Saba Bank research expedition 2013 – Progress Report

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Summary

The Saba Bank is the largest submerged carbonate platform of 2,200 km^2 in the Caribbean Sea, which lies partially within the Exclusive Economic Zone of the Netherlands and partially within the territorial waters of Saba and St. Eustatius. The Saba Bank houses an expansive coral reef ecosystem with a rich diversity of species and as such is also an important source of commercial fish for the nearby islands.

The Saba Bank furthermore forms the largest protected area of the Kingdom of the Netherlands, after the Dutch part of the Wadden Sea in Europe. It was declared a protected area by the Dutch Government in 2010 and has been registered as such in the Specially Protected Areas and Wildlife (SPAW) protocol of the Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean. In 2012 it was internationally declared a Particularly Sensitive Sea Area (PSSA) by the International Maritime Organization (IMO) and an Ecological or Biological Significant Area (EBSA) by the Convention on Biological Diversity (CBD). As there are no large land masses nearby, the Saba Bank can be considered as relatively pristine and remote from human influences. Anthropogenic threats such as fisheries and environmental threats such as climate change, sea surface temperature increase and acidification, however, also threaten the Bank's coral reefs.

As part of the Saba Bank research program 2011-2016, commissioned by the Dutch Ministry of Economic Affairs (EZ), expeditions to the Saba Bank were conducted in October 2011 and from 19 to 26 October 2013. The Saba Bank research program aims to obtain information on the biodiversity, ecological functioning and carrying capacity for commercial fisheries to facilitate sustainable management of the area. The expedition was funded by the Dutch Ministry of Economic Affairs and the World Wildlife Fund in the Netherlands.

The primary objectives of the 2011 and 2013 research expeditions were to collect data on benthic and reef fish communities, and on sponges and nutritional sources of the sponge community. Studies added to the 2013 expedition were research into the structural complexity of the reef; coral-algal interactions; and connectivity between populations. An international, multidisciplinary team of marine biologists investigated the coral reef structure as well as the spatial variation in species assemblages and population genetic connectivity of corals, algae, fish and sponges during eleven SCUBA dives at 20-30m depth.

During the expedition thirty-three 50m long transects resulted in more than 2000 images of the reef, and over 5000 fish counts of almost 100 fish species. A preliminary comparison with the data from 2011 gives the impression of a reduction in snappers, groupers and grunts, while there were noticeably more sharks. There were fewer algae on the Saba Bank than in 2011, possibly indicating a healthier reef, although there appeared to be a gradient of increasing algal cover towards the island of Saba. It seems unlikely that this is related to anthropogenic activities on the island, but more likely to natural causes.

An overview of collected data and preliminary results is given in this progress report. Further comparative analysis between the data collected in the 2011 and 2013 and further analysis between research components, e.g. between algal biomass, herbivorous fish biomass and nutrient levels, will be performed in 2014. This may give more information on the potential causes of the observed south-north algal gradient.

The expedition elicited large public interest and media coverage in both Dutch and Caribbean media (details provided in Appendix F). The work of the researchers, both above and under water, was also recorded on film as part of the documentary series Marine Life for Discovery Channel.

1 Introduction

The Saba Bank in the north-eastern Caribbean Sea (17°25′ N, 63°30' W) is a large submerged carbonate platform, located 3-5 km Southwest of Saba and 16-19 km West of St. Eustatius in the Dutch Caribbean (Figure 1).It has a roughly rectangular shape with a length of 60-65 km and a width of 30-40 km. The total surface area is approximately 2,200 km2, as measured to the 200-meter isobath.

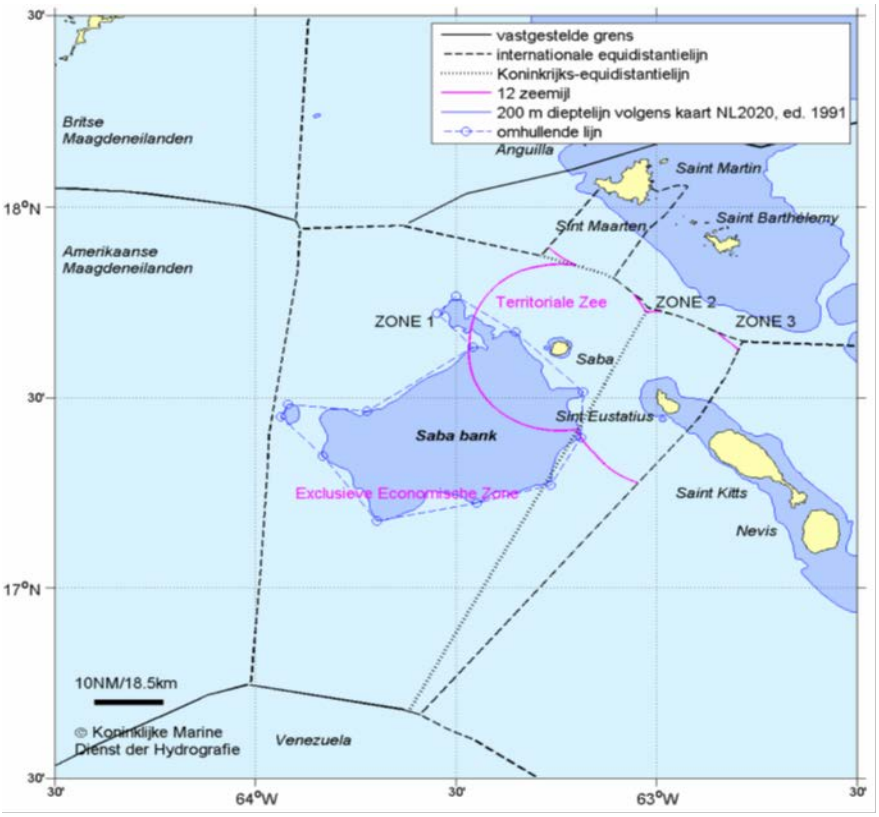

Figure 1. Location and zonation of the Saba Bank, Exclusive Economic Zone and Territorial Sea (Staatscourant 2010).

The Saba Bank is raised about 1000 meter above the general depths of the surrounding sea floor. The bathymetric map (Figure 3) shows the surface slopes gradually from the shallower south-eastern part to the deeper north-western part. On the eastern and south-eastern edges, where a prominent and actively growing coral ridge of 55 km long runs along the platform, minimum depths vary between 7 and 15 m. On its western rim depths are around 50 m and without actively growing coral. The largest part of the Saba Bank is between 20 and 50 m depth, but a substantial eastern part (approximately 225 km^2) is between 10 and 20 m depth (Macintyre et al. 1975; Van der Land 1977).

The Saba Bank lies partially within the Exclusive Economic Zone of the Netherlands. The other part of the Bank is within 12 nautical miles of mainly Saba as well as for a very small part St. Eustatius, and falls under the island authorities (Figure 1). The Saba Bank has been declared a protected area by the Dutch Government on 15 December 2010 (Staatscourant, 2010) and has been registered as such in the Specially Protected Areas and Wildlife (SPAW) protocol of the Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean. The Saba Bank also obtained special status in 2012 as a Particularly Sensitive Sea Area (PSSA) by the International Maritime Organization (IMO) [1] and was granted the status of an Ecological or Biological Significant Area (EBSA) by Convention for Biological Diversity (CBD) [2].

The first biodiversity studies of the Saba Bank were a quick field survey commissioned by the Netherlands Antilles Department of Environment and Nature in 1996, and the Conservation International Rapid Assessment Program in 2006. The first survey concluded that the Saba Bank is a regionally unique and relative pristine ecosystem with high biodiversity and productivity (Meesters et al. 1996) and the second study demonstrated the richness of its biodiversity with the identification of many species of fishes, corals, sponges and macro-algae (Etnoyer et al. 2010; Hoetjes and Carpenter 2010; Littler et al. 2010; McKenna and Etnoyer 2010; Thacker et al. 2010; Toller et al. 2010; Williams et al. 2010).
The research expedition in 2011 and the expedition of 2013 were performed to check the status of the benthic communities and associated fish populations. Because the Saba Bank is situated fairly distant from densely populated and industrialized regions in the Caribbean, relatively pristine oligotrophic conditions characteristic for open water reefs can be expected. Observations from the above studies indicated that the Saba bank generally has healthy corals, compared to other coral reefs, and that it is a good area for fishes to reproduce. However, more recent observations (Meesters and Debrot, pers. comm.) indicate a decline in living coral and in fish populations in this area. Recent fisheries research as part of this Saba Bank research program 2011-2016 show declining catches in the main fisheries on the Saba Bank, lobster (Van Gerwen, 2014) and redfish (Boonstra, in press).

1.1 Research question

This research has been commissioned by the Dutch Ministry of Economic Affairs (EZ) as part of the Saba Bank research program 2011-2016. The aim of this research program is to obtain information on the biodiversity, key ecological processes and carrying capacity for commercial fisheries to facilitate sustainable management of the area.

The aim of the Saba Bank research expedition 2013 was to:

- Collect data for monitoring of benthic reef communities;
- Collect data on fish abundance and fish size for fish density, biomass and biodiversity estimates;
- Collect data on structural complexity of the reef;
- Improve our understanding of coral-algal interactions;
- Improve our understanding of water quality and nutritional sources of the sponge community;
- Improve our understanding of connectivity between Saba Bank populations.

1.2 Acknowledgements

We like to thank the following people for their support in making this research expedition possible: the entire crew of the Caribbean Explorer II for taking care of our safety and wellbeing on board of the research vessel and in particular Claire Keany, Brett Lookhoff, Lynn Bean and Nestor Vidotto for assisting the fish research team; Hayo Haanstra and Astrid Hilgers, policy advisors of the department of Nature and Biodiversity for the Dutch Ministry of Economic Affairs (EZ) for arranging the funding for this study under grant no. BO-11-011.05-008 and Mariska Bottema, Marine Advisor at World Wildlife Fund (WNF-NL) for co-financing this study. Participation of Fleur van Duyl was funded by IMARES and NIOZ and participation of Benjamin Müller was funded by FORCE (European Union 7th Framework programme (P7/2007-2013) under grant agreement No. 244161). Maggy Nugues acknowledges support from the CNRS Chaire d'Excellence and FORCE (European Union 7th Framework programme (P7/2007-2013) under grant agreement No. 244161).

2 Materials and Methods

The Saba Bank expedition 2013 was, just as in 2011, conducted with the Caribbean Explorer II, a 32 m long live-aboard research vessel (Figure 2). We embarked on 19 October and disembarked on 26 October 2013 at St Maarten. Due to excellent weather conditions in the first few days and bad weather forecasts for the last days, we managed to complete our sampling after four very effective sampling days.

Figure 2. The research vessel the Caribbean Explorer in St Maarten (Photo: Fleur van Duyl).

From 20-23 October 11 stations at the Saba Bank were sampled using SCUBA diving with Nitrox, 5 stations along the edge of the South and South East side, 1 station on top of the bank (Tertre de Fleur) and 5 stations along the edge of the North East side of the Saba Bank. Figure 3 shows the locations of survey stations on a map.

The first location was a test station, later called Dutch Plains, to enable all survey teams to test their materials and methods. The other 10 stations were in close vicinity to the dive sites surveyed in the 2011 expedition. Former dive sites 1 and 2 were named Scottish hills (site 1 in 2011, site 3 in 2010) and Gorgonian Delight (site 2 in 2011, site 4 in 2010). Besides data of fish and benthic reef communities, data were collected on topographic complexity (also called rugosity or relief), nutrients, sponges, and coral-algal interactions by participating researchers.

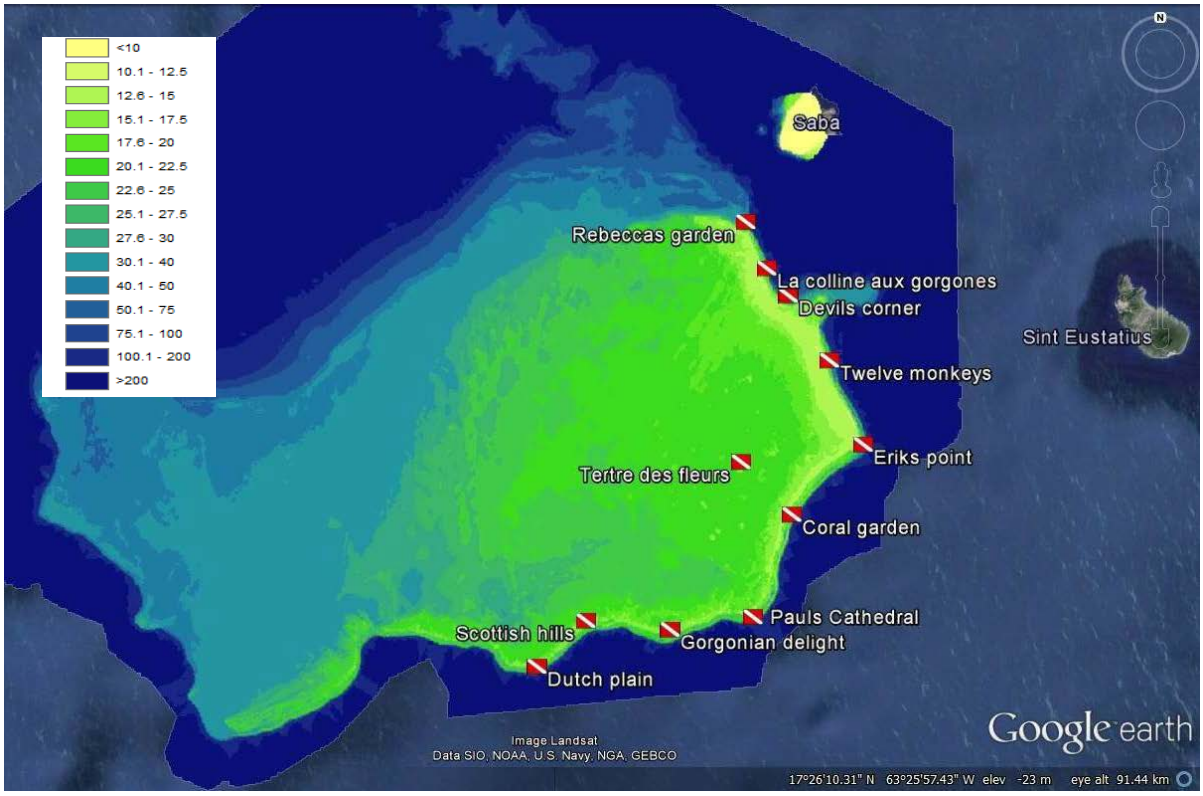

Figure 3. Bathymetry of the Saba Bank with isobath depth contour lines (Data from the Netherlands Hydrographic Service), the islands of Saba (Northeast of the Saba Bank) and St. Eustatius (East of the Saba Bank) and the 11 stations which were visited. Fore-reef stations were in the 17-32m depth range and the patch reef on top of the Saba Bank, Tertre de Fleur, is at 15m depth.

2.1 Sponges, macro algae and nutrients (Van Duyl and Mueller)

At all eleven stations, including the test location, sponges and benthic macroalgae were collected for stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$). On each site, targeted common sponges and dominant algae were photographed and pieces were collected in plastic zipper bags. Sponge and macroalgal samples were again photographed during processing and subsequently wrapped in aluminium foil and stored in a deep freezer for later analysis. For images of the sponges and algae see Appendix A. Sponge species collected were the same as during the previous expedition in October 2011.

Water was collected by Scuba diving and by hand with a 2L niskin bottle at the bottom of the visited sites and at the surface immediately after the dive from the rear platform of the research vessel. Samples for inorganic nutrients (NH_3, NO_2, NO_3, PO_4), total organic carbon (TOC), total nitrogen (TN), dissolved organic carbon (DOC), total dissolved nitrogen (TDN) were processed directly after diving.

2.2 Connectivity of Saba Bank populations (Becking and Bakker)

At all eleven stations, including the test location, and seven additional locations on the Saba Bank, Saba, St. Eustatius, St. Maarten and Curacao samples were collected from barrel sponge, star coral, lionfish, and silk snapper. The samples of silk snapper were bought from Saban fishermen who target deep water snapper species on the slopes of the Saba Bank. Tissue was preserved in RNAlater or 96% pure ethanol to preserve the DNA. All samples were stored at 4°C during the expedition and stored at -20°C upon arrival in The Netherlands. DNA extractions and PCR amplifications of the genetic markers will be performed in the NIOZ laboratory. The obtained sequences will be compared with previously published data of populations within the Wider Caribbean that have been stored on GenBank (NCBI).
Population genetic diversity and population connectivity will be inferred using the different software programs.

2.3 Coral-algal interactions (Nugues)

Macroalgae are defined as all benthic algae which project more than 1 cm above the substrate. These include articulated calcareous algae such as *Halimeda*. We also included benthic cyanobacterial mats (BCMs) as a separate entity in the study.
At ten stations between 7 and 12 small quadrats (60 cm x 40 cm) were randomly placed on the reef. Distance between quadrats was determined by random number and sampling was only conducted on hard substratum. Each quadrat was first photographed. Next, all macroalgae and BCMs were removed, and the quadrat was rephotographed. By comparing pre- and post-removal photographs, we will determine the surface area of coral tissue damaged by macroalgae and BCMs. A maximum of 3 minutes was allocated to the removal process. Removed macroalgae and BCMs from the first 5 quadrats were stored in plastic bags. Their biomass was subsequently estimated by rinsing samples with freshwater to remove salt, air-drying and weighing. It should be noted that BCMs are difficult to harvest due to their propensity to break loose, thus biomass data are only indicative.

2.4 Structural complexity (Phillipson)

At each of the ten stations two of the three transect lines (A and B) were assessed for complexity. This assessment was done along the first 30m of each transect line using two methods: visual assessment and vertical height.
The first method to estimate structural complexity was a visual assessment of the reef topography, assigning each transect a grade from 0 to 5, where 0= no vertical relief, 1 = low and sparse relief, 2 = low but widespread relief, 3 = moderately complex, 4 = very complex with numerous fissures and caves, 5 = exceptionally complex with numerous caves and overhangs (Polunin and Roberts 1993). The habitat complexity was linked to the biodiversity present at each visual graded transect. Species cover was determined from the photographs.
The second method to measure structural complexity involved the measurement of the tallest reef height (vertical distance between the lowest and highest point on the reef structure) along each 5 meter of the transect line in an area of $10m^2$, 5m long and 1m width on either side of the transect line (Lang et al., 2010). Using excel 2010 the height average and standard deviation was then calculated and compared with the transects visual grade.

2.5 Fish and benthos (other researchers)

At all eleven stations fish and benthos were monitored along three 50m transect lines (A, B and C). Transects were separated by placing the three lines with an angle of 45 degrees between them from the same starting point. The measuring tape was rolled out by a diver assisting the fish surveyor. The fish surveyors passed the measuring tape twice (forth and back) counting fish in a belt of 5m wide (2.5m on each side of the transect tape measure). In total 30 belt transects of 250m^2 were surveyed. The first pass from the starting point to the end of the transect line was used to count medium to large more mobile fish (parrotfish, surgeonfish, grunt and snapper). The second pass back was used to count small (damselfish) and cryptic (grouper) less mobile species. Fish abundance and fish biomass per survey site was standardized to respectively numbers and grams per 100 m^2, a unit commonly used in fish surveys. The fish surveyor of transect B recorded their transect line on stereo video, a method used in IMARES fish monitoring programs on Saba and St. Eustatius, to compare the visual fish count with the video count.

The benthic surveyors started photographing at the beginning of the transect line after the fish survey team had finished and collected the measuring tape on their way back. In contrast to the expedition in 2011 photographs were preferred because of the higher resolution of the resulting images. Along each transect a total of approximately 50 photographs were taken. For the preliminary analyses 2 transect per site (total 22) were analyzed. From each transect ten randomly selected photographs were analyzed by counting 144 points per image.

3 Preliminary results

3.1 Sponges, macro algae and nutrients

Spatial and species-specific variations in the diet of sponges
Researchers: Fleur C. van Duyl and Benjamin Muller (Royal Netherlands Institute for Sea Research (NIOZ), The Netherlands).
Author: Fleur C. van Duyl

3.1.1 Introduction

Sponges play an important role in fluxes of matter in many benthic ecosystems including coral reefs (Maldonado et al. 2012). By drawing down organic matter from the passing water, they deposit organic matter in the benthic compartment. This way they supply the detritivorous benthic (microbial) community with food and regenerate inorganic nutrients available for primary producers. Therefor it is important to know whether sponges mainly feed on plankton or food derived from the benthos.

The aim of the study is basically the same as during the 2011 Saba Bank expedition – to study the food sources for several dominant sponges – but more focused after analysis of results of the first expedition. It is hypothesized that sponges exposed to the incoming western bound currents on the Saba Bank (the Antilles current and the Caribbean current) mainly feed on plankton and that sponges in the lee of the current complement their nutrition with bank derived food (benthic primary production). This may be reflected in consistent differences in the stable isotope signature of sponges with respect to their $\delta^{13}C$ and $\delta^{15}N$ content the further the sponges occur from the reef rim and incoming current from the ocean. Since benthic primary producers are usually heavier in $\delta^{13}C$ than phyto -and bacterioplankton, it is hypothesized that sponges in the lee of the Bank (S-side), are heavier in $\delta^{13}C$ and depend more on bank food (organic matter released by corals and benthic algae) than the current exposed fore-reef sponges along the E/NE-side. Sponges on sheltered reefs have been reported to rely for a large extent on the food (e.g. dissolved organic carbon) produced by the reef itself (Van Duyl et al. 2011).

The Saba Bank expedition in 2011 showed very low nutrient concentrations comparable to oceanic conditions. Stable isotope ($\delta^{13}C$) results of sponges collected during the Saba Bank expedition of October 2011 suggest that sponges might indeed be heavier in $\delta^{13}C$ at the south side than along the E/NE-side, in support of our hypothesis. Patterns may, however, be complicated by the fact that waters along the S-side of the Bank were relatively enriched with nitrate, possibly due to upwelling or passage of different water masses (Caribbean Current in particular). $\delta^{15}N$ of upwelled water is usually higher than in ambient surface water, but we did not find enhanced $\delta^{15}N$ values in benthic macroalgae or sponges along the S-side. The enhanced N supply may have stimulated the plankton growth as reflected by enhanced particulate organic carbon (POC) concentrations in the reef overlying water along the S-side as compared to POC values along the E-side.

This follow-up study aims to improve our understanding of the distribution and nutritional sources of the Saba Bank sponge community and to determine whether the cover of commonly occurring sponge species is related to the nature of the food supply.

3.1.2 Data collected

Sponge species collected were the same as during the previous expedition in October 2011. Table 1 shows which data were collected at each station.

Table 1. Overview of samples taken during theSaba Bank expedition 2013. Collected sponges and benthic algae are indicated by X. Cyano=cyanobacterial turf, Sarg.=Sarbassum spec., Ph.di.=possible Phormidium cf dimorphum *(course pencil-like cyanobacterium), FR=fringing reef, PA=patch reef. Water samples were taken at the surface (S: 0-0.5m) and at the bottom (B, see depth of different stations).*

site name	depth (m)	coral reef transect	sponge dive	reef zone	*other algae*	*Lobophora sp*	*Dictyota sp*	*Agelas conifera*	*Xestospongia muta*	*Aplysina caulliformis*	*Amphimedon compressa*	*Plakortis halochondrioides*	*Callyspongia plicifera*	*Aiolochoia crassa*	depth watersamples (m)	inorganic nutrient sample nrs	DOC/TDN sample nrs	TOC/TN sample nrs	POC sample nrs
DP	27	test	1	FR		X	X	X	X	X	X	X	X	X	S	3/4	3	4	1
															B	1/2	1	2	2
SH	18	1	2	FR	Cyano			X	X	X	X	X	X	X	S	7/8	7	8	3
				FR											B	5/6	5	6	4
GD	17	2	3	FR	Sarg.	X		X	X	X	X	X	X	X?	S	9/10	11	12	5
				FR											B	-	-	-	-
CG	24	3	4	FR		X	X	X	X	X	X	X	X	X	S	15/16	15	16	6
				FR											B	13/14	13	14	7
PC	21	4	5	FR		X	X	X	X	X	X	X	X	X	S	19/20	19	20	9
				FR											B	17/18	17	18	8
TDF	15	5	6	PA	Sarg.					X	X			X	S	23/24	23	24	11
				PA	Ph. di.										B	21/22	21	22	10
EP	26	6	7	FR		X	X	X	X	X	X	X	X	X	S	27/28	25	26	13
				FR											B	25/26	23	24	12
TM	26	7	8	FR		X	X	X	X	X	X	X	X	X	S	31/32	29	30	15
				FR											B	29/30	27	28	14
LCG	25	8	9	FR		X	X	X	X	X	X	X	X	X	S	35/36	33	-	17
				FR											B	33/34	31	-	16
DC	32	9	10	FR		X	X	X	X	X	X	X	X	X	S	39/40	36	-	19
				FR											B	37/38	35	-	18
RG	24	10	11	FR	Sarg.	X	X	X	X	X	X	X	X	X	S	43/44	38	-	21
				FR											B	41/42	37	-	20

Benthic macroalgae, *Dictyota* spec and *Lobophora* spec were collected at 8 and 9 of the 11 sites respectively. When these genera were not found during the ca 30 min dive, dominant other algal species were sampled, e.g. *Sargassum* at 3 stations (Gorgonian Delight, Tertre de Fleur, Rebecca's Garden), *Phormidium cf dimorphum* at Tertre de Fleur and cyanobacterial mat at Scottish Hill.

Sponge samples for comparison between stable isotopes and connectivity

Samples of the sponge *X. muta* were split in two. One part will be used for stable isotope analysis (this study by F. van Duyl and B. Müller) and the other part will be used for molecular work (intraspecific variation in sponge DNA by L. Becking, D. de Bakker in cooperation with J. van Bleijswijk) to study connectivity. It concerns the samples as stated in Table 2.

Table 2. Overview of shared X. muta samples. At Tertre de Fleur (dive 6) no X. muta was collected for stable isotopes, although it was very common. We check whether we can use alcohol fixed X. muta for the stable isotope analysis.

Date	Sponge dive	Site ID	Code X muta (Duyl)	Code X muta (Becking)	Depth range (m)
20-10	1	DP		X1, X3	23, 26
20-10	2	SH	Zak 17	X8	17.3
20-10	3	GD	Zak 26	X13	17.1
21-10	4	CG	Zak 35	X16	24.1
21-10	5	PC	Zak 44	X22	21
21-10	6	TDF	-	-	-
22-10	7	EP	Zak 52B	X44???	26-26.7
22-10	8	TM	Zak 60 reeks	X44	26
22-10	9	LCG		X43	24
23-10	10	DC		X51	31,32
23-10	11	RG		X56	23,24

Sponge samples for taxonomy and microbial diversity

To confirm the species names of sponges, subsamples of several collected sponges were taken, and handed over to Lisa Becking. In particular the taxonomy of the rope sponge *Aplysina "cauliformis"* was unclear. In addition sponge subsamples were taken of the 7 species collected at 4 of the 11 stations for Detmer Sipkema (WUR) for microbial diversity of sponge associated microbes. An overview of subsamples is given in Table 3.

Table 3. Overview of sponge subsamples that will be analyzed for taxonomy (L. Becking) and/or microbial diversity (D. Sipkema). Sponge dive # refers to the Fleur # sponge samples

Site ID	Sponge dive #	Sponge taxonony	Microbial diversity	
CG	4	27, 29, 30, 31, 32, 34 and X. muta (X16)		L. Becking (IMARES)
TDF	6	Rope sponge 46a, 46b, 46c Minibarrel sponge 48		L. Becking
EP	7		Rope sponge (51a, 51b, 53) and 52, 55, 56, 57, 59 and X. muta (X44)	D. Sipkema (WUR)
TM	8	Rope sponge 66		L. Becking
LCG	9		7 sponge species, 70, 71, 75, 76, 77, 80 and X. muta (X43)	D. Sipkema
DC	10		7 sponge species, 72, 73#10, 76#10, 77#10, 78, 79, X. muta (X51)	D. Sipkema
RG	11		7 sponge species, 80, 81, 84, 86, 87, 88, X. muta (X56)	D. Sipkema

3.1.3 Preliminary results and discussion

Nitrate concentrations (NO_3) measured along the S-SE and E-NE side of the Saba Bank were on average 2.5 and 4 times higher (0.4-0.5 µmol NO_3.L-1) respectively than the concentrations measured in 2011 (0.1-0.2 µmol $NO_3.L^{-1}$) at the same time of the year at the same stations (October). Nitrate concentrations were higher along the S-SE side than along the E-NE side. A comparable pattern was found in 2011. Enhanced NO_3 concentrations are possibly due to upwelling of deep water along the S-SE side of the Bank or variations in the path and jet stream of the Caribbean Current. Water masses with enhanced nutrient concentrations may also have reached the E-NE side of the Bank, where nitrate concentrations were 4 times higher than in 2011.
Phosphate concentrations (PO_4) were on average 1.5-2 times higher than in 2011 and ammonia (NH_3) was on average lower than in 2011. Average NH_3 concentrations tended to be higher along the E-NE side than the S-SE side (0.140 vs 0.166 µmol NH_3.L-1). Molar inorganic N/P concentrations suggest an excess of N (NO_x and NH_3) on average compared to P with ratios exceeding 16 (18-45) in 86% of water samples. PO_4 and NH_3 concentrations tended to be higher close to the reef bottom than in surface water. This was not recorded for nitrate and nitrite, which did not show a clear depth distribution between surface water and water at the reef bottom (15-32m depending on reef site visited). Results suggest that the Saba Bank is not always as oligotrophic as originally assumed. The present dominance of filter feeding sponges on the Bank and the purported increase in sponge cover since the mass coral bleaching event in 2005 (Eakin et al. 2010), may indeed suggest that there is abundant food (organic matter) available. Besides this space occupation by sponges, the occasionally relatively high N concentrations may prevent stony corals in regaining their former dominance in cover on the Bank. It has been shown that nutrient stress negatively affects stony coral resilience (Vega Thurber et al. 2013). Coral resilience is important in the recovery of coral bleaching, resistance against microbial infections and competitive interactions for space with other benthic organisms (e.g. benthic macroalgae and sponges).

3.2 Connectivity of Saba Bank populations

Researchers: Leontine E. Becking (IMARES & Naturalis Biodiversity Center, The Netherlands) and Didier de Bakker (IMARES & University of Amsterdam).
Author: Leontine E. Becking

3.2.1 Introduction

Mesophotic reefs as refuge

Saba Bank houses an expansive coral reef ecosystem at depths of 17-50m with a vast number of species and as such it is also an important source for commercial fisheries for the nearby islands. The Saba Bank furthermore forms the largest protected area of the Kingdom of the Netherlands, after the Dutch part of the Wadden Sea in Europe. As there are no large land masses nearby, the Saba Bank can be considered as relatively pristine and remote from human influences, and remarkably free of diseases. Anthropogenic threats such as fisheries and environmental threats such as climate change, sea surface temperature increase and acidification, however, also threaten the Saba Bank coral reefs.
Anthropogenic global ocean warming is predicted to cause bleaching of many near-sea-surface coral reefs, placing increased importance on deeper reef habitats to maintain coral reef biodiversity and ecosystem function (Harris et al. 2013). It has been suggested that degraded shallow reefs (<20m) are increasingly reliant on recruitment of larvae from elsewhere, and that brood stocks in other habitats - such as mesophotic reefs (30 – 150 m) for example - could play a key role in in managing coastal seascapes (Slattery et al. 2011). Most coral and sponge species that are found in the shallow reefs are also found in the upper mesophotic zone. Mesophotic reefs, such as those in the Saba Bank, may have the capacity to act as a refuge against hurricanes, diseases and bleaching for endangered corals and

sponges from which they could recolonize the shallow reefs and thus increase their resilience (Bridge et 2013). Therefore, knowledge of marine population connectivity and larval dispersal between the Saba Bank and the surrounding region is critical to understand future prospects for conservation, and to design appropriate management plans for coral reef ecosystem biodiversity (Slattery et al. 2011).

Genetic connectivity

A key question for this project is how populations of reef organisms on the Saba Bank are connected within the bank and elsewhere in the Wider Caribbean. In order to answer this, we will investigate the population genetic structure of two common benthic species, the Giant Barrel Sponge (*Xestospongia muta*) and the reef-building Great Star Coral (*Montastraea cavernosa*), the Red Lionfish (*Pterois volitans*) and the Devil Firefish (*Pterois miles*), both invasive species in the Caribbean, and the silk snapper (*Lutjanus vivanus*), a commercially important fish (Figure 4D).

An important factor for coral-reef resilience is the connectivity between and within coral reefs in different regions. The exchange of larvae creates and maintains high levels of genetic diversity, which is crucial in terms of resilience against disturbance. Larval-exporting or source reefs with diverse populations of healthy adult coral reef organisms are essential to maintain the genetic diversity and resilience of larval-importing or sink reefs in other locations.

Obtaining direct estimates of connectivity by tracing small larvae (with high-mortality rates) through an expanse of sea is like searching for a needle in a haystack. Therefore we will make an assessment of larval transport in and out of the Saba Bank by indirect means, namely through inferences from genetics. Successful migrants should leave a genetic trail of their movements, offering an indirect means of estimating population connectivity (Hellberg et al. 2002). The amount of variation in an organism's DNA is the combined product of past and present population processes. Geographical surveys of genetic variation can thus provide a means of tracing dispersal patterns between marine populations by larvae and other dispersing life stages (Hellberg et al. 2002).

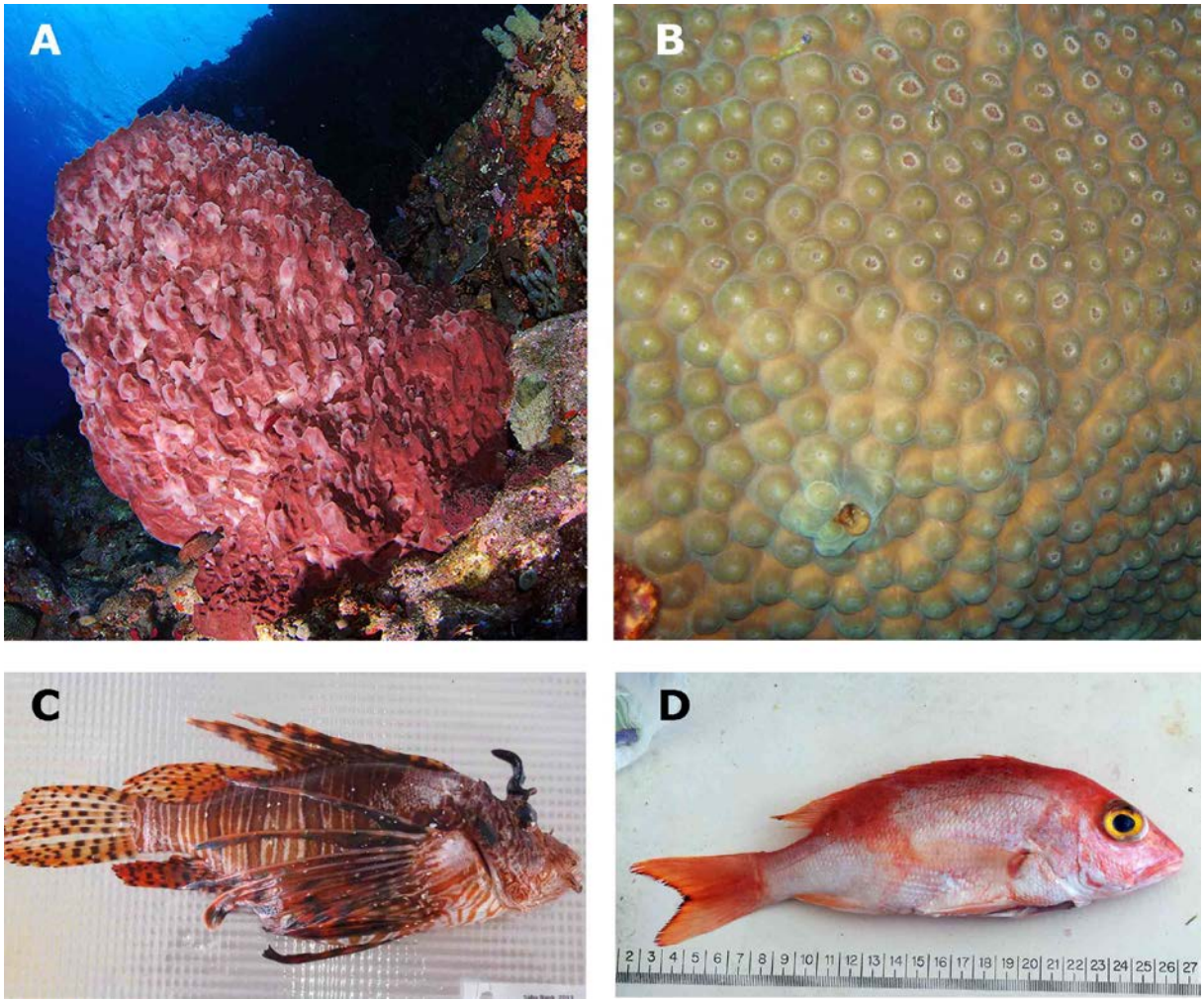

Figure 4. ***A*** *Barrel sponge with some bleaching (photo: Maggy Nugues.),* ***B*** *star coral (photo: Didier de Bakker),* ***C*** *Lionfish (photo: Lisa Becking),* ***D*** *Silk snapper (photo: Didier de Bakker)*

3.2.2 Data collected

In total 77 barrel sponge, 61 star coral, 47 lionfish, and 24 silk snapper samples were collected from the locations as indicated in Table 4. The samples of silk snapper were bought from fisherman from Saba who fished these fish from the Saba Bank.

Table 4. Sample locations and numbers

Area	Station	Lionfish	Silk Snapper	Barrel sponge	Star Coral
Saba Bank	Sta. 1			5	4
Saba Bank	Sta. 2			6	6
Saba Bank	Sta. 3			3	3
Saba Bank	Sta. 4	4		5	6
Saba Bank	Sta. 5	4		3	3
Saba Bank	Sta. 6			12	
Saba Bank	Sta. 7	6		5	7
Saba Bank	Sta. 8	4		8	8
Saba Bank	Sta. 9			4	4
Saba Bank	Sta. 10			5	6
Saba Bank	Sta. 11			5	4
Saba Bank	Sta. 12			11	10
St. Eustatius	Sta. 13			5	
Saba Bank	D4 (Didier)		24		
St. Maarten	Proselyte Reef	17			
St. Maarten	Fuh Seng	4			
Saba	Tent Wall	4			
Curacao	Holiday Beach	4			
Total		**47**	**24**	**77**	**61**

3.2.3 Preliminary observations

Sponges are dominant and important components of the Saba Bank (Thacker et al. 2010) and of coral reefs in general throughout the Caribbean (Pomponi et al. 1996). They are a source of nutrition for fish, turtles, and echinoderms and they provide refuge for a diversity of micro- and macro-organisms (e.g. Westinga and Hoetjes 1981, Erwin and Thacker 2008). Furthermore, they may be a significant source of dissolved organic matter on coral reefs (De Goeij et al. 2013). Moreover, they are the most prolific source of natural products with potential biomedical importance (Blunt et al. 2009) and may, therefore, provide the basis for evaluation of sustainable development of this resource in the Dutch Caribbean (Schippers et al. 2012).

At all sites the *Xestospongia muta (*barrel sponges) had small patches of bleached tissue (Figure 4A). Like reef-building corals, *X. muta* is subject to occasional bleaching - loss of the reddish-brown coloration (Vicente 1990, Lopez-Legentil and Pawlik 2009). Reports of sponge bleaching and disease have increased dramatically in recent years and have been observed throughout the Caribbean (reviewed in Webster 2007).

Overall, *Montastrea cavernosa* on the Saba Bank seemed to be relatively healthy, virtually no diseases were observed. Nevertheless, at several sites *M. cavernosa* colonies were greatly reduced or even absent (*e.g.* station 6). Most likely, as a consequence, of previous coral bleaching events, such as in 2005 (Donner et al. 2007). However, at many sites *M. cavernosa* seems to be recovering, marked by a high abundance of young healthy colonies.

In recent years, reports of sponge and coral bleaching, disease, and subsequent mortality have increased alarmingly. Population recovery may depend strongly on colonization capabilities of the affected species (Gardner et al. 2003; Lopez-Legentil and Pawlik 2009), calling for a comprehensive investigation of the population connectivity in the region.

3.3 Coral-algal interactions

Researcher & author: Maggy Nugues (Centre de Recherches Insulaires et Observatoire de l'Environnement (CRIOBE), France)

3.3.1 Introduction

Our previous expedition has indicated a decline in corals and an increase in macroalgae. Once established, macroalgae can compete with corals, cause coral mortality, and impair coral recruitment, making them a concern for the Saba bank. Reduced herbivory, increased nutrient levels and coral mortality from bleaching and disease can all lead to increased macroalgal abundance (Mumby and Steneck 2008). This study aims to investigate algal abundance and competition with corals on the bank. Specifically, we will study associations between algal biomass and coral overgrowth and identify the macroalgae most damaging to corals, as well as the most susceptible coral species. Finally, together with data on herbivorous fish biomass and nutrient levels, we will identify key factors driving macroalgal abundance and their interactions with corals.

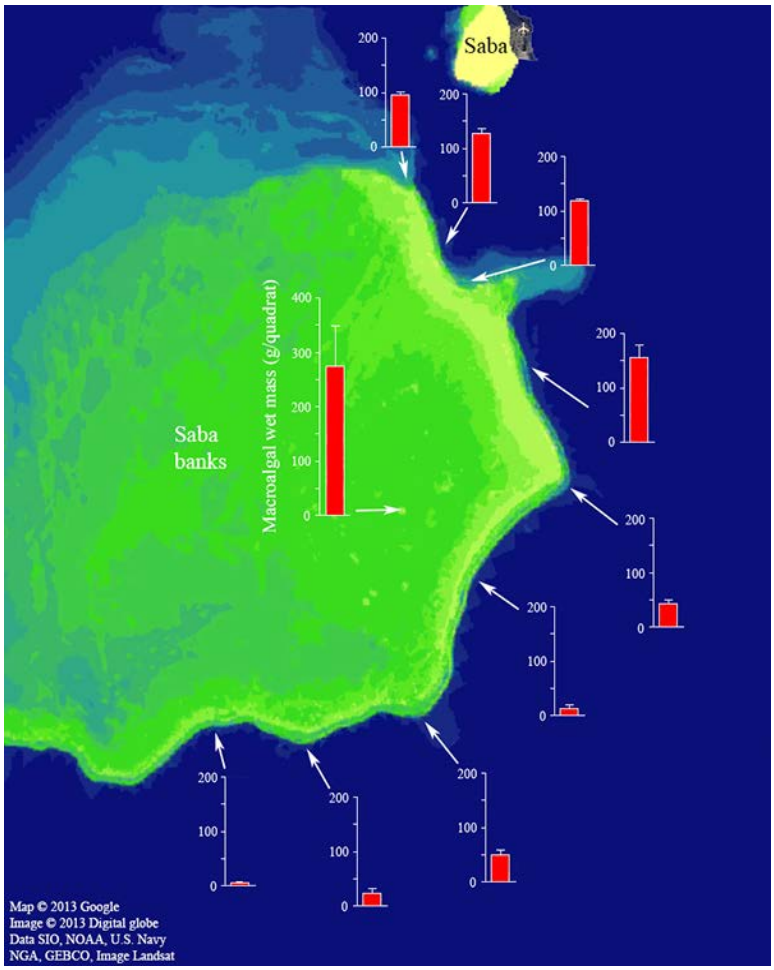

Figure 5. Macroalgal biomass at each dive site. Error bars represent one standard error. Surface area of quadrats: 0.24m^2.

3.3.2 Data collected and preliminary results

A total of 105 quadrats were deployed across the 10 study sites. Preliminary data are available on the biomass (in wet mass) of macroalgae and benthic cyanobacterial mats (BCMs). Macroalgal biomass varied more than 50 fold, from 5 to 272 g/quadrat (0.24m^2 area) (Figure 5). It was noticeably higher on the northern part of the bank in the vicinity of Saba. Further correlative analysis with herbivorous fish biomass and nutrient levels will give information on potential causes of this south-north contrast.
BCM biomass varied 19 fold, from 0.2 to 3.8 g/quadrat (Figure 6). Rebecca's garden, the site further north, showed the highest biomass, but there was no marked south-north contrast in BCM biomass.

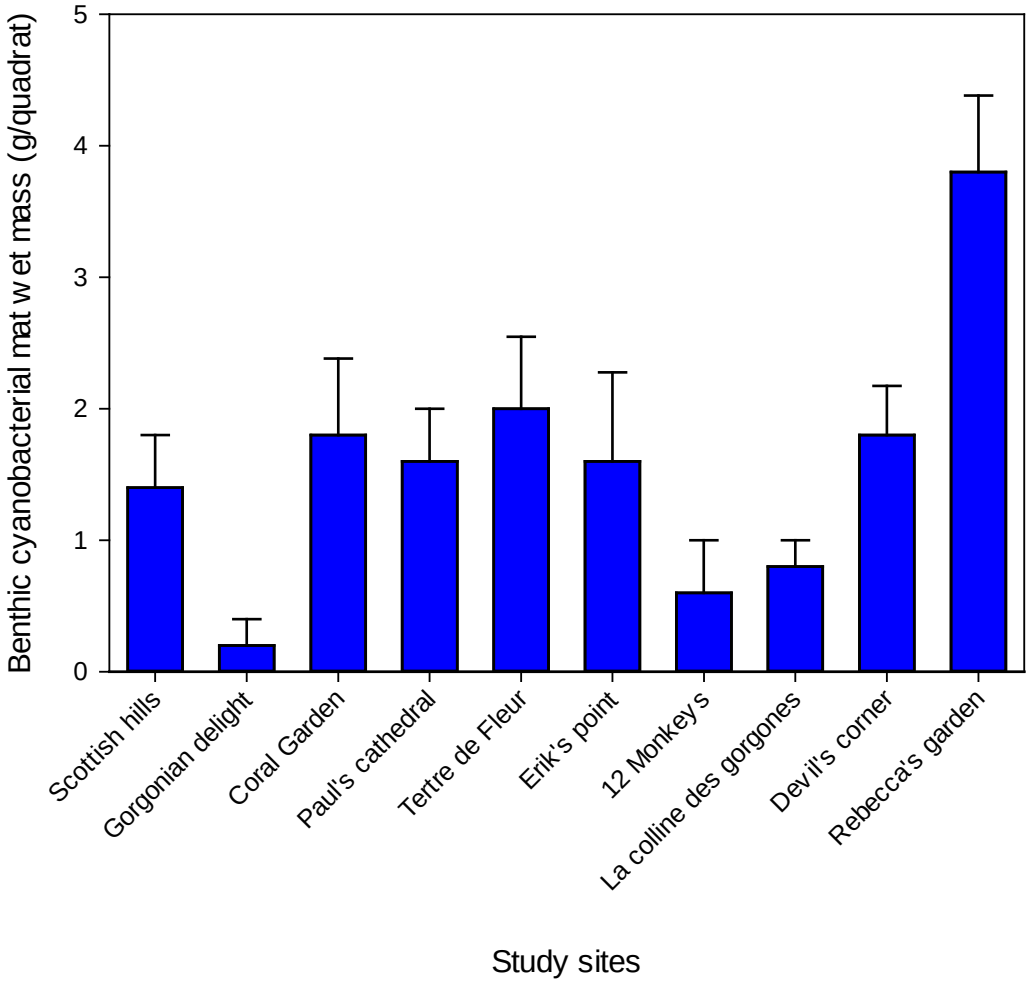

Figure 6. Biomass of benthic cyanobacterial mats at each dive site. Error bars represent one standard error. Surface area of quadrats: 0.24m^2.

Data on coral-algal interactions from the photographs are pending. Preliminary observations suggest that interactions increased as a function of macroalgal biomass. Coral bleaching (but not disease) was frequently observed in contact with macroalgae. Corallivores and sediments were sometimes found under macroalgae contacting corals. Both were frequently associated with coral tissue death underneath the algal canopy.

3.4 Corals of the Saba Bank

Researcher: Erik Meesters (IMARES), Jean Philippe Marechal (l'Observatoire du Milieu Marin (OMMM), Martinique), Franck Mazéas (Direction de l'Environnement de l'Aménagement et du Logement (DÉAL), Guadeloupe) and Joe Philipson (IMARES & Applied University CAH Almere Vilentum)
Authors: Joe Philipson (IMARES & Applied University CAH Almere Vilentum) and Erik Meesters (IMARES)

3.4.1 Introduction

The biodiversity of the benthos particularly the coral species have been researched multiple times (Van der Land, 1977; Meesters et al., 1996; Klomp and Kooistra, 2003; McKenna and Etnoyer, 2010; Van Beek and Meesters, 2013). Marine life uses coral reefs either for shelter, reproduction, and/or foraging. Even though coral reefs cover less than a tenth of a percentage of the ocean's surface, it is estimated that over 25% of all marine life is dependent of reefs for survival of their populations (Spalding et al., 2001). This is partly because coral reefs have a higher structural complexity (rugosity), thus creating micro habitats suitable for more specialized species (Munday et al., 1997).
Because of the remoteness from large human population centers the Saba Bank can be viewed as a relatively pristine reference area when comparing reefs that suffer from human disturbances (EL&I, 2010). However, there still are threats that can diminish coral populations like bleaching, diseases, eutrophication, acidification, and algae growth. By periodically surveying the coral populations across the Saba Bank it is possible to record and analyze changes on the reef. During the Saba Bank research expeditions data on the benthos cover were collected in respectively ten (2011) and eleven (2013) research areas, by respectively HD-film survey (2011) or photographic survey (2013).

3.4.2 Preliminary results and conclusions

Table 5 gives mean percentages cover for main benthic categories in 2011 and 2013. Coral cover generally is low and not more than 10%. Algae cover most of the bottom often almost up to 50%. These values may change when more transects are added.
The map with benthos cover at each survey station (Figure 7) shows that hard corals, soft coral and sponges are somewhat more abundant at the south-west point of the Saba Bank. Further north cover of these categories decreases while cover by algae and sand increases.

Table 5. Comparison of the average benthos cover within the main functional groups at each site in 2011 and 2013. Dutch plains was not sampled in 2011.

Site	Stony Corals		Soft Corals		Sponges		Algae		Sand, Rubble, Pavement		Other	
	2011	2013	2011	2013	2011	2013	2011	2013	2011	2013	2011	2013
DP		11.6		3.1		10.1		37.9		37.2		0.1
SH	8.3	15.0	0.9	6.5	2.4	10.5	58.9	28.8	29.5	37.2		0.1
GD	15.6	7.3	1.2	6.1	5.0	13.9	52.1	23.2	26.1	49.4		0.2
CG	12.4	6.5	1.1	2.1	8.2	5.3	48.3	48.7	30.0	37.3		0.1
PC	6.0	9.3	1.1	3.9	7.9	10.1	62.3	50.8	22.7	25.9		0.1
TDF	2.6	1.2	0.1	0.1	6.8	9.0	52.2	50.2	38.3	39.2		0.3
EP	9.3	6.9	1.7	3.2	11.6	13.7	38.0	31.6	39.4	44.7		0.1
TM	8.9	8.6	0.3	2.1	11.1	1.4	56.7	34.3	23.0	53.6		0.0
LCG	4.1	5.4	0.9	2.5	4.0	4.2	54.9	35.6	36.0	52.3		0.0
DC	4.4	3.6	0.1	0.6	4.9	3.8	61.3	55.6	29.3	36.5		0.0
RG	3.8	3.1	0.3	0.7	7.5	3.9	65.1	52.5	23.2	39.9		0.0

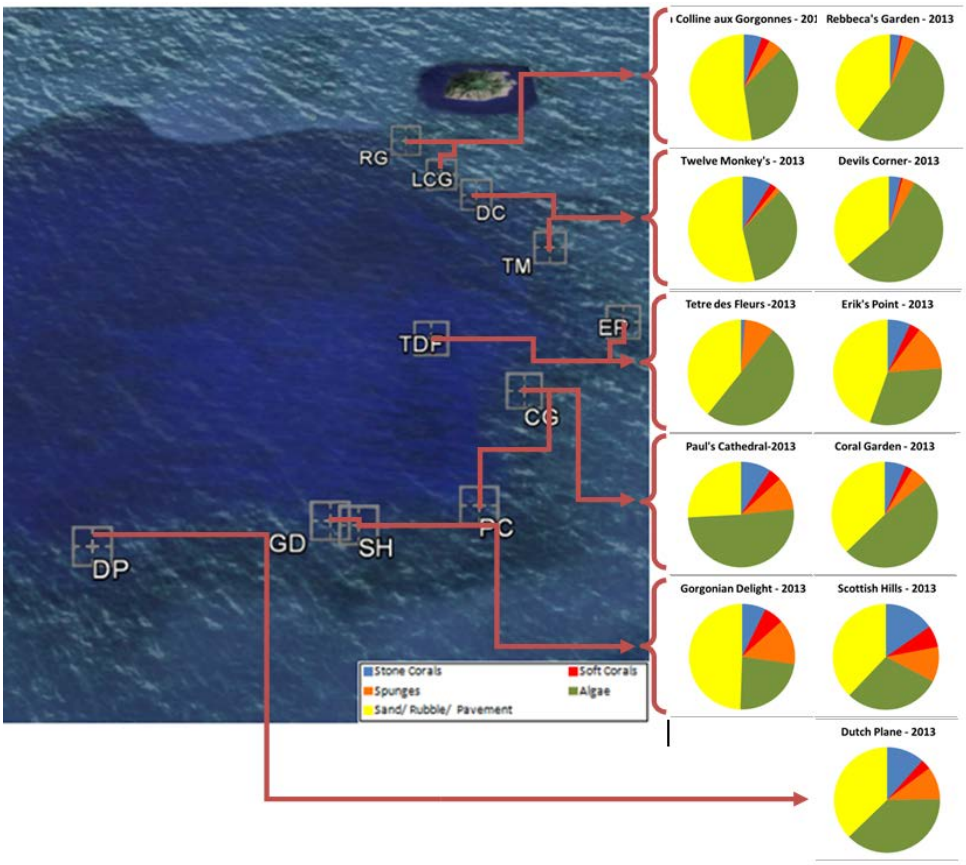

Figure 7. Map of eastern Saba Bank with sample stations and station names with a pie chart indicating the mayor benthos cover groups of 2013.

The majority of the benthic community which inhabits the Saba Bank consists of algae or 'sand/rubble/pavement'. When comparing algae cover between the two years a general decline of algal cover (mean approximately 11%) is seen, with the exception of Coral Garden (CG) where the algae cover slightly increased. In 2011 algae cover ranged from 38.02% to 65.12% while the sand/rubble/pavement cover was between 22.96% and 39.41%.

A total of 34 stony coral species and 17 soft coral species were documented in 2011, while the 2013 analysis documented 39 stony and 19 soft coral species. One new species of stony coral was documented in the 2011 footage and three extra were documented after analyzing the 2013 footage. Together with previous surveys (Van der Land, 1977; Meesters et al., 1996; Klomp and Kooistra, 2003; McKenna and Etnoyer, 2010; van Beek and Meesters, 2013) a total of 63 species have now been identified within 17 families. This research has also identified 20 soft coral species within five families. Also a number of corals on the pictures could not be identified below genus level. It is likely that more rare coral species still remain to be found on the Saba Bank as the number of surveys increases.

The data obtained was divided in six mayor functional groups: stony corals, soft corals, sponges, algae, sand/rubble/pavement and other. Algae cover the majority of the Saba Bank in 2011, but appeared to have declined in 2013 on 9 out of 10 sites. Stony corals declined on average 3% at seven sites, but increased on three an average of 3.7% leading to an overall rather constant (low) mean cover of around 7%. At many sites however, algal cover decreased and free space (Sand, Rubble, and Pavement) increased. This may lead to settlement of new corals and a future increase in coral cover.
Preliminary overviews of the data are given in Appendices B and C.

3.5 Reef fish

Researchers: Ingrid J.M. van Beek (IMARES), Steve Piontek (STENAPA) and Erik Boman (LVV Sint Eustatius), assisted by Fleur Holtrop (IMARES & Van Hall Larenstein) and the crew of the Caribbean Explorer (Brett Lookhoff, Claire Keany, Lynn Bean and Nestor Vidotto).
Author: Ingrid J.M. van Beek

3.5.1 Introduction

The objective of the fish survey was to collect data on the occurrence, abundance and size (length classes) of fish species at the Saba Bank. 98 species of the 270 fish species known to exist on the Saba Bank, were also observed at our sample sites.
The abundance and size data of the fish survey were used to estimate biomass and differences between sites for the most common species. Selection of surveyed species was based on a functional group approach. Functional groups are defined as a collection of species that perform a similar function irrespective of their taxonomic affinities (Steneck and Dethier 1994). Species included in the sampling were 58 species of the main 7 families:
Herbivores: Scaridae (parrotfish), Acanthuridae (surgeonfish), Pomacentridae (damselfish)
Planktivores: Pomacentridae (chromis)
Omnivores: Haemulidae (grunts), Lutjanidae (snappers)
Piscivores: Serranidae (groupers), Carangidae (jacks)
An additional 8 predatory species from 7 families were distinguished and included in the piscivorous functional group and another 34 species from 20 families were included for the biodiversity assessment. For a list of all species see Appendix D.

3.5.2 Results

Fish abundance varied per site between 51 and 175 fish per 100m^2 (Figure 8). This was considerably higher than in the 2011 research expedition, when fish abundance varied between 23 and 100 fish per 100m^2 (Figure 10, see also Van Beek and Meesters, 2013).
Fish biomass varied per site between 1.6 and 15.9 kg per 100m^2 (Figure 9). The upper boundary was considerably higher than in the 2011 research expedition, when fish biomass varied between 1.3 kg to 4.4 kg (Figure 10, see also Van Beek and Meesters, 2013).
Highest fish abundance and biomass in 2013 was recorded at Paul's Cathedral (PC), due to a large school of creole wrasse (*Clepticus parrae*, in the category other fish). When excluding this school of creole wrasse, biomass was still highest at Pauls Cathedral with 6.1 kg per 100m^2. Next highest fish abundance and biomass in 2013 were recorded at Erik's Point (EP) and La Colline aux Gorgones (LCG). In 2011 highest fish abundance and biomass were seen in Coral Garden (CG), Twelve Monkeys (TM) and Erik's Point (EP).
Herbivore biomass, an important indicator for reef health because herbivory is one of the most important processes in maintaining ecological balance in the Caribbean, was not the highest at Paul's Cathedral. This site with the highest fish abundance and biomass had a key herbivores biomass of 0.8 kg per 100 m^2 (Scaridae and Acanthuridae, see Table 6). This is 'critical' according to the Healthy Reefs SIRHI index for ecosystem health (Table 7). The sites with the next highest fish abundance and biomass, Erik's Point (EP) and La Colline aux Gorgones (LCG), had the highest key herbivores biomass of 1.9 and 2.3 kg per 100 m^2 (Table 6). This is 'fair' according to the Healthy Reefs SIRHI index for ecosystem health (Table 7). Commercial fish biomass is another indicator in the SIRHI index including Serranidae and Lutjanidae. Almost all sites had a 'critical' score on this indicator, only Paul's Cathedral had a slightly better, but still 'poor' score. The SIRHI index (Simplified Integrated Reef Health Index) is applied to assess the Mesoamerican reefs in the Caribbean Sea. The SIRHI index does not consider habitat complexity in its assessment. Habitat complexity has a positive correlation with coral reef fish assemblages (Roberts and Ormond, 1987). If the habitat complexity of the Mesoamerican reefs is higher than the low to moderately

complex relief at the Saba Bank (see chapter 3.6) than the standards of the SIRHI index may be too high.

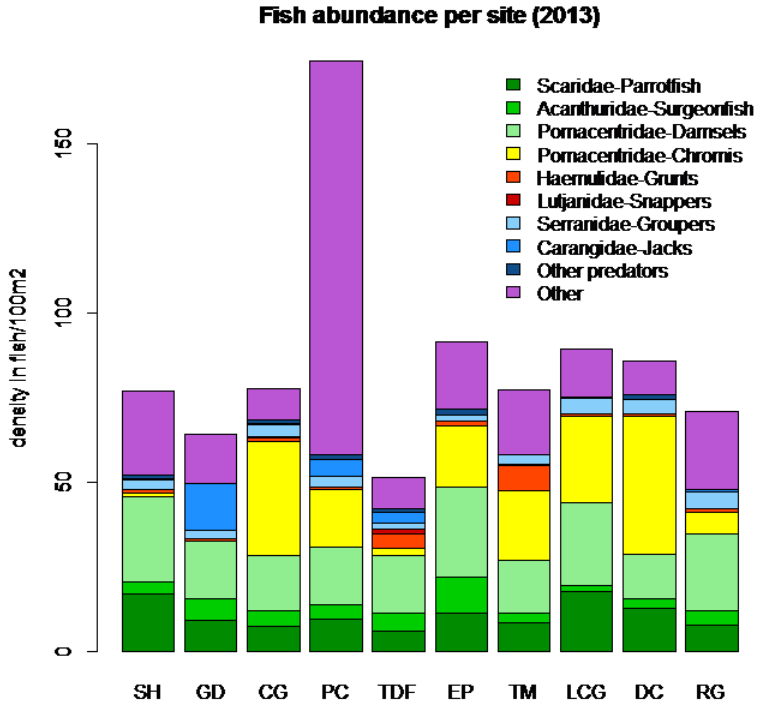

Figure 8. Fish abundance in number of fish per 100m^2 at each dive site (see Table 1 for Site ID) in October 2013. Green are herbivores, red are omnivores and blue are predators.

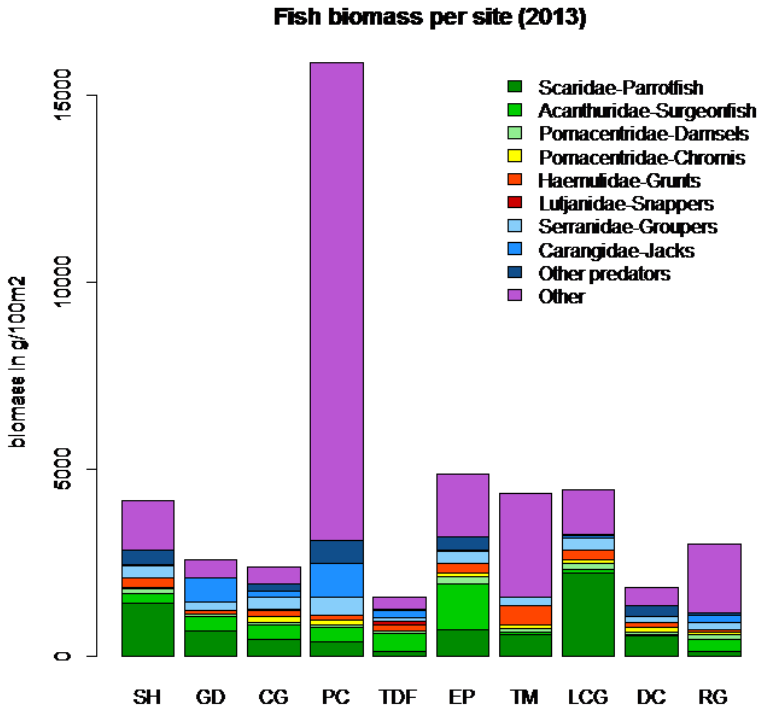

Figure 9. Fish biomass in grams per 100m^2 at each dive site (see Table 1 for Site ID) in October 2013. Green are herbivores, red are omnivores and blue are predators.

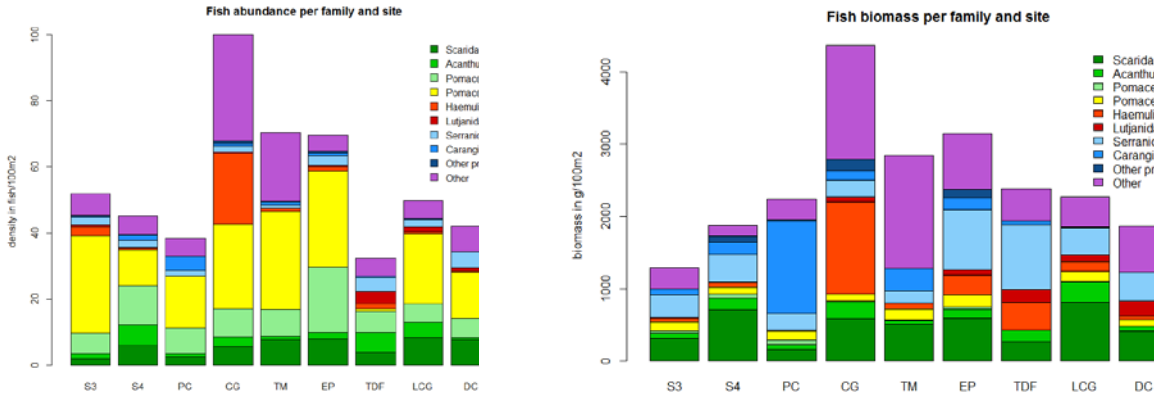

Figure 10. Fish abundance and fish biomass in October 2011. Left: fish abundance in number of fish per 100m² at each dive site (see Table 1 for Site ID). Right: fish biomass in grams per 100m² at each dive site. Dive site S3 was named Scottish Hills (SH) and dive site S4 was named Gorgonian Delight (GD) in the research expedition in (see Table 1 for Site ID) in October 2013. Green are herbivores, red are omnivores and blue are predators.

Table 6. Fish biomass per functional group in grams per 100m² at each dive site (see Table 1 for Site ID) in October 2013.

Biomass g/100m2	SH	GD	CG	PC	TDF	EP	TM	LCG	DC	RG
Scaridae	1425.3	668.5	448.5	360.6	107.5	704.2	567.4	2228.7	522.4	132.8
Acanthuridae	233.8	398.0	368.3	393.9	484.1	1207.5	70.1	75.2	62.7	296.6
Pomacentridae	154.2	42.6	243.2	188.2	83.0	318.3	195.9	283.4	163.5	190.0
Herbivores	**1813.3**	**1109.0**	**1060.0**	**942.8**	**674.6**	**2230.0**	**833.4**	**2587.3**	**748.5**	**619.4**
Haemulidae	283.6	101.6	162.6	159.8	164.6	256.4	499.9	234.8	138.4	94.2
Lutjanidae	0.0	0.0	25.5	0.0	77.2	1.5	1.5	0.0	0.0	0.0
Omnivores	**283.6**	**101.6**	**188.1**	**159.8**	**241.8**	**257.9**	**501.5**	**234.8**	**138.4**	**94.2**
Serranidae	303.0	242.6	338.0	461.1	92.2	306.3	228.5	336.6	159.2	194.9
Carangidae	45.6	622.7	149.8	925.9	201.0	28.2	7.1	73.3	0.0	164.9
Other predators	381.1	2.5	193.5	595.7	45.5	361.7	0.0	12.9	287.9	82.6
Predators	**729.7**	**867.8**	**681.3**	**1982.7**	**338.8**	**696.2**	**235.6**	**422.7**	**447.0**	**442.5**
Other	1323.0	503.7	436.1	12779.3	328.5	1672.8	2781.4	1196.1	485.1	1820.1
Total biomass	**4149.6**	**2582.1**	**2365.4**	**15864.6**	**1583.6**	**4856.9**	**4351.8**	**4440.9**	**1819.1**	**2976.2**

Biomass g/100m2	SH	GD	CG	PC	TDF	EP	TM	LCG	DC	RG
Scaridae	1425.3	668.5	448.5	360.6	107.5	704.2	567.4	2228.7	522.4	132.8
Acanthuridae	233.8	398.0	368.3	393.9	484.1	1207.5	70.1	75.2	62.7	296.6
Key herbivores	**1659.1**	**1066.5**	**816.8**	**754.5**	**591.6**	**1911.7**	**637.5**	**2303.9**	**585.1**	**429.4**
Lutjanidae	0.0	0.0	25.5	0.0	77.2	1.5	1.5	0.0	0.0	0.0
Serranidae	303.0	242.6	338.0	461.1	92.2	306.3	228.5	336.6	159.2	194.9
Key commercial fish	**303.0**	**242.6**	**363.4**	**461.1**	**169.4**	**307.8**	**230.0**	**336.6**	**159.2**	**194.9**

Table 7. The SIRHI index for the evaluation of ecosystem health of coral reefs [6]

SIRHI INDICATORS	VERY GOOD (5)	GOOD (4)	FAIR (3)	POOR (2)	CRITICAL (1)
Coral cover (%)	≥40	20.0-39.9	10.0-19.9	5.0-9.9	<5
Fleshy macroalgae cover (%)	0-0.9	1.0-5.0	5.1-12.0	12.1-25	>25.0
Key herbivorous fish (g•100 m²) note: only parrotfish and surgeonfish	≥3480	2880-3479	1920-2879	960-1919	<960
Key commercial fish (g•100 m²) note: only snapper and grouper	≥1680	1260-1679	840-1259	420-839	<420

3.5.3 Conclusions and recommendations

In our observations we included pelagic fish passing through the transect, such as certain species of jacks (*Carangidae*). We also included observations of large schools of fish, resulting in a higher density and higher biomass at the sites where they were observed. Most remarkable were large schools of 550 and 135 Creole wrasse (*Clepticus parrae*) in Paul's Cathedral accounting for 14.6kg and 58.7kg respectively. In addition we included many observations of small fish in size category 0-5cm of the family *Pomacentridae*, such as bicolor damselfish (*Stegastes partitus*), blue chromis (*Chromis cyanea*) and brown chromis (*Chromis multilineata*). Because of their small size this had a minor impact on the biomass and because of their presence on most sites it also did not influence differences between sites. In the biomass data we did not include two observations of nurse sharks (*Ginglymostoma cirratum*), one in Paul's Cathedral and one in Erik's Point, because the length estimates were not accurate (recorded as '>40 cm') and because the maximum published weight of 110kg would inflate the dataset.

Data collected can also be used to analyse size structure, which is important for the role of herbivores in coral reef resilience, which varies depending on their size (Green and Bellwood 2008). The results of the fish survey will also be compared to the outcomes of other research components of this expedition. The research of the coral-algal interactions will look at the relationship between algae biomass and herbivorous fish biomass, the population genetics study will use the lionfish data and the benthic reef communities will be compared to the fish communities. The data collected of one transect (B) with the stereo video will be analysed and compared to the visual fish count, to compare different methods used in fish surveys.

3.6 Structural complexity

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Authors: Joe Philipson (IMARES & Applied University CAH Almere Vilentum) and Erik Meesters (IMARES)

3.6.1 Introduction

Structural complexity can be explained as the spatial three-dimensional structure of an ecosystem (Graham and Nash, 2013). It can be considered as variation in topographic structure of a habitat and can be measured in terms of relief, interstitial space, and surface area (Hill and Wilkinson, 2004). Much of the structure can be provided by the physical shape and complexity of living organisms, such as kelp and corals, often termed ecosystem engineers or foundation species (Jones et al., 1994; Bruno and Bertness, 2001). However, other structural elements of the environment, such as geological features and underlying dead matrices formed by organisms can also provide structural complexity (Kleypas et al., 2001, Graham and Nash, 2013).

Structural complexity is an integral component of coral reef ecosystems (Graham and Nash, 2013). Fish communities are known to be affected by the structure and heterogeneity of the benthic habitat (Wilson et al., 2007). At a large spatial scale certain fish assemblages are characteristic for habitat types such as mangroves, seagrass beds or coral reefs (Chittaro et al. 2005; Wilson et al. 2005), while at smaller spatial and taxonomic scales some fish species are habitat specialists and are closely associated with specific microhabitats (Munday et al. 1997; Wilson et al. 2007). Thus a more complex reef creates more micro niches in which species can exist, resulting in a higher biodiversity and a higher biomass of associated communities. Because coral communities on the Saba Bank are generally in deeper water were growth morphologies are often rather flat in order to capture enough light, complexity values were expected to be low. Biodiversity was calculated as the Shannon-Wiener index, a diversity index that reflects how many different species are present, and simultaneously takes into account how evenly the number of individuals are distributed among the species.

3.6.2 Data collected

Data were collected on structural complexity using two different methods: visual assessment and height measurement. The visual assessment uses the scale developed by Polunin and Roberts (1993) with values between 0 and 5 indicating increasing complexity (see caption of Table 8). The height measurement measures the maximum colony height of the closest coral colony each 5 m along a transect line. For safety reasons the transect length was limited to 30m giving 6 measurements per transect.

3.6.3 Results and conclusions

Table 8. Transects per site and their respective visually assessed complexity grade and measured vertical height each 5 meters along transect lines A and B. Complexity grades used (Polunin and Roberts 1993) are 0= no vertical relief, 1 = low and sparse relief, 2 = low but widespread relief, 3 = moderately complex, 4 = very complex with numerous fissures and caves, 5 = exceptionally complex with numerous caves and overhangs. Gorgonian Delight (GD) was skipped because sickness.

Site	Transect	Depth	Complexity grade	Height measurement (cm) along the transect line each 5 meters						Average	STD.dev
	(A. B. C)	(m)	1-5	0 - 5m	5 - 10m	10 - 15m	15 - 20m	20 - 25m	25 - 30m	(cm)	(cm)
DP	B	27	2	35	33	22	30	45	40	33.1	7.8
SH	A	17	1	20	25	20	15	30	35	23.1	7.2
SH	B	17	2	18	20	110	200	55	120	77.1	69.4
CG	A	23	2	50	75	120	55	47	35	57.9	31.8
CG	B	23	3	36	35	25	70	30	60	39.9	18.1
PC	A	26	2	30	25	50	60	40	30	37.3	13.4
PC	B	26	2	60	30	50	53	47	30	42.3	13.4
TDF	A	16	1	10	17	13	27	40	15	19.7	10.4
TDF	B	16	1	17	35	25	20	100	30	34.7	29.6
EP	A	30	3	60	52	140	52	50	42	60.9	36.2
EP	B	30	2	40	105	73	37	42	51	54.0	26.4
TM	A	23	3	50	48	65	40	60	125	58.7	32.3
TM	B	23	2	52	0	79	62	1	24	34.4	30.5
LCG	A	25	2	45	32	60	50	131	38	54.4	35.7
LCG	B	25	2	50	40	62	47	53	42	45.6	11.6
DC	A	33	2	55	120	43	62	83	42	62.6	30.1
RG	A	25	2	25	32	20	37	31	28	28.3	5.6
RG	B	25	2	24	29	31	44	23	25	28.7	7.3

Table 8 describes the results of both the visual assessment and the vertical height survey at the Saba Bank reef sites. The visual reef complexity grades observed ranged from grade 1 to 3, meaning from 'low and sparse relief', to 'low but widespread relief' to 'moderately complex'. The majority of the transects received a category 2 which is a low but widespread relief. The sites which have the lowest complexity are Scottish Hills (SH-A) and both transects of Tertre de Fleur (TDF-A and B). These were also the most shallow sites. A total of three transects were labeled as category 3, which were Coral Garden (CG-B), Erik's Point (EP-A), and Twelve Monkeys (TM-A). The results from the vertical height survey show that the average reef height ranges between 19.1 - 77.1 cm.

Figure 11 plots the visual reef complexity against the average reef height. It illustrates that median reef height and visual grade are strongly correlated. From grade 1 to 3, reef height increases from 23.1 cm, to 43.95 cm and 58.7 cm. Visual grade category 2 has a wider range, which also contains the full category 3 range. Category 1 has the lowest average reef height.

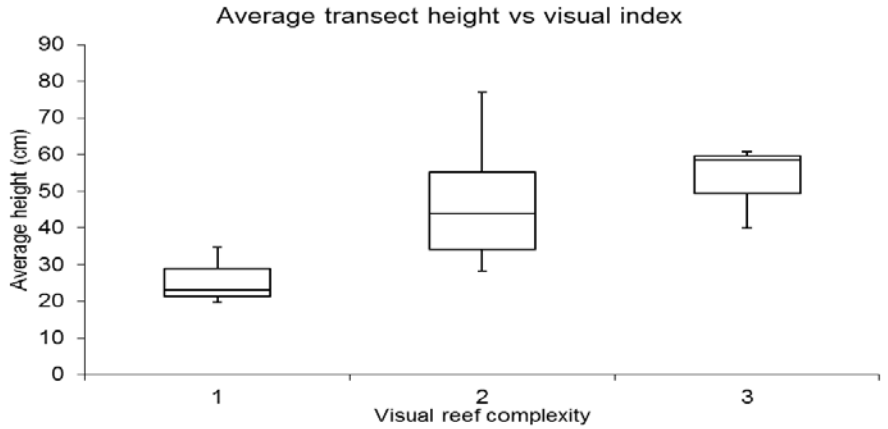

Figure 11. Box plot comparing the Visual Reef complexity (x-axis) against the average reef height (y-axis).

However, the transects with the highest visual reef complexity which also have the highest average median height do not contain the highest biodiversity. The Shannon-Wiener diversity values vary between visual grade categories (Figure 12). The range of category 2 (2.8-3.0) is higher and does not overlap with the range of category 3 (2.6-2.8). The median ranged respectively from 1.6, to 3.0 and 2.7 for complexity categories 1, 2 and 3. At intermediate complexity biodiversity appeared highest, though probably not significantly higher than at the highest complexity.

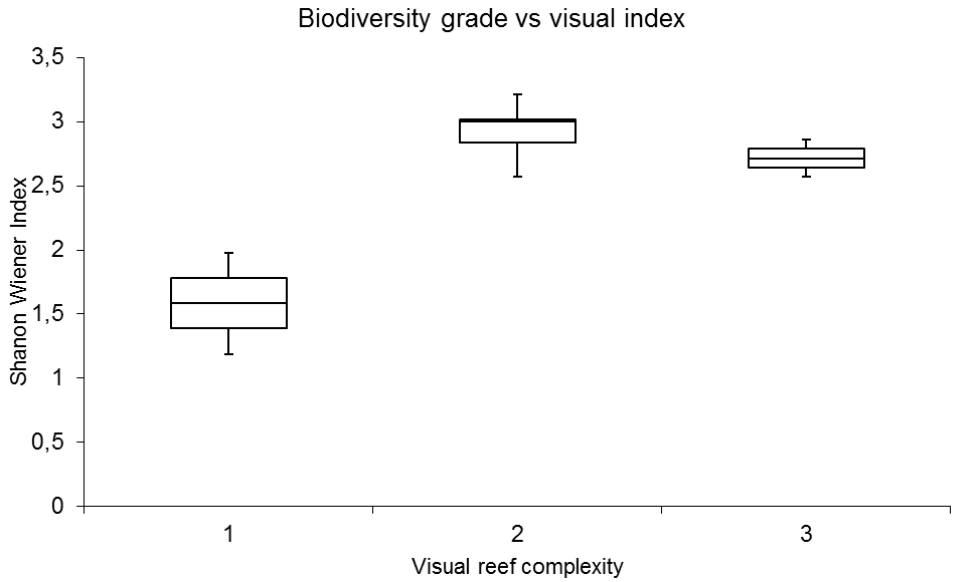

Figure 12. Box plot comparing the Visual Reef complexity (x-axis) against the Shannon-Wiener biodiversity index (y-axis)

4 Conclusions and recommendations

At present two research expeditions have been carried out as part of the Saba Bank research program 2011-2016, commissioned by the Dutch Ministry of Economic Affairs (EZ), in October 2011 and October 2013. The objectives were to collect data on benthic and reef fish communities; sponges and nutritional sources of the sponge community; structural complexity of the reef; coral-algal interactions; and connectivity between Saba Bank populations. An international, multidisciplinary team of marine biologists investigated the coral reef structure as well as the spatial variation in species assemblages and population genetic connectivity of corals, algae, fish and sponges.
The Saba Bank houses an expansive coral reef ecosystem with a rich diversity of species and as such is also an important source of commercial fish for the nearby islands. As there are no large land masses nearby, the Saba Bank can be considered as relatively pristine and remote from human influences (Meesters et al, 1996). Environmental threats such as climate change, sea surface temperature increase and acidification, however, also threaten the Bank's coral reefs. In 2011 high cover of algae was found, it was then hypothesized that bleaching events may have led to a shift from coral dominated in the late nineties to algal dominated reefs in the present situation. Cover by algae, however, appears to be somewhat decreasing, possibly indicating a recovery towards higher coral coverage.

Macroalgal biomass varied more than 50 fold, from 5 to 272 g/quadrat (0.24m^2 area). It was noticeably higher on the northern part of the Saba Bank in the vicinity of Saba. Further correlative analysis with herbivorous fish biomass and nutrient levels will give information on potential causes of this south-north contrast. Benthic cyanobacterial mats (BCM) biomass varied 19 fold, from 0.2 to 3.8 g/quadrat. The site furthest north, showed the highest biomass, but there was no marked south-north contrast in BCM biomass. Data on coral-algal interactions from the photographs are pending. Preliminary observations suggest that interactions increased as a function of macroalgal biomass. Coral bleaching (but not disease) was frequently observed in contact with macroalgae. Corallivores and sediments were sometimes found under macroalgae contacting corals. Both were frequently associated with coral tissue death underneath the algal canopy.

Large numbers of fish species inhabit the reefs and algal plains of the Saba Bank and these fish communities provide important information on the status of the ecosystem. Fish abundance varied per site between 51 and 175 fish per 100m^2 . This was 2 fold higher than in the 2011 research expedition, when fish abundance varied between 23 and 100 fish per 100m^2. Fish biomass varied per site between 1.6 and 15.9 kg per 100m^2 . This was up to 4 fold higher than in the 2011 research expedition, when fish biomass varied between 1.3 kg to 4.4 kg. However, after correction of two large schools of creole wrasse (*Clepticus parrae*) in Paul's Cathedral (PC), biomass was between 1.3 and 6.1 kg per 100m^2. The three stations with highest fish abundance and biomass in 2013 were different stations than those in 2011, except for Erik's Point (EP). Key herbivore biomass, an important indicator for reef health, was second highest in EP and highest in a site further north (La Colline aux Gorgones), but still only 'fair' according to the Healthy Reefs SIRHI index for ecosystem health. Two other stations had a 'poor' key herbivore biomass and all other stations had a 'critical' biomass. Commercial fish biomass is another indicator in the SIRHI index including Serranidae and Lutjanidae. Almost all sites had a 'critical' score on this indicator, only PC had a slightly better, but still 'poor' score.

The topographic complexity of the reef has direct consequences for the biomass and diversity of fish using the reef. Reefs along the Saba Bank have a low but widespread relief. The visual assessment method proved to be a useful method which can be used while performing other tasks and should be incorporated in future expeditions. Diversity was lower at the lowest visual complexity. The complexity data obtained during the 2013 expedition should be linked with fish biodiversity and biomass in future analysis of the data.

Sponges are essential components of the reef as vacuum cleaners of pathogens from the water and as producers of food and nutrients for other reef organisms. Preliminary results show nitrate concentrations (NO3) measured along the S-SE and E-NE side of the Saba Bank were on average 2.5 and 4 times higher respectively than the concentrations measured in 2011. Nitrate concentrations were higher along the S-SE side than along the E-NE side. A comparable pattern was found in 2011. Enhanced NO_3 concentrations are possibly due to upwelling of deep water along the S-SE side of the Bank or variations in the path and jet stream of the Caribbean Current. Water masses with enhanced nutrient concentrations may also have reached the E-NE side of the Bank, where nitrate concentrations were 4 times higher than in 2011. Phosphate concentrations (PO_4) were on average 1.5-2 times higher than in 2011 and ammonia (NH_3) was on average lower than in 2011. Average NH_3 concentrations tended to be higher along the E-NE side than the S-SE side. Results thus suggest that the Saba Bank is not always as oligotrophic as originally assumed.

The present dominance of filter feeding sponges on the Bank and the purported increase in sponge cover since the mass coral bleaching event in 2005, may indeed suggest that there is abundant food (organic matter) available. Besides this space occupation by sponges, the occasionally relatively high N concentrations may prevent stony corals in regaining their former dominance in cover on the Bank. It has been shown that nutrient stress negatively affects stony coral resilience.
An important factor for coral-reef resilience is the connectivity between and within coral reefs in different regions. A key question is how populations of reef organisms on the Saba Bank are connected with populations in the region and in the Wider Caribbean. The population genetic structures of two common benthic species (barrel sponge and great star coral), an invasive species in the Caribbean (lionfish) and two commercially relevant fish (silk snapper and red hind) will be studied with samples collected. At all sites the *Xestospongia muta (*barrel sponges) had small patches of bleached tissue. Overall, *Montastrea cavernosa* on the Saba Bank seemed to be relatively healthy, virtually no diseases were observed. Nevertheless, at several sites *M. cavernosa* colonies were greatly reduced or even absent. Most likely, as a consequence of previous coral bleaching events, such as in 2005. However, at many sites *M. cavernosa* seems to be recovering, marked by the high abundance of young healthy colonies. In recent years, reports of sponge and coral bleaching, disease, and subsequent mortality have increased alarmingly and have been observed throughout the Caribbean. Population recovery may depend strongly on colonization capabilities of the affected species, calling for a comprehensive investigation of the population connectivity in the region.

Further comparative and correlative analysis will be performed in 2014: between the data collected during the research expeditions and fisheries research of the Saba Bank research program, and between research components, i.e. algal biomass with herbivorous fish biomass and nutrient levels. This will give information on potential causes of the observed south-north contrast. The Saba Bank Research program is still ongoing for two remaining years. During these two years additional research is needed to monitor future changes.

5 References

Blunt JW, Copp BR, Hu WP, Munro MH, Northcote PT, Prinsep MR (2009) Marine natural products. Natural products reports 26: 170-244

Boonstra, M (in press) Status of the redfish fishery on the Saba Bank. University of Amsterdam BSc thesis.

Bridge TCL, Hughes TP, Guinotte JM, Bongaerts P 2013 Call to protect all coral reefs. Nature Clim Change 3: 528–530

Bruno JF, Bertness MD (2001) Habitat modification and facilitation in benthic marine communities. In: Bertness MD, Gaines SD, Hay ME (eds) Marine community ecology. Sinauer, Sunderland, MA, pp 201–218

Chittaro PM, Usseglio P, Sale PF (2005) Variation in fish density, assemblage composition and relative rates of predation among mangrove, seagrass and coral reef habitats. Environ Biol Fish 72:175–187

De Goeij JM, van Oevelen D, Vermeij MJA, Osinga R, Middelburg JJ, de Goeij AFPM, Admiraal W (2013) Surviving in a marine desert: the sponge loop retains resources within coral reefs. Science 342: 108-110

Eakin CM, Morgan JA, Heron SF, Smith TB, Liu G, Alvarez-Filip L, Baca B, Bartels E, Bastidas C, Bouchon C, Brandt M, Bruckner AW, Bunkley-Williams L, Cameron A, Causey BD, Chiappone M, Christensen TRL, Crabbe MJC, Day O, de la Guardia E, Diaz-Pulido G, DiResta D, Gil-Agudelo DL, Gilliam DS, Ginsburg RN, Gore S, Guzman HM, Hendee JC, Hernandez-Delgado EA, Husain E, Jeffrey CFG, Jones RJ, Jordan-Dahlgren E, Kaufman LS, Kline DI, Kramer PA, Lang JC, Lirman D, Mallela J, Manfrino C, Marchal J-P, Marks K, Mihaly J, Miller WJ, Mueller EM, Muller EM, Orozco Toro CA, Oxenford HA, Ponce-Taylor D, Quinn N, Ritchie KB, Rodriguez S, Ramirez AR, Romano S, Samhouri JF, Sanchez JA, Schmahl GP, Shank BV, Skirving WJ, Steiner SCC, Villamizar E, Walsh SM, Walter C, Weil E, Williams EH, Roberson KW, Yusuf Y (2010) Caribbean corals in crisis: record thermal stress, bleaching, mortality in 2005. PLoS One 5: e13969

Erwin PM, Thacker RW (2008) Phototrophic nutrition and symbiont diversity of two Caribbean sponge-cyanobacteria symbioses. Mar Ecol Prog Ser 362: 139-147

Etnoyer PJ, Wirsching HH, Sánchez JA (2010) Rapid assessment of octocoral diversity and habitat on Saba Bank, Netherlands Antilles. PLoS One 5: e10668

Gardner TA, Côte IM, Gill JA, Grant A, Watkinson RA (2003) Long-term region-wide declines in Caribbean corals. Science 301: 958-960

Graham NAJ, Nash KL (2013) The importance of structural complexity in coral reef ecosystems. Coral Reefs 32:315–326

Graham NAJ, Wilson SK, Jennings S, Polunin NVC, Bijoux JP, Robinson J (2006) Dynamic fragility of oceanic coral reef ecosystems. Proc Natl Acad Sci USA 103:8425–8429

Green AL, Bellwood DR (2008) Monitoring functional groups of herbivorous reef fish as indicators of coral reef resilience: a practical guide for coral reef managers in the Asia Pacific region. *Working paper series*. IUCN Resilience science group

Harris PT, Bridge TCL, Beaman RJ, Webster JM, Nichol SL, Brooke BP (2013) Submerged banks in the Great Barrier Reef, Australia, greatly increase available coral reef habitat. – ICES J Mar Sci 70: 284–293

Hellberg ME, Burton RS, Neigel JE, Palumbi S R (2002) Genetic assessment of connectivity among marine populations. Bull Mar Sci: 273-290

Hill J, Wilkinson C (2004) Methods for ecological monitoring of reefs: a resource for managers. Australian Institute of Marine Science, Townsville, Australia. 117 p

Hoetjes PC, Carpenter KE (2010) Saving Saba Bank: Policy Implications of Biodiversity Studies. PLoS ONE 5: e10769

Jones CG, Lawton JH, Shachak M (1994) Organisms as ecosystem engineers. Oikos 69:373–386

Kleypas JA, Buddemeier RW, Gattuso J-P (2001) The future of coral reefs in an age of global change. Int J Earth Sci 90:426–437

Klomp K, Kooistra DJ (2003) A post-hurricane, rapid assessment of reefs in the Windward Netherlands Antilles (stony corals, algae and fishes). In: Lang JC, ed. Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program Atoll Res Bull 496: 404–437.

Lang JC, Marks KW, Kramer PA, Richards Kramer P, Gingsburg RN (2010) AGRRA protocols version 5.4. *Atlantic and Gulf Rapid Reef Assessment Program*. 31p

Littler MM, Littler DS, Brooks BL (2010) Marine Macroalgal Diversity Assessment of Saba Bank, Netherlands Antilles. PLoS ONE 5: e10769

López-Legentil S, Pawlik JR (2009) Genetic structure of the Caribbean giant barrel sponge *Xestospongia muta* using the I3-M11 partition of CO1. Coral Reefs 28: 157-165

Lundvall, S (2008) Saba Bank Special Marine Area Management Plan 2008

Maldonado M, Ribes M, Duyl FC van (2012) Nutrient fluxes through sponges: Biology, Budgets, and Ecological Implications. Adv Mar Biol 62: 113-182.

Macintyre IG, Kinsman DJJ, German RC (1975) Geological reconnaissance survey of Saba Bank, Caribbean Sea. Carib J Sci 15: 11-20

McKenna SA, Etnoyer P (2010) Rapid Assessment of Stony Coral Richness and Condition on Saba Bank, Netherlands Antilles. PLoS ONE 5: e10749

Meesters EHWG, Nijkamp H, Bijvoet L (1996) Towards sustainable management of the Saba Bank. A report for the Department of Public Health and Environment (VOMIL), Curacao, Netherlands Antilles, AIDEnvironment, Amsterdam, The Netherlands. 58p

Mumby PJ, Steneck RS (2008) Coral reef management and conservation in light of rapidly evolving ecological paradigms. TREE 23: 555-563

Munday PL, Jones GP, Caley MJ (1997) Habitat specialization and the distribution and abundance of coral-dwelling gobies. Mar Ecol Prog Ser 152:227–239

Polunin, NVC, Roberts CM (1993) Greater biomass and value of target coral-reef fishes in two small Caribbean marine reserves. Mar Ecol Prog Ser 100: 167-176

Pomponi SA, Reed JK, Wright AE, McCarthy PJ (1996) Diversity and bioactivity of marine sponges of the Caribbean: The Turks and Caicos Islands. Carib J Agr Nat Res 1: 41-49

Roberts CM, RFG Ormond (1987) Habitat complexity and coral reef fish diversity and abundance on Red Sea fringing reefs. Marine Ecology Progress Series 41, 1-8

Schippers KJ, Sipkema D, Osinga R, Smidt H, Pomponi SA, Martens DE Wijffels, RH (2012). Cultivation of sponges, sponge cells and symbionts: achievements and future prospects. Adv Mar Biol 62: 273-337

Spalding, MD, Ravilious C, Green EP (2001) United Nations Environment Programme, World Conservation Monitoring Centre. World Atlas of Coral Reefs. University of California Press: Berkeley. 416p

Staatscourant (2010) Regeling van de Staatssecretaris van Economische Zaken, Landbouw en Innovatie van 15 december 2010, nr. 169929, houdende aanwijzing van de Saba Bank als natuurpark. Nr. 20424

Steneck RS, Dethier MN (1994) A Functional-Group Approach to the Structure of Algal-Dominated Communities. Oikos 69, 476-498

Slattery M, Lesser MP, Brazeau D, Stokes MD, Leichter JJ (2011) Connectivity and stability of mesophotic coral reefs. J Exp Mar Biol Ecol 408: 32–41

Thacker RW, Díaz MC, Voogd NJ de, Soest RWM van, Freemand CJ, Mobley AS, LaPietra J, Cope K, McKenna S (2010) Preliminary assessment of sponge biodiversity on Saba Bank, Netherlands Antilles. PLoS ONE 5: e9622

Toller W, Debrot AO, Vermeij MJA, Hoetjes PC (2010) Reef fishes of Saba Bank, Netherlands Antilles: Assemblage structure across a gradient of habitat types. PLoS ONE, 5: e9207

Van Beek IJM, Meesters EHWG (2013) Saba Bank research expedition 2011 – Progress Report, IMARES report C018/13

Van Duyl FC, Moodley L, Nieuwland G, van Ijzerloo L, van Soest RWM, Houtekamer M, Meesters EH, Middelburg JJ (2011) Coral cavity sponges depend on reef-derived food resources: stable isotope and fatty acid constraints. Mar Biol 158: 1653-1666

Van Gerwen, I (2014) The effects of trap fisheries on the populations of Caribbean spiny and reef fish species at the Saba Bank. Wageningen University MSc Thesis T1914

Van der Land, J (1977) The Saba Bank - A large atoll in the northeastern Caribbean. FAO Fish Rep 200: 469-481

Vega Thurber RL, Burkepile DE, Fuchs C, Shantz AA, McMinds R, Zaneveld JR (2013). Chronic nutrient enrichment increases prevalence and severity of coral disease and bleaching. Glob Change Biol 20: 544-554

Vicente VP (1990) Response of sponges with autotrophic endosymbionts during the coral-bleaching episode in Puerto Rico. Coral Reefs 8: 199–202

Westinga E, Hoetjes P (1981) The intrasponge fauna of *Spheciospongia vesparia* (Porifera, Demospongiae) at Curacao and Bonaire. Mar Biol 62: 139-150

Webster NS (2007) Sponge disease: a global threat?. Environ Microbiol 9: 1363–1375

Williams, JT, KE Carpenter, Van Tassell JL, Hoetjes P, Toller W, Etnoyer P, Smith M (2010) Biodiversity Assessment of the Fishes of Saba Bank Atoll, Netherlands Antilles. PLoS ONE 5: e10676

Wilson SK, Street S, Sato T (2005) Use of discarded conch shells by coral reef Wshes. Mar Biol 147:179–188

Wilson SK, Graham NAJ, Polunin NVC (2007) Appraisal of visual assessments of habitat complexity and benthic composition on coral reefs. Mar Biol 151:1069–1076

Internet sites

[1] IMO (2012) Saba Bank designated Particularly Sensitive Sea Area by IMO Marine Environment Protection Committee, Briefing: 42 (www.imo.org/MediaCentre/PressBriefings/Pages/42-MEPC-64.aspx)

[2] CBD (2012) Report of the eleventh meeting of the Conference of the parties to the Convention on Biological Diversity. Annex I. Decisions adopted by the Conference of the parties to the Convention on Biological Diversity at its eleventh meeting. Decision XI/17. Marine and Coastal biodiversity: ecologically or biologically significant marine areas. Hyderabad, India, 8-19 October 2012 (www.cbd.int/doc/meetings/cop/cop-11/official/cop-11-35-en.pdf)

[3] www.fishbase.org

[4] AGGRA training powerpoints Coral ID 1-4 and Coral Flash 1-3 www.agrra.org/method/trainingid.html

[5] www.coralpedia.warwick.ac.uk

[6] Report Card for the Mesoamerican Reef 2012. An evaluation of ecosystem health. Healthy Reefs for Healthy People. www.healthyreefs.org/cms/wp-content/uploads/2012/12/2012-Report-Card.pdf

6 Justification

Report number : C086/14
Project number : 4308201109

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

Approved: M. de Graaf
Senior Researcher Department Fish

Signature:

Date: 27 May 2014

Approved: Drs. F.C. Groenendijk
Head Department Maritime

Signature:

Date: 27 May 2014

Appendices

Appendix A: Common sponges and macro algae of the Saba Bank

Figure A1. Aplysina spec (Row pore rope sponge) in the middle and Agelas conifera (Brown tube sponge) left.

Figure A2. Aplysina spec (possibly other species than in a).

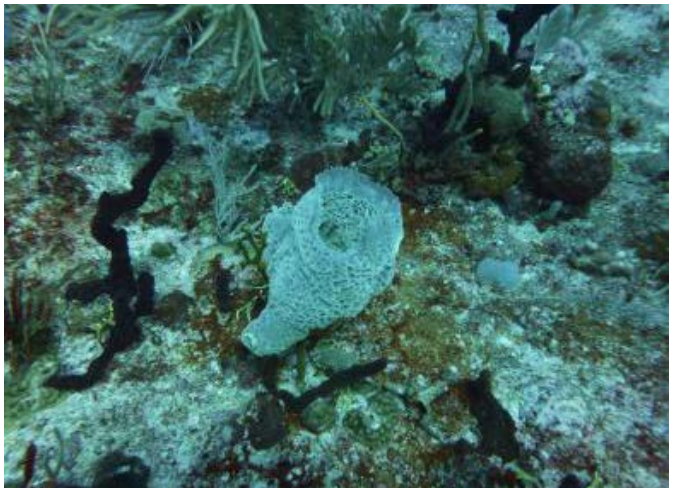

Figure A3. Callyspongia plicifera (Azure vase sponge).

Figure A4. Plakortis halichondroides.

Figure A5. Amphimedon compressa (Erect rope sp).

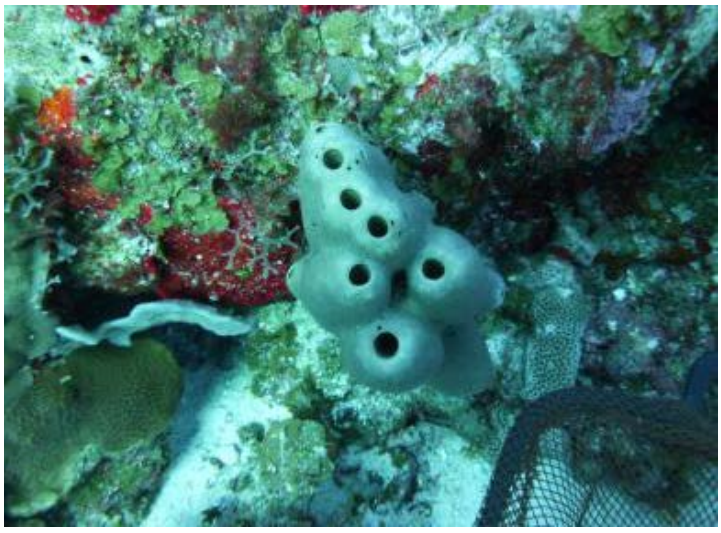

Figure A6. Macroalgae Lobophora (oval leaves) and Dictyota (forked thalli) around the sponge Agelas conifera.

Figure A7. Aiolochroia crassa (Yellow throated tube sponge).

Figure A8. Piece of Xestospongia muta (Barrel sponge)

Stony Coral species in percentage per site and transect – 2011

	SH		GC		CG		PC	TDF		EP		TM		LCG		DC		RG	
Transect	A	C	B	C	B	C	A	A	C	A	C	A	C	A	C	A	C	A	C
Agaricia *agaricites*	0.0	0.1	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.6	0.0	0.0	0.1	0.0	0.1
Agaricia *fragilis*	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Agaricia *grahamae*	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agaricia *humilis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Agaricia *lamarcki*	0.0	0.0	0.0	0.0	2.9	0.0	1.3	0.0	0.0	2.0	1.9	0.0	1.3	0.0	0.0	2.8	0.0	0.0	0.0
Colpophyllia *natans*	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploria *labyrinthiformis*	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dichocoenia *stokesi*	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Erythropodium *caribaeorum*	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Eusmilia *fastigiata*	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Favia *fragum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Helioseris *cucullata*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isophyllia *sinuosa*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Millepora *alcicornis*	1.4	0.4	0.3	0.0	0.1	0.2	0.2	1.3	1.6	0.0	0.1	0.1	0.1	0.0	0.1	0.3	0.0	0.0	0.0
Mycetophyllia *aliciae*	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Mussa *angulosa*	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montastraea *cavernosa*	0.5	0.8	1.0	0.3	3.4	4.6	0.4	0.4	0.0	0.4	3.0	2.0	2.4	0.6	0.0	2.0	0.6	5.8	0.5
Millepora *complanata*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis *decactis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mycetophyllia *lamarckiana*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meandrina *meandrites*	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.2
Millepora *squarrosa*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Orbicella *annularis*	0.0	0.0	0.0	0.1	0.4	0.7	0.1	0.0	0.0	0.5	0.5	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0
Orbicella *faveolata*	6.4	2.1	8.7	1.8	2.6	0.4	1.9	0.0	0.0	1.6	2.0	5.6	1.1	3.2	0.4	1.2	0.5	0.0	0.2
Porites *astreoides*	2.1	0.6	1.3	0.2	0.2	1.5	1.8	0.0	0.0	0.9	0.5	0.6	0.9	0.2	0.2	0.3	0.0	0.0	0.0
Palythoa *Caribbaeorum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites *divaricata*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites *furcata*	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites *porites*	0.2	0.2	0.7	0.1	0.3	0.6	0.1	0.1	0.1	0.3	0.2	0.6	0.6	0.2	0.0	0.1	0.0	0.0	0.4
Stephanocoenia *intersepta*	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0
Siderastrea *radians*	0.1	0.0	0.1	0.5	0.0	0.0	0.0	0.1	0.4	0.0	0.1	0.2	0.0	0.8	0.2	0.1	0.2	0.0	0.0
Siderastrea *siderea*	0.2	1.0	0.0	0.3	0.2	1.3	0.2	0.1	0.1	0.5	0.4	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0
Total coral cover (%)	10.9	5.3	15.4	3.9	10.6	13.8	6.0	2.7	2.4	7.9	10.0	10.4	6.9	6.5	1.1	7.3	1.7	6.0	1.6
Species (n)	8	7	10	10	10	12	9	12	3	10	13	10	10	10	5	9	5	2	5

Stony Coral species in percentage per site and transect – 2013

	DP		SH		GC		CG		PC		TDF		EP		TM		LCG		DC		RG	
Transect	**B**	**C**	**B**	**C**	**A**	**C**	**A**	**C**	**A**	**B**	**A**	**B**	**A**	**C**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**C**
Agaricia *agaricites*	0	0.1	0.1	0	0.1	0.1	0	0.5	0.3	0	0	0	0.3	0.1	0	0	0.1	0.1	0.1	0.1	0.1	0.2
Agaricia *fragilis*	0	0.4	0	0	0	0	0	0.1	0.1	0.2	0	0	0.1	0	0	0	0.1	0	0	0	0	0
Agaricia *grahamae*	0.1	0	0	0	0	0	0	0.1	0	0.1	0	0	0.2	0	0	0	0.1	0	0	0	0	0
Agaricia *humilis*	0.1	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Colpophyllia *breviserialis*	0	0.1	0.2	0	0	0.3	0.1	0	0	0	0	0.2	0	0	0.4	0	0	0	0.2	0.4	0	0
Colpophyllia *natans*	0	0.3	0.1	1.2	0.1	0	0	0	0	0.1	0.1	0	0.1	0	0	0	0	0	0	0.1	0	0
Diploria *labyrinthiformis*	0	0	0.6	0.2	0.4	0.4	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0.3	0
Dichocoenia *stellaris*	0	0	0	0.1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0
Dichocoenia *stokesi*	0	0	0.1	0.2	0	0.1	0	0	0	0	0.1	0	0	0	0	0	0.1	0.1	0	0	0	0
Diploria *strigosa*	0.1	0.7	0.1	0.9	0.8	0.4	0	0	0	0	0	0	0	0.1	0.4	0.1	0.4	0	0	0	0.4	0
Eusmilia *fastigiata*	0.1	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0
Favia *fragum*	0.1	0	0	0.1	0	0	0.3	0	0	1.4	0	0	0	0	0	0	0	0	0.1	0	0	0
Favia *leptophylla*	0.1	0.1	0	0	0	0	0	0	0.4	0	0.1	0.1	0	0.3	0	0	0	0	0	0.1	0	0
Isophyllastrea *rigida*	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0
Isophyllia *sinuosa*	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0
Millipora *alcicornis*	1.0	0.4	0.6	2.7	1.3	0.8	0.6	0.7	1.5	1.2	0.3	0.1	0.6	0.3	0.1	0	0.4	0.2	0.1	0.2	0.2	0.6
Mycetophyllia *aliciae*	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Montastraea *cavernosa*	1.8	0.5	0.8	1.0	0.4	0.1	0.8	0.6	0.3	0.6	0.2	0.1	1.3	1.3	0.3	0.2	0.4	0.4	0.5	0.1	0.1	0.1
Millipora *complanata*	0	0	0	0.1	0.1	0	0.1	0	0.1	0	0	0.1	0	0	0	0	0	0	0	0	0	0
Mycetophyllia *danaana*	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Madracis *decactis*	0	0.8	0.2	1.2	0.1	0	0	0.6	0.3	0.3	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0.6	0.2	0
Meandrina *meandrites*	0.2	0.1	0.3	0.1	0	0	0	0	0	0.1	0	0	0	0.6	0	0	0.1	0	0.1	0.1	0.1	0
Millipora *squarrosa*	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orbicella *faveolata*	4.7	4.2	4.7	1.4	0.6	0.1	2.7	1.1	1.4	0.9	0	0	2.4	1.9	4.2	4.9	3.8	2.8	0.8	1.3	0.3	1.1
Orbicella *franski*	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3	0	0.1	0	0	0.2	0	0.3	0
Oculina *varicosa*	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Porites *astreoides*	1.5	1.6	2.6	1.5	2.3	1.7	0.7	1.0	2.0	3.0	0	0	0.9	0.3	0.9	0.8	0.1	0.1	0	0.1	0.3	0.4
Porites *divaricata*	0	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0	0.1	0.4	0.1	0	0	0.1	0	0	0.1	0.1	0	0	0
Porites *furcata*	0.1	0	0	0.1	0.1	0	0	0.1	0.2	0	0	0	0	0	0	0.3	0	0	0.1	0	0.1	0
Porites sp.	0	0	0.1	0	0.1	0	0	0	0.1	0	0	0	0	0.2	0.1	0	0	0	0	0	0	0
Porites *porites*	0.7	0	0.4	0.5	0.1	0	1.4	0	0.3	0.3	0.1	0	0.2	0.2	0	0.5	0.1	0	0.2	0.1	0.1	0
Ricordea *florida*	0	0	0	0	0	0	0	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0
Scolymia *wellsi*	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0
Scolymia *cubensis*	0.1	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solenastrea *hyades*	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Siderastrea sp.	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.1	0	0.1	0
Stephanocoenia *intersepta*	0	0.1	0.6	1.0	0.5	0.1	0	0.3	0	0.1	0	0	0.4	0.1	0.1	0	0.1	0.1	0.2	0.1	0.1	0.1
Scolymia *lacera*	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0
Siderastrea *radians*	0.3	0.3	0.5	0.4	0.1	0.4	0.2	0	0.2	0.1	0	0.1	0.3	0.1	0	0.2	0.1	0.1	0.2	0	0.1	0.1
Siderastrea *siderea*	1.0	0.7	1.8	3.0	0.8	1.7	0.2	0.2	1.3	1.0	0.3	0.1	0.9	0.1	3.4	0	0.1	0.1	0.2	0.4	0.7	0.2
Total coral cover (%)	12.2	10.9	14.2	15.8	8.3	6.3	7.5	5.6	9.1	9.4	1.5	0.9	7.9	5.8	10.1	7.2	6.3	4.5	3.1	4.1	3.3	2.8
Species (n)	17	17	20	19	18	13	15	13	19	15	9	8	14	17	11	9	15	12	15	17	16	8

Soft Coral species in percentage per site and transect – 2011

	SH		GD	CG		PC	TDF		EP		TM		LCG		DC		RG	
Transect	**A**	**C**	**B**	**B**	**C**	**A**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**
Briareum asbestinum	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Erythropodium caribaeorum	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Eunicea calyculata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunicea laciniata	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Eunicea mammosa	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunicea palmeri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Eunicea succinea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunicea sp.	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.1	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Gorgoniidae sp.	0.4	0.2	0.4	0.0	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.2	0.2	0.3	0.0	0.0	0.0	0.0
Gorgonia ventalina	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudopterogorgia acerosa	0.0	0.2	0.3	0.0	0.3	0.5	0.0	0.0	0.1	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pseudopterogorgia americana	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pseudopterogorgia bipinnata	0.1	0.1	0.0	0.1	0.3	0.1	0.0	0.0	0.2	0.3	0.0	0.1	0.2	0.2	0.0	0.0	0.0	0.1
Pterogorgia citrina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudodiploria Clivosa	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0
Plexaurella dichotoma	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pseudoplexaura flagellosa	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plexaurella grisea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pterogorgia guadalupensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plexaurella sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudoplexaura sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Total coral cover (%)	1.2	0.5	1.2	1.0	1.5	1.1	0.1	0.1	1.2	2.1	0.1	0.5	0.8	0.7	0.0	0.2	0.2	0.2
Species (n)	9	5	8	7	9	9	1	2	8	12	3	6	8	5	0	4	2	4

Soft Coral species in percentage per site and transect – 2013

	DP		SH		GC		CG		PC		TDF		EP		TM		LCG		DC		RG	
Transect	**B**	**C**	**B**	**C**	**A**	**C**	**A**	**C**	**A**	**B**	**A**	**B**	**A**	**C**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**C**
Eunicea calyculata	0.1	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Erythropodium caribaeorum	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunicea mammosa	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Eunicea palmeri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Eunicea succinea	0.3	0.1	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0
Pexaurella dichotoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Briareum asbestinum	0.3	0.3	0.0	0.6	0.0	0.1	0.1	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Briareum sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Erythropodium	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunicea sp.	1.1	0.1	0.3	0.5	0.4	0.4	0.0	0.0	0.5	0.8	0.0	0.0	0.4	0.0	0.5	0.1	0.7	0.2	0.2	0.0	0.0	0.2
Gorgoniidae sp.	0.2	0.1	1.3	2.0	1.9	1.1	0.2	0.5	1.0	0.7	0.0	0.0	0.3	0.3	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0
Gorgonian ventalina	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.1	0.0	0.0
Iciligorgia schrammi	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.4
Pseudopterogorgia acerosa	0.1	0.0	0.2	0.6	0.6	0.6	0.1	0.4	0.0	0.1	0.0	0.0	1.1	0.0	0.6	0.2	0.2	0.4	0.0	0.1	0.0	0.0
Pseudopterogorgia americana	0.2	0.4	0.4	1.1	1.4	0.1	0.3	0.2	0.6	0.1	0.0	0.0	1.1	0.8	0.1	0.6	0.1	0.4	0.0	0.0	0.0	0.1
Pseudopterogorgia bipinnata	0.2	0.6	0.4	1.2	0.3	0.5	0.3	0.7	0.3	0.0	0.0	0.0	0.7	0.3	0.1	0.5	0.1	0.5	0.1	0.1	0.1	0.2
Pterogorgia citrina	0.0	0.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pseudoplexaura crucis	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudoplexaura flagellosa	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Pterogorgia guadalupensis	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plexaura sp.	0.1	0.0	0.0	0.0	0.2	0.1	0.2	0.2	0.3	0.4	0.0	0.0	0.0	0.1	0.0	0.2	0.3	0.4	0.1	0.1	0.1	0.0
Pseudoplexaura sp.	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0
Pseudopterogorgia sp.	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Pterogorgia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Palythoa Caribbaeorum	0.8	0.6	1.7	1.0	1.9	1.5	0.0	0.1	0.4	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0
Pseudopterogorgia elisabethae	0.0	0.0	0.1	0.5	0.6	0.0	0.0	0.0	0.3	0.7	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Plexaurella grisea	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total coral cover (%)	3.8	2.5	5.1	8.0	7.5	4.7	1.9	2.4	3.8	4.1	0.1	0.2	4.7	1.7	1.8	2.3	2.2	2.9	0.5	0.7	0.4	1.0
Species (n)	15	10	11	13	11	11	14	10	12	15	1	2	9	6	8	11	10	11	6	8	6	5

Appendix D: Fish species included in the monitoring

No.	Code	Common name	Scientific name
	PARROT		
1	S_STOP	Stoplight parrotfish	*Sparisoma viride*
2	S_QUEE	Queen parrotfish	*Scarus vetula*
3	S_PRIN	Princess parrotfish	*Scarus taeniopterus*
4	S_STRIP	Striped parrotfish	*Scarus iserti/croicensis*
5	S_RAIN	Rainbow parrotfish	*Scarus guacamaia*
6	S_REDB	Redband parrotfish	*Sparisoma aurofrenatum*
7	S_REDT	Redtail parrotfish	*Sparisoma chrysopterum*
8	S_REDF	Redfin parrotfish	*Sparisoma rubripinne*
9	S_MIDN	Midnight parrotfish	*Scarus coelestinus*
	SURGEON		
10	A_OCEA	Ocean surgeonfish	*Acanthurus bahianus*
11	A_DOCT	Doctorfish	*Acanthurus chirurgus*
12	A_BLUE	Blue Tang	*Acanthurus coeruleus*
	DAMSEL		
13	D_SPOT	Three spot damselfish	*Stegastes/Pomacentrus planifrons*
14	D_BEAU	Beaugregory	*Stegastes/Pomacentrus leucostictus*
15	D_LONG	Longfin damselfish	*Stegastes/Pomacentrus diencaeus*
16	D_DUSK	Dusky damselfish	*Stegastes adustus/Pomacentrus fuscus*
17	D_BICO	Bicolor damselfish	*Stegastes/Pomacentrus partitus*
18	D_YELL	Yellowtail - *Microspathodon chrysurus*	*Microspathodon chrysurus*
	CHROMIS		
19	C_BLUE	Blue Chromis	*Chromis cyanea*
20	C_BROW	Brown Chromis	*Chromis multilineata*
	GRUNT		
21	H_CAES	Caesar grunt	*Haemulon carbonarium*
22	H_SMAL	Smallmouth grunt	*Haemulon chrysargyreum*
23	H_FREN	French grunt	*Haemulon flavolineatum*
24	H_SPAN	Spanisch grunt	*Haemulon macrostomum*
25	H_BLUE	Bluestriped Grunt	*Haemulon sciurus*
26	H_WHIT	White grunt	*Haemulon plumieri*
27	H-WHMAR	White margate	*Haemulon album*
28	H_BLMAR	Black margate	*Anisotremus surinamensis*
29	H_SAIL	Sailors choice	*Haemulon parra*
30	H-TOMT	Tomtate	*Haemulon aurolineatum*
31	H_COTW	Cottonwick	*Haemulon melanurum*
	SNAPPER		
32	L_SCHO	Schoolmaster	*Lutjanus apodus*
33	L_CUBE	Cubera snapper	*Lutjanus cyanopterus*
34	L_GREY	Grey snapper	*Lutjanus griseus*
35	L_MAHO	Mahogany snapper	*Lutjanus mahogoni*
36	L_DOGS	Dog snapper	*Lutjanus jocu*
37	L_MUTT	Mutton snapper	*Lutjanus synagris/analis*
38	L_YELL	Yellow-tail snapper	*Ocyurus chrysurus*
	GROUPER		
39	G_NASS	Nassua grouper	*Epinephelus striatus*
40	G_BLAC	Black grouper	*Mycteroperca bonaci*
41	G_TIGE	Tiger grouper	*Mycteroperca tigris*
42	G_YELL	Yellowfin grouper	*Mycteroperca venenosa*
43	G_GRAY	Graysby	*Epinephelus cruentatus/Cephalopholis cruentata*
44	G_CONE	Coney	*Epinephelus fulvus/Cephalopholis fulva*
45	G_REDH	Red hind	*Epinephelus guttatus*
46	G_ROCK	Rock hind	*Epinephelus adscensionis*
47	G_HARL	Harlequin bass	*Serranus tigrinus*
48	G_HAML	Hamlets	*Hypoplectrus spp.*

No.	Code	Common name	Scientific name
	JACK		
49	J_HORS	Horse eye jack	*Caranx latus*
50	J_BARJ	Bar jack	*Caranx ruber*
51	J_PALO	Palometa	*Trachinotus goodei*
52	J_BLAC	Black jack	*Caranx lugubris*
53	J_CREV	Crevalle	*Caranx hippos*
54	J_PERM	Permit	*Trachinotus falcatus*
55	J_POMP	African Pompano	*Alectis ciliaris*
56	J_RAINB	Rainbow runner	*Elegatis bipinnulata*
57	J_BLUE	Blue Runner	*Caranx crysos*
58	J_ALMAC	Almaco jack/Longfin yellowtail	*Seriola rivoliana*
	PREDATOR		
59	P_TRUM	Trumpetfish	*Aulostomus maculatus*
60	P_HOGF	Spanish hogfish	*Bodianus rufus*
61	P_FLOU	Peacock flounder	*Bothus lunatus*
62	P_MORA	Moray	*Gymnothorax spp.*
63	P_SCOR	Spotted scorpionfish	*Scorpaena plumieri*
64	P_LION	Lionfish	*Pterois volitans*
65	P_BARR	Great Barracuda	*Sphyraena barracuda*
66	P_LIZA	Sand diver / lizardfish	*Synodus intermedius*
	OTHER		
67	SERG_MAJ	Sergeant major	*Abudefduf saxatilis*
68	GOAT_YELL	Yellow goatfish	*Mulloidichthys martinicus*
69	GOAT_SPOT	Spotted goatfish	*Pseudupeneus maculatus*
70	ANGE_ROCK	Rockbeauty	*Holacanthus tricolor*
71	ANGE_FREN	French angelfish	*Pomacanthus paru*
72	ANGE_QUEE	Queen angelfish	*Holacanthus ciliaris*
73	ANGE_GRAY	Gray angelfish	*Pomacanthus arcuatus*
74	BALL_TRUN	Trunkfish	*Lactophrys spp.*
75	BALL_COWF	Cowfish	*Acanthostracion spp.*
76	BALL_BURR	Burrfish	*Chilomycterus spp.*
77	BALL_PORC	Porcupine	*Diodon spp.*
78	BUTT_LONG	Longsnout butterflyfish	*Chaetodon aculeatus*
79	BUTT_BAND	Banded butterflyfish	*Chaetodon striatus*
80	BUTT_4EYE	4 eye butterflyfish	*Chaetodon capistratus*
81	BUTT_REEF	Reef butterflyfish	*Chaetodon sedentarius*
82	WRAS_BLUE	Bluehead wrasse	*Thalassoma bifasciatum*
83	WRAS_YELL	Yellowhead wrasse	*Halichoeres garnoti*
84	WRAS_PUDD	Puddingwife	*Halichoeres radiatus*
85	WRAS_CREO	Creole wrasse	*Clepticus parrae*
86	TRIG_BLAC	Black durgon	*Melichthys niger*
87	TRIG_OCEA	Ocean triggerfish	*Canthidermis sufflamen*
88	TRIG_QUEE	Queen triggerfish	*Balistes vetula*
89	CHUB_SPP	Bermuda chub	*Kyphosus sectatrix*
90	SOLD_SPP	Squirrelfish	*holocentridae spp.*
91	FILE	Filefish	*Monacanthidae spp.*
92	CREO	Atlantic Creolefish	*Paranthias furcifer*
93	SOAP	Greater soapfish	*Rypticus saponaceus*
94	MAJO	Yellowfin mojarra	*Gerres cinereus*
95	BONE	Bonefish	*Albula vulpes*
96	WAHO	Wahoo	*Acanthocybium solandri*
97	TARP	Tarpon	*Megalops atlanticus*
98	TURT	Turtle	
99	SHARK	Shark	
100	RAY	Southern stingray	*Dasyatis americana*

Appendix E: Research expedition members

Name	Role	Organisation and function
Erik Meesters	Expedition leader, benthic communities	Researcher IMARES
Fleur van Duyl	Sponges and nutrients	Researcher Royal Netherlands Institute for Sea Research (NIOZ)
Benjamin Müller	Sponges and nutrients	Researcher Royal Netherlands Institute for Sea Research (NIOZ)
Lisa Becking	Genetics and connectivity	Researcher IMARES
Didier de Bakker	Genetics and connectivity	MSc student IMARES
Maggy Nugues	Coral-algal interactions	Centre de Recherches Insulaires et Observatoire de l'Environnement (CRIOBE)
Joe Phillipson	Structural complexity	BSc student IMARES
Steve Piontek	Fish communities	Director of St. Eustatius National Parks (STENAPA)
Erik Boman	Fish communities	Agriculture and fisheries department (LVV) St. Eustatius
Ingrid van Beek	Fish communities	Researcher IMARES
Willem Mouissie	Documentary maker	Mouissie Corporation AVV
Javier Boezem	Filmer	Hobebon BV
Fleur Holtrop	Fish communities (video)	MSc student IMARES and Applied University CAH Almere Vilentum
Franck Mazeas	Benthic communities	Initiative Française pour les Récifs Coralliens (IFRECOR) and Direction de l'Environnement de l'Aménagement et du Logement (DÉAL) Guadeloupe
Jean-Philippe Marechal	Benthic communities	Director of l'Observatoire du Milieu Marin (OMM) Martinique
Jean-Francois Chabot	Captain of the boat	Explorer Ventures

Appendix F: Media exposure

Newspapers and Magazines

Bionews, November Edition 2013: “Research of the Month: Saba Bank Expedition 2013” by L.E. Becking and Erik H.W.G. Meesters
Amigoe, 2 November 2013: “Saba Bank Epicentrum van Biodiversiteit”
Antilliaans Dagblad, 2 November 2013: “Expeditie Saba Bank”
Onderwatersport, February 2014 Edition: “Reportage: Extreem rijk aan soorten”

Websites:

WUR
28 October 2013: http://www.wageningenur.nl/en/show/Researchers-back-from-Saba-Bank-Expedition.htm
28 October 2013: http://www.wageningenur.nl/nl/show/Onderzoekers-terug-van-expeditie-Sababank.htm
28 October 2013: https://nl-nl.facebook.com/sababank

Other
28 October 2012: http://www.divelicious.net/NewsItem/1000000866
29 October 2013: Your Subsea news: http://www.yoursubseanews.com/wageningen+ur+announces+researchers+back+from+saba+bank+expedition_95641.html
29 October 2013: The Daily Herald: http://www.sabanews.nl/fewer-fish-species-sharks-saba-bank/
29 October 2013: http://www.duikeninbeeld.tv/nieuws/bericht/expeditie-sababank/
4 November 2013: http://www.amigoe.com/napa/napa/168236-epicentrum-biodiversiteit
2 November 2013: http://www.natuurbericht.nl/?id=11675