NIOZ-Saba Bank/Saba Cruise report:

Net coral community calcification and hydrodynamics (Saba Bank/Saba)

Caribbean Explorer II

17/24-31 October 2015

<u>Research cruise contributing to Project</u>:

Seawater chemistry of CO_2 system and nutrients as drivers of benthic community structure and carbon metabolism of coral reef ecosystems of different trophic status

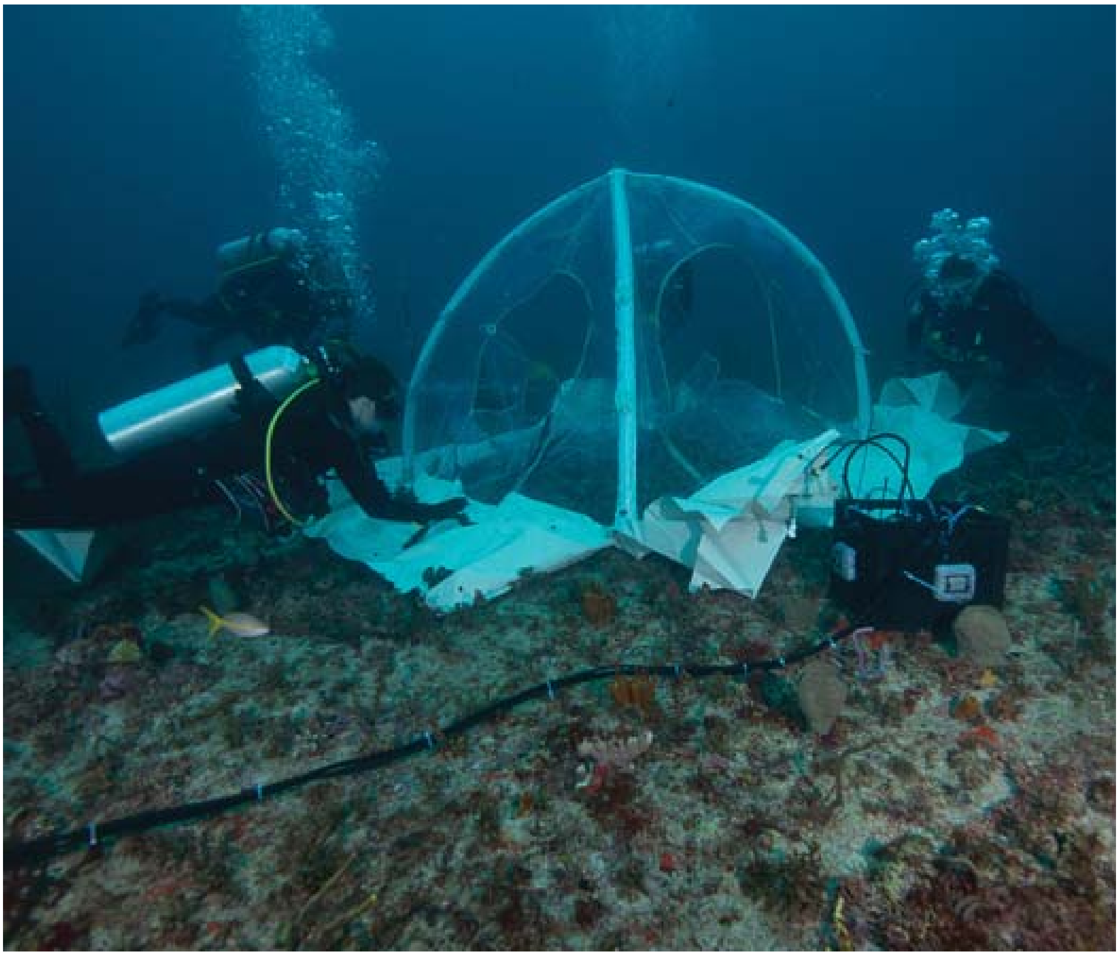


Photo Erik Meesters

Compiled by:

Fleur C. van Duyl

Contents

I. Introduction

I.1. Cruise background

Many islands in the Caribbean sea are fringed by coral reefs and/or coral veneers, which produce $CaCO_3$ for their skeletons. Not only stony corals but also coralline algae and other organisms form $CaCO_3$ skeletons and contribute to the $CaCO_3$ production of these systems. Synchronously forces are at work to mechanistically and chemically destruct the $CaCO_3$ structure. Erosion of $CaCO_3$ by organisms such as grazing sea urchins, fishes and by scouring of coral skeleton-derived debris (e.g. rubble, sand, silt) is mainly mechanical. Boring worms and sponges combine mechanical and chemical removal of $CaCO_3$. Chemical dissolution by sponges can be substantial. Up to 75% of the bioerosion ($CaCO_3$ mass loss) by coral excavating sponges has been reported to be due to dissolution, but more frequently values between 10%-30% have been found. Endolithic microorganisms bore purely chemically and infest bare $CaCO_3$ substrates on reefs.

$CaCO_3$ production and dissolution is influenced by the seawater chemistry of CO_2 (Andersson & Gledhill, 2013). The average pCO_2 in water is enhanced by ocean acidification and by increased benthic mineralization of organic matter due to eutrophication. There are indications that seawater chemistry of CO_2 and carbonate effects calcifying as well as decalcifying organisms differently and as such influence the balance between construction and destruction. How the balance is influenced in relation to variation in the carbonate system over different coral reef communities and whole reef systems of different trophic status is still poorly understood.

Focus of this short NIOZ cruise was on benthic community carbon metabolism and the seawater carbonate system. With different methods we explored the balance between calcification and dissolution of $CaCO_3$. Bottom-water fluxes of the carbonate system were measured in relation to the cover and composition of the coral reef bottom community. This was done by (1) placing a dome tent over $4m^2$ of a coral reef community (and a small triangle tent as control) and follow the diurnal changes of the chemistry in the tents and (2) by measuring diurnal changes in carbonate chemistry (e.g. pH and DIC in relation to light) at the reef bottom outside of the tent in conjunction with physical and hydrodynamic measurements and (3) by determining the benthic community with special focus on cover of calcifying and bioeroding organisms. In addition depth profiles of conductivity, temperature, pressure and oxygen were taken, to characterize the water masses over time in the research area.

The Saba Bank site was selected on basis of the purported oligotrophic status of the Bank. The selected site on the bank was at least 20 nautical miles removed from coastal run-off and/or sewage pollution of closest islands, the small islands of Saba an St Eustatius. Moreover the Saba Bank is separated from these islands by >800 m deep waters. The selected location at Saba was more eutrophic than the Saba Bank site due to run-off from land. Physics and hydrodynamics (see CHAP II) were addressed with the aim to describe characteristics of water masses flowing over the reef, and water movement profiles from the bottom to the surface. In CHAP III the experiments addressing the C metabolism and the carbonate system in the benthic compartment in and outside incubation tents (placed *in situ* over benthic communities) were elucidated. In Chap IV methods used to survey the benthic community were explained and preliminary results are presented. Chap V comprises a report of the coral species surveys of a site on the Saba Bank and a site in Ladder Bay, Saba.

Figure I.1. Caribbean Explorer II supporting SCUBA divers. Photo David Stevens.

I.2. General cruise information and itinerary

The NIOZ cruise of 24-31 October with the 32 m long commercial live-aboard *Caribbean Explorer II* (CEII) followed the IMARES cruise on the Saba Bank of 17-24 October 2015 also with the CE II (**Figure I.1.**). Part of the NIOZ-team joined the IMARES cruise to test equipment and methods, conduct extra CTD profiles and support with additional benthic community surveys on the IMARES benthic monitoring sites (IMARES cruise report 2013). These additional activities/measurements as well as the test measurements made from St Maarten and St Eustatius are also described in Chaps II and III.

The NIOZ cruise left St. Maarten in the early afternoon of Oct 24th, 2015, with 6 crew and 9 cruise participants of our research team on board. After a transit of 4 hours, she docked in the harbour of St. Eustatius in the evening of Oct 24th where another 5 participants embarked of the research team. Most of the equipment for the experiment had already been loaded one week earlier during an earlier stop at St. Eustatius during the IMARES cruise.

From 25-26 October measurements were conducted from a fixed mooring on the Saba Bank (Tertre de Fleur) and from 27-29 October from a fixed mooring in Ladder Bay, Saba (Ladder Labyrinth). Two cruise participants disembarked on the 29th in the evening on Saba. The next day (30 October) we sailed from the Ladder Bay mooring, Saba to St Eustatius, where 4 cruise participants disembarked and the equipment was unloaded. After that we sailed to St Maarten where we arrived around 12:00h local time. The remaining cruise passengers disembarked from the CE II on 31 October in St Maarten.

II. Physics & Hydrodynamics

Janine Nauw, Steven van Heuven

This chapter describes the hydrodynamic measurements that have been performed from 17-30 October 2016 along St Maarten, St Eustatius, Saba Bank and along Saba.

II.1. Locations

During the first week (17-24 October), some CTD casts were made from St Maarten and tests with the ADCP have been performed from St Eustatius in preparation of the *in situ* experiments (chemical flux studies) of the NIOZ-cruise week. **Figure II.1.** shows the bathymetry (logarithmic scale) of the area of the windward Dutch Caribbean, including the islands of St. Maarten, St. Eustatius, Saba and the Saba Bank. Bathymetric data (multibeam) of the Dutch Windward Caribbean was obtained from Erik Meesters (IMARES) and "SSSbathymetry" shapefiles from https://dcbd.services.geodesk.nl/geoserver/.

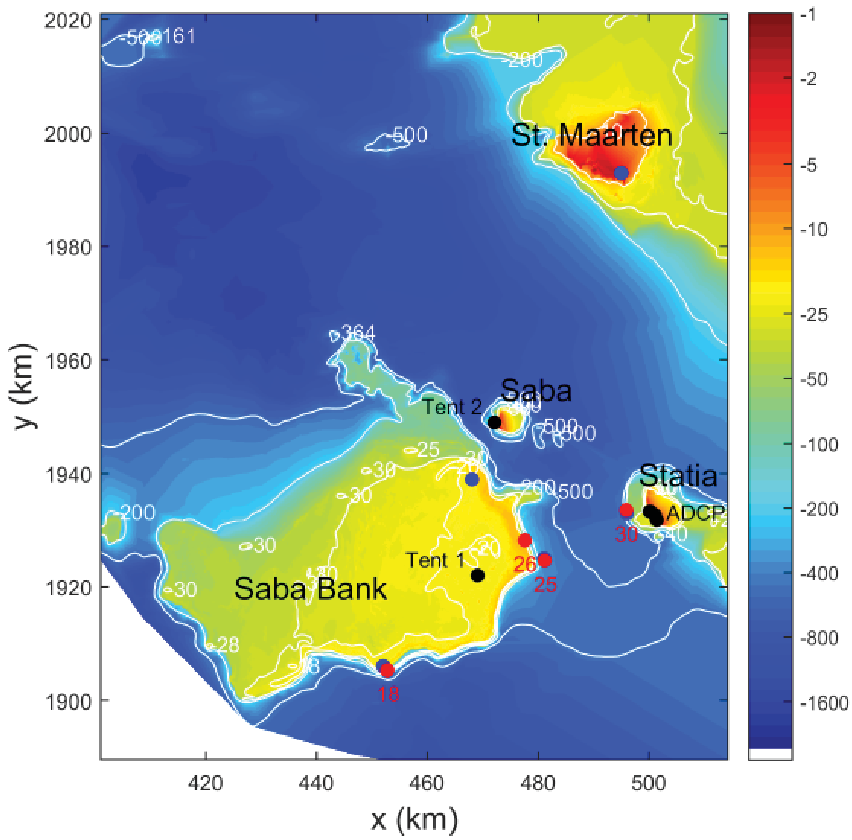


Figure II.1: Bathymetry of the area (logarithmic scale) with the locations of the deep CTD stations (red); the locations of the tent experiments and ADCP measurements (black) and the location of the CastAwayCTD profiles (blue). Note, that not all cast-away profiles are clearly marked, because their location mostly coincided with the location of CTD and/or ADCP profiles.

The dots show the locations were observations have been performed. Four deep CTD casts (>100 m) are shown by the red dots, where profiles of temperature, salinity and oxygen have been taken (the red numbers indicate the day in October 2015 on which the deep cast was performed); blue dots indicate locations were shallow CTD castaway measurements have been taken (temperature and salinity). The black dots (ADCP) near St. Eustatius indicate the locations were tests have been performed with various settings, in terms of measurement frequency and averaging time, of the ADCP to measure profiles of currents and turbulence. The black dots “tent 1” and “tent 2” indicate the locations were the tent experiments have taken place. The tent experiment was performed at:

- Tent site 1: The Saba Bank reef location was at **Tertre de Fleur** (lat, lon) = (17.3845, -63.2897), where we worked from the newly installed mooring between 25-10-2015 and 26-10-2015 (morning).
- Tent site 2: The Saba reef location was west of Saba in Ladder Bay at the **Ladder Labyrinth** mooring of the Saba National Marine Park (lat,lon)=(17.6261, -63.2602) between 26-10-2015 (afternoon) and 29-10-2015.

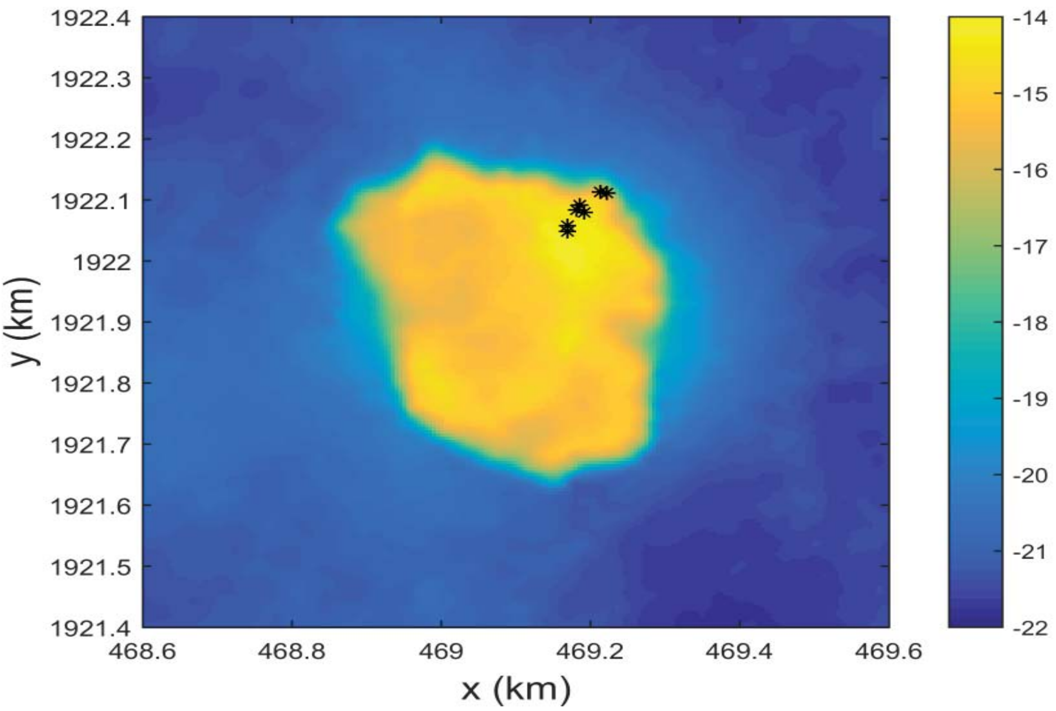


Figure II.2: Bathymetry of the area around “Tertre de Fleur” on the Saba Bank and the locations of the CastAwayCTD profiles (black stars). Please note that the oxygen profiles of the lowest two panels are invalid. Data were wrongly converted from the raw measurements (Voltage> ▯mol.kg-1).

A zoom of the bathymetry near the location of the first tent experiment, Tertre de Fleur, is given in Figure II. 2. It consists of a relatively shallow flat area of about 15 m depth of 250 m wide and 500 m long surrounded by an area with a depth of about 21 meter. The locations were castAwayCTD measurements were performed are indicated by black asterisks. In the night of 25 to 26 October a squal passed the experimental site and waves increased significantly. The wave driven currents were that strong that it was no longer possible to keep the tent fixed on that location in such a way that the exchange between the water inside and outside of the tent were within the limits for the experiment to succeed. Therefore a new location was chosen on the leeward side of the island of Saba.

Figure II.3. shows the bathymetry of the area of Ladder Bay near Saba in logarithmic scale. The white area in the figure indicates the island of Saba. The bathymetry is very steep, the location is at about 20-25 m depth, but the local water depth decreases to over 100 m within 500 m from the experimental location. The asterisks show the locations were the castAwayCTD was used. The Caribbean Explorer II was located on the landward side of experimental location and therefore at significantly less water depths.

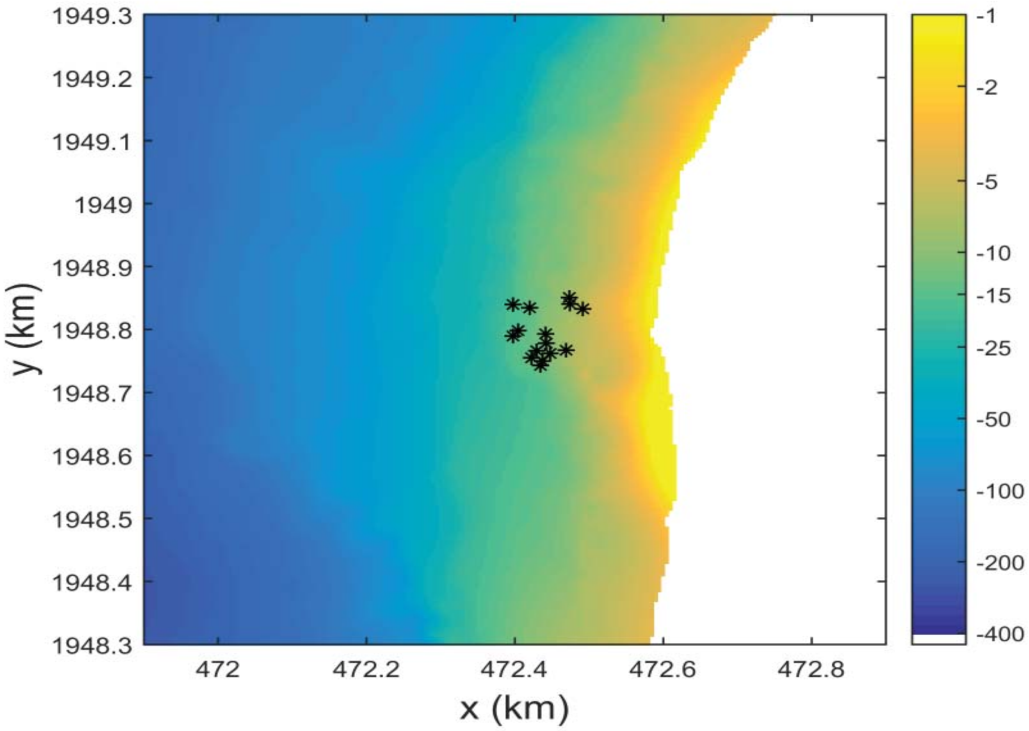
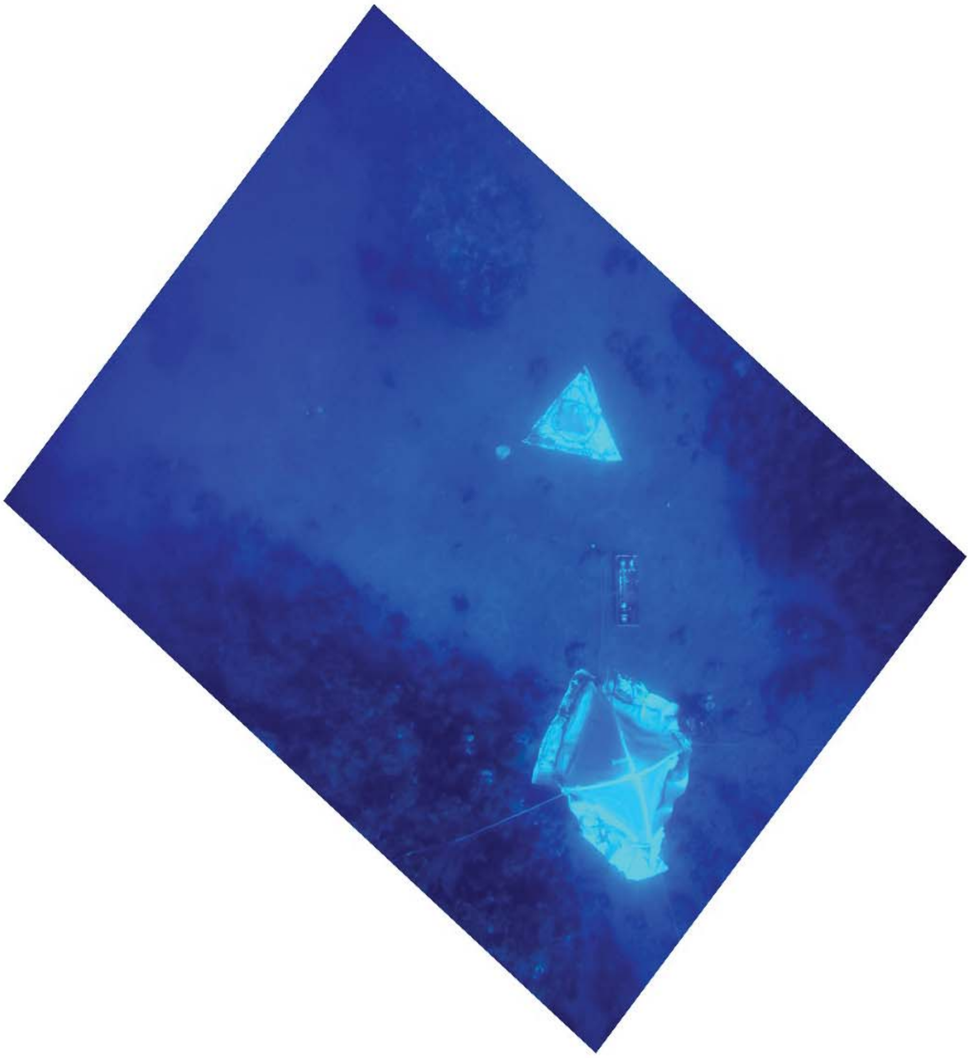


Figure II. 3: Bathymetry of part of Ladder Bay around "Ladder Labyrinth" in (logarithmic scale) and the locations of the CastAwayCTD profiles (black stars).

A sketch of the layout of the tent experiment with equipment position is shown in **Figure II. 4**. The distances between the devices were measured using a tape-measure and the angles were determined with an underwater compass. The direction from the half dome tent to the tipi tent was accidently straight towards the North. **Figure II.4.** also shows the relative locations of the half dome tent, the tipi tent (reference on the sand), the ADCP to measure currents & turbulence structure as well as the SeasDIC, the microcat (in the half dome tent) and the CastAwayCTD (just outside of the half dome tent). The local depth at the half dome tent was shallower than at the tipi tent and the ADCP was located deepest on the sandy plane. The area was surrounded by so-called lava-fingers – 1-2 m high rocks or reefs covered with coral and sponges. These small scale bathymetric features may have a profound impact on the current structure.



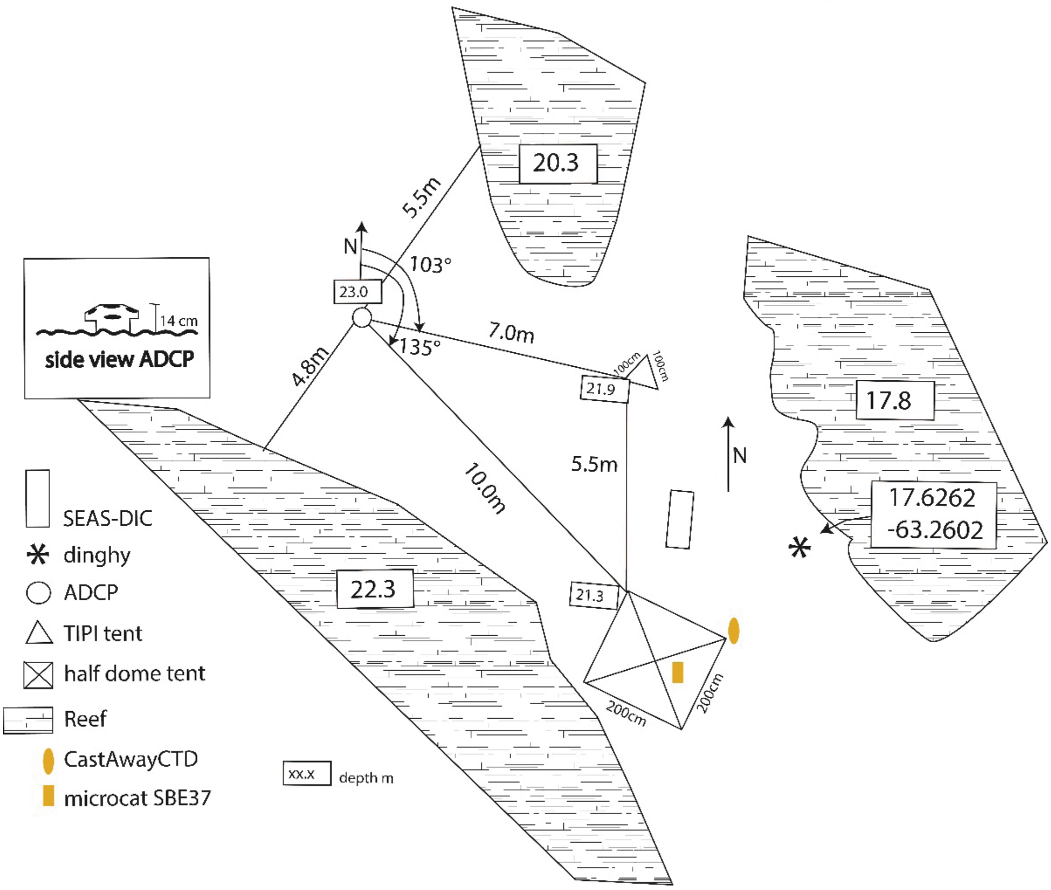


Figure II.4: Top: gopro image of the campsite by Oscar Bos. Bottom: sketch of the layout of the experiment in Ladder Bay at Ladder Labyrinth. Measurements done by Oscar Bos and Janine Nauw on 2015-10-29, artwork by Nelleke Krijgsman.

II.2. Instrumentation

For measuring the physics/hydrodynamics part of this cruise, we used the following instrumentation.

- AD2CP signature 1000 (Nortek), serial number: S100109
- SBE 37-SMP-ODO MicroCAT C-T-ODO (P) (Seabird), serial number: 92279, containing the following sensors:
    - Temperature, serial number 03713665
    - Conductivity, serial number 03713665
    - Pressure, serial number 4412777
    - Oxygen, serial number 1084
- SBE 19 *plus* V2 SeaCat (Seabird), serial number 01906458, containing the following sensors:
    - Temperature, serial number 01906458
    - Conductivity, serial number 01906458
    - Pressure, serial number 2860334
    - SBE 43 (Seabird) Oxygen sensor, serial number SBE43-1146
- CastAwayCTD (Sontek, San Diego, CA, USA), serial number CC1238002
- Light loggers (Odyssey), serial numbers 4607 and 4608

AD2CP (Acoustic Doppler Current Profiler). The AD2CP was mounted in a frame placed on the reef of the Saba Bank on Tertre de Fleur (location 1) and was dug into the sand in Ladder Labyrinth west of the island of Saba (location 2). The AD2CP uses acoustic pulses to determine the current velocity in the water column using the Doppler shift in the frequency of the returned signal.

SBE 37 CTD (MicroCat). The MicroCat measures conductivity, temperature, pressure, and dissolved O_2 optically, while moored. It was equipped with a standalone light logger (see below) . The MicroCat was placed in and later suspended from the roof of the tent at both benthic locations, and mostly sampled with a 5 minute interval.

SBE 19 CTD (SeaCat). The SeaCat was used in the profiling mode, measuring conductivity, temperature and pressure. A SBE 43 membrane-type, fast-response oxygen sensor with voltage output was connected to the SeaCat for O_2 profiling. The instrument was mounted in a frame and manually lowered and hauled from the port-side of the ship (with a hand winch). Four 'deep' profiles were taken outside of the experimental locations, the rest was taken on the anchor position of the ship (hence not exactly at the measurement locations, but about 100 m away).

CastAwayCTD. The castaway CTD was used for different purposes: for profiles of temperature and salinity, it was placed in the tent to measure these variables in time and out of the tent to determine the temperature and the salinity of the environment for reference with the MicroCat that was measuring inside of the tent.

Light loggers. Two light loggers were employed (model "Odyssey", Dataflow Systems, Christchurch, New Zealand). Calibrations were performed in air against a high-accuracy instrument (ULM-500, Walz GmbH, Effeltrich, Germany). Calibration coefficients (with and without constant) are:
BIO2: PAR flux [µmol/($m^{-2}s^{-1}$)] = 2.813*RAW. R^2 = 0.99894, OR
BIO2: PAR flux [µmol/($m^{-2}s^{-1}$)] = 2.797*RAW + 5.3601. R^2 = 0.99902
BIO1: PAR flux [µmol/($m^{-2}s^{-1}$)] = 3.134*RAW. R^2 = 0.9951, OR
BIO1: PAR flux [µmol/($m^{-2}s^{-1}$)] = 3.175*RAW - 1.0514. R^2 = 0.99539
Instrument BIO2 (ID 4607) was connected to the MicroCAT, and thus measured tent interior light conditions (Chap III)

.

Fig. II.5. ADCP at the campsite in Ladder Bay (Tent site 2)- Photo by Erik Meesters

Instrument BIO1 (ID4608) was connected to the SEAS instrument (see chap III), and thus measured tent exterior light conditions, albeit only on the last day of the experiment.

Note that all data collected in the physics part of this cruise is in UTC and that local time is UTC minus four hours).

II.3. ADCP measurements

ADCP data contain many variables, including pressure and temperature. The ADCP operated at 8 Hz and had a vertical spacing of 20 cm. The first bin nearest to the bed was at 30 cm above the head of the device. Besides measuring currents, the operating frequency allows for estimating the turbulent dissipation rate. Moreover, the pressure measurements along with the current measurement at this high sampling rate allow for estimation of the wave parameters.

In the week before the cruise, four tests were performed with different settings to establish the optimal setting for the duration of the tent experiments. These tests were performed in Gallows Bay near St. Eustatius and the data files are called:

- S100109A017_div12: 20 Oct 2015, just south of the harbor, dive site: Paul's Place (17.485852, -62.999246)
- S100109A017_div14: 21 Oct 2015, next to a wreck: dive site: Chien Tong (17.485770, -62.998301)
- S100109A017_div15: 22 Oct 2015, dive site: training area Gallows Bay, Statia (17.480695, -62.990319)
- S100109A017_div17: 23 Oct 2015, dive site: crooks castle (17.472426, -62.986628)

On location 1 on the Saba Bank, two data sets were created:

- S100109A026_sab01.ad2cp from 25-Oct-2015 15:10:00 UTC to 25-Oct-2015 21:39:24 UTC
- S100109A027_sab01.ad2cp from 26-Oct-2015 12:30:00 UTC to 26-Oct-2015 15:14:16 UTC

On 25-Oct-2015 around 21:30 UTC the ADCP was retrieved due to miscommunication. A strong squal passed the site on the night of 25 to 26-Oct-2015, which is unfortunately not captured by the measurements. Temperature measurements (**Figure II.6**) show a decrease from 30.4 to slightly less than 29.9 ^{o}C on 25 Oct and an apparent further decrease during the stormy night to less than 29.6 °C after which the temperature increased to values between 29.7 and 29.8 °C (**Figure II.6**).

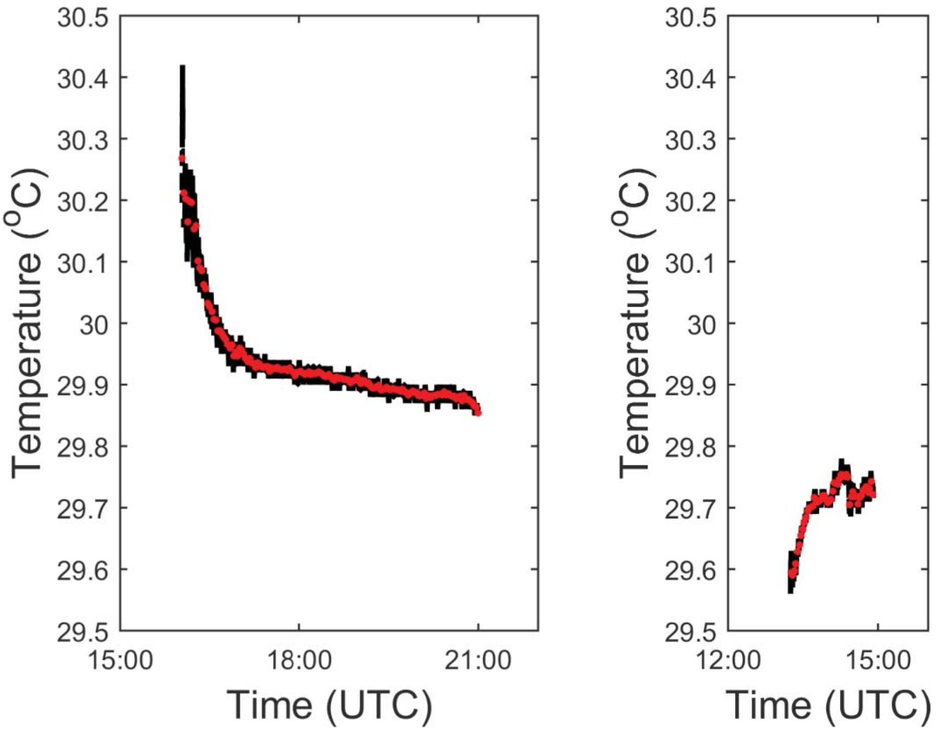


Figure II.6: Temperature as a function of time as measured at the ADCP, left for 25 October between 15:10 and 21:40 UTC and right for 26 October between 12:30 UTC and 15:15 UTC. Black is the original data and red dots indicate the 2-minute averaged values.

Heading, pitch and roll measurements (F**igure II.7**) show odd behavior; most of the measurement period, these angles are fairly constant, but during some parts, the angle measurements show very erratic behavior, which may be related to the CE II with its steel hull disrupting the earth's magnetic field and thereby distorting the measurements. The median heading, pitch and roll are 327.93°, -0.35° and 2.01° for 25 October and 22.39°, -1.03ᵖ and -0.68° on 26 October, respectively, and should probably be used for the entire time-series to rotate the velocity from the coordinate system of the instrument to earth coordinates.

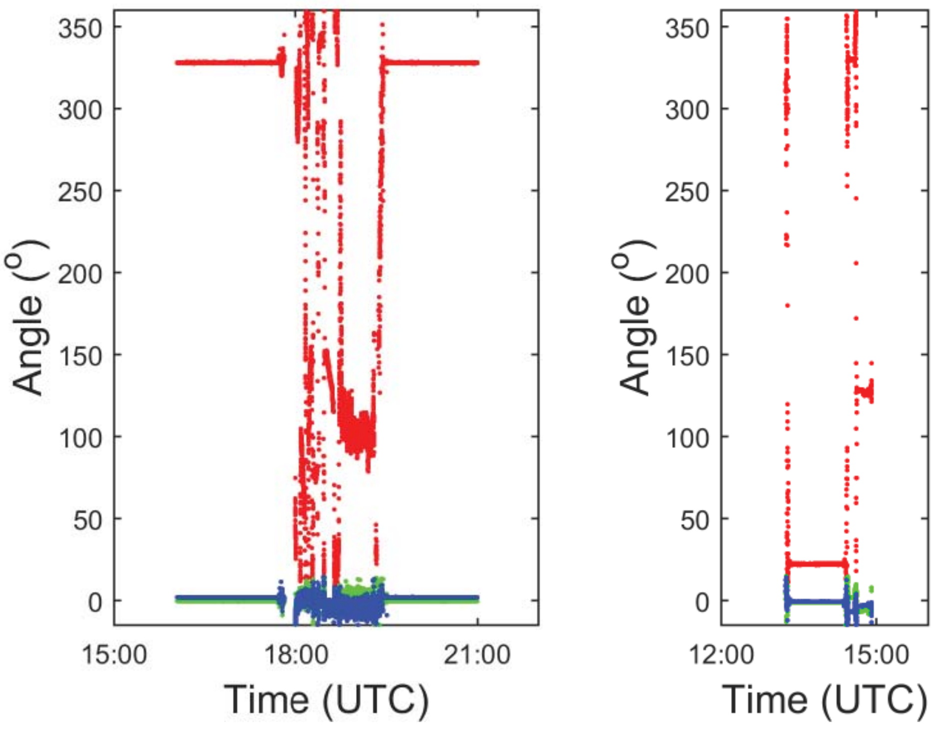


Figure II.7.: Heading (red), Pitch (green) and Roll (blue) as a function of time.

There appears to be a linear relation between the depth-averaged northward and depth-averaged eastward current at Tertre de Fleur (**Figure II.8**). The angle of the linear fit is -34.5°; the velocities are rotated in the along-stream and cross-steam contribution and plotted in **Figure II.8**.

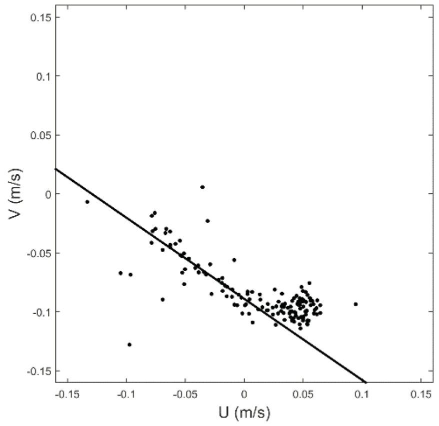


Figure II.8: The depth-averaged northward component of the current, V on y-axis, versus the depth-averaged eastward component of the current, U on x-axis, at Tertre de Fleur on 25 October 2015; the dominant current direction is -34.5°. The main current direction varies between north-northeast to north-northwest.

The maximum along-stream current is about 0.2 m/s and is found near the surface between 17:00 and 18:00 UTC; after 20:00 UTC the current changes sign and starts flowing in the opposite direction. The cross-stream current remains fairly constant at about -0.1 to -0.05 m/s.

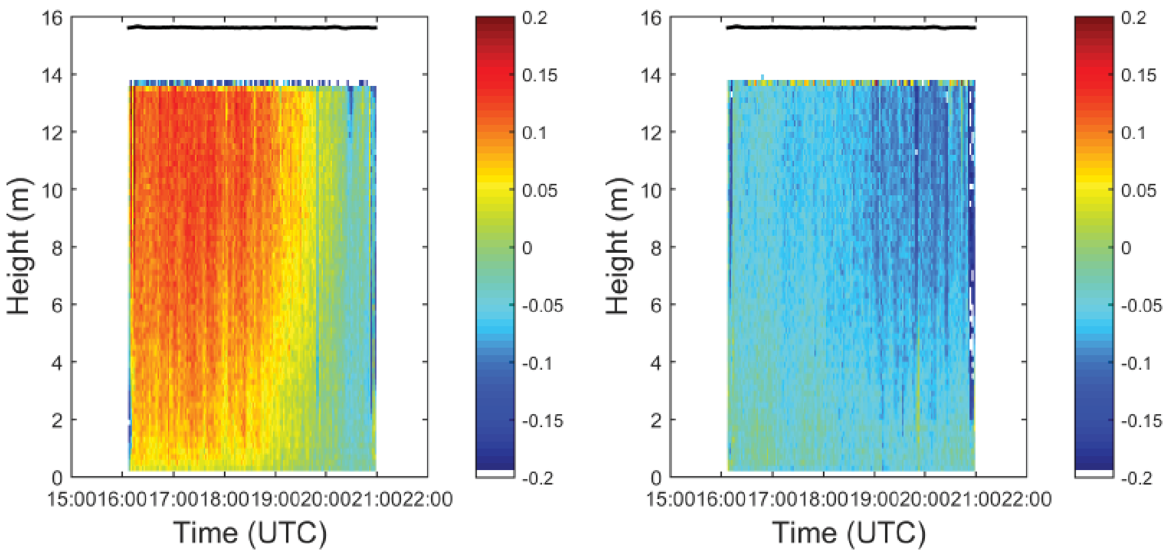


Figure II.9: Along-stream (left) and cross-stream (right) component of the current at Tertre de Fleur on 25 October 2015.Height is in meter above the bottom. In the top bin near 14 m above the seafloor some interference is visible leading to unreliable results.

The dominant current direction in on 26 October is -0.5°, hence the current direction is almost east-west. However, the data here is significantly influenced by the strong variations in the heading, pitch and roll of the internal compass of the instrument. These variations are probably related to the nearby presence of divers and/or the ship the Caribbean Explorer. The metal of the tanks and the hull of the ship influence the local magnetic field around the device and lead to strong variations in the heading, pitch and roll of the internal compass unrelated to movement of the device. Hence in the post-processing, one should assume that the device is motionless and take a constant heading, pitch and roll from the period where the magnetic field likely is undisturbed, e.g. before 18:00 and after 20:30 UTC.

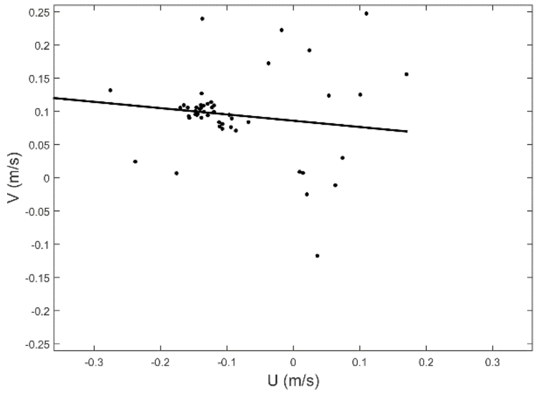


Figure II.10: The depth-averaged northward component of the current versus the depth-averaged eastward component of the current at Tertre de Fleur on 26 October 2015; the dominant current direction is -0.5°.

The velocity in along-stream and cross-stream directions are slightly higher on 26 October compared with 25 October and seem to display a sudden change around 14:30 UTC, but that may be related to the erratic variations in the heading, pitch and roll.

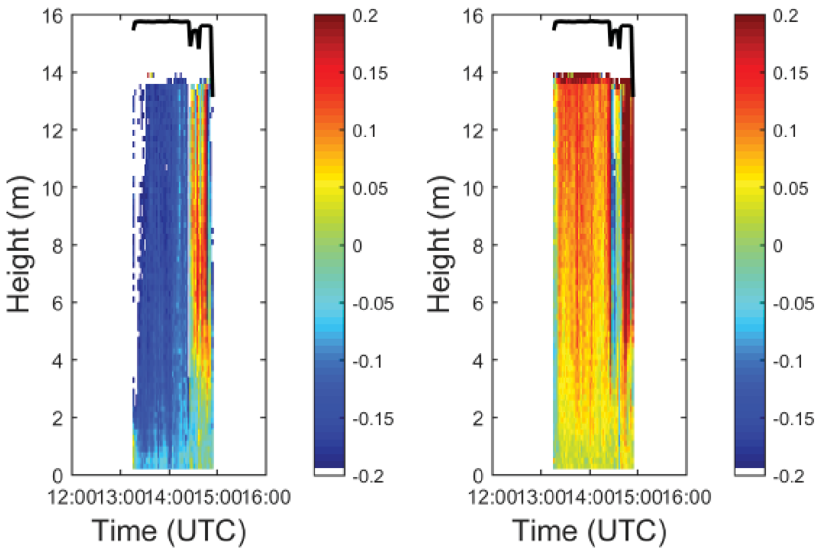
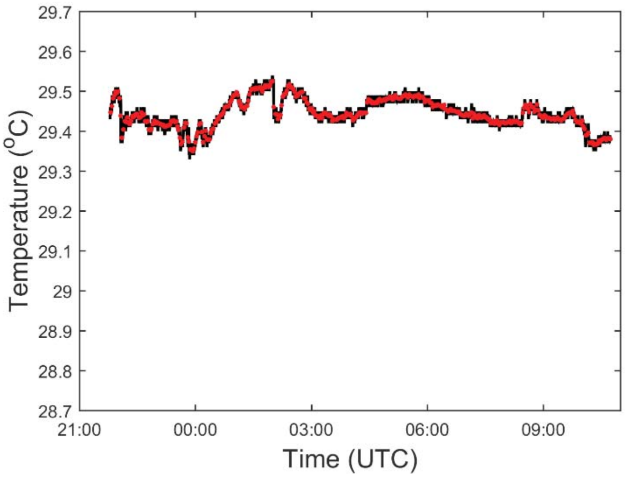


Figure II.11: Along-stream (left) and cross-stream (right) component of the current at Tertre de Fleur on 26 October 2015.

On tent site 2 in Ladder Labyrinth west of Saba, four sets of data were created:

- S100109A028_sab01_00.ad2cp from 26-Oct-2015 21:00:00 to 27-Oct-2015 10:43:37 UTC
- S100109A028_sab01.ad2cp, which is unfortunately lost due to an error of the operator
- S100109A029_sab01_00.ad2cp from 28-Oct-2015 20:35:00 to 29-Oct-2015 10:15:31 UTC
- S100109A029_sab01.ad2cp from 29-Oct-2015 10:15:31 to 29-Oct-2015 22:19:18 UTC

Temperature in Ladder Labyrinth shows fairly constant values on 26 Oct, 21:00 UTC and 27 Oct 10:45 UTC between 29.3°C and 29.5°C (**Figure II.12**). Between 28 Oct, 21:00 UTC and 29 Oct, 22:20 UTC, two large excursions are found in temperature from the ‘normal’ to colder values of about 29.0°C, between 00:00 and 02:00 UTC, and even below 28.9°C, between 18:10 and 19:40 UTC.



Figur e II.12: Temperature as a function of time as measured at the ADCP for 26-Oct-2015 21:00 to 27-Oct-2015 10:45 UTC. Black is the original data and red dots indicate the 2-minute averaged values.

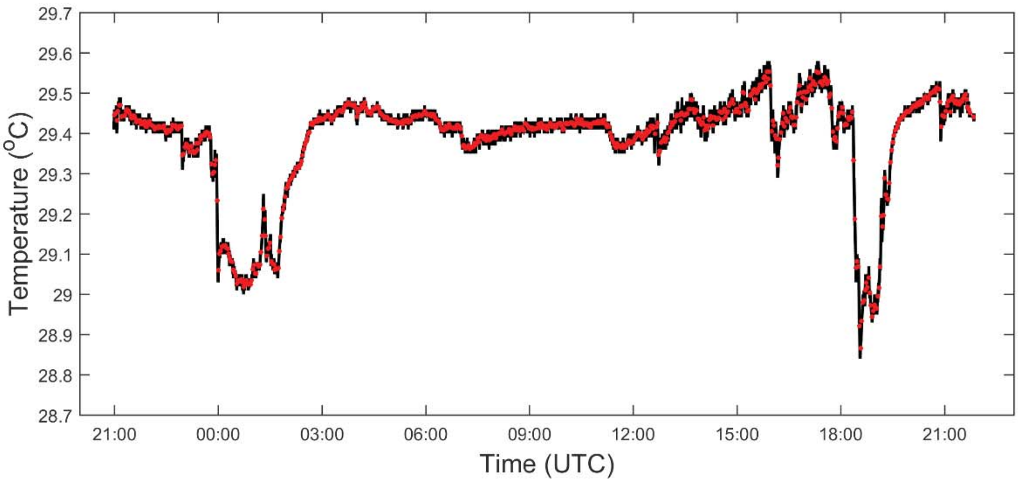


Figure II.13: Temperature as a function of time as measured at the ADCP for 28-Oct-2015 20:35 to 29-Oct-2015 22:20 UTC. Black is the original data and red dots indicate the 2-minute averaged values.

The heading, pitch and roll again show fairly constant values of 36.95°, 3.13° and -1.40° on 26&27 October and 22.15°, 1.33° and 0.3° on 28&29 October, respectively, but also showed some erratic behavior.

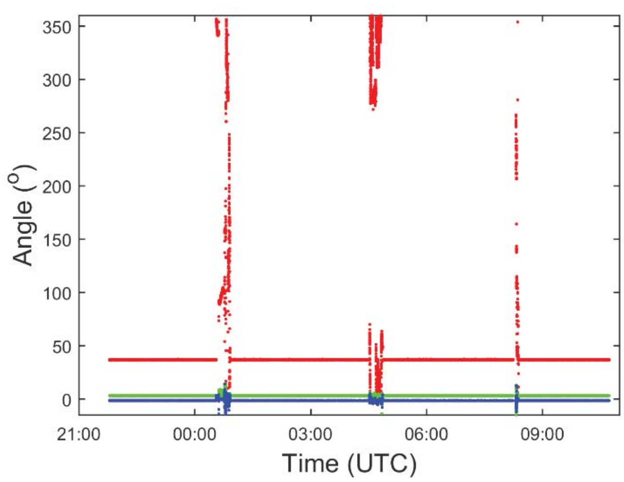


Figure II.14: Heading (red), Pitch (green) and Roll (blue) as a function of time on 26 (before 00:00) & 27 (after 00:00) October.

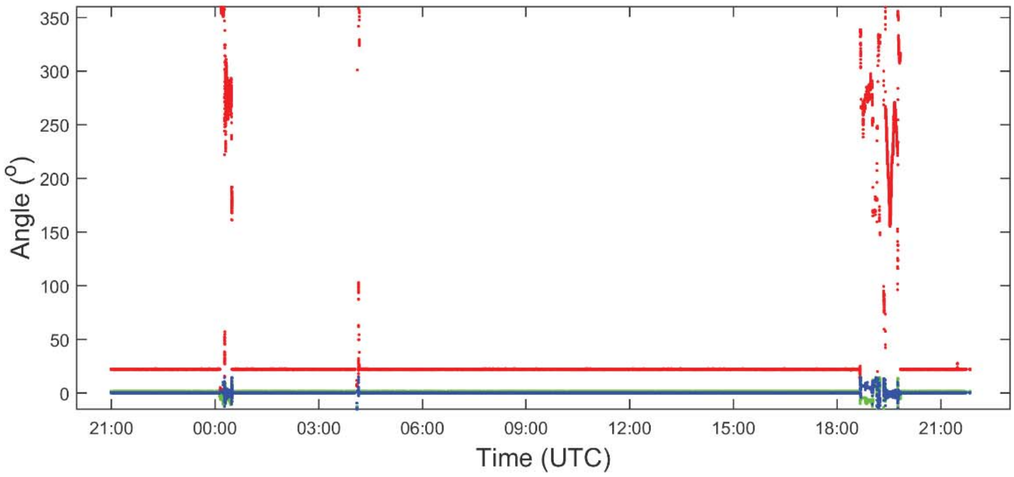


Figure II.15: Heading (red), Pitch (green) and Roll (blue) as a function of time on 28&29 October.

The dominant angle of the depth-averaged current in Ladder Bay was -20.9 degrees based on the data of 26&27 October and -18.9 degrees based on the data of 28&29 October. It therefore follows the local bathymetry with the lava fingers also having approximately the same orientation (see **Figure II.15**) of about 20 degrees with the east-west line.

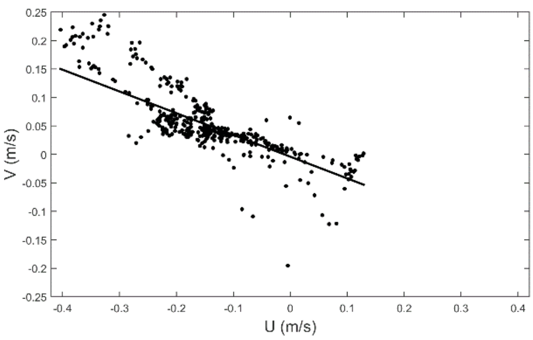
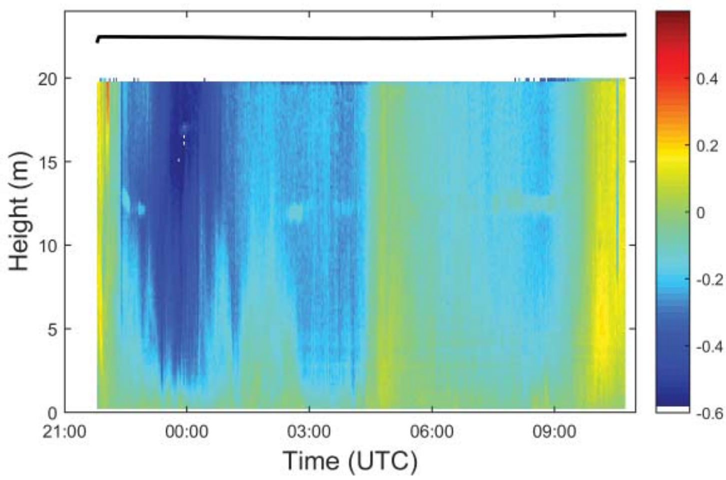


Figure II.16: The depth-averaged northward component of the current versus the depth-averaged eastward component of the current at Ladders Bay on 26 October 2015; the dominant current direction is -20.9 degrees.

The along-stream velocity on 26/27 October shows primarily downslope values (from the tents towards the ADCP) with maximum velocities of about 0.5 m/s in the near-surface region. Some short lasting periods with currents in the opposite direction can be observed in the beginning of the measurement, at 4:30 UTC and 10:00 UTC with maximum velocities of about 0.15 m/s. At mid-depth, sometimes, odd behavior is observed, which may be related to one of the beams crossing something drifting in the water column, such as cables. The cross-stream current also shows alternating behavior, however, not all alternations in the direction of the flow can be related to changes in the along-stream current.



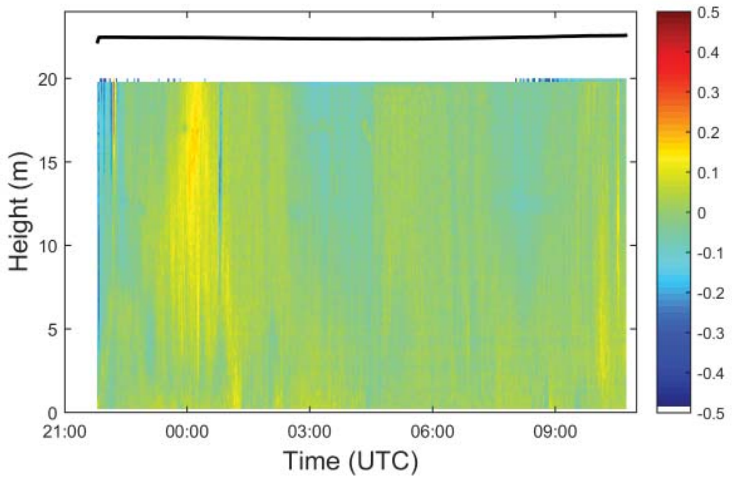


Figure II.17: Along-stream (top) and cross-stream (bottom) component of the current at Ladders Bay Labyrinth starting on 26 October 2015. Positive currents are directed towards the north (top) and the east (bottom).

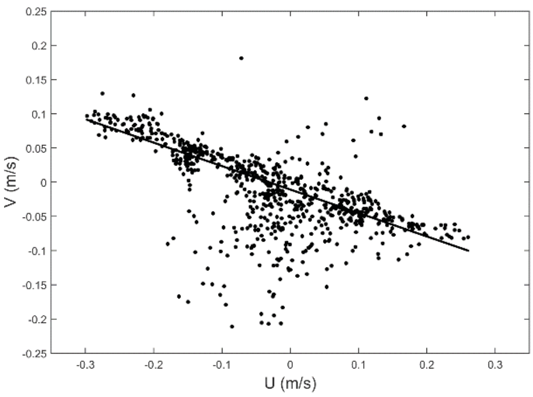
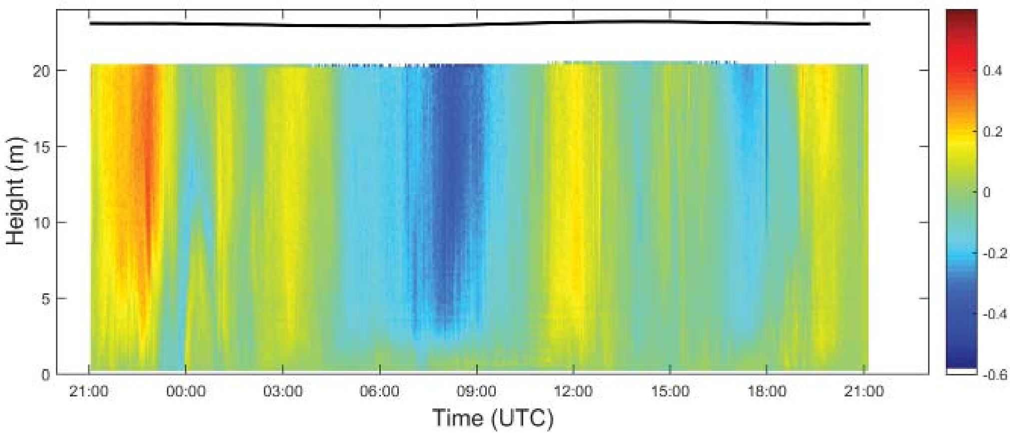


Figure II.18: The depth-averaged northward component of the current versus the depth-averaged eastward component of the current at Ladders Bay on 28 October 2015; the dominant current direction is -18.9 degrees.

The along-stream current on 28&29 October again shows alternations between up-slope (positive) and down-slope (negative) currents. What is most striking is the upslope currents near the sea-floor associated with a downslope current higher in the water column at 0:00 and 18:00 UTC, exactly at the moment when the strong decrease in temperature values is observed at the location of the ADCP. Clearly, colder, more saline water is advected from the deep channel located westward of the campsite a compensating flow near the surface is also generated.

The cross-stream component of the current shows sometimes strong negative pulses in the near surface. These pulses have also been observed in the field, while diving. On one dive, we started our safety stop at 5 m right below the CE II and after 3 minutes we had drifted back to the dinghy again, some 100 m away from the ship.



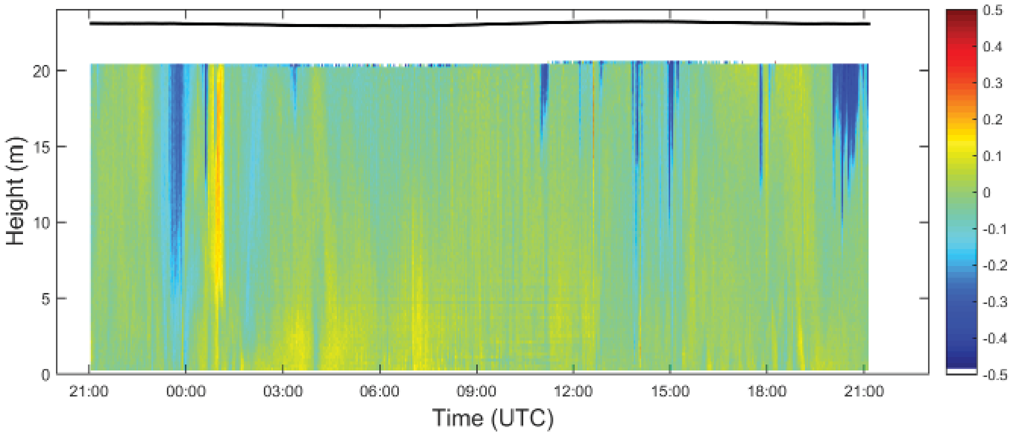


Figure II.19: The depth-averaged northward component of the current versus the depth-averaged eastward component of the current at Ladders Bay starting on 28 October 2015.

II.4. Temperature, Salinity and Oxygen measurements, Microcat SBE37

During the cruise, 9 sets of files were created. Due to an error of the operator, some files contain both new and older data. The microcat files are:

- SBE37SMP-ODO-RS232_03713665_2015_10_25_cast01
- SBE37SMP-ODO-RS232_03713665_2015_10_26
- SBE37SMP-ODO-RS232_03713665_2015_10_26_delay_test
- sbe37smp-odo-rs232_03713665_2015_10_26_delay_test2
- sbe37smp-odo-rs232_03713665_2015_10_27_tent_saba
- sbe37smp-odo-rs232_03713665_2015_10_27_test3
- sbe37smp-odo-rs232_03713665_2015_10_28_tent_saba_dl2
- sbe37smp-odo-rs232_03713665_2015_10_28_tent_saba_dl3
- sbe37smp-odo-rs232_03713665_2015_10_29_tent_saba_dl4

The raw data is read with a Matlab script and saved in individual *.mat files. All data files are merged, leading to 9227 individual samples. This merged dataset contains 5075 unique timestamps. A quick plot of the pressure data shows that the device was turned on the 21st of October for a test and that the proper data collection started on 25-Oct-2015 (**Figure II.6**). Zooming in between 25-Oct-2015 12:00 UTC and 30-Oct-2015 and 14 to 22 dbar (hence about 14 to 22 m, as one dbar is approximately equal to 1 meter of seawater), we recognize the series collected at location 1 between 25-Oct-2015 16:00:21 and 26-Oct-2015 13:03:22 UTC and the one at location 2 between 27-Oct-2015 12:45:38 UTC and 29-Oct-2015 20:33:43 UTC. A first processing is performed, removing all data for which the pressure is less than 13 dbar for location 1 and less than 19 dbar at location 2, to remove before deployment and after recovery. These data are clearly collected when the device was above sea level or going up or down (transit). The data is separated in two files, one for the first location and one for the second.

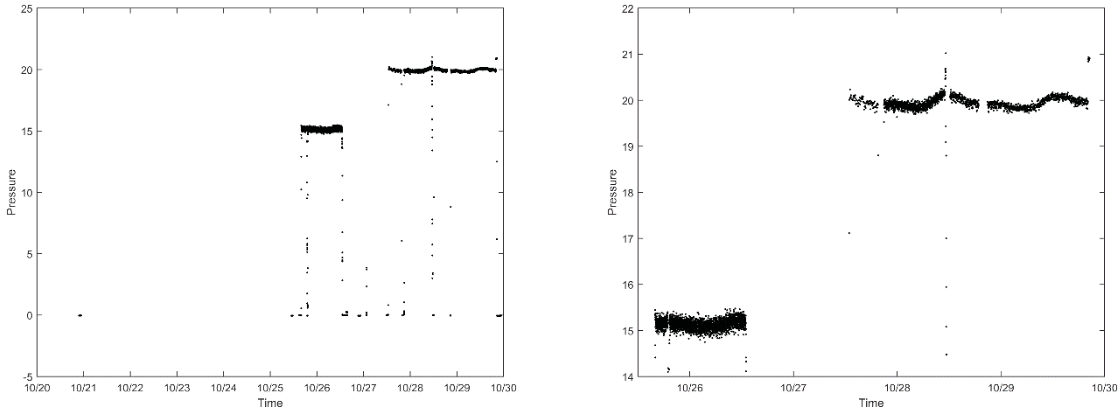
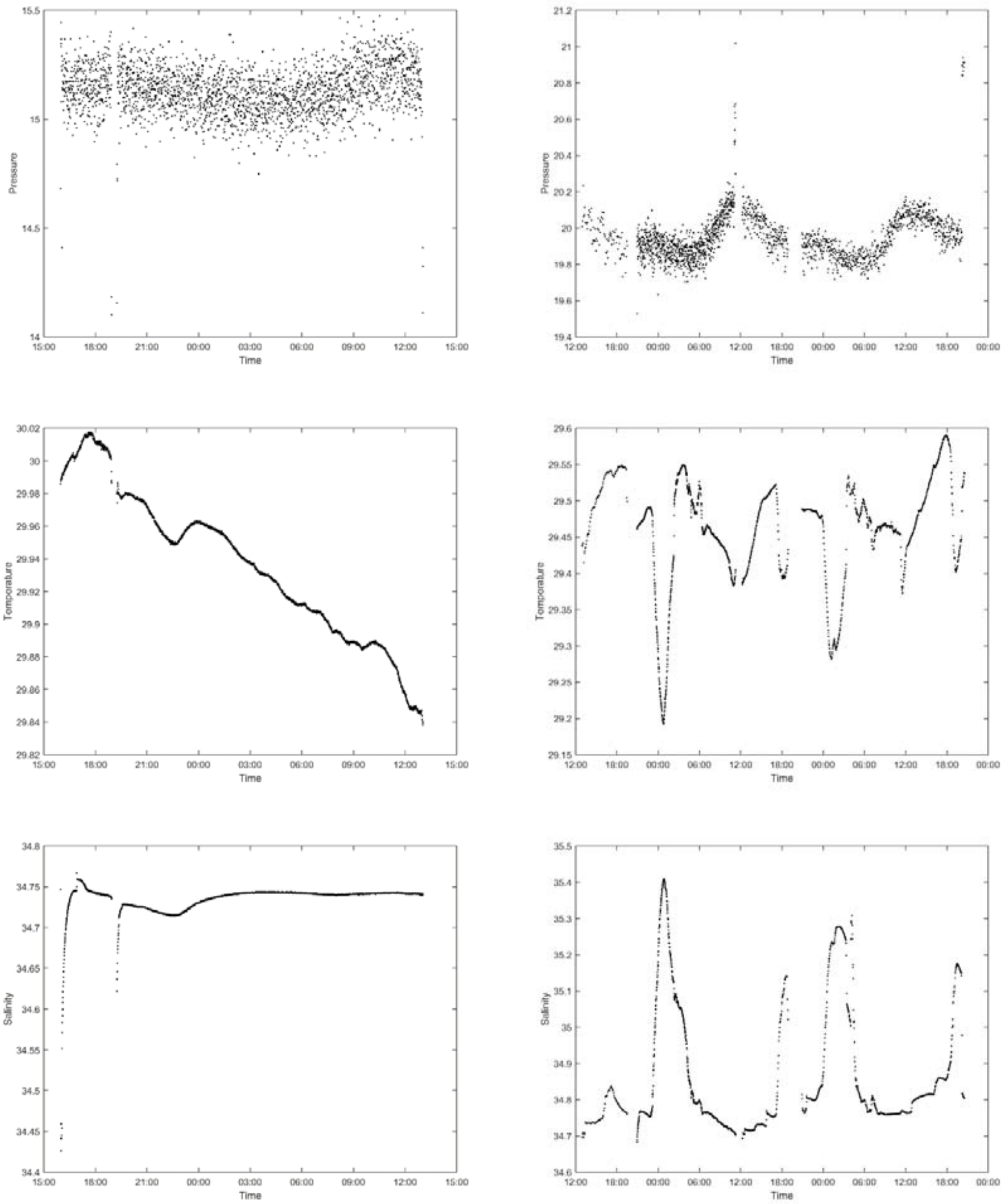


Figure II.20: Time series of the pressure data collected with the SBE37 on location 1 (25/26 October) and Tent site 2 (27 -29 October).



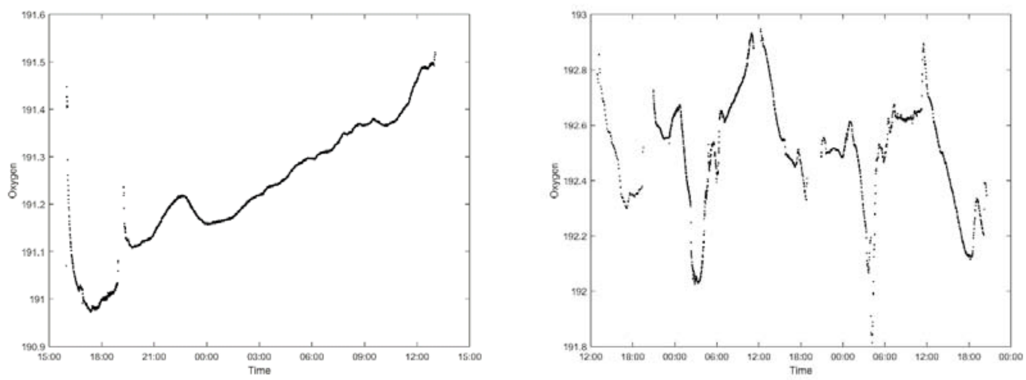


Figure II.21: Left: Tent site 1; Right, Tent site 2, Top to Bottom: Pressure, Temperature, Salinity, Oxygen as a function of time. Please note that the oxygen profiles of the lowest two panels are invalid. Data were wrongly converted from the raw measurements (Voltage> mol.kg-1).

II.5. CTD profiles with the MicroCat SBE19

Files of the SBE19 were sorted according to the time (in UTC), when they were measured. The files are named cast[yyyymmddHHMM(1)]_ [yyyymmddHHMM(end)].mat, where [yyyymmddHHMM(1)] = start_time in years, months, days, hours, minutes and [yyyymmddHHMM(end)] = end_time in years, months, days, hours, minutes. And a number was added if the particular file already existed, e.g. _01 or _02 etc. A total number of 82 individual files was thereby created, containing multiple files with the same contents. Amongst these files were 2 files (and their duplicates) of only 1 kB that hardly contained data. These were discarded. Also 30 clear duplicates were formed that had the exact same name as the originals; these were placed in a different folder for later reference. Another 9 files were checked, because the times indicated in the name were consecutive. The first five files that were consecutive only contained data at a depth of 0.5 meter and were therefore discarded; of the following two files, the first one was short and had only data at 0.5 m and was discarded, whereas the second file contained a profile as shown by the time-depth plot, therefore the first file was discarded and the second retained. Something similar occurred with the last two files, but here it was the other way around and the first file had the profile and the second one just some surface measurements. Checking the contents of the files, suggested that the times and the data were mixed up, because the time-depth plots did not show the typical profile containing a 1-minute waiting followed by the downcast and subsequently the upcast. The following list contains files that did show a typical profile:

Deep & Secchidisk

D:\caribbean\SBE-19Plus\post\cast201510181729_201510181744.mat – deep

D:\caribbean\SBE-19Plus\post\cast201510251305_201510251319.mat – deep

D:\caribbean\SBE-19Plus\post\cast201510251320_201510251329.mat – secchidisk depth

D:\caribbean\SBE-19Plus\post\cast201510261717_201510261735.mat – deep

D:\caribbean\SBE-19Plus\post\cast201510261735_201510261745.mat – secchidisk depth

D:\caribbean\SBE-19Plus\post\cast201510301047_201510301105.mat – deep

D:\caribbean\SBE-19Plus\post\cast201510301106_201510301114.mat – secchidisk depth

These were performed on the following locations:

- (lat,lon) = (17.232412, -63.444390), total depth = 500 ft, South of Dutch Plane
- (lat,lon) = (17.4075, -63.1777), secchidisk depth SD=33.6 m and Forel-Ule FU=3
- (lat,lon) = (17.4401, -63.2119), secchidisk depth SD=31 m and Forel-Ule FU=3
- (lat,lon) = (17.4882, -63.0391), secchidisk depth SD=30 m and Forel-Ule FU=3

Tertre de Fleur on the Saba Bank 25-26 Oct 2015:

D:\caribbean\SBE-19Plus\post\cast201510251721_201510251726.mat

D:\caribbean\SBE-19Plus\post\cast201510251833_201510251838.mat

D:\caribbean\SBE-19Plus\post\cast201510261327_201510261332.mat

D:\caribbean\SBE-19Plus\post\cast201510261429_201510261439.mat

Ladder Labyrinth in Ladder Bay, Saba – 26 Oct 2015

D:\caribbean\SBE-19Plus\post\cast201510262106_201510262109.mat

D:\caribbean\SBE-19Plus\post\cast201510262132_201510262301.mat

D:\caribbean\SBE-19Plus\post\cast201510270007_201510270012.mat

D:\caribbean\SBE-19Plus\post\cast201510270039_201510270043.mat

D:\caribbean\SBE-19Plus\post\cast201510270208_201510270213.mat

Ladder Labyrinth in Ladder Bay, Saba – 27 Oct 2015

D:\caribbean\SBE-19Plus\post\cast201510271146_201510271207.mat

D:\caribbean\SBE-19Plus\post\cast201510272230_201510272234.mat

D:\caribbean\SBE-19Plus\post\cast201510272338_201510272342.mat

D:\caribbean\SBE-19Plus\post\cast201510280026_201510280031.mat

D:\caribbean\SBE-19Plus\post\cast201510280132_201510280134.mat

D:\caribbean\SBE-19Plus\post\cast201510280308_201510280311.mat

Ladder Labyrinth in Ladder Bay, Saba – 28 Oct 2015

D:\caribbean\SBE-19Plus\post\cast201510281505_201510281508.mat

D:\caribbean\SBE-19Plus\post\cast201510281529_201510281534.mat

D:\caribbean\SBE-19Plus\post\cast201510281558_201510281603.mat

D:\caribbean\SBE-19Plus\post\cast201510281631_201510281637.mat

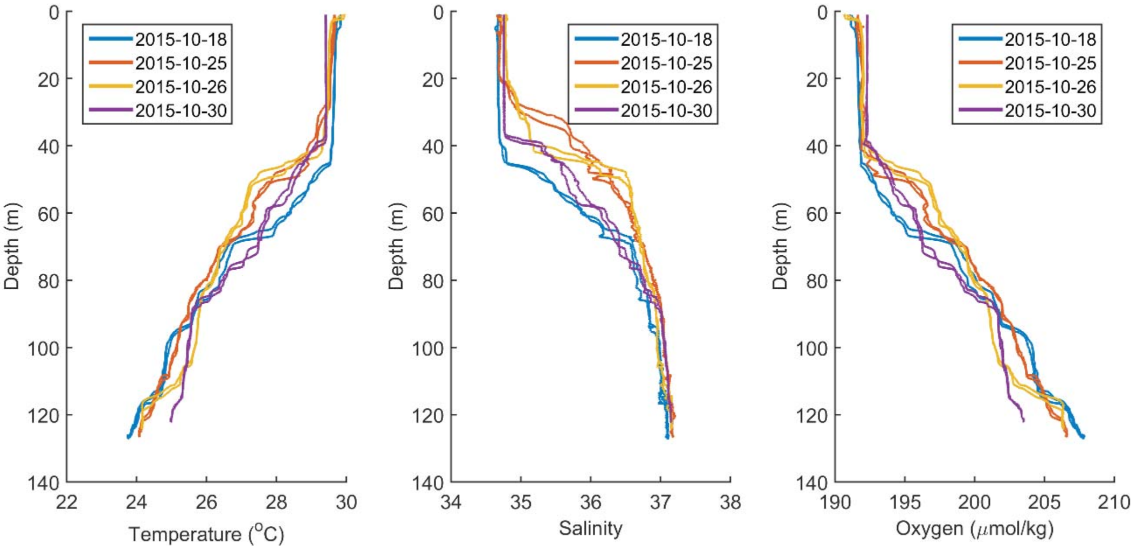
D:\caribbean\SBE-19Plus\post\cast201510281658_201510281704.mat

D:\caribbean\SBE-19Plus\post\cast201510281724_201510281729.mat

D:\caribbean\SBE-19Plus\post\cast201510281804_201510281809.mat

D:\caribbean\SBE-19Plus\post\cast201510281842_201510281846.mat

Of the 30 files, 4 were the deep profiles; 3 of these profiles were repeated until the secchidisk depth. At this depth the color was measured on the Forel-Ule scale and the app: EyeOnWater was applied to contribute to the database of colours of the world's oceans. Five profiles were taken on the Saba Bank, two of which were taken on 25 and two on 26 October. A total of 17 profiles was taken in Ladder Bay near Saba, 5 on 26 October, 6 on 27 October and 8 on 28.



FigureII.22: Temperature, Salinity and Oxygen profiles for the four deep casts.

The deep profiles of temperature, salinity and oxygen (Figure 21) show that the mixed layer depth is about 25-50 m deep below which the temperature decreases from 29 ^{O}C at the surface to values of 24 ^{o}C at 120 m depth; the salinity increases from about 35 at the surface to 37 at 120 m depth and the oxygen concentration increases from 192 mmol/kg at the surface to 205 mmol/kg at 120 m depth.

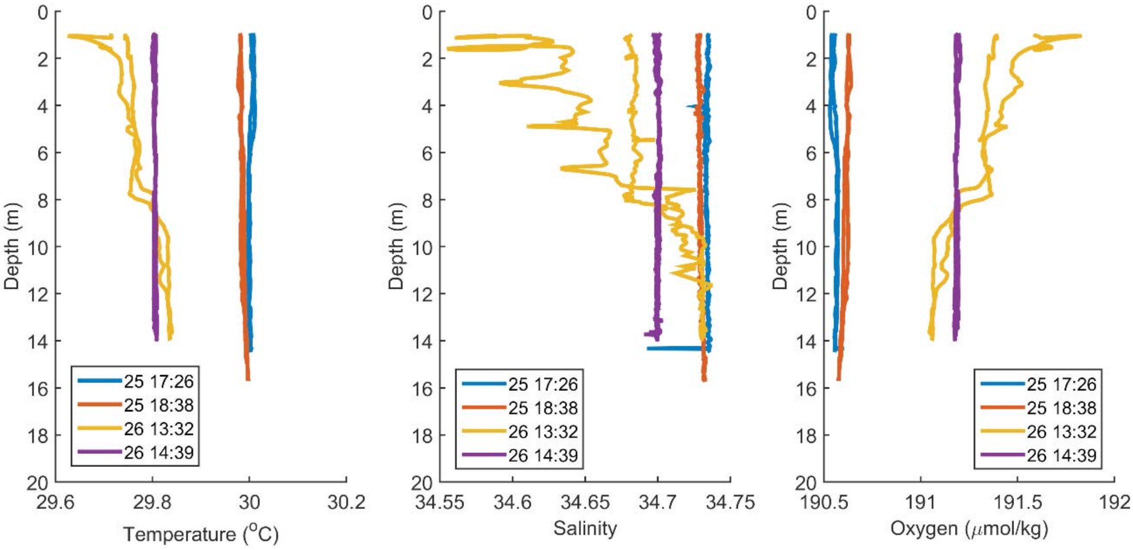


Figure II.23:Temperature, Salinity and Oxygen profiles for the four casts on the Saba Bank. The time in the legend is in UTC.

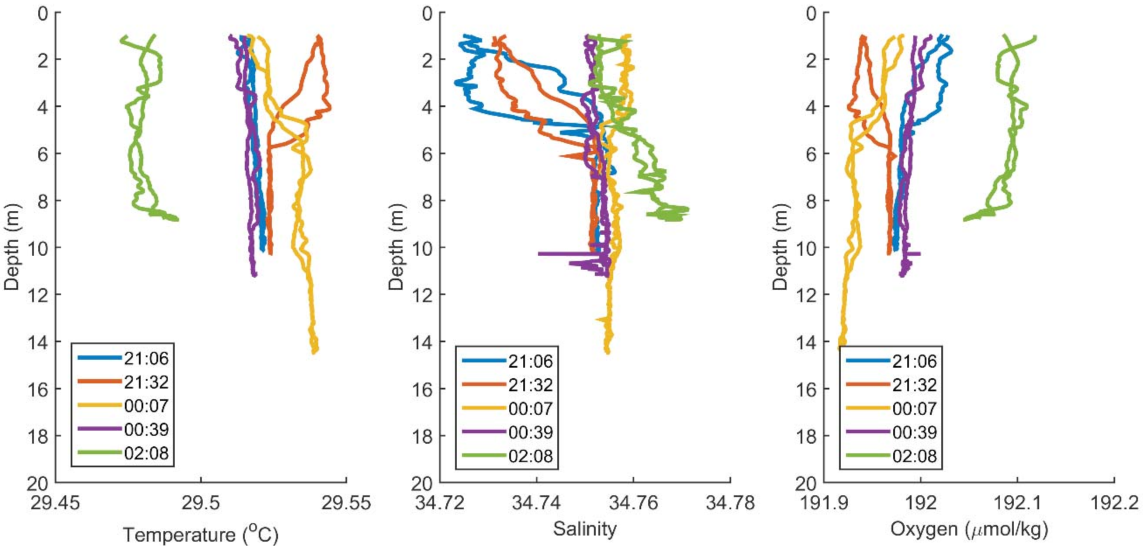


Figure II.24:Temperature, Salinity and Oxygen profiles for the five casts in Ladder Labyrinth in Ladder Bay on 26-10-2015.

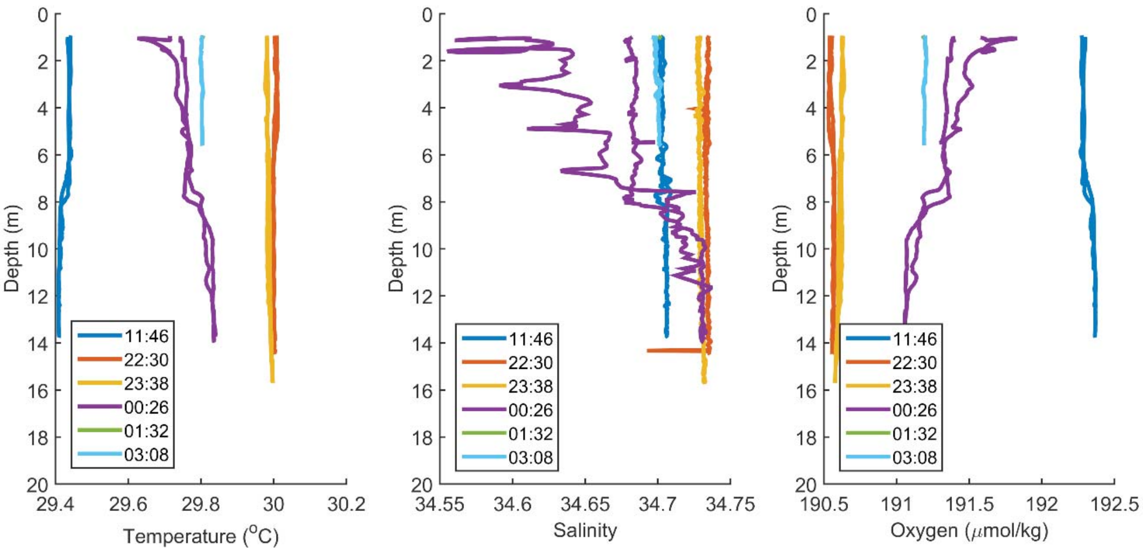


Figure II.25: Temperature, Salinity and Oxygen profiles for the six casts in Ladder Labyrinth in Ladder Bay on 27-10-2015.

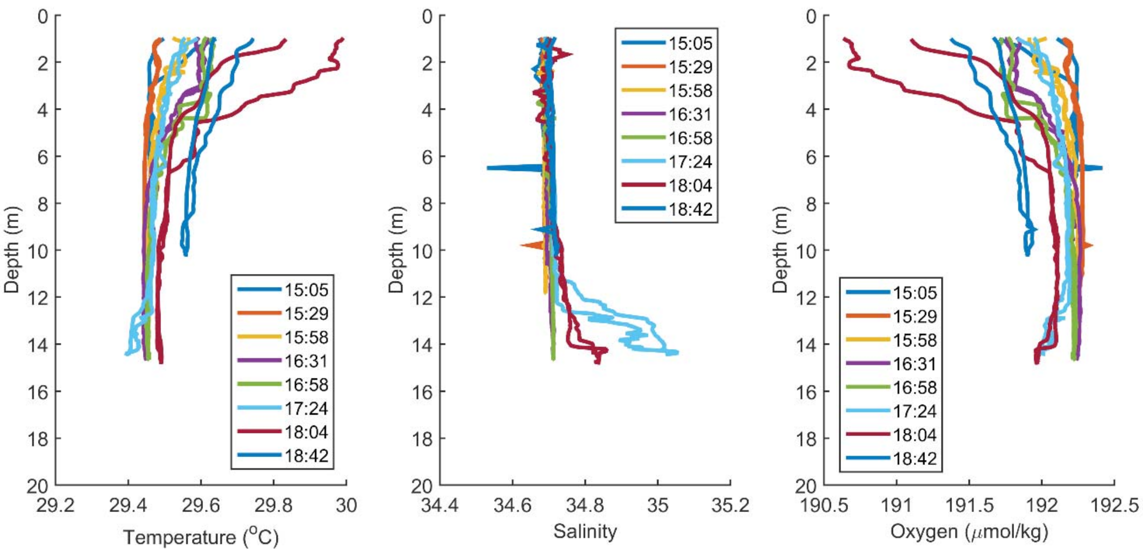


Figure II.26: Temperature, Salinity and Oxygen profiles for the eight casts in Ladder Labyrinth in Ladder Bay on 28-10-2015.

The other CTD casts that were performed with the SBE19 primarily showed that the temperature, salinity and oxygen concentrations were neither always constant over depth nor constant in time. Further analysis is necessary to explain the variations in these variables.

No CTD profiles are available on 29-10-2015.

II.6. CastAwayCTD measurements

A total of 38 samples were taken of Temperature and Salinity measurements using the easy to use CastAwayCTD. The first two casts were taken at the beach in front of the Sea View Hotel in Phillipsburg, St. Maarten. Numbers 3 to 5 were taken in de harbor of Phillipsburg aboard the CE II. Ten casts were taken in the first week at different locations on the Saba Bank.

Most of the casts were profiles taken from the CE II. But three of the casts were long time-series, one taken in the tent (27-Oct-2015 12:42:11) and two just outside of the tent (28-Oct-2015 18:36:28 UTC & 29-Oct-2015 13:49:14 UTC).

Beach in front of Sea View Hotel & harbor Phillipsburg, St Maarten:

16-Oct-2015 16:45:58 -63.0471 18.02343

16-Oct-2015 16:47:43 -63.04713 18.02338

17-Oct-2015 19:20:06 NaN NaN

17-Oct-2015 19:22:23 NaN NaN

17-Oct-2015 19:29:29 -63.04396 18.0203

Shallow water casts at 3 stations (IMARES-cruise):

18-Oct-2015 15:06:15 -63.44811 17.23476 Dutch Plain

18-Oct-2015 15:10:05 -63.4489 17.23445 Dutch Plain

18-Oct-2015 15:15:11 -63.4499 17.23409 Dutch plain

19-Oct-2015 19:28:43 -63.28983 17.38448 Tertre de Fleur

20-Oct-2015 10:38:35 -63.29003 17.38419 Tertre de Fleur

21-Oct-2015 10:35:39-63.29013 17.38422 Tertre de Fleur

21-Oct-2015 10:36:12-63.29009 17.38429 Tertre de Fleur 22-Oct-2015 01:09:12 -63.29694 17.53969 Mooring near Rebecca's Garden

22-Oct-2015 10:35:40 -63.29693 17.53971 Mooring near Rebecca's Garden

23-Oct-2015 10:38:15 -63.29691 17.53983 Mooring near Rebecca's Garden

Deep water Cast (NIOZ-cruise):

25-Oct-2015 13:09:10 -63.17781 17.40736

25-Oct-2015 13:16:00 -63.17837 17.40695

Tertre de Fleur (NIOZ-cruise):

25-Oct-2015 17:32:50 -63.28975 17.38447

26-Oct-2015 12:54:15 -63.29024 17.3839 – test @ surface

26-Oct-2015 15:03:28 -63.29024 17.38399 – test @ surface

26-Oct-2015 21:14:26 -63.25948 17.62621 – test @ surface

Ladder Labyrinth in Ladder Bay (NIOZ-cruise):

27-Oct-2015 01:02:13 NaN NaN

27-Oct-2015 01:07:05 -63.25984 17.62524

27-Oct-2015 01:31:53 -63.25982 17.6253

27-Oct-2015 12:42:11 NaN NaN – time-series in the tent

28-Oct-2015 13:16:27 -63.25947 17.62612

28-Oct-2015 13:20:12 -63.25931 17.62605

28-Oct-2015 15:12:55 -63.25952 17.62546

28-Oct-2015 15:17:41 -63.25972 17.62541

28-Oct-2015 16:04:04 -63.25977 17.62556

28-Oct-2015 16:07:08 -63.25978 17.62569

28-Oct-2015 16:36:04 -63.26013 17.62573

28-Oct-2015 17:02:40 -63.2599 17.62545

28-Oct-2015 17:25:29 -63.25996 17.62534

28-Oct-2015 18:16:28 -63.25999 17.62606

28-Oct-2015 18:36:28 -63.2602 17.62566 – time-series outside of the tent

29-Oct-2015 13:49:14 -63.26019 17.62611 – time-series outside of the tent

Deep water Cast (NIOZ-cruise):

30-Oct-2015 11:06:33 -63.03802 17.48609

The locations of the CastAwayCTD casts are shown in **Figure II. 1** and the profiles of temperature and salinity are shown in **Figure II.27**. Some profiles seem odd, like the purple one; these are related to a long-term in-situ measurement in or just outside of the tent. When processing these data into bin averages, fairly odd profiles are generated.

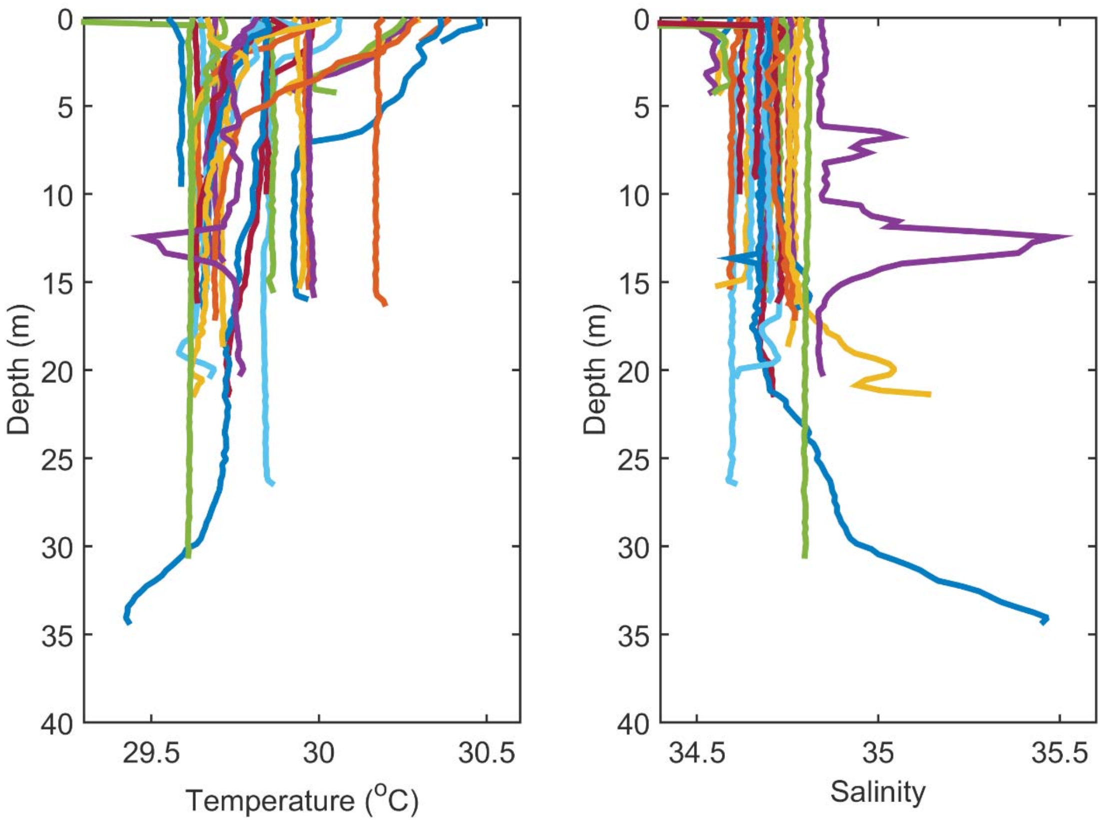


Figure II.27: Temperature and Salinity profiles measured with the CastAwayCTD for all locations for the duration of the cruise, the latitude and longitude are logged in the files themselves.

Three longer time-series have been collected with the CastAwayCTD; one in the tent (on 27-10-2015) and two outside of the tent (on 28 and 29 October 2015). The data are shown in **Figure II.28**, **Figure II.29** and **Figure II.30**.

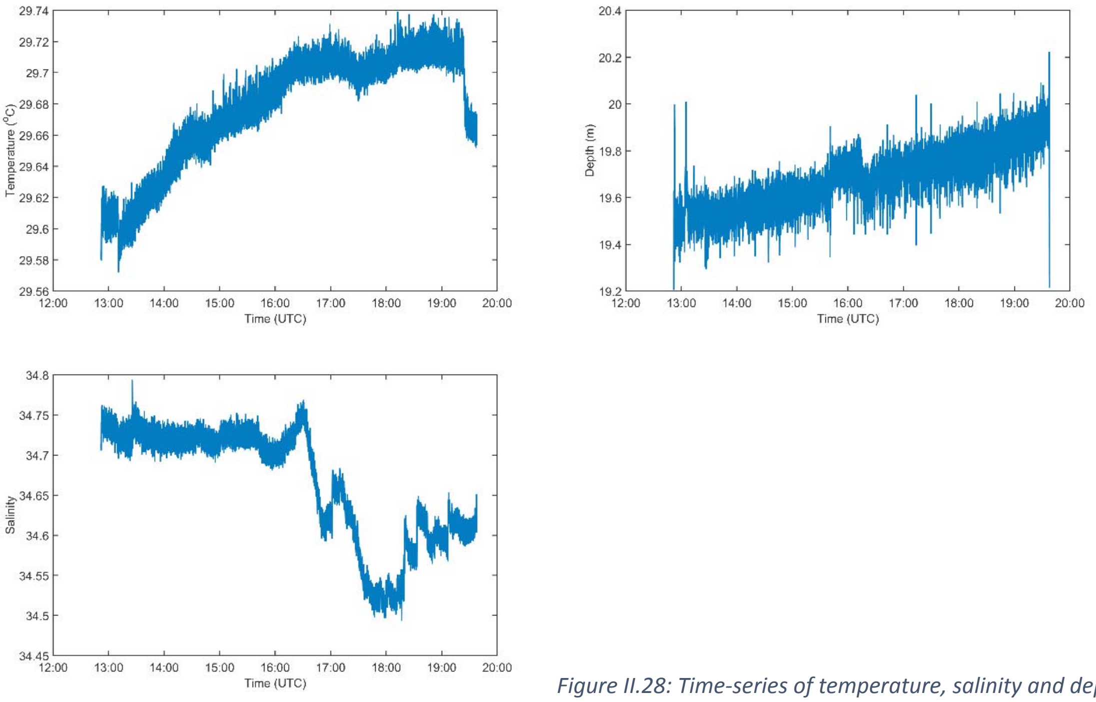


Figure II.28: Time-series of temperature, salinity and depth as measured with the CastAwayCTD inside the tent on 27-10-2015.

On 27-10-2015, the panels show a slow increase in temperature, fairly constant salinity until 16:00 UTC, were significant drops in the salinity can be observed. The castaway was lying somewhere on the ground and these drops could possibly by related to suspended material settling in the conductivity sensor. The salinity inside the tent is changed both by adding salt to the tent, but also by water intruding from outside. The salinity of the waters outside has not been measured, so it is impossible to determine why the salinity changes occur.

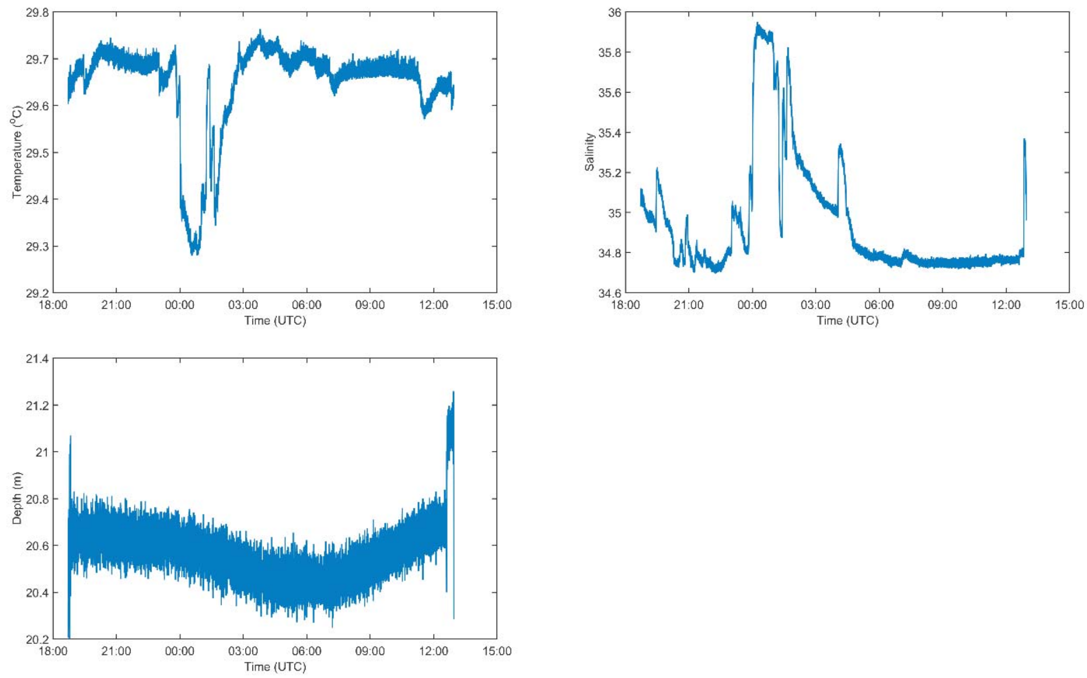


Figure II.29: Time-series of temperature, salinity and depth as measured with the CastAwayCTD just outside of the tent on 28-10-2015.

On 28-10-2015, the temperature outside of the tent is shown to be around 29.7. A significant drop in temperature is observed at around 0:00 UTC to values of 29.3. This temperature drop corresponds with a salinity increase from about 34.8 to 35.8. Around 1:30 UTC a spike is seen in both temperature and salinity back to the original values, but T and S only return to their median values after 3:00 UTC. It is likely that cooler, more saline water from the nearby deeper waters have moved up the slope of Ladder Bay. The depth measurements show a small tidal signal with an amplitude of about 0.1 m.

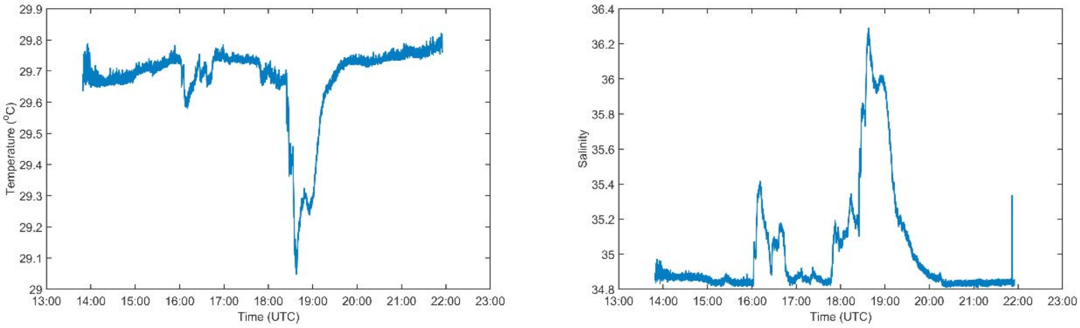


Figure II.30: Time-series of temperature, salinity as measured with the CastAwayCTD just outside of the tent on 29-10-2015.

Time-series continued on 29-10-2015 after the batteries were changed and the data uploaded to the computer. Again the median temperature was around 29.7 to 29.8 degrees Celsius and the salinity was about 34.9. In this time-series a smaller excursion towards cooler temperatures and more saline waters is found between 16:00 and 17:00 UTC and a bigger excursion between 18:00 and 20:00 UTC. During the latter period the temperature dropped to 29.05 degrees and the salinity increased to 36.2.

II.7. Weather

Meteorological data were found on www.wunderground/personal-weather-station. Data were downloaded for both locations on Saba, e.g. the Bottom at (lat, lon, height) = (17.627, -63.249, 238) and Fort Bay (lat, lon, height) =(17.616, -63.252, 10) and in Oranjestad on St. Eustatius at (lat, lon, height) = (17.478, -62.974, 175). Note that there are also some of these weather stations on St. Maarten.

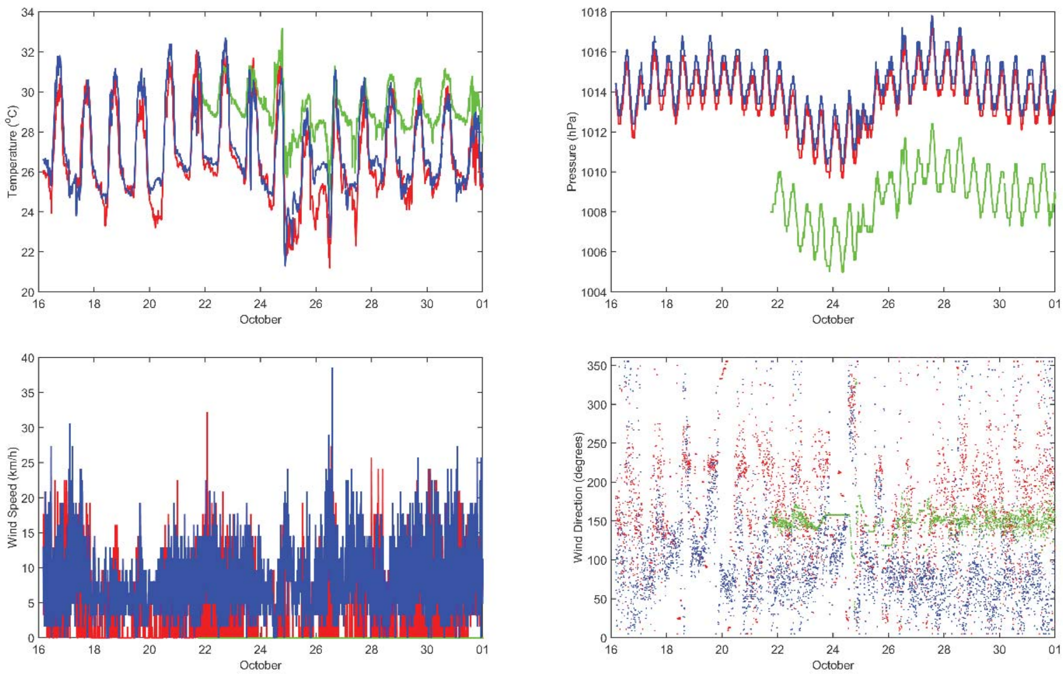


Figure II.31: Air Temperature, Pressure, Wind Speed and direction measured at the Bottom (red), Fort Bay (green) and Oranjestad (blue).

The temperature and the pressure show a daily cycle. The temperature in Fort Bay is strongly influenced by the water temperature and therefore doesn't drop as much during the night as the temperatures in the central parts of the island. The storm in the evening of 25 and early morning of 26 October is clearly visible in the wind speed, direction and temperature (note that the time axis is in UTC). The wind direction at Fort Bay seems too constant to be true, moreover, the wind speed is always zero there and the pressure (in Fort Bay at sealevel) is lower than that at the higher stations location at the Bottom (238 m) and in Oranjestad (175 m). The wind directions on the islands (Red and green) are very different and probably strongly affected by the local topography. But it seems there are daily variations in the wind direction which may affect the local currents strongly.

II.8. Light measurements

Light was measured using Odyssey light loggers. "Eriktry_001_007.csv" represents files of light meter BIO2 (#4607), which was attached to the microcat SBE37, the latter was mostly used for measuring salinity and temperature in the tent, during the CEX II cruise. "Saba_001_004" represents files of light meter BIO1 (#4608), which was attached to the SEAS-DIC during last deployment from CEX II. In csv files only raw data are shown without calibration.

The calibration curve for BIO2 (#4607) was made by Steven van Heuven. So we first apply the calibration curve for BIO1 (#4608), which was made by Erik Meesters and Fleur van Duyl. Light was also monitored during the whole second week cruise of the CEX with a sensor on the roof of the CEXII with the calibrated IMARES light meter, ULM-500. Those data are still with IMARES (Erik Meesters).

The Odyssey light logger BIO1 (#4608) was calibrated against the calibrated ULM-500 light meter on board. A linear fit was made with R^2=0.9945 (Fig 31).

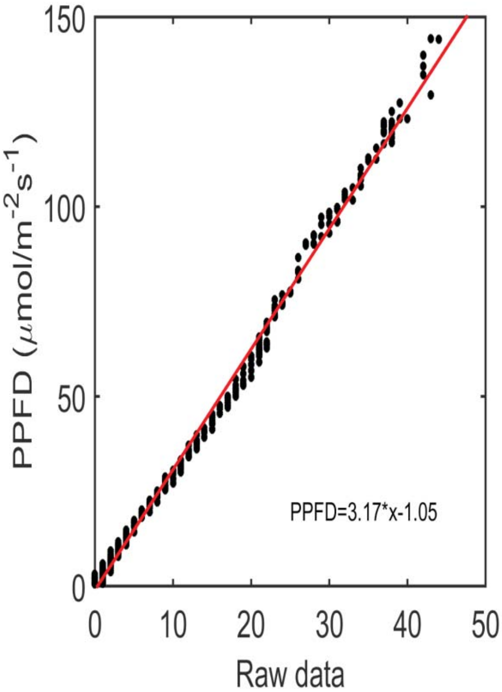
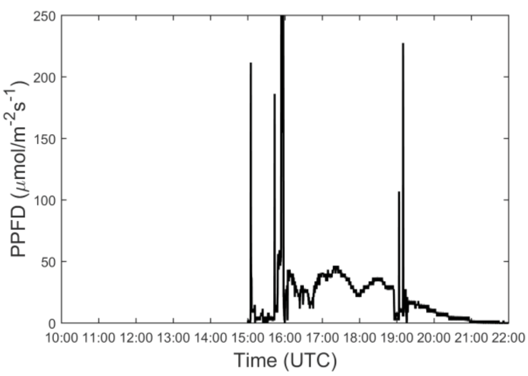
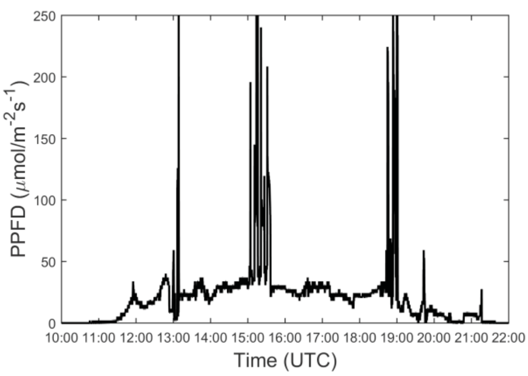


Figure II.32: Calibration of the light logger BIO1/4608(x-axis) against the calibrated ULM-500 lightmeter (y-axis).

After applying the linear fit, the PPFD (Photosynthetic Photon Flux Density) could be determined for the days between 25 and 29 October. Daily PPFD observations are shown in **Figure II.33**, which have been cut at 250 µmol/(m^2s). Spikes in the data represent periods that the logger was above sea level, which dramatically increased the PPFD and hence should be removed from the data in the analysis. Clearly 25&26 October represent cloudy days, followed by a day with intermittent clouds on 27&28 October and a sunny day on 29 October. Spiked to more negative values may be related to the logger not having a clear view above, because of interference of parts of the tent that didn't pass light or maybe even divers above.





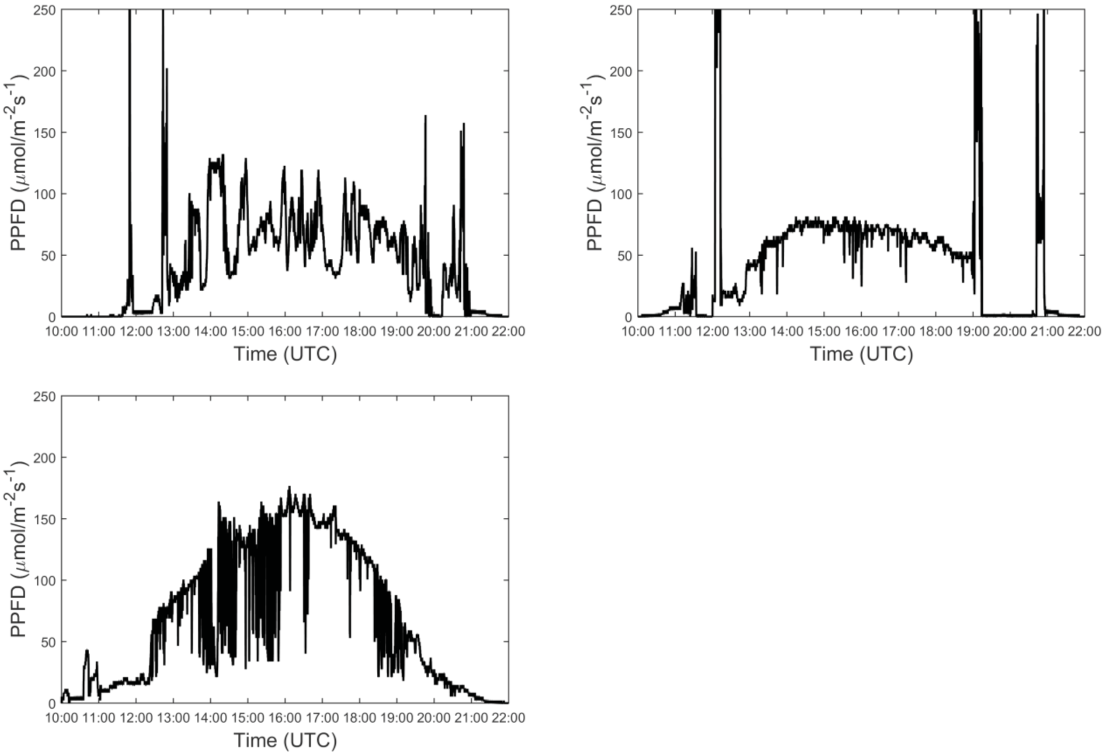


Figure II.33: PAR as a function of time in the tent on the Microcat at or near the sea floor for 24, 25, 26, 27 & 28 October. The first four are from Eriktry_001_007.csv and the last one from Saba_001_004.

Chap III: Tent incubations

Steven van Heuven, Alice Webb, Didier de Bakker, Paul Peters, Fleur C. van Duyl

III.1. Background information

The net growth of a coral reef depends in part on the balance between (i) aragonite accretion by corals and (ii) mechanical-chemical degradation by bioeroding organisms such as euendolithic microorganisms and sponges. The gradual decrease of surface ocean concentrations of carbonate ion ('ocean acidification') and increasing availability of organic material (e.g., from sewage) may for many reefs shift the balance towards net mass loss. We investigated in-situ the natural dynamics of the seawater carbonate system on the relatively pristine carbonate platform Saba Bank, and on a coral reef just offshore from the island of Saba, Dutch Caribbean.

III.2. Cruise narrative

Early in the morning of Sunday, October 25th, we sailed to our first site on the Saba Bank, at Tertre de Fleur. This rather planar location at approximately 15 m depth (**see Chap II, Figure II.2**)for bathymetry) features extensive calcifying algae and was therefore considered a candidate location for strong $CaCO_3$ accretion. Upon arrival, equipment was rapidly lowered and the tent was pitched. Fluorescin was injected to assess leakage after deployment (**Figure III.1**). Strong undulating horizontal motion ('surge') induced swaying of the tent and repeated lateral displacement when surge length exceeded the natural flex of the tent. This was expected to influence the water exchange between ambient and tent water (pumping). The tent could not be fastened tighter to the seafloor. Repeated attempts to stabilize the tent with tension wires were unsuccessful due to lack of suitable anchoring points on the substrate. In the morning of the 26th after a squal (**see chap II.7, Figure II.31**) which also dislodged parts of the equipment it was decided to abandon our attempt, and all equipment was successfully recovered.

Figure III.1: Tent injected with fluorescin after deployment on the Saba Bank (Tent site 1). Photo Erik Meesters

Not confident that a sufficiently favourable location would be found elsewhere on Saba Bank under the current weather conditions, we opted to relocate to the lee of the island of Saba, where the CEII attached to a central mooring in Ladder Bay (Ladder Labyrinth). Here, current and surge conditions appeared much more favourable. However, visibility was very limited, likely as a result of the squal of the preceeding night. However, within the first hour after our arrival, the visibility improved greatly. Ladder Bay is a spur-and-groove-like system with abundant coral cover. Nonetheless, a suitable, solitary patch of coral on a sandy surface was found (depth: ~20 m). All required equipment could be lowered before dusk. Early on the morning of the 27th, the tent was pitched over the coral patch, and all equipment was put in place. Several injections of fluoroscein into the closed tent did not reveal visual leakage of the tent.

The tent was subsequently re-opened and allow to flush thoroughly. Between 2015-10-27 11:00 and 2015-10-29 16:00, a total of 8 incubations (including 3 control incubations) were performed. Samples were collected both in-situ and by means of pumping water to the surface, where it was collected by an operator in a small dingy. Samples were rapidly returned to CEII for analysis or processing and storage. Sampling generally took place between 07:00 and 23:00. In-situ measurements were continued approximately continuously, which occasional brief recoveries of instrumentation for data download.

All equipment was recovered in the afternoon of the 29th, after which photographic and visual surveys were made of the previously enclosed coral patch and its surroundings.

Disembarkation of 4 participants and offloading of most of the equipment took place in the harbour of St. Eustatius in the morning of the 30th, after which the CEII returned to St. Maarten where the remaining participants disembarked and last freight were offloaded.

III. 3. Site descriptions

Tent Site 1: Tertre de Fleur on the Saba Bank (17.3845 ºN; 63.2897 ºW). A planar location (depth: 15 m) featuring extensive cover of encrusting and free-living branched calficying algae.

Tent Site 2: Ladder Labyrinth in Ladder Bay (17.6261ºN; 63.2602ºW). A solitary coral boulder colonized by sponges and some live corals (depth: 20 m). An illustration of the layout of the tent and surrounding is provided in **CHAP II.1. Figure II. 4**.

III.4. Tent(s)

The main enclosure was a custom-made, semi-hemisperical, bottomless, transparant dome tent with a square 4 m^2 footprint and ~3.5 m^3 volume. Tent arcs are butanyl-covered fire hoses and walls consisted mostly of transparent vinyl of 0.8 mm thickness, with butanyl reinforcements along edges. Butanyl flaps extended ~50 cm outward from the four sides of the tent, allowing for proper sealing of the tent to the substrate by means of placing weights (dive lead and short lengths of anchor chain) on the flaps. All 4 sides of the tent contained a zipable door of ~0.3 m^2 to allow flushing of the enclosed volume between incubations. Tent arcs were initially filled with seawater using a small underwater pump (BLDC Pumps, China), powered from a small battery pack in the dingy (see section on 'umbilical', below) until a final pressure of circa +1 bar relative to ambient pressure. Subsequently pressurization to +3 bars was attained using a humble bicycle pump.

Enclosed water was constantly homogenized by means of a propeller pump commonly used in tropical aquaria, running of a dedicated battery pack. This pump was positioned close to one of the tent arches, at half the height of the tent, and generated a slight circulating turbulence, while minimizing stirring up sediment. Effectiveness of the stirring was easily demonstrated using fluorescein.

A secondary tent has been used during the latter three days of the expedition. This tent was tetrahedron-shaped, with transparant vinyl-and-butanyl walls and rigid edges, and again with ~50 cm long flaps extending from is bottom edges. It could be deployed like a tripod covering a planar benthic surface of 0,43 m^2. Edge length was 1 meter, thus volume was 118 liters ($2^{0.5}/12*a^3$, where a is the edge length). This tent was deployed on the sandy substrate that surrounded the main tent, and constituted an impromptu 'blank' experiment against which the results from the main dome tent may be compared.

III.5. Tent incubations

Over a period of three days, a total of 8 incubations, each lasting several hours were performed with the big dome tent (n=5) and with the Pyramid (TIPI) tent (n=3). Between incubations tent windows were open to restore the tent interior to ambient conditions.

Dome Tent closed	Dome Tent opened
2015 -10-27 09:17	2015 -10-27 14:59
2015 -10-27 16:45	2015 -10-27 22:13
2015 -10-28 08:33	2015 -10-28 14:47
2015 -10-28 17:15	2015 -10-28 23:00
2015 -10-29 08:10	2015 -10-29 16:40

Pyramid Tent closed	Pyramid Tent opened
2015 -10-27 13:00	2015 -10-27 22:13
2015 -10-28 08:36	2015 -10-28 23:15
2015 -10-29 08:26	2015 -10-29 16:40

During the incubations tents were sampled every h by pumping water up from the tent to a rubber dinghy anchored firmly above the tent and manned by 2 operators. Sampling by Scuba divers was done just before closure, just before opening up and every 3 h in between when the tent(s) were closed.

III.6. In-situ measurements with autonomous instruments

Multiple instruments have been deployed in situ for monitoring various hydrographic and chemical parameters. Instruments for measuring physics and hydrodynamics in and near the tents are described in CHAP II.2. For autonomous measurement of the chemical variables, dissolved inorganic carbon (DIC) and pH we used a SEAS-DIC & pH instrument on loan from the University of South Florida, St. Petersburg. This instrument was placed alongside the tent, and analyzed water that it pumped from the tent.

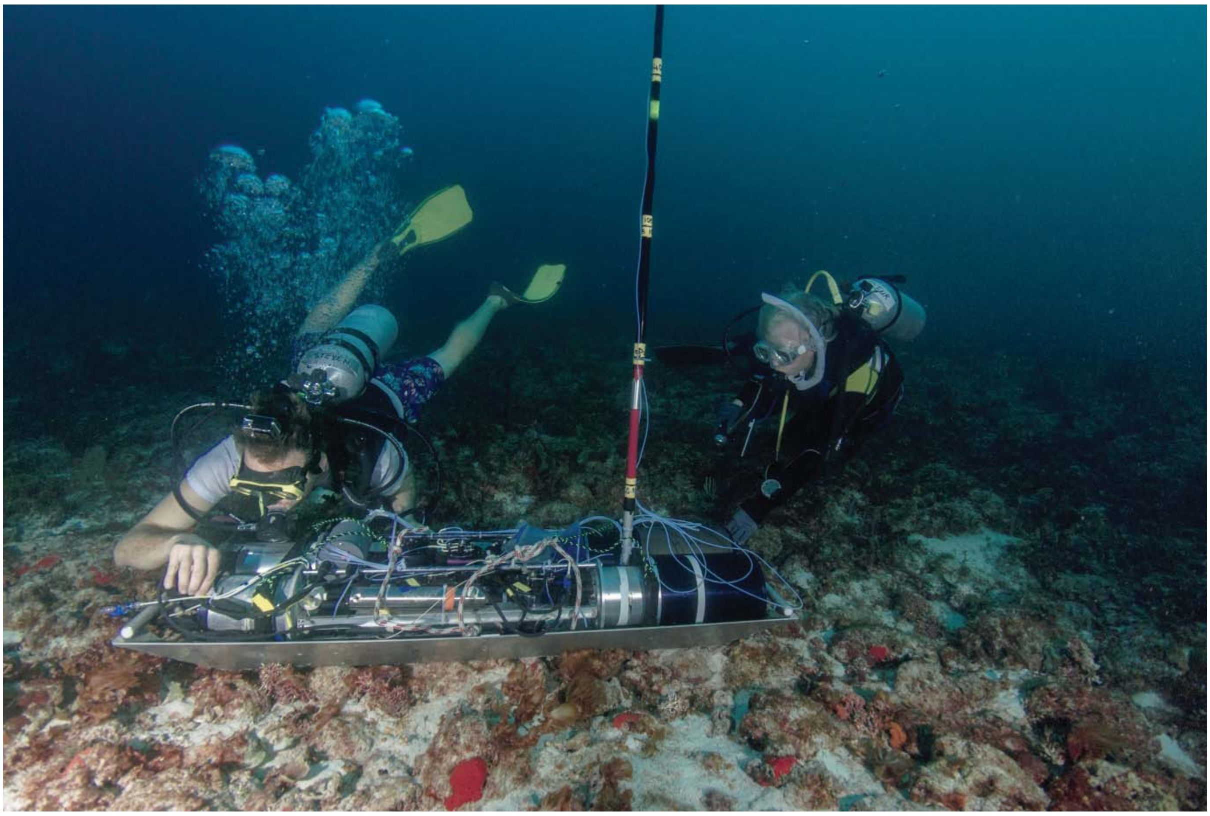


Figure III.2: Test deployment SEAS-DIC instrument on the Saba Bank. Photo David Stevens

Although the week prior to tent deployment (IMARES cruise) the principal developer of the SEAS instrument, Dr. Xuewu 'Sherwood' Liu of USFSP, was on board the CEII, the DIC measurement capability of the instrument could not be reliably used at any time. Also, the pH signal only proved usable during the last two days of the tent deployment. With assumptions on alkalinity (ALK), however, the pH signal may well be converted to DIC. However, no in-situ estimate of ALK is obtained, which would have been possible from the data if both pH and DIC would have worked. A detailed description of the instrumentation is provided in Liu et al. (2013).

III.7. Sampling for shipboard and shore-based measurements

For measurements that could not be performed *in situ*, samples were collected by (i) pumping seawater from the tent interior (or exterior) up to the sampling dingy and (ii) in-situ collecting of seawater in large-volume syringes, where syringes would also be returned as soon as possible after sampling to the dingy. Sample originated from (i) ambient water (pump or syringe), (ii) dome tent interior (pump or large syringe) or (iii) pyramid tent (100 ml syringes only).

a. **Pump sampling.** A small aquarium pump was placed adjacent to the tent. Every hour, it was energized by connecting its 50 m long power cable to a 24 V battery in the dingy. Water was pumped from tent, through a coarse particle filter and up towards the surface through 6mm OD (3.5 mm ID) *Dekabon* semi-rigid, aluminium-core tubing, also of length 50 m (internal volume: ~500ml). For structural strength, both the Dekabon and power cable were strapped to a strong synthetic line. The Dekabon tubing material prevents exchange of CO2, maintaining sample integrity during transport to surface. Flow rate was slightly over ~100 ml/min. The sampling line was therefore flushed for well above 5 minutes prior to collecting samples.

*Figure III.3: Note the pump tubing line from the dinghy down to the tent***.** *Photo Erik Meesters*

b. **Large Syringe sampling.** Samples were collected at depth by means of filling 2 or 3 large volume syringes (~300-500 ml). Samples were drawn from (i) the tent through a short piece of flexible tubing inserted into dedicated sampling holes in the tent or (ii) from the ambient water surrounding the tent. Two types of syringe have been used, both suffering from important drawbacks:

The first type of syringe was a custom-built unit, consisting of an acrylic barrel with a flat disk plunger on a steel pull rod. On the last day of the incubations, it was discovered that in at least one of the two used units, the o-ring between plunger and barrel did not maintain sufficient closure, and allowed ambient water to enter into the barrel during filling. Therefore, we expect all samples that nominally came from the tent interior to be contaminated with ambient water to unknown degree (but likely as much as 50%). Syringe was closed by the mundane means of tying a knot in the (permanently attached) sampling line.

The second type of syringe (4 units used) was a rather cheap design from a discount store, intended for declogging sinks. It consists of a simple plastic barrel and rubber-covered plunger, as has a volume of ~300 ml. Seal was determined to be excellent. However, the plunger had a ~15% dead volume (i.e., some water could not be expelled by the plunger), meaning that even after one or two pre-fillings, a small percentage would remain in the sample. A secondary drawback was that there syringes had to be closed with a rubber stopper, a procedure with may have contributed some more contamination of sample with ambient water.

We rather subjectively expect the second type of syringe to have delivered the better samples. However, there is no record of which syringes were used for which samples for the big dome tent, so we must necessarily assume all samples that have been 'pulled' from the "big" tent to have been contaminated with ambient water. Obviously, ambient samples may safely assumed to be good.

c. **Small syringe sampling**. The small triangle tent was first deployed on 27 October around 13:00h and regularly sampled with six 100ml clean Plastipak syringes until 29 October 16:00h. Initially 3 syringes ambient water and 3 tent water were collected. Later when sampling of tents was done synchronously and ambient water was sampled at the big tent, all 6 100 ml syringes were filled with tent water. The triangle tent was also vented regularly synchronous with big tent.

d. **Sample preparation.** After syringes were brought up to the dingy, or after the pump tubing had been sufficiently pre-flushed, up to three borosilicate glass bottles of 250 ml would be filled in rapid succession. These bottles would be rapidly returned to the CEII for further processing. One of the returned bottles would remain as-is, and be dedicated to on-board analysis for total alkalinity (TA) using a novel optical titrator (see below). A second bottle was poisoned with HgCl2 for storage for later shore-based analysis for dissolved inorganic carbon (DIC) and AT on a VINDTA instrument. A third bottle would subdivided into smaller samples. About 40 ml would be poured into a pre-combusted 60 ml EPA vial. Before closing these vials, approximately 250 µl??? of 8M HCl would be added for preservation and conversion of carbonate species to CO2, aiding in later analysis. From a syringe, two 'pony vials' would be filled through 0.8/0.2 µm filter (Acrodisk) from a syringe for shore based measurement of dissolved inorganic nutrients (NO_2+NO_3, NO_2, PO_4, $SiOH_4$ and NH_4).

III.8. Measurements and preliminary results

From pumps and dive-samples, we measured:

e. total alkalinity (optical alkalinity, Liu 2015)

f. total alkalinity (VINDTA3C, Mintrop 2003)

g. dissolved inorganic carbon (vindta)

h. dissolved organic carbon

i. nutrients (PO_4, NO_3, NO_2, NH_4, Silicate)

Figures III.4-6 on the following pages show data from most of the data sources outlined above. Not yet available are data of DOC and approximately half of the samples for DIC/ALK (currently being analysed). In many of the panels, the effect of opening and closing of the tent is evident.

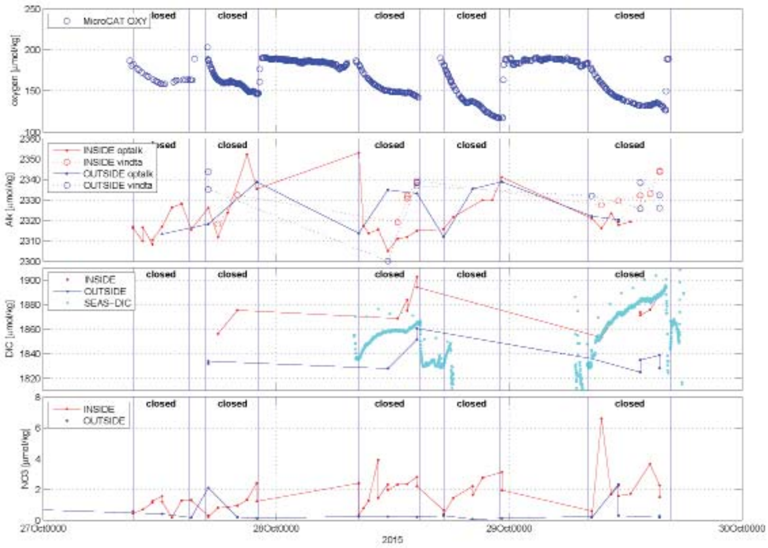


Figure III.4: Preliminary data of changes in oxygen (O2), Alkalinity (ALK), Dissolved inorganic carbon (DIC) and nitrate (NO_3) during tent incubations at Tent site 2 in Ladder Bay (Ladder Labyrinth).

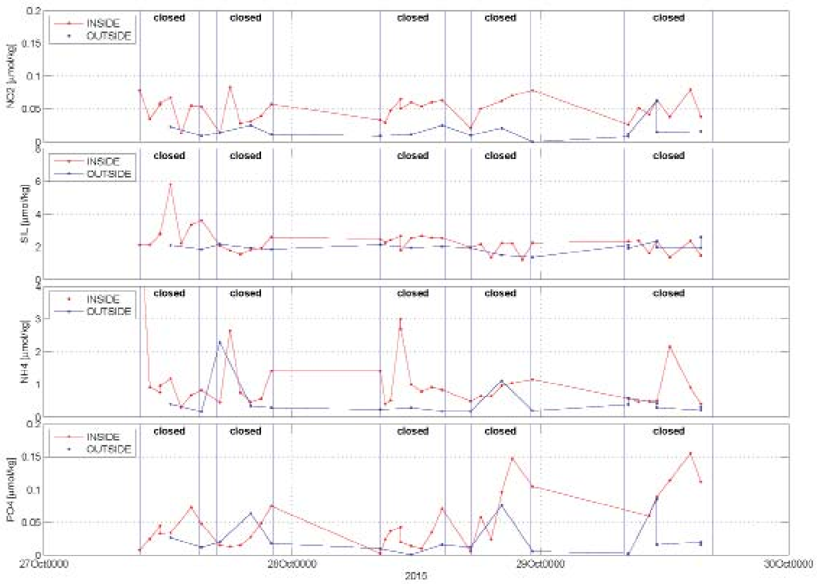


Figure III.5: Preliminary data of changes in nitrite(NO_2), silicate, ammonium (NH4) and phosphorus (PO_4) during tent incubations at Tent site 2 in Ladder Bay (Ladder Labyrinth).

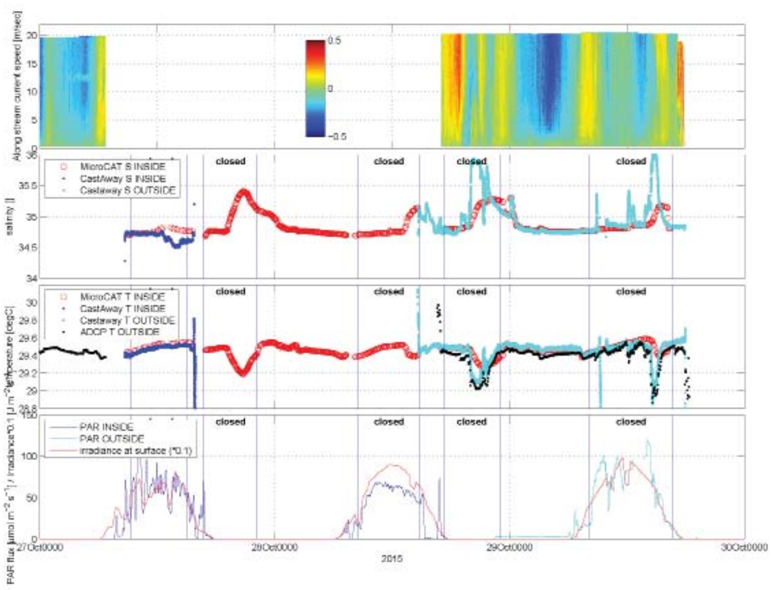


Figure III.6: Preliminary data of changes in along stream current speed, salinity, temperature, irradiance (PAR) during tent incubations at Tent site 2 in Ladder Bay (Ladder Labyrinth).

Tent leak rates were expected to be obtainable from decay behaviour of injected salinity spikes. Injection of circa 750 ml of saturated solution of NaCl (total: ~300 g) would have increase in-tent S (total: ~100 kg) by approximately 0.3% (or, say, from 35.0 to 35.1), which is well above the resolution and precision of the CTD). However, unexpected short-lived upwelling events of relatively cold, high-salinity water obscured the spikes. However, due to ad hoc placement of the 'cast-away' CTD sensor outside the tent, the leak rate may still be inferred. During times where the tent windows were open, both CTDs are observed to perfectly match. While the tent windows are closed, dynamics of S (and T) are strongly dampened.

IV. Benthic communities

Didier de Bakker, Alice Webb, Fleur van Duyl

IV.1. Tent quadrat surveys.

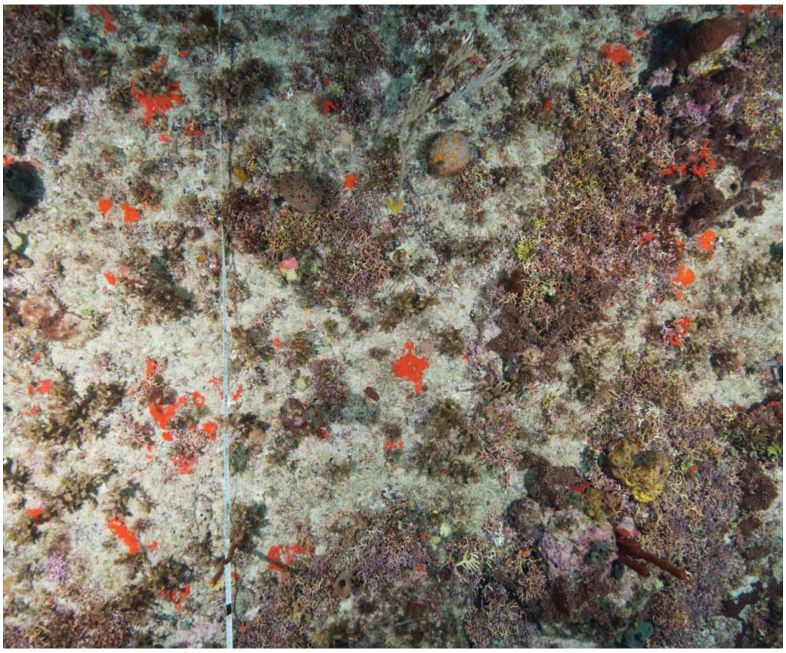
During the NIOZ cruise the benthic community within and outside the dome tent were recorded at tent site 1: Tertre de Fleur on the Saba Bank and at tent site 2: Ladder Labyrinth in Ladder Bay, Saba. The benthic surface area covered by the dome tent was approximately 4 m^2 (2 x 2 m) at both sites.

Tertre de Fleur

The tent quadrat at Tertre de Fleur is characterized by algal and sponge dominance (**Figure IV.1a**) . There is very little structural complexity (almost exclusively some larger sponges) and surface enlargement is only 1.5%. Remarkable at this site is the high density of calcifying branching algae (likely *Bossiella sp.* and/or *Calliarthron sp.*). Benthic cover was dominated by fleshy/ turf algae (32.7%) and crustose or branching coralline algae (20.7%). Sponge cover was 13.3%, benthic cyanobacterial mats 10% and corals less than 1%. Abiotic components (sand and bare calcareous substrate) covered 13.3%. No bioeroding species were present in the quadrat. Community surveys around the tent still need to be analysed.

Ladder Labyrinth in Ladder Bay

Within the tent quadrat several differently sized carbonate patches were present which acted as the main substratum for benthic macrobiota and were responsible for a total surface enlargement of 14% (4+0,56=4,56 m^2). Abiotic components (sand, bare rock) accounted for 58.2% of the total benthic cover within the quadrat. Algae (algal turf, *Lobophora sp., Dictyota sp.*) covered 23.6%, sponges 11.8% and calcifying species such as corals (including: *Meandrina meandrites, Orbicella annularis* and *Diploria stigosa*) and crustose coralline algae covered 6.5%. Bioeroding microbenthic species were not encountered in the quadrat. In addition Benthic community surveys around the tent were conducted , but still need to be analysed.



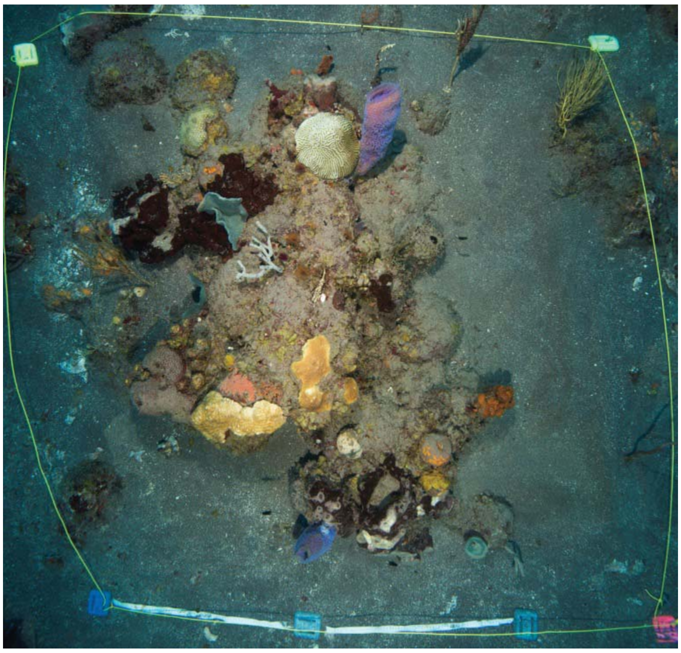


*Figure IV.1. (a) Detail of benthic cover at Tertre de Fleur. (b). Overview of enclosed surface at Ladder Labyrinth (perimeter of tent indicated by yellow cord, ca 2*2m).*

Multiple heterotrophic animals, including small fish and crustaceans, were present during the time of enclosure at Ladder Labyrinth. Just before the tent was removed on 29 October the fish survey yielded :

- 8 specimen of *Stegastes partitus*
- 1 specimen *Thalassoma bifasciatum*
- 11 specimen of *Coryphopteris sp.*

In addition several nudibranchs were observed in the tent.

After the tent was removed a set of images was made with the aim to reconstruct a 3D picture of the coral patch of tent site 2. Therefore a cube with axes of 31 cm was placed on the different images to allow reconstruction (**Figure IV.2**). The reconstruction still needs to be done.

Figure IV.2. Coral patch with cube, Tent site 2 . Photo Erik Meesters

In addition macro images were made of the sessile community of the benthic community covered by the tent at tent site 2. Complete species diversity still needs to be analysed. A few images are added below.

Figure IV.3: Macro images of benthic organisms in the tent quadrat at Tent site 2. Photos by Oscar Bos

IV.2. Transect work on Saba Bank reefs

During the IMARES cruise week (17-24 October) transect work was conducted on 11 Saba Bank stations (IMARES monitoring program stations). With the aim of determining the current net reef growth on Saba Bank we applied a calcium carbonate budget assessment method (adapted from the *ReefBudget* method*:* Perry *et al.* 2012) to 11 reef sites along the South-East rim of the Bank.

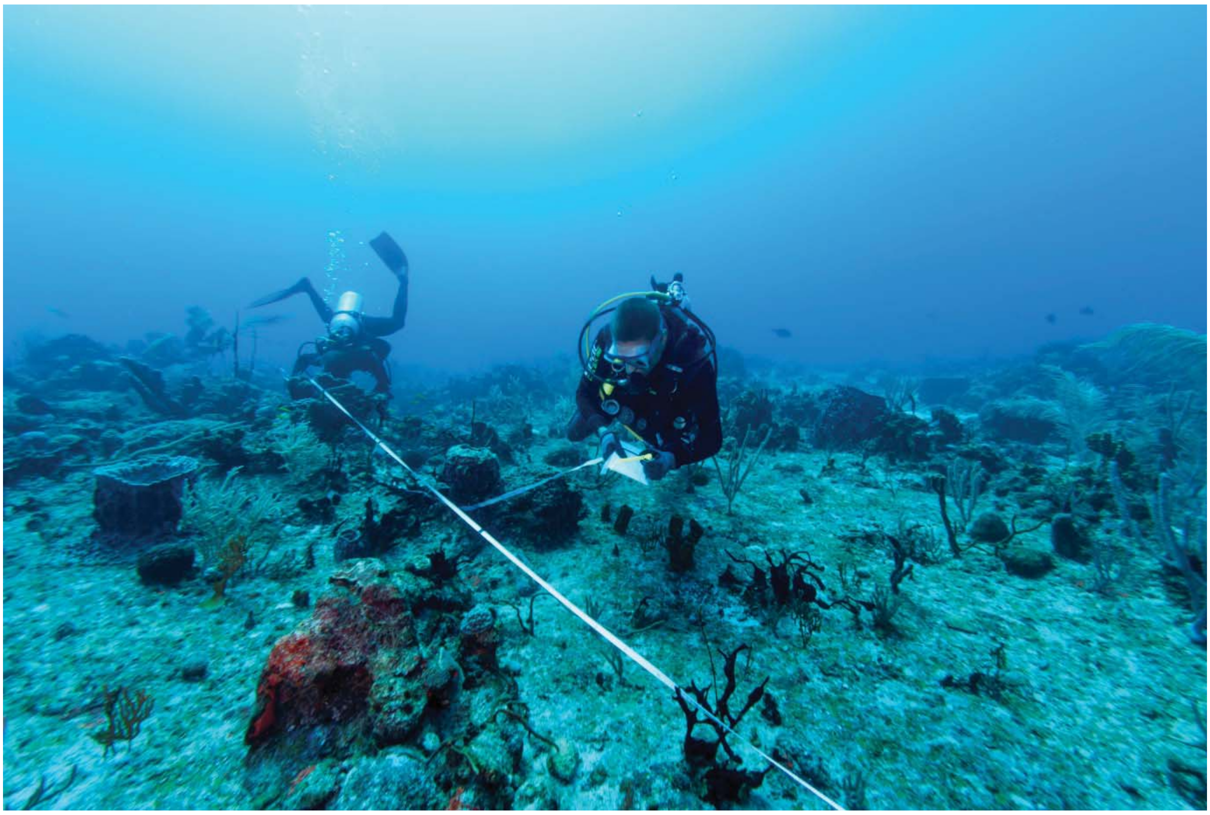


Figure IV.4: Transect work on the Saba Bank during IMARES week. Photo David Stevens

Data on the bioeroder community (excavating sponges and sea urchins), reef structural complexity *i.e.* rugosity and sediment depth were collected *in situ* along three 10 m belt (30 m^2 in total) at each site. Within each transect the size of every excavating sponge and sea urchin was estimated (**Table IV.1**). Data of bioerosion will be combined with data of calcifying organisms (stony corals and coralline algae) and size and abundance of bioeroding fish (mainly parrot fish). These data, which were collected as well, are not yet available. The degree of reef rugosity was determined following Risk's chain-and-tape method (Risk, 1972): underneath the main 10 m transect line a second transect tape is draped over the contour of the reef and the difference is a measure surface for enlargement (**Table IV.1**). Sediment depth (**Table IV.1**) was measured every meter by piercing a ruler into the sediment until hard substrate was reached. High quality photographs were taken of the transects for detailed benthic community analysis. The images still have to be analysed, but will eventually also be used to calculate the ratio of calcifying:bioeroding surface at every site.

Table IV.1. Preliminary results of the calcium carbonate budget assessment method on Saba Bank. Including mean surface enlargement (%) and sediment depth (cm) at each site; total cover (in cm^2) per excavating sponge species [Cl: *Cliona laticavicola*, Cc: *C. caribbaea*, Ct: *C. tenius*, Cv: *C. varians* and AC: *Syphonodictyon coralliphaga*] at each site and number of sea urchins present with their respective size in parenthesis. * for coordinates and depth of sites see cruise report IMARES 2014 (Van Beek & Meesters, 2014).

Site*	Surface							
Enlargement	Sediment depth	CL	CC	CT	CV	AC	Sea Urchins	
Scottish Hills	14.0	0.50	2895	0	0	0	0	0
Paul's Cathedral	36.6	0.20	3159	307	0	0	17	0
Gorgonian Delight	17.7	2.45	2366	0	0	0	28	1 (2 cm)
Tertre de Fleur	26.3	1.68	0	119	0	0	171	1 (3 cm)
Erik's Point	6.6	0.47	813	111.6	0	0	149.4	0
Coral Gardens	17.1	1.43	3155	2743	0	0	0	0
Devil's Corner	23.8	1.90	205	0	2018	286	9	0
12 Monkeys	27.2	0.32	2317	209	0	0	0	0
La Coline aux Gorgones	18.1	1.17	1554	592	4324	15	292	0
Rebecca's Garden (RG)	2.9	3.45	299	0	0	0	2	0
Mooring Line RG	10.6	0.15	451	0	0	0	2	0

V. Coral fauna of Saba and Saba Bank

Bert W. Hoeksema, Naturalis Biodiversity Center, Leiden, The Netherlands

V.1. Coral species diversity

The original aim of the coral diversity survey was (1) to find out whether the coral fauna of Saba Bank matches the coral fauna of St Eustatius and (2) to check whether the Saba Bank coral fauna has remained the same over nearly half a century by a comparison with results of an earlier marine biodiversity expedition to Saba Bank, which was organized in 1971 by the Dutch Navy and Naturalis.

Due to weather conditions and other circumstances, only three dives were made on Saba Bank, all at a single locality, which is not enough for the planned comparisons. A total of **18 stony coral species** was recorded (15-17 per dive). Some of the encountered coral species showed morphological variation by being either attached or free-living. The latter are so-called coralliths or living rolling stones. However, coralliths belonging to the genus *Madracis* were not ball-shaped as regular coralliths but disk-shaped (**Figure V.1**), similar to many species of mushroom corals in the Indo-Pacific. This particular coral shape may be related to swell-generated currents that push free-living coral fragments over the shallow sea floor.

Because diving at Saba Bank had to be aborted, the survey was continued at Ladder Labyrinth in Ladder Bay, Saba, where nine dives were made. Here a total of **42 species** was encountered (26-37 per dive), which is a very high number for a single locality in the Caribbean. One of these species is *Tubastraea coccinea*, a non-indigenous species from the Indo-Pacific (**Figure V.2**). This species may have been introduced as fouling organism on an oil rig and was first reported from Curaçao in 1943. It is known as an aggressive invasive species in Brazil, where it competes for space with local, endemic coral species.

Some stony corals were observed as host for the Christmas tree worm (*Spirobranchus giganteus*). Various host coral species were previously not known as associate for this tube worm, which is probably a generalist with regard to its host preference. However, many coral species have never been reported as its habitat (**Figure V.3**).

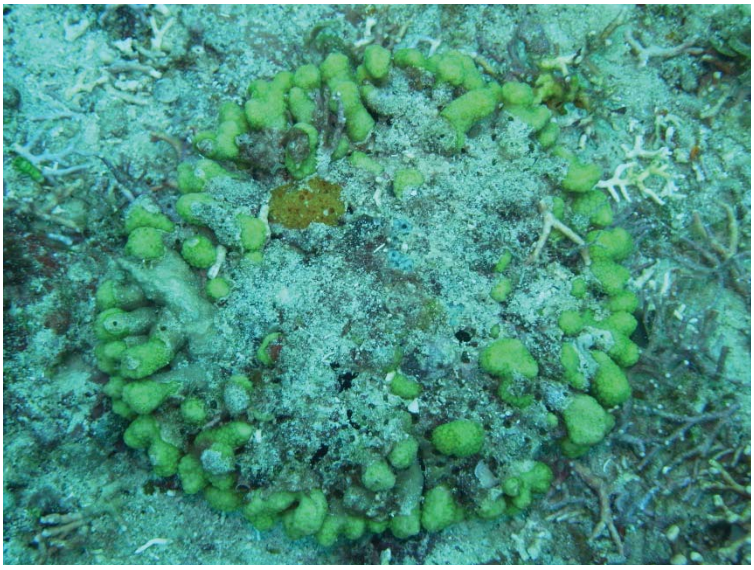


Figure V.1. A disk-shaped corallith at Saba Bank. Photo Bert Hoeksema

Figure V.2: Tubastraea coccinea is a non-indigenous coral species, which accidently has been introduced from the Indo-Pacific. Photo Bert Hoeksema

Figure V.3: Christmas tree worm as associate of an Agaricia fragilis coral at Saba, which probably represents a new host record. Photo Bert Hoeksema

VI. Acknowledgements

We are particularly grateful to the captain and crew of CEII, who have been outstandingly helpful and accomodating. We also would like to thank support of the Saba Marine parks, CNSI, Johan Stapel, Steve Piontek , NWO for external funding and IMARES for joining their cruise. Special thanks go to our IMARES colleagues
Eric Meesters, Oscar Bos and our volunteers Dahlia Hassell, Jarno Knijff, Ewan Tregarot, Lodewijk van Walraven and Bas Westerhof without whom this expedition would have been virtually impossible.

VII. References

Andersson AJ, Gledhill D (2013) Ocean acidification and coral reefs: Effects on breakdown, dissolution, and net ecosystem calcification. Annu Rev Marine Sci 5: 1.1-1.28.

Liu, Xuewu, Robert H. Byrne, Lori Adornato, Kimberly K. Yates, Eric Kaltenbacher, Xiaoling Ding and Bo Yang (2013). In Situ Spectrophotometric Measurement of Dissolved Inorganic Carbon in Seawater. Environmental Science and Technology 47(19), 11106–11114.

Liu, Xuewu, Robert H. Byrne , Michael Lindemuth , Regina Easley , Jeremy T. Mathis (2015) An automated procedure for laboratory and shipboard spectrophotometric measurements of seawater alkalinity: Continuously monitored single-step acid additions. Mar Chekm 174:141-146

Perry CT, Edinger EN, Kench PS, Murphy GN, Smithers SG, et al. (2012) Estimating rates of biologically driven coral framework production and erosion: a new census-based carbonate budget methodology and applications to the reefs of Bonaire. Coral Reefs 31: 853-868.

DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2, A. G. Dickson & C. Goyet, eds., ORNL/CDIAC-74.

Van Beek I.J.M., E H.W.G. Meesters (2014) Saba Bank research expedition 2013 – Progress Report. IMARES report nr C086/14

Appendix A: Cruise participants

Fleur van Duyl	NIOZ	Chief Scientist, Marine micr. Ecologist
Didier de Bakker	NIOZ/IMARES	PhD Marine Ecologist
Oscar Bos	IMARES	Marine Ecologist
Dahlia Hassel	Saba Conservation Foundation	Saba Bank Officer
Steven van Heuven	NIOZ	Ocean Chemist
Bert Hoeksema	Naturalis	Coral Taxonomist
Jarno Knijff	Saba Conservation Foundation	Dive instructor, volunteer assistant
Erik Meesters	IMARES/NIOZ	Marine Ecologist
Janine Nauw	NIOZ	Ocean Physicist (adcp, CTD)
Paul Peters	NIOZ/UU	Biology Student Geosciences UU
Ewan Tregarot	Marine Observatory of Martinique	Marine Biologist, volunteer assistant
Lodewijk van Walraven	NIOZ	Marine Ecologist, Volunteer assistant
Alice Webb	NIOZ	PhD Marine Ecologist / Chemist
Bas Westerhof	NIOZ	Marine Biologist, Volunteer assistant

Appendix B.

Table with data of tent incubations

datetime	exp	intent	collector	VINDTA				OPTALK			DOC		NUTS										
				Sample ID	Bottle no.	TA	DIC	sample ID	Bottle ID.	TA	Sample ID	DOC	Sample ID	PO4	QF	NH4	QF	NO23	QF	NO2	QF	SIL	QF
2015-10-26 00:00	1	0	1	1	1						1		1										
2015-10-26 00:00	1	0	1	2	2						2		2	0.039	1	0.4	1	1.235	1	0.051	1	1.298	1
2015-10-27 09:15	2	1	2	3	3			1	3	2292.84	3		3										
2015-10-27 09:15	2	1	2	4	4			2	4	2292.36	4		4	0.008	1	6.609	1	0.681	1	0.078	1	2.103	1
2015-10-27 09:15	2	1	3	5	5	2318.82	1852.18	3	6	2292.11	5		5										
2015-10-27 09:15	2	1	3	6	6	2318.73	1837.35				6		6	0.074	1	1.599	1	0.479	1	0.036	1	2.017	1
2015-10-27 10:15	2	1	2	7	7			4	5	2285.89	10		10										
2015-10-27 10:15	2	1	2	8	8			5	7	2292.63	9		9	0.025	4	0.906	1	0.734	1	0.035	1	2.116	1
2015-10-27 11:15	2	1	2	9	9			6	8	2284.27	8		8	0.045	1	0.759	1	1.203	1	0.056	1	2.768	1
2015-10-27 11:15	2	1	2	10	10			7	9	2286.53	11		11	0.033	4	0.952	1	1.305	1	0.059	1	2.789	1
2015-10-27 12:15	2	1	2	11	11			8	11	2292.93	12		12	0.034	1	1.177	1	1.64	1	0.067	1	5.822	1
2015-10-27 12:15	2	1	2	12	12						13		13										
2015-10-27 12:15	2	1	3	13	14	2299.28	1861.72				14		14	0.019	4	2.647	1	1.245	1	0.038	1	3.261	1
2015-10-27 12:15	2	1	3	14	19						15		15										
2015-10-24 00:00	1	0	1	15	15	2464.5	1954.04																
2015-10-24 00:00	1	0	1	16	16	2468.27	1978.85																
2015-10-27 12:15	2	0	3	17	17			9	12	2289.35	16		16	0.027	4	0.399	1	0.443	1	0.023	1	2.096	1
2015-10-27 12:15	2	0	3	18	14						17		17										
2015-10-27 13:15	2	1	2	19	20			10	10	2302.31	18		18	0.015	8	0.304	1	0.195	1	0.013	1	2.202	1
2015-10-27 13:15	2	1	2	20	22						19		19										
2015-10-27 14:15	2	1	2	21	13			11	13	2304.14	20		20	0.073	1	0.676	1	1.339	1	0.055	1	3.36	1
2015-10-27 14:15	2	1	2	22	18						21		21										
2015-10-27 15:15	2	1	2	23	21			12	14	2291.57	22		22	0.048	1	0.821	1	1.377	1	0.053	1	3.618	1
2015-10-27 15:15	2	1	2	24	23						23		23										
2015-10-27 15:15	2	0	3	25	24						25		26	0.012	8	0.169	1	0.185	1	0.009	1	1.848	1
2015-10-27 15:15	2	0	3										27										
2015-10-27 15:15	2	1	3	26	26						24		24	0.046	1	0.59	1	1.345	1	0.05	1	3.237	1
2015-10-27 15:15	2	1	3	27	29								25										
2015-10-27 17:00	2	1	2	28	25			13	7	2302.07	26		28	0.015	1	0.447	1	0.313	1	0.014	1	2.076	1
2015-10-27 17:00	2	1	2	29	28								29										
2015-10-27 17:00	2	0	3	30	32	2343.71	1831.94	14	19	2294.19	28		32	0.02	4	2.283	1	2.126	1	0.014	1	2.151	1
2015-10-27 17:00	2	0	3	31	33	2335.17	1833.98						33										
2015-10-27 17:00	2	1	3	32	30	2320.91	1829.58	15	11	2293.29	27		30	0.004	4	0.161	1	0.218	1	0.005	1	1.434	1
2015-10-27 17:00	2	1	3	33	31	2321.79	1820.18						31										
2015-10-27 18:00	2	1	2	34	34			16	6	2287.84	29		34	0.013	4	2.646	1	0.905	1	0.083	1	1.778	1
2015-10-27 18:00	2	1	2	35	35	2318.19	1856.22						35										
2015-10-27 19:00	2	1	2	36	36			17	10	2299.82	30		36	0.015	4	0.747	1	0.879	1	0.028	1	1.532	1
2015-10-27 19:00	2	1	2	37	47								37										
2015-10-27 20:00	2	1	2	38	55			18	1	2409.3	31		38	0.028	4	0.46	1	1.005	1	0.031	1	1.827	1
2015-10-27 20:00	2	1	2	39	56	2332.36	1875.47						39										
2015-10-27 20:00	2	0	3	40	51			19	2	2405.04	33		42	0.064	1	0.343	1	0.232	1	0.025	1	1.927	1
2015-10-27 20:00	2	0	3										43										
2015-10-27 20:00	2	1	3	41	49			20	8	2327.77	32		40	0.037	4	5.028	1	1.009	1	0.07	1	2.105	1
2015-10-27 20:00	2	1	3	42	43								41										
2015-10-27 21:00	2	1	2	43	53			21	9	2328.25	34		44	0.049	1	0.556	1	1.387	1	0.039	1	1.905	1
2015-10-27 21:00	2	1	2	44	54								45										
2015-10-27 22:00	2	1	2	45	37			22	3	2311.34	35		46	0.075	1	1.415	1	2.483	1	0.057	1	2.595	1
2015-10-27 22:00	2	1	2	46	38								47										
2015-10-27 22:00	2	0	3	47	39			23	5	2314.78	37		50	0.018	1	0.289	1	0.146	1	0.011	1	1.85	1
2015-10-27 22:00	2	0	3	48	45								51										
2015-10-27 22:00	2	1	3	49	44			24	6	2301.4	36		48	0.049	1	0.664	1	1.272	1	0.031	1	1.913	1
2015-10-27 22:00	2	1	3	50	50								49										
2015-10-28 08:30	2	1	2	51	61			25	7	2328.99	38		52	0.003	1	1.413	1	2.447	1	0.033	1	2.47	1
2015-10-28 08:30	2	1	2	52	62								53										
2015-10-28 08:30	2	0	3	53	63			26	19	2289.76	40		56	0.01	1	0.235	1	0.264	1	0.009	1	2.12	1
2015-10-28 08:30	2	0	3	54	64								57										
2015-10-28 08:30	2	1	3	55	65			27	4	2291.64	39		54	0.012	1	0.323	1	0.357	1	0.015	1	2.162	1
2015-10-28 08:30	2	1	3	56	68	2265.52	1836.54						55										
2015-10-28 09:00	2	1	2	57	66			28	11	2293.29	41		58	0.024	1	0.399	1	0.825	1	0.029	1	2.245	1
2015-10-28 09:00	2	1	2	58	67								59										
2015-10-28 09:30	2	1	2	59	72			29	14	2289.7	42		60	0.037	1	0.503	1	1.315	1	0.047	1	2.403	1
2015-10-28 09:30	2	1	2	60	71								61										
2015-10-28 08:30	3	1	4								43		62	0.017	8	0.502	1	0.421	1	0.021	1	2.291	1
2015-10-28 08:30	3	1	4										63										
2015-10-28 10:30	2	1	2	61	27			30	16	2291.57	44		64	0.043	1	3.002	1	3.991	1	0.065	1	2.655	1
2015-10-28 10:30	2	1	2	62	59								65	0.02	4	2.695	1	1.51	1	0.05	1	1.8	1
2015-10-28 11:30	2	1	2	63	81			31	5	2281.04	46		69										
2015-10-28 11:30	2	1	2	64	73								70	0.014	1	0.999	1	2.4	1	0.06	1	2.531	1
2015-10-28 11:30	2	0	3	65	74	2300.16	1827.96	32	6	2310.91	48		73										
2015-10-28 11:30	2	0	3	66	80								74	0.001	1	0.287	1	0.255	1	0.011	1	1.942	1
2015-10-28 11:30	2	1	3	67	69			33	12	2296.74	47		71										
2015-10-28 11:30	2	1	3	68	70								72	0.005	1	0.812	1	2.032	1	0.053	1	2.466	1
2015-10-28 11:30	3	1	4								45		67	0.004	1	2.241	1	2.515	1	0.049	1	2.867	1
2015-10-28 11:30	3	1	4										68	0	1	0.559	1	0.254	1	0.017	1	2.76	1
2015-10-28 12:30	2	1	2	69	77			34	8	2286.98	49		75										
2015-10-28 12:30	2	1	2	70	76	2319.07	1868.74						76	0.01	4	0.781	1	2.383	1	0.054	1	2.669	1
2015-10-28 13:30	2	1	2	71	75	2330.7	1883.82	35	9	2287.9	50		77										
2015-10-28 13:30	2	1	2	72	79	2332	1875.02						78	0.035	4	0.911	1	2.422	1	0.06	1	2.555	1
2015-10-28 14:30	2	1	2	73	86	2338.3	1902.54	36	18	2290.95	51		79										
2015-10-28 14:30	2	1	2	74	83	2339.47	1894.13				52		80	0.071	4	0.835	1	2.881	1	0.063	1	2.541	1
2015-10-28 14:30	2	0	3	75	89	2338.53	1851.51	37	17	2309.18	54		83										
2015-10-28 14:30	2	0	3	76	87	2336.82	1860.64				55		84	0.016	8	0.184	1	0.243	1	0.025	1	2.025	1
2015-10-28 14:30	2	1	3					38	7	2300.13	53		81										
2015-10-28 14:30	2	1	3										82	0.08	4	0.852	1	2.27	1	0.056	1	2.587	1
2015-10-28 14:30	3	1	4								56		85										
2015-10-28 14:30	3	1	4										86	0.017	8	0.809	1	0.339	1	0.026	1	2.866	1
2015-10-28 17:15	3	1	4								57		87										
2015-10-28 17:15	3	1	4										88	0.006	1	0.626	1	0.262	1	0.011	1	2.703	1
2015-10-28 17:15	2	1	2	77	115			39	3	2291.7	58		89										
2015-10-28 17:15	2	1	2	78	116						59		90	0.006	1	0.484	1	0.683	1	0.021	1	1.973	1
2015-10-28 17:15	2	0	3	79	117	-9999	-9999	40	9	2287.9	61		93										
2015-10-28 17:15	2	0	3	80	118								94	0.012	1	0.184	1	0.314	1	0.01	1	1.927	1
2015-10-28 17:15	2	1	3	81	119			41	8	2274.31	60		91										
2015-10-28 17:15	2	1	3	82	20								92	0.008	1	0.331	1	0.439	1	0.016	1	1.966	1

datetime	exp	intent	collector	VINDTA				OPTALK			DOC		NUTS										
				Sample ID	Bottle no.	TA	DIC	sample ID	Bottle ID.	TA	Sample ID	DOC	Sample ID	PO4	QF	NH4	QF	NO23	QF	NO2	QF	SIL	QF
2015-10-28 18:15	2	1	2	83	65			42	13	2297.72	62		95										
2015-10-28 18:15	2	1	2	84	88								96	0.058	1	0.642	1	1.512	1	0.05	1	2.145	1
2015-10-28 19:15	2	1	2								63		97										
2015-10-28 19:15	2	1	2										98	0.024	4	0.641	1	1.366	1	0.026	8	1.333	1
2015-10-28 20:15	2	1	2	85	91			43	999122		64		99										
2015-10-28 20:15	2	1	2	86	95						65		100	0.096	4	0.961	1	2.284	1	0.062	1	2.224	4
2015-10-28 20:15	2	1	3	87	98			44	11	2314.16	66		101										
2015-10-28 20:15	2	1	3	88	93								102	0.08	1	0.787	1	1.704	1	0.048	1	2.061	1
2015-10-28 20:15	2	0	3	89	112			45	15	2311.42	67		103										
2015-10-28 20:15	2	0	3	90	114								104	0.076	1	1.114	1	0.093	1	0.021	1	1.488	1
2015-10-28 20:15	3	1	4								70		109	0.032	1	3.307	1	0.126	1	0.035	1	2.994	1
2015-10-28 20:15	3	1	4										110										
2015-10-28 21:15	2	1	2	91	103			46	5	2305.92	68		105										
2015-10-28 21:15	2	1	2	92	104								106	0.147	1	1.037	1	2.836	1	0.07	1	2.209	1
2015-10-28 22:15	2	1	2	93	97			47	18	2305.92	69		107										
2015-10-28 22:15	2	1	2	94	99								108									1.211	1
2015-10-28 23:15	2	1	2	95	92			48	4	2317.11	72		113										
2015-10-28 23:15	2	1	2	96	105								114	0.105	1	1.152	1	3.218	1	0.078	1	2.235	1
2015-10-28 23:15	2	0	3	97	108			49	14	2314.85	74		117										
2015-10-28 23:15	2	0	3	98	107								118	0.006	4	0.194	1	0.134	1	0	1	1.351	1
2015-10-28 23:15	2	1	3	99	106			50	10	2290.47	73		115										
2015-10-28 23:15	2	1	3	100	109								116	0.099	4	0.949	1	2.007	1	0.05	1	2.421	1
2015-10-28 23:15	3	1	4								71		111	0.02	1	0.283	1	0.176	1	0.016	1	3.088	1
2015-10-28 23:15	3	1	4										112	0.017	1	0.499	8	0.167	1	0.015	1	3.108	4
2015-10-29 08:30	3	1	4										119										
2015-10-29 08:30	3	1	4										120	0.011	8	0.462	1	0.209	1	0.012	1	2.425	1
2015-10-29 08:30	2	0	2	101	121			51	9	2298	76		123										
2015-10-29 08:30	2	0	2	102	133								124	0.003	4	0.389	1	0.259	1	0.008	1	2.093	1
2015-10-29 08:30	2	1	2	103	122			52	17	2296.95	75		121										
2015-10-29 08:30	2	1	2	104	132								122	0.016	8	0.567	1	0.639	1	0.026	1	2.316	1
2015-10-29 08:30	2	0	3	105	125			53	15	2354.02	77		125										
2015-10-29 08:30	2	0	3	106	123	2331.99	1835.98						126	0.001	4	0.582	1	0.189	1	0.012	1	1.92	1
2015-10-29 08:30	2	1	3	107	126	2325.37	1835.53	54	1	2297.02	78		127										
2015-10-29 08:30	2	1	3	108	131	2329.88	1835.48						128	0.004	1	0.285	1	0.206	1	0.015	1	2.374	1
2015-10-29 09:30	2	1	2	109	128			55	5	2292.16	79		129										
2015-10-29 09:30	2	1	2	110	60	2327.51	1853.26						130	0.045	8	0.468	1	6.653	1	0.051	1	2.36	1
2015-10-29 10:30	2	1	2	111	124			56	13	2299.33	80		131										
2015-10-29 10:30	2	1	2	112	127								132	0.06	4	0.482	1	1.725	1	0.041	1	1.599	1
2015-10-29 11:15	2	0	2	113	137			57	5	2296.44	83		137										
2015-10-29 11:15	2	0	2	114	139								138	0.086	1	0.429	1	2.41	1	0.062	1	2.334	1
2015-10-29 11:15	2	1	2	115	145	2329.56	1873.75	58	19	2293.76	84		139										
2015-10-29 11:15	2	1	2	116	144								140	0.089	1	0.501	1	2.318	1	0.063	1	2.337	1
2015-10-29 11:15	2	0	3					59	8	2295.37	81		133										
2015-10-29 11:15	2	0	3										134	0.016	8	0.299	1	0.318	1	0.015	1	1.972	1
2015-10-29 11:15	2	1	3	117	129						82		135										
2015-10-29 11:15	2	1	3	118	136			60	7	2300.29			136	0.051	8	0.481	1	1.631	1	0.046	1	2.208	1
2015-10-29 11:15	3	1	4								85		141										
2015-10-29 11:15	3	1	4										142	0.028	1	0.575	1	0.181	1	0.024	1	2.712	1
2015-10-29 12:30	2	1	2	119	102			61	2	2295.37	86		143										
2015-10-29 12:30	2	1	2	120	140								144	0.114	1	2.148	1	1.763	1	0.038	1	1.35	1
2015-10-29 13:30	2	1	2	121	166	2332.24	1873.76	63	7		88		147										
2015-10-29 13:30	2	1	2	122	141	2325.73	1871.31						148										
2015-10-29 13:30	2	0	2	134	58	2325.69	1825.05	62	8		87		145										
2015-10-29 13:30	2	0	2	130	142	2338.45	1834.91						146										
2015-10-29 13:30	2	0	3	140	168			64	10		89		149										
2015-10-29 13:30	2	0	3	141	143								150										
2015-10-29 13:30	2	1	3	127	167	2330.24	1839.63	65	4		90		151										
2015-10-29 13:30	2	1	3										152										
2015-10-29 13:30	3	1	4								91		153										
2015-10-29 13:30	3	1	4										154										
2015-10-29 14:30	2	1	2	125	42	2332.99	1875.69	66	17		92		155										
2015-10-29 14:30	2	1	2	142	82								156	0.155	1	0.904	1	3.738	1	0.079	1	2.352	1
2015-10-29 15:30	2	1	2	128	160	2344.13	1888.04	67	18		93		157										
2015-10-29 15:30	2	1	2	136	163	2343.78	1888.63						158	0.112	4	0.4	1	2.312	1	0.038	1	1.457	1
2015-10-29 15:30	2	0	2	124	158	2332.28	1838.96	68	11		94		159										
2015-10-29 15:30	2	0	2	138	154								160	0.02	8	0.21	1	0.207	1	0.016	1	1.943	1
2015-10-29 15:30	2	1	3	131	155	2337.84	1858.57	69	16		95		161										
2015-10-29 15:30	2	1	3	135	150	2336.71	1862.34						162	0.061	1	0.373	1	1.543	1	0.028	1	1.63	1
2015-10-29 15:30	2	0	3	133	149	2326.08	1828.42	70	14		96		163										
2015-10-29 15:30	2	0	3	139	148								164	0.016	8	0.304	1	0.291	1	0.016	1	2.594	1
2015-10-29 00:00				123	169	2328.05	1848.67																
2015-10-29 00:00				126	132	2329.79	1843.83																
2015-10-29 11:15	3	1	4	137	146	2330.95	1836.22	71	5														
2015-10-29 13:30	3	1	4	129	152	2336.68	1841.15	72	3														
2015-10-29 13:30	3	1	4					73	1														
2015-10-29 15:30	3	1	4	132	156	2304.38	1846.02				97		165										
2015-10-29 15:30	3	1	4										166	0.018	1	0.239	1	0.072	1	0.009	1	3.021	1