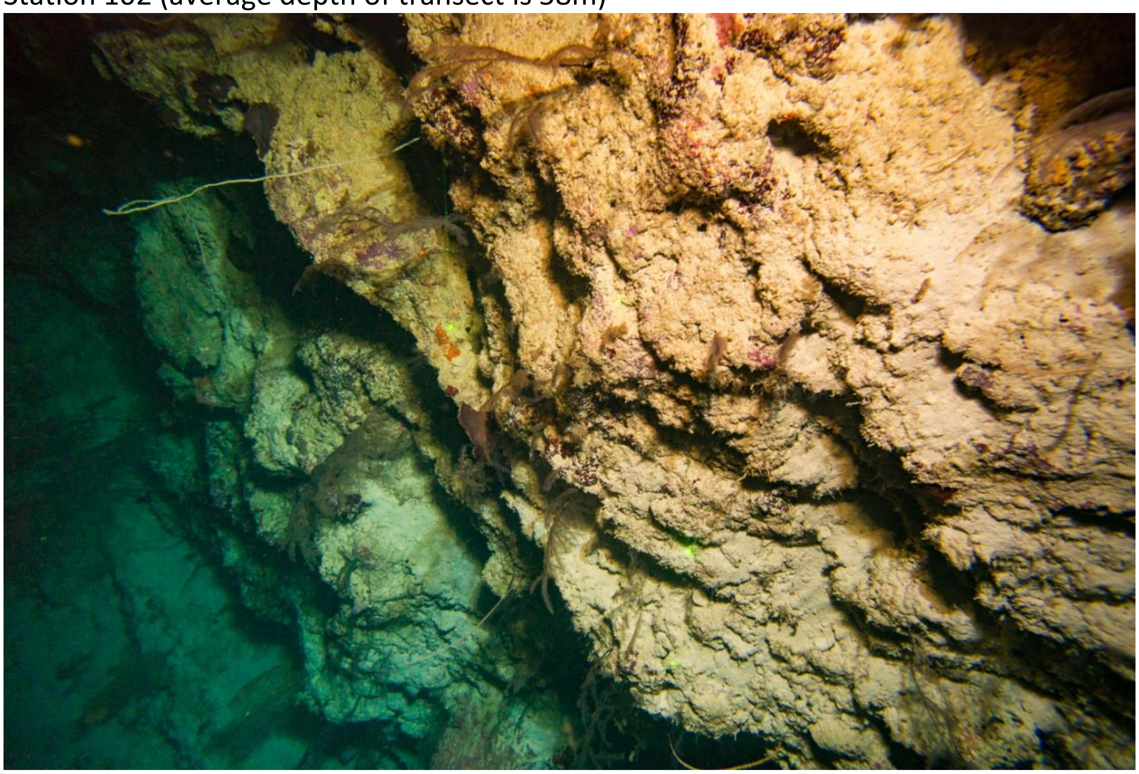


Large brittle crinoids (Nemaster grandis) on sparse rocky substrates.

Rocky outcrops attract fish and predators such as these three lion fish (Pterois volitans).

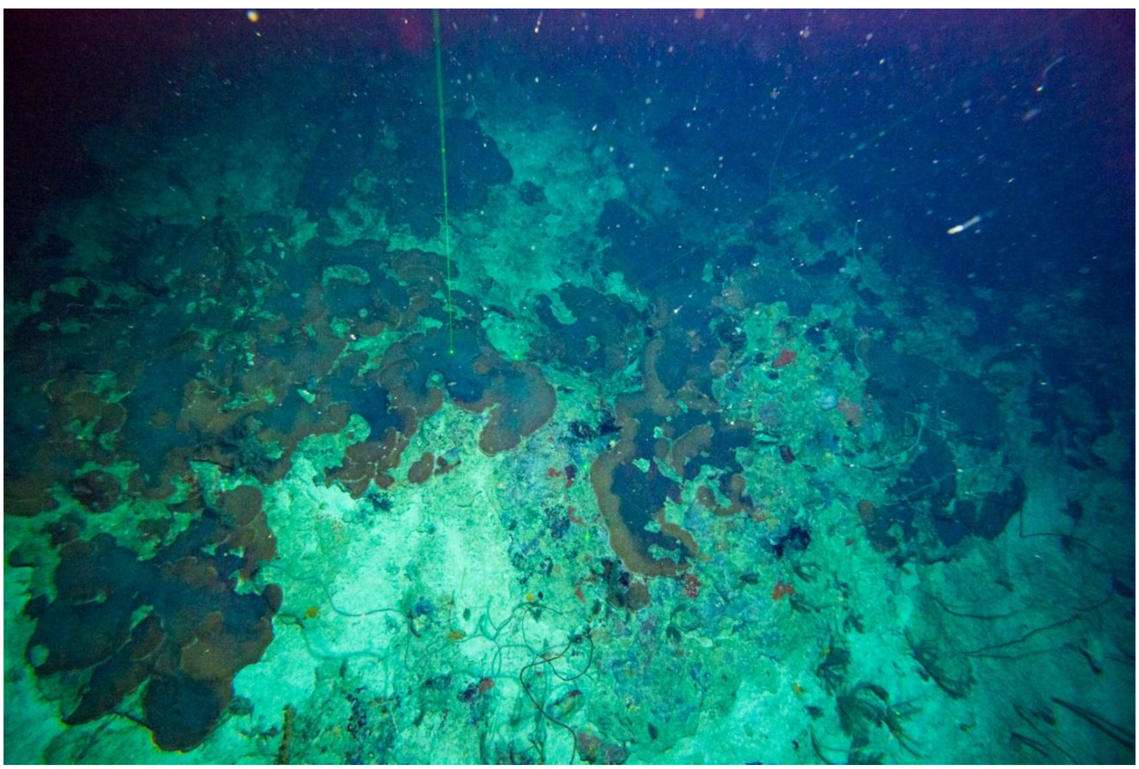
Benthic cyanobacterial mats in front of Kralendijk.

Station 102 (average depth of transect is 58m)



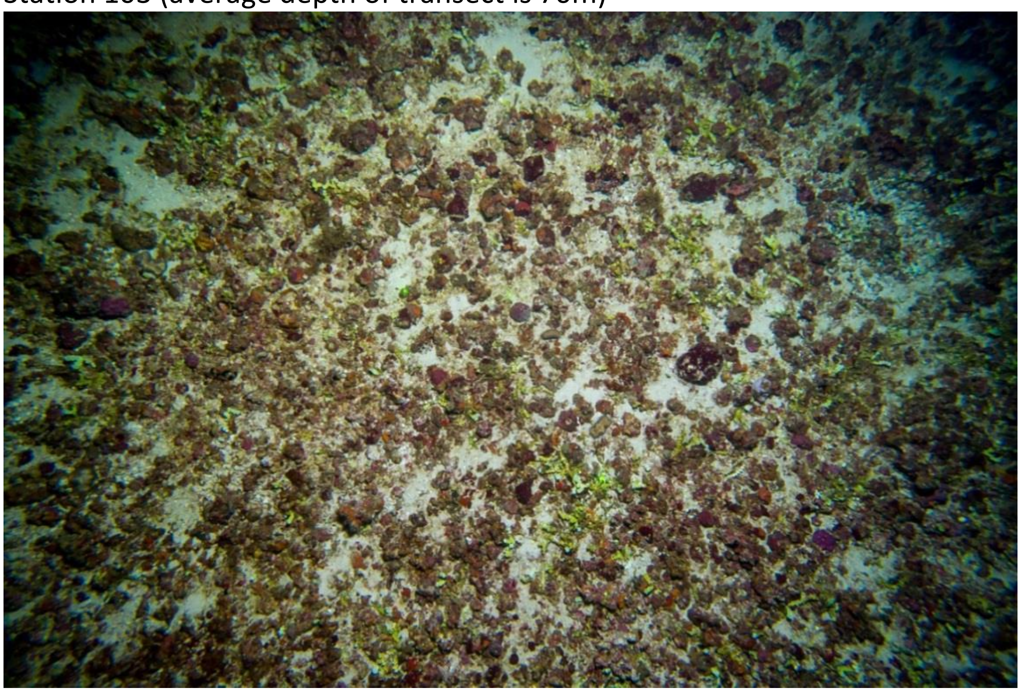
Deep, steep overhangs probably build-ups by crustose coralline algae can be observed.

Hard substratum is quickly colonized by sponges, crustose coralline algae and black coral.

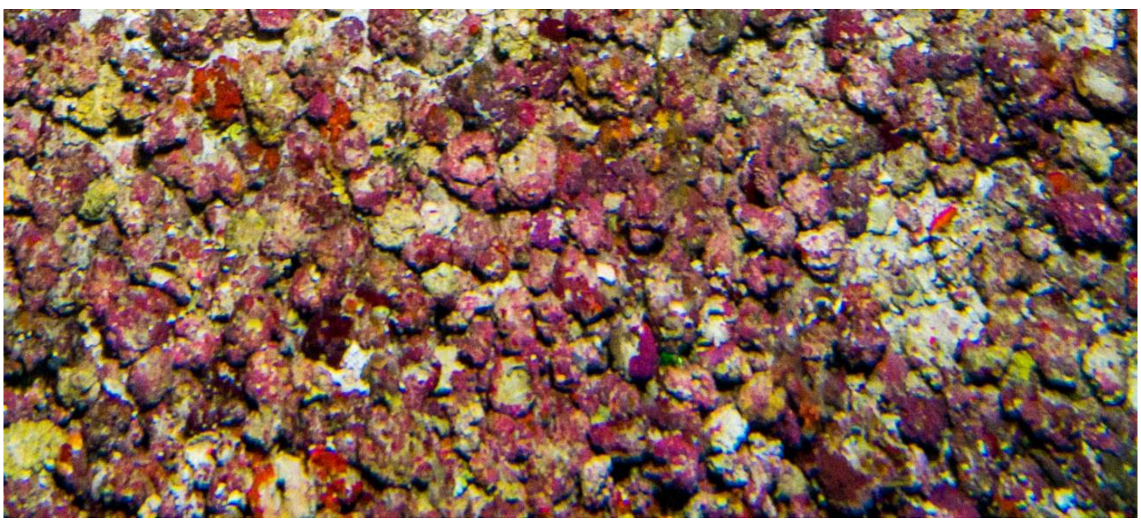

In some areas large parts of the bottom are covered by plate corals.

Sometimes large sponges (Xestopongia spec) can be observed.

Station 103 (average depth of transect is 70m)


Large fields with Rhodoliths are found on this side of the island. They are mixed with sponges and calcareous algae like Halimeda spec. Rhodoliths are colorful, unattached, branching, crustose, benthic marine red algae that resemble coral. Rhodolith beds create biogenic habitat for diverse benthic communities.

	
A rhodolith.	*Close –up of a rhodolith in which one can see that it is made up of a large number of species.*

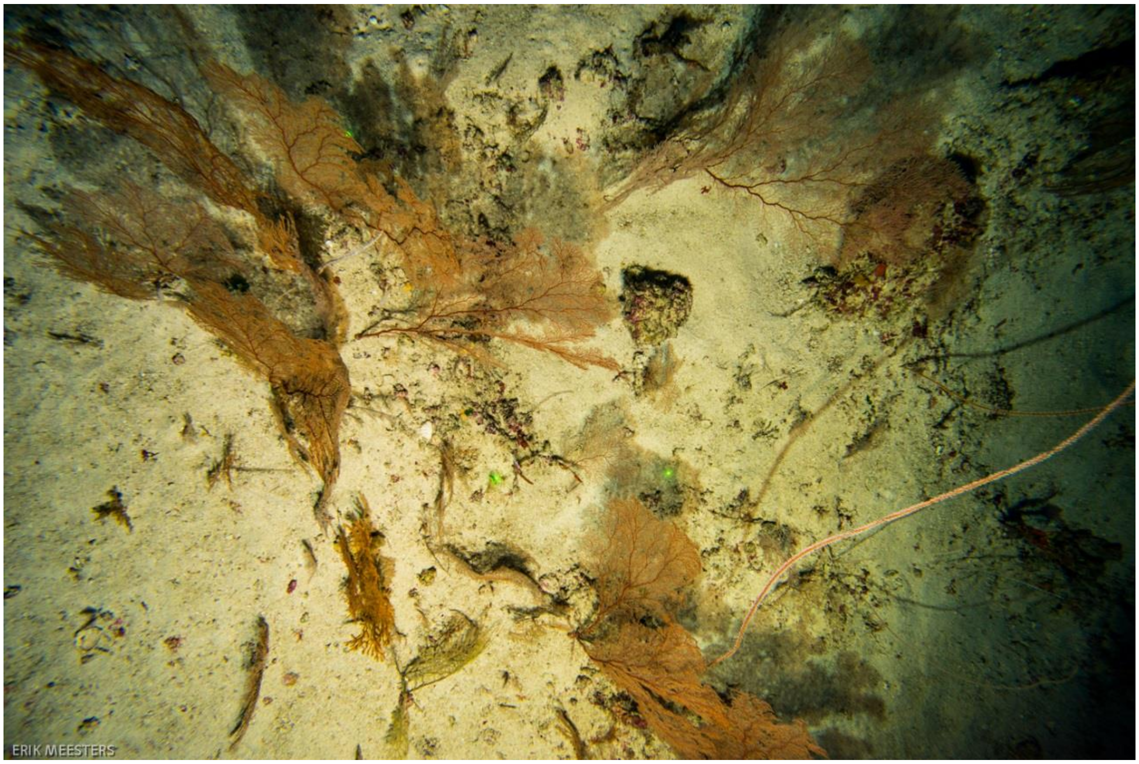


Rhodoliths can be found in very high densities on this track.

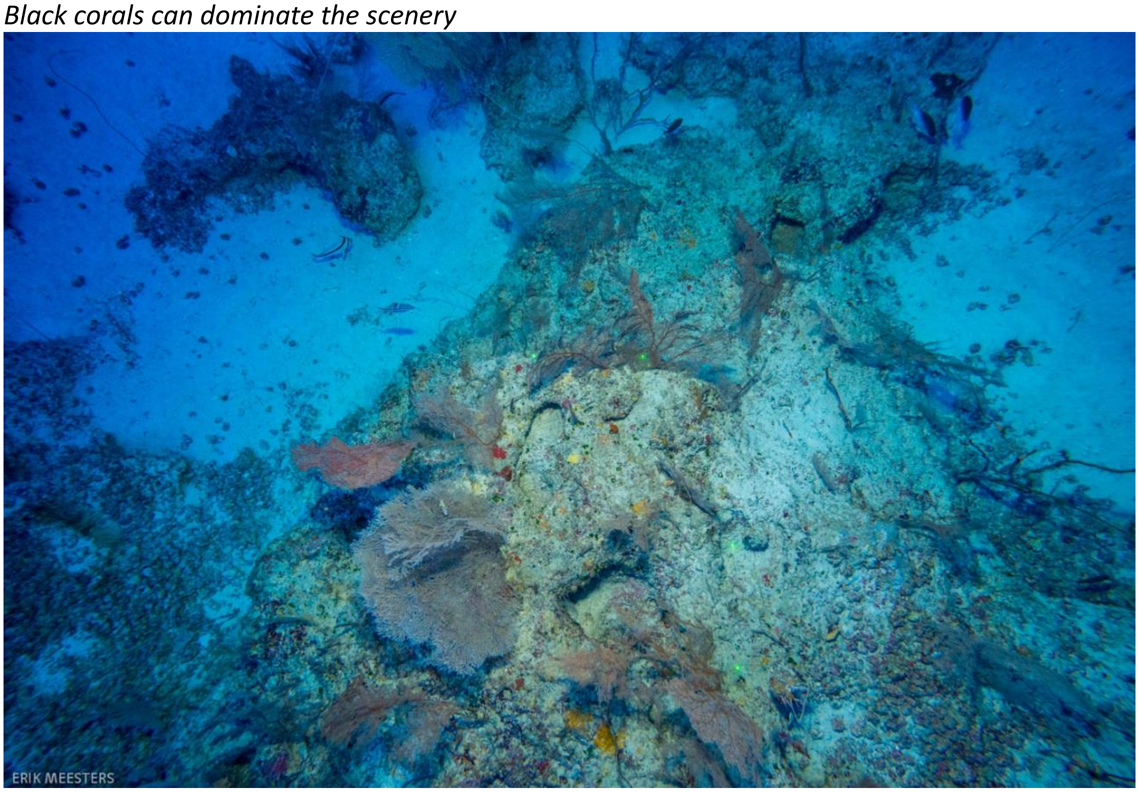
Station 104 (average depth of transect is 74m)

Around 70m there are colorful soft corals on hard bottom that protrude from a mostly sandy bottom.

Sometimes the sand is covered by many rhodolitic stones.

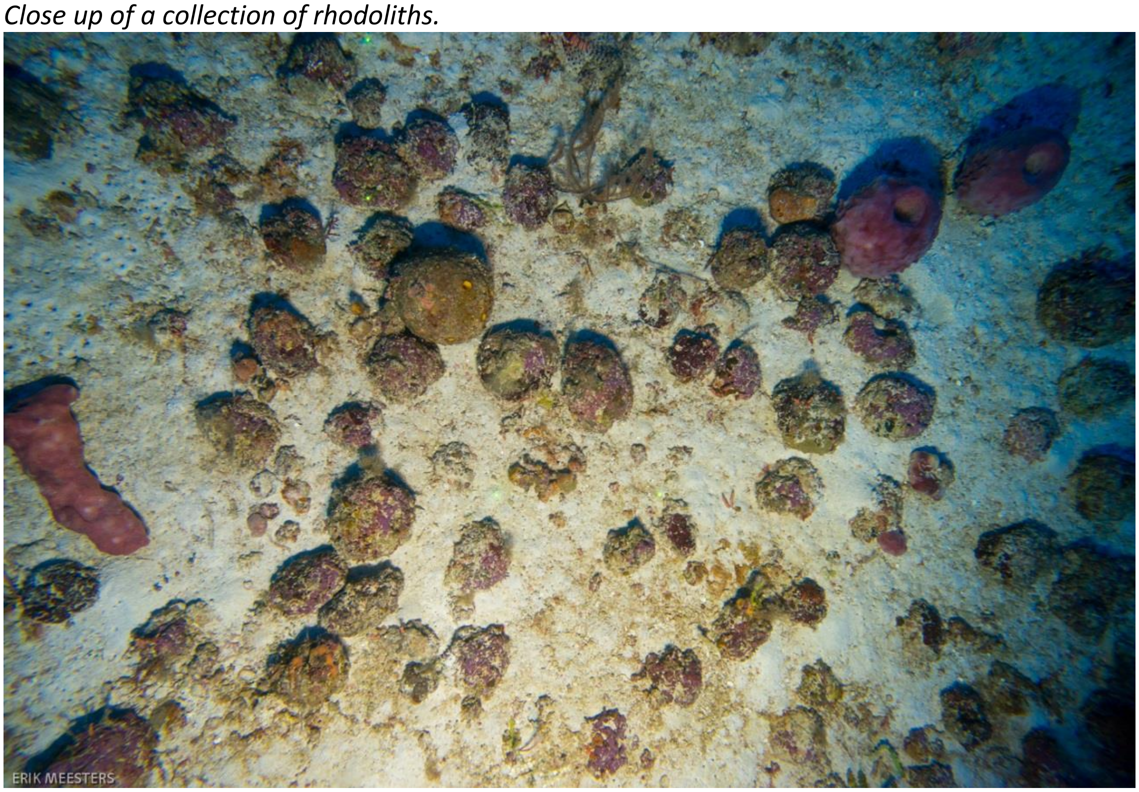


Black corals can dominate the scenery



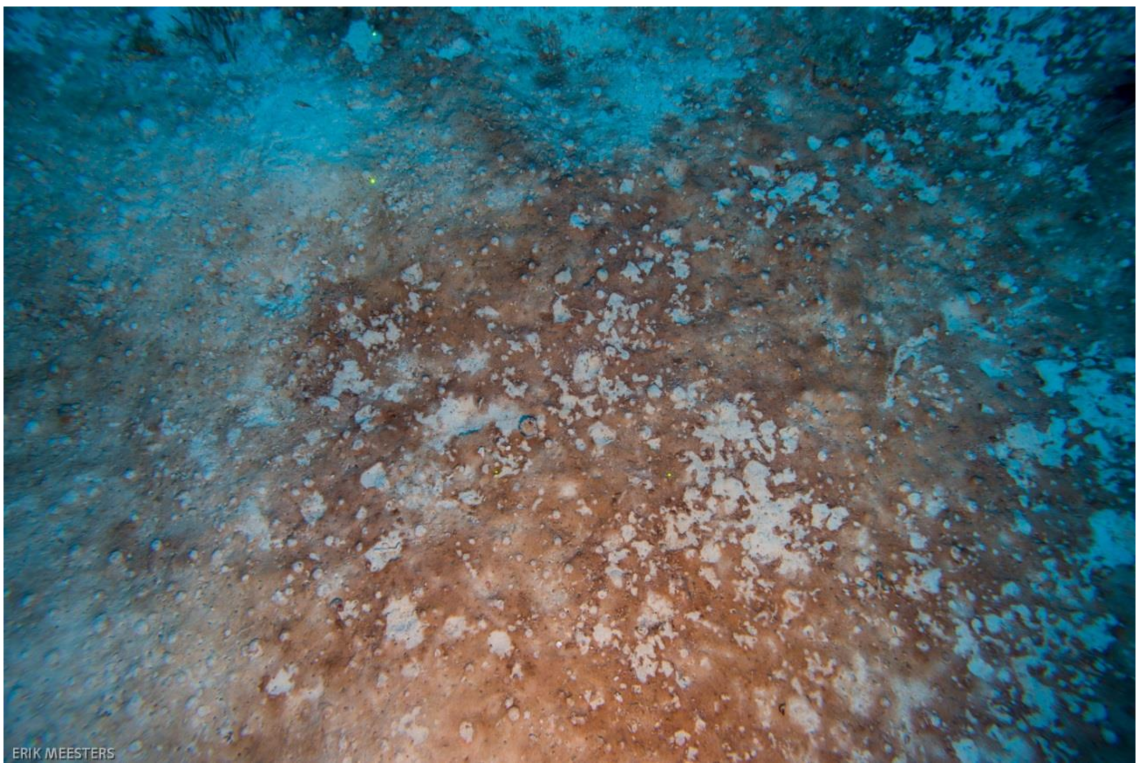
Hard bottom outcrops provide substrate for fish to hide and for soft corals to attach to.

Close up of a collection of rhodoliths.

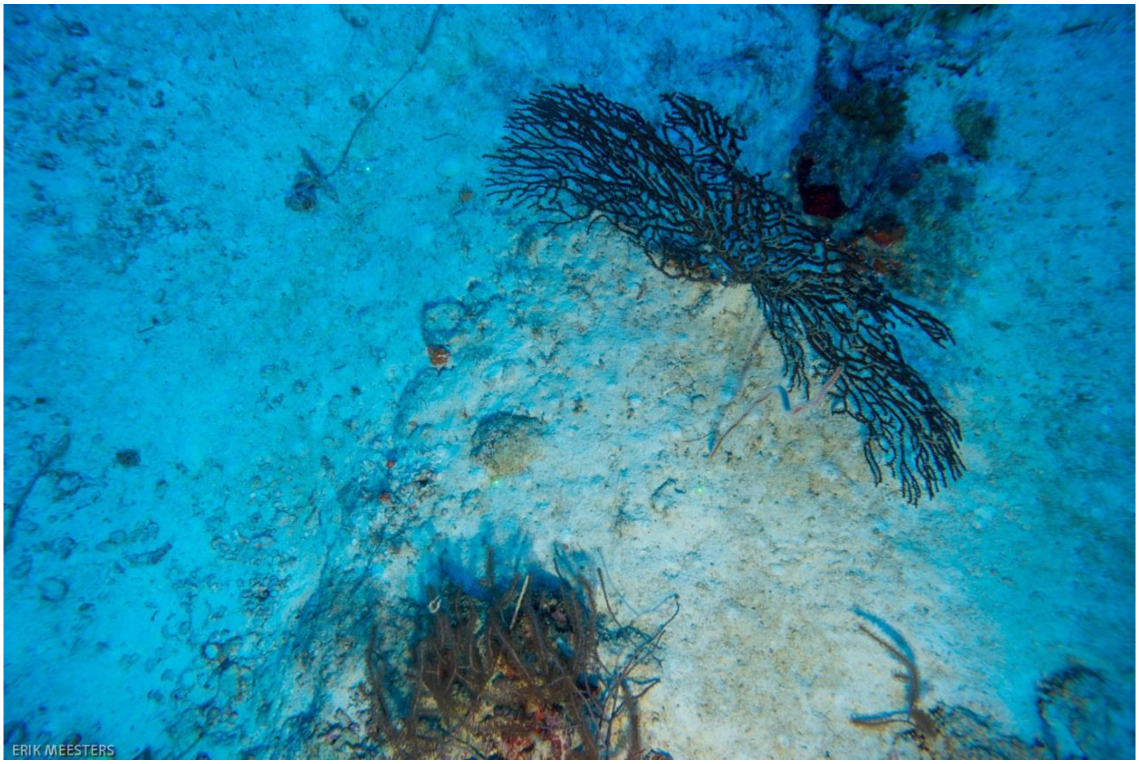


In some places the rhodoliths are more spread out equally and interspersed with sponges.

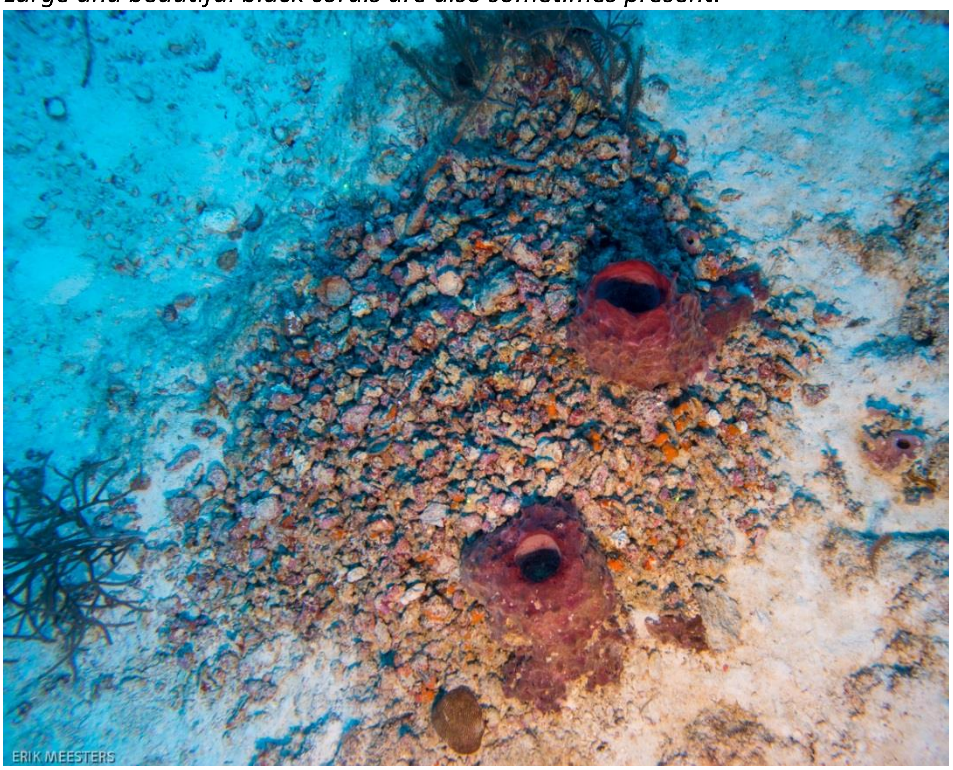
Like previous picture, but with a large Xestospongia muta sponge.



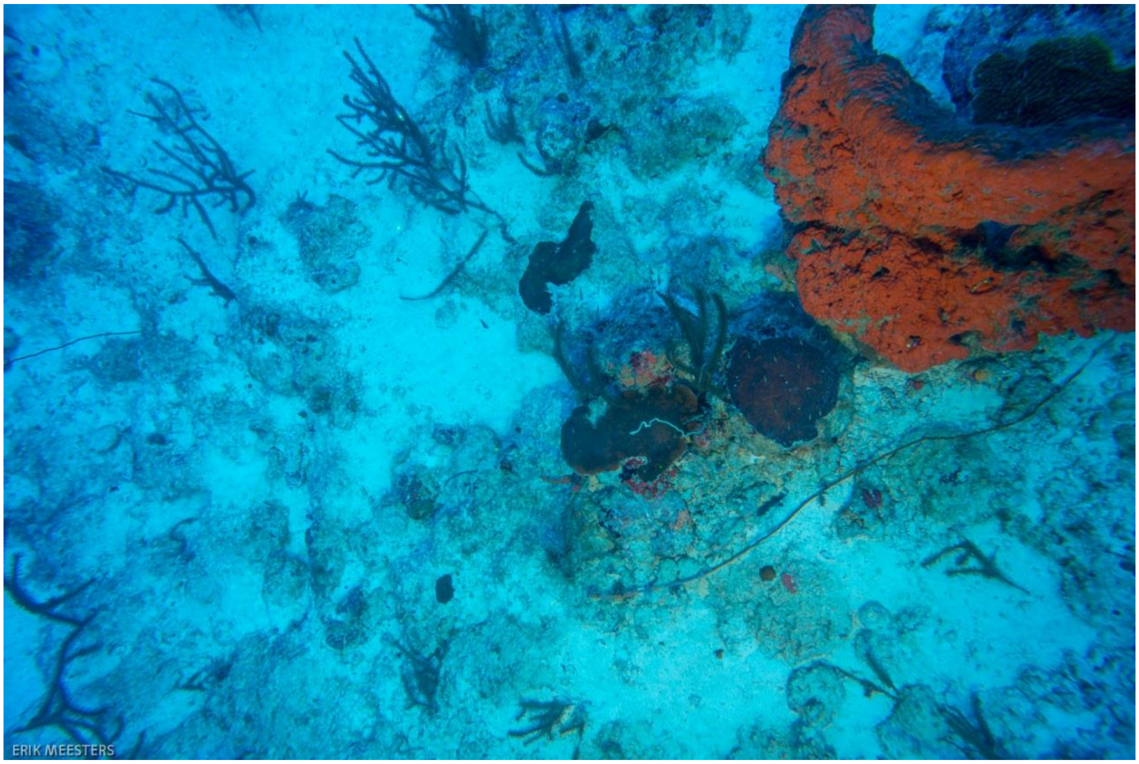
In the more shallow areas of the photo transect around 45m the bottom is in places strongly dominated by benthic cyanobacterial mats.



Large and beautiful black corals are also sometimes present.



Rhodolith mounds provide hard substrate for other organisms to attach to, such as these sponges.



At the shallowest part of the transect corals appear and large sponges.