



UV filter pollution Bonaire by tourism

Lac Bay monitoring and survey results 2017

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Wageningen University &
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Contents

Acknowledgements	5
Summary	6
1 Introduction and assignment	8
1.1 General introduction	8
1.2 Assignment	8
2 Approach	9
2.1 UV filter monitoring	9
2.1.1 Sampling and analysis	9
2.1.2 Risk Assessment	10
2.2 Beach tourist survey	11
2.3 Awareness raising	11
2.3.1 Shop surveys	11
2.3.2 Sunscreen Awareness Conference	12
2.3.3 Media	12
3 Monitoring results and discussion	13
3.1 Lac Bay monitoring	13
3.1.1 UV filters	13
3.1.2 Biocides	14
3.1.3 Risk assessment	14
3.1.4 Comparison 2016	15
3.2 Beach tourist survey	15
3.2.1 Generic statistics on tourists in Sorobon	15
3.2.2 Products and oxybenzone	18
3.2.3 Awareness	19
4 Awareness raising- Stakeholder involvement	21
4.1 Shop surveys	21
4.2 Awareness conference	22
4.2.1 Legal ban	22
4.2.2 Changing consumer behaviour	23
4.2.3 Environmental Tax for cruise tourists	23
4.3 Stakeholder remarks	24
4.4 Research questions from stakeholders	24
4.5 Opportunities for on-island cooperation	25
4.6 Conclusions and steps forward	25
5 Overall conclusions and recommendations	27
5.1 Monitoring	27
5.2 Tourist beach survey	27
5.3 Awareness raising/Stakeholder involvement	27
6 Quality Assurance	28
References	29

Justification	30
Annex 1 Field monitoring and risk assessment	31
Annex 2 Beach survey information	32
Annex 3 Additional stakeholder involvement	33

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Summary

Chronic stressors such as water pollution, overfishing, and ocean warming are major threats to the resilience of coral reefs as they influence processes that underlie resistance and recovery of reef ecosystems. Local management actions and policy increasingly have to focus on supporting the resilience of these ecosystems. This requires customization of management on smaller spatial scales.

Tourism contributes to reduced water quality due to the emission of sun care products by swimming recreationists. Recent research shows that UV filters (*viz.* oxybenzone) in sun care products can contribute to reduced vitality of coral ecosystems. Monitoring in 2016 showed that these substances are also present in coastal waters of Bonaire, at levels of serious environmental concern.

Although water quality of Bonaire seems to be affected by sunscreen pollution, the local action perspective is also specific. The public opinion can be influenced by translating scientific results to articles suitable for a broader public audience and by providing accessible information via various media. Raising public awareness may result in both reduced supply and use of specific harmful products, since appropriate alternatives are already available.

WWF and the Ministry of Economic affairs assigned various smaller projects of which the activities, results and conclusions are presented in this report. WMR and Boneiru Duraderu worked together on these assignments in the so called "Sunscreen awareness project".

Main research questions were:

- Was the presence of polluting UV filters at Sorobon in 2016 a one-time observation, or are these substances found in other time periods as well. Do concentrations depend on tourism intensity and products used?
- How can the local use of sunscreen products containing oxybenzone be effectively influenced, so that coral ecosystems on Bonaire are no longer at risk from such products.

To answer these question various activities were exploited:

- Monitoring and surveys:
 - o Chemical monitoring with focus on field concentrations of UV filters in November 2017 during the peak of the cruise season.
 - o Conducting Beach surveys among tourists in order get preliminary information on tourist intensity and sunscreen use during field monitoring.
- Stakeholder involvement:
 - o Conduct shop surveys in order to get information on products sold and willingness of owners to make a change.
 - o Host a conference to present results and to prepare a voluntary covenant and involve stakeholders.
 - o Contribute with scientific knowledge to media and local provide information.

Monitoring of UV filter levels showed that UV filters oxybenzone and octocrylene were present in the water, at levels indicating environmental risk. Risk quotients (RQ) of oxybenzone range between 0 and 2.8 whereas risk quotients of octocrylene range between 6 and 52. It should however be noted that the RQ's of octocrylene are derived from a rather limited data set, and are higher due to the higher uncertainty factor applied.

Although the study was indicative, UV-filter levels and thus risk seem to be related to tourist intensity, origin and product use. Levels of especially oxybenzone were higher when more oxybenzone products were used among tourists on the beach. These tourists originated mostly from the US, enjoying a cruise holiday. Stay-over tourists from the EU show a relatively limited use of oxybenzone-based sunscreen products.

Stakeholder involvement included surveys and interviews in the preparation towards the Sunscreen Awareness conference at which various stakeholder were invited to discuss how to move forward on the topic.

The attendees of the conference participated in a lively discussion, and the following paths forward were identified:

1. Legal Ban for sunscreens.
2. Changing consumer behaviour.
3. Introduction of an environmental tax for cruise tourist.

Stakeholders vary in their view towards the daily practice and effectivity of a legal ban, and pro's and con's are listed in the report. Common ground was found in the possibility to include a rule in the Marine Park management plan to strengthen the communication about the subject. Awareness and influencing consumer behaviour was viewed as the best way to move forward. Moreover, an awareness campaign can be implemented much faster than a law. To pay for such an ongoing awareness campaign, the introduction of an environmental tax for cruise tourists was suggested. Remarks and additional research questions are listed in the report.

In summary, future research and awareness should focus on:

- additional monitoring at the west coast to broaden the scope and relation to tourist origin, density and product use
- effects of field relevant levels of sunscreen
- study the effect of so called "safe alternatives"
- involvement of the cruise sector, and study the willingness to change to other products

1 Introduction and assignment

1.1 General introduction

Cumulative pressures of climate change combined with multiple regional and local stressors pose fundamental challenges for coral reef managers worldwide. Chronic stressors such as water pollution, sedimentation, overfishing, and ocean warming are major threats to the resilience of coral reefs. They influence processes that underlie resistance and recovery, while acute stressors (e.g. storms) increase the demand for resilience. Local management actions and policy will increasingly have to focus on supporting the resilience of reef ecosystems. This requires customization, with a look out on smaller spatial scales and closely linked to ecosystems and ecosystem services (Anthony et al., 2015).

Tourism is an important, if not the largest source of income on Bonaire. But tourism also contributes to reduced water quality as a result of the emission of sunscreens by swimming recreationalists. Recent research shows that UV filters in sunscreen products in particular contribute to reduced vitality and thus resilience of coral ecosystems (Downs et al., 2016, Tsui et al., 2014). In brief, UV filters (especially oxybenzone) in sunscreens can have effects on coral bleaching, the induction of viral infections, DNA damage and deformities in coral larvae (planula) and thus reproductive success (e.g. Danovaro et al., 2008, Downs et al., 2014, 2016). Laboratory tests demonstrated effects at very low – field relevant- concentrations.

Exploratory research on Bonaire in 2016 showed that UV filters such as oxybenzone are present in the coastal water, in concentrations that are worrisome in relation to the local ecosystems (Slijkerman and Schaap, 2018 submitted). Environmental risks cannot be excluded.

The local action perspective, however, also seems obvious: 1. Scientific results are translated into publicly accessible information. 2. Public awareness leads to the choice of suitable environmentally-friendly alternatives. 3. Information can influence public opinion on both the supply and use of specific harmful products.

However, additional questions were:

- Was the presence of polluting UV filters at Sorobon in 2016 a one-time observation, or are these substances found in other time periods as well. Do concentrations depend on tourism intensity?
- How can specifically the local use of sunscreen products containing oxybenzone be effectively influenced, so that coral ecosystems on Bonaire are no longer at risk from such products.

1.2 Assignment

In this report the assignments of various small projects are combined in order to present the overview of activities, results and conclusions so far.

This report includes the results from

- field monitoring focussing on field concentrations of UV filters (project KB-24-003-012)
- beach surveys among tourists in order get preliminary information on tourist intensity and sunscreen use (project BO-43-021.04-008) and Boneiru Duraderu- WWF funds
- shop surveys in order to get information on products sold and willingness of owners to make a change (work done via Boneiru Duradero and WWF funds)
- a conference to present results and to prepare a voluntary covenant and involve stakeholders (project BO-11-019.02-064) and Boneiru Duraderu- WWF funds
- contribution with scientific knowledge to media and local information (project BO-11-019.02-064, Boneiru Duraderu- WWF funds).

2 Approach

Via various approaches, results were obtained. This included chemical monitoring of UV filters, beach surveys among tourists, and stakeholder awareness raising via shop surveys and organisation of a stakeholder conference.

2.1 UV filter monitoring

2.1.1 Sampling and analysis

Based on literature and local conditions, the hypotheses was that UV filters from sunscreens might build up in Sorobon/Lac Bay, resulting from the day-after-day visit of cruise ship tourists. Monitoring thus focussed on high intensity tourism at Sorobon, depending on cruise ship visitors that allow for peak numbers (Debrot, 2012).

Water sampling was performed on four consecutive days at two different locations at Lac Bay- one at the beach front of Sorobon Beach in the middle of tourism activity and seagrass fields (12° 5'36.93"N, 68°14'8.71"W). The second was near the mangrove rim (12° 6'26.91"N, 68°14'3.43"W, approximately 800 m downstream of the beach location (Figure 1). At sampling locations, samples of the water surface microlayer (SML) and the water column were collected. Samples of the water layer were taken by opening a closed bottle 30 cm under the surface, resulting in a passively filling of the bottle with water and closing the lid again under water. The person who performed the sampling did not use sunscreen during sampling and (1, 2, some) weeks prior to sampling.

Sampling moments corresponded with cruise tourism peaks. The cruise schedule of November 2017 showed 3 subsequent days of harbour calls of large cruise ships, promising peak visits a few days on a row. This allowed to study potential build-up of UV filter concentrations. Prior to sampling, no cruise ships were in Kralendijk for at least 2 days, allowing for a "T0" sampling. The monitoring schedule and details are provided in table 1.

The T0 sampling was originally planned to be on the early morning of T1. However, two cruise ships visited unexpectedly on Tuesday, and last minute the T0 sampling had to be advanced. The T1 sampling could, however, not be advanced due to limitations in field logistics.

In addition to the water samples taken at Sorobon, water samples in the lab were prepared with known concentrations of oxybenzone and octocrylene. The levels were based on the expected range of levels in the field based on 2016 results. Two levels of spiked water samples were prepared: high concentrations of oxybenzone and octocrylene ((1.08 resp. 1.03 µg/l), and low concentrations ((0.092 resp. 0.088 µg/l). The recovery percentage during chemical analysis was used to correct for recovery of the UV filters in field samples.

Samples were analysed for a set of UV filters (oxybenzone, octocrylene, 4-MBC and benzophenone-4), as well as for biocides and parabenes. UV filters were analysed with liquid chromatography (reversed phase Atlantis T3 C18 column) coupled by mass spectrometry (Agilent triple quadrupole 6460 mass spectrometer equipped with an electrospray ionization source and jet stream (ESI- JS)) by Eurofins Omegam B.V (Amsterdam-Duivendrecht).

Table 1 Monitoring schedule and info on the beach survey (paragraph 2.2). Count daily average is the average of hourly counts of tourists present between 10AM and 15PM.

Day + Date	Cruise ships + passengers	Type of monitoring	Remarks
Tuesday Oct 31	Monarch (2744) + Norwegian Jade (2224)	T0 (8.45)	Sampled before tourists enter the beach. Many south American and US tourists on the beach (no interviews). At 11 AM > 400 people in water
Wednesday Nov 1	Equinox (2800)	T 1 (15.00)	Count daily average: 99 97 Interviews. Ships leaves at 16 PM, tourists leave early, shortly after midday
Thursday Nov 2	Regal princess (3600)	T 2 (14.00)	Count daily average: 168 93 Interviews
Friday Nov 3	Koningsdam (2650)	T 3 (14.30)	Count daily average: 98 39 Interviews
Tuesday Nov 14	Adventure of the Seas (3114) + Balmoral (1778)	Samples taken, but not analysed yet	Count daily average: 233 30 interviews
Wednesday Nov 15	Aida Diva (2050) + Britannia (4324)	Samples taken, but not analysed yet	Count daily average: 245 28 interviews



Figure 1 Sample locations in Lac Bay

2.1.2 Risk Assessment

A risk assessment was performed according to the most recent risk assessment guidelines of the European Chemicals Agency (ECHA) (ECHA, 2008). Measured environmental concentrations of the UV filters were used for risk estimation. A dataset (n=90) containing both marine (n=64) and freshwater (n=26) water toxicity endpoints was constructed from the EPA toxicity database ECOTOX and complemented by reviewing literature (Schaap & Slijkerman, submitted). The aquatic ecotoxicity dataset was used to derive the predicted no-effect concentration (PNEC), using the criteria set by ECHA (2008). Depending on data coverage, an assessment factor (AF) was selected for each UV filter, and applied to the lowest effect concentration available (Sang et al., 2016; Schaap & Slijkerman, submitted). Risk quotients (RQ) were determined by dividing an environmental concentration by the

lowest toxicity end-point value, in this case by dividing PNEC by the corresponding AF. Ratio values above 1 indicate potential risk from the compound towards the environment (EC, 2003).

PNEC's per UV filter are presented in annex 1. PNEC estimation comprised both freshwater and marine data, as the number of marine toxicity data was limited. The toxicity data used to derive PNEC's were obtained according to standard test guidelines, such as OECD or ISO, which are favoured in environmental risk assessments. Coral toxicity data are available for oxybenzone, but left out in the generic assessment because of inconsistency in LC50 and No Observed Effect Concentration (NOEC) derivation. The lowest toxicity endpoints for all UV filters comprised chronic test data, either a NOEC or an LC10 value. Oxybenzone data coverage resulted in an AF of 10 (annex 1). Toxicological data was limited for octocrylene, resulting in an AF of 500. A risk assessment for coral species and sensitivity was performed separately.

2.2 Beach tourist survey

At T1,T2 and T3 a survey was conducted among the tourists at Sorobon, in order to get information on the sunscreens used and the level of oxybenzone in the products. Origin (country) of the tourist, and being a cruise tourist or stay-over were noted as general information. In addition, questions on sunscreen use (application rate), purchase location (home or during trip) and swimming frequency were asked. Awareness on the environmental issues with oxybenzone was asked for, in order to get information on the awareness level and willingness to change products. The list of questions is presented in annex 2. A team of 5 persons conducted the interviews on T1, 3 persons on T2 and T3. In addition, two additional days with high tourist numbers were surveyed. On November 14 and 15 additional interviews were held as large numbers of tourists were to be expected due to large cruise ship arrivals.

Each hour between 10AM-15PM, the total number of tourists on the beach and total number of tourist in the water was counted (each count double, average taken).

2.3 Awareness raising

Besides monitoring, the project "Sunscreen Awareness Bonaire" uses the field results in the awareness program on Bonaire, in order to improve local water quality. Sunscreen Awareness Bonaire is a joint project of Wageningen Marine Research (WMR) and Boneiru Duradero (BD). Boneiru Duradero (Sustainable Bonaire) is a small-scale initiative, focusing on sustainable awareness and activity on Bonaire. BD is coordinated by Sharon Bol and funded by the World Wildlife Fund (WNF) and the Ministry of Economic Affairs, The Netherlands. BD's mission is to convert the concept of sustainable living into concrete, practical and easy to understand activities that people can relate to. BD's activities aim to raise awareness and at the same time create an action perspective for our target audience. After all, awareness is great, but motivating people to make (small) changes in their behavior is better. Overall awareness by BD is created through a.o. seminars and stakeholder sessions. By using the latest scientific results obtained from the monitoring and literature studies done by WMR, the awareness program on sunscreen is strengthened.

2.3.1 Shop surveys

Shop surveys were held in order to get information from shop owners on product sales and incentives to change to other, oxybenzone free products.

In total 9 interviews were held, and the results were qualitatively noted. Results and impressions were used for the conference to start the discussion and to verify statements done. Interview questions are listed in annex 3.

2.3.2 Sunscreen Awareness Conference

The conference comprised two workshops on March 21 in order to involve as many stakeholders as possible. The conference had the following objectives:

1. share current insights about the UV-filter oxybenzone, and the effect this sunscreen ingredient has on corals;
2. indicate Relevancy and Urgency of harmful sunscreens to Bonaire;
3. receive input from conference participants on how to move forward;
4. determine a coordinated island wide effort to protect the reef on Bonaire.

The conference comprised science presentations and works sessions (see annex 3 for participants list).

2.3.3 Media

Several media platforms are used in the project to get people informed.

- Posts via <https://www.facebook.com/boneiruduradero/> and <http://www.boneiruduradero.nl/category/sunscreen/>
- TV NOS: via pre-arranged interview local news item was broadcasted during the conference week
- interviews and articles: NRC, DiveWire, Down to Earth Magazine, Bionews

3 Monitoring results and discussion

3.1 Lac Bay monitoring

3.1.1 UV filters

Spiked samples showed varying recovery, depending on the concentration (high/low) (Table 1 in Annex 1). Field sample data were corrected for these recovery values.

At T0, no UV filters were detected in the water and SML of Sorobon beach. At T0, at the mangrove, octocrylene was detected at levels up to 0.18 µg/l. The concentrations 4-MBC and BP-4 of all collected samples were below LOQ¹ independent of sampling location and moment (data not shown). Near the mangrove, oxybenzone was detected just above the LOQ (0.01 µg/L) in both the water column and SML on two days. At Sorobon, oxybenzone was detected in both the SML (0.32-1.03 µg/L) and water column (0.17-0.65 µg/L) and all three sampling events (table 2). The highest concentrations of oxybenzone were found in the water column.

Octocrylene was found in the SML (0.04-0.25 µg/L), as well as in the mangrove water column (< LOQ-0.18 µg/l) (table 3). The highest concentrations of octocrylene were detected in the SML (0.04-2.06µg/L) instead of in the water layer (0.22-0.67 µg/L).

The presence of oxybenzone and octocrylene is in line with expectations, since the majority of the tourists visiting the area use sunscreen products consisting oxybenzone and octocrylene due to the tourists' origin (Rastogi, 2002; Osterwalder and Hareng, 2016; Debrot, 2012, survey results- this report, next paragraph).

Although increasing concentrations were expected during the week, because of the many cruise ships visiting the island and the persistence of the compounds, no increase of concentrations over the days was observed. Instead, the results suggest a renewed load of sunscreen chemicals each day. However, on the consecutive sampling days no clear relation was found between tourist densities and concentrations.

Table 2 Oxybenzone concentrations (µg/l) at four moments, two locations and two depths. SML= Surface Micro Layer.

	Sorobon SML	Sorobon 30 cm	Mangrove SML	Mangrove 30 cm
T0	<	<	<	<
T1	0.32	0.17	0.06	0.01
T2	1.03	0.65	<	<
T3	0.36	0.47	0.01	0.01

Table 3 Octocrylene concentrations (µg/l) at four moments, two locations and two depths. SML= Surface Micro Layer.

	Sorobon SML	Sorobon 30 cm	Mangrove SML	Mangrove 30 cm
T0	0.22	0.36	0.06	0.18
T1	2.06	0.22	0.04	<
T2	0.80	0.52	<	<
T3	1.24	0.67	0.25	0.06

¹ Limit of quantification (<0.01 µg/l)

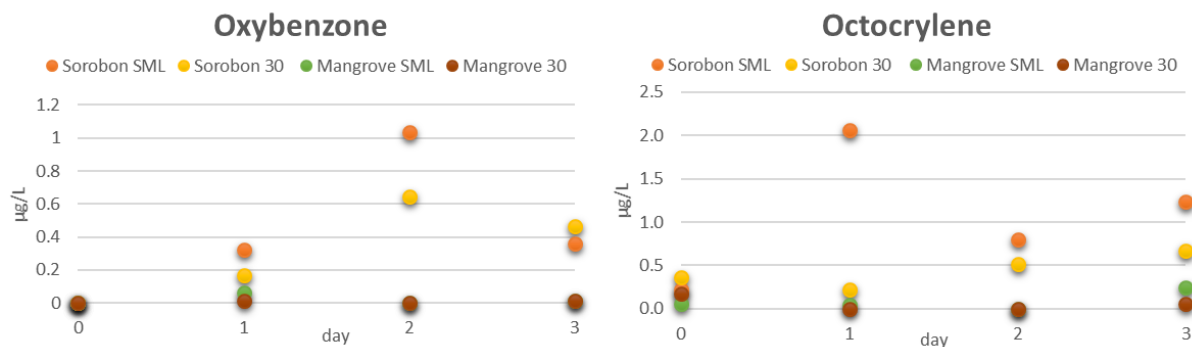


Figure 2 Levels of oxybenzone and octocrylene at T0, 1,2, 3 at 4 different locations. SML= Surface microlayer/ 30 = 30 cm below surface.

3.1.2 Biocides

Water samples taken at T0 and T2 were also analysed for biocides and parabenes- compounds that can be present in sunscreens (see Table 4 for compounds list). None of the samples contained biocides or parabenes at levels above detection.

Table 4 Biocides and their detection levels

Compound	CAS	LOD
Benzyl-Paraben	[CAS 94-18-8]	<0.02
BIT	[CAS 2634-33-5]	<0.05
Butyl-Paraben (som)		<0.03
DMSA	[CAS 4710-17-2]	<0.02
Ethyl-paraben	[CAS 1204-47-8]	<0.01
Methyl-paraben	[CAS 99-76-3]	<0.02
n-propyl-paraben	[CAS 94-13-3]	<0.01
Sulcosulfuron	[CAS 3567-25-7]	<0.01
Triclocarban	[CAS 101-20-2]	<0.01
Triclosan	[CAS 3380-34-5]	<0.2
2-Fenylfenol	[CAS 90-43-7]	<0.2

3.1.3 Risk assessment

Risk quotients (RQs) could only be derived for octocrylene and oxybenzone, as the other UV filters and compounds were below the LoQ.

Early morning at T0, no risk was observed from oxybenzone but, a risk of OCT was present, although high numbers of tourists were not likely in the days before (assumed, not counted). An overnight tide was assumed to have diluted the concentrations too. Also, the mangrove poses a certain risk at T0, after days of lower tourist counts.

RQs for oxybenzone ranged between n.d.-2.8 at Sorobon, and n.d.-0.1 for the mangrove area (Table 5). RQs for octocrylene ranged between 6-52 at Sorobon and between n.d.-4.4 at the mangrove fringes. Overall, SML shows higher risk than the water column.

The mangrove is not at risk from oxybenzone, but is at risk from octocrylene at some occasions. It should, however, be noted that the RQs of OCT are derived from a rather limited data set compared to oxybenzone, and the safety actor in the risk assessment for OCT was higher than for oxybenzone, resulting in lower PNEC values, and thus higher risk quotients. RQs larger than 1, indicate that

Sorobon beach faces a potential environmental risk concerning the measured environmental concentrations of both OCT and oxybenzone.

Table 5 Risk quotients (RQ) per compound, derived from measured concentrations (table 2) and PNECs (table 5) at two locations, two depths (SML= Surface microlayer) and four sampling moments. N.d.= concentration below limit of quantification. Oxybenzone- coral means NOEC for coral cell lines derived from Downs et al (2015)

	UV filter	Sorobon SML	Sorobon Column	Mangrove SML	Mangrove Column
T0	octocrylene	5.5	9	1.5	4.4
T1		52	6	1	n.d.
T2		20	13	n.d.	n.d.
T3		31	17	6	1.5
T0	oxybenzone	0	0	0	0
T1		1	0	0	0
T2		2.8	1.7	n.d.	n.d.
T3		1.0	1.3	0.0	0.0
T0	Oxybenzone- coral low	0	0	0	0
T1		1.4	1	0	0
T2		4.5	2.8	n.d.	n.d.
T3		1.6	2.0	0.1	0.1

3.1.4 Comparison 2016

The concentrations observed in 2016 were slightly higher than those observed in 2017, and consequently so were the RQs. Variability in UV filter concentrations can result from differences in tourist intensity, products used by the tourist present and weather conditions. In 2016 no tourist counts were done.

Table 6 Measured concentrations ($\mu\text{g/L}$) for three UV filters, at three locations, two depths (SML= Surface microlayer) and two moments. < 0,0x = below limit of quantification (from Schaap & Slijkerman, submitted)

		Sorobon SML	Sorobon Column	Mangrove SML	Mangrove Column	Cai reef SML	Cai reef Column
August 23rd	Octocrylene	1.95	0.81	0.03	<0,02	<0,02	<0,02
	Oxybenzone	0.90	1.54	0.01	0.01	<0,01	<0,01
November 18th	Octocrylene	0.10	0.16	<0,02	<0,02	<0,02	<0,02
	Oxybenzone	0.28	<0,01	<0,01	<0,01	<0,01	<0,01

Table 7 Risk quotients (RQ) per compounds, derived from MEC (table 2) and PNECs (table 5) at three locations, two depths (SML= Surface microlayer) and two sampling moments. N.d.= concentration below limit of quantification. (From Schaap & Slijkerman, submitted)

		Sorobon SML	Sorobon Column	Mangrove SML	Mangrove Column	Cai reef SML	Cai reef Column
August 23rd	Octocrylene	49	20	0.8	n.d.	n.d.	n.d.
	Oxybenzone	2.4	4.2	0.0	0.0	n.d.	n.d.
November 18th	Octocrylene	2.4	4.0	n.d.	n.d.	n.d.	n.d.
	Oxybenzone	0.7	n.d.	n.d.	n.d.	n.d.	n.d.

3.2 Beach tourist survey

3.2.1 Generic statistics on tourists in Sorobon

Per day, between 10 AM and 4 PM, the number of tourists were counted in the water and on the beach. The average of two counts per moment serves as a rough estimation of people over the day.

On T0 (October 31st) of the monitoring, no people were counted every hour, but a rough estimation was made between 10-11 AM, at which ~400 people were in the water and on the beach.

Figure 3 shows the dynamics in counts of tourists on the beach and in the water per day and during the day. Estimates show that tourism intensity on Sorobon per day varies largely (Figure 3). This is related to the number of cruise ships in town and the capacity of the ships. Over the day, no clear pattern in tourist counts was observed.

The average peak of beachgoers at Sorobon on days with cruise ships in port was higher in the study of Debrot, approximately 359 (Debrot, 2012). Debrot reported that visitor numbers on Sorobon beach vary depending on time, whether a cruise ship is in port or not, and whether it is a week or weekend day (Debrot, 2012).

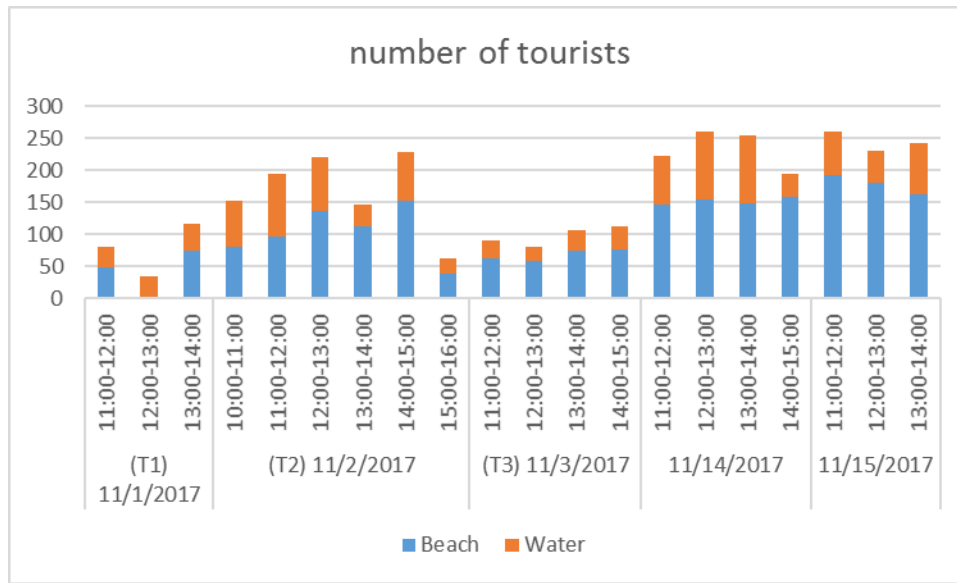


Figure 3 Tourist counts per day

In total, 287 tourists were interviewed in 5 days (1-2-3-14-15 November 2017). The number of interviews were not equally distributed over these days and ranged between 28-98 per day (table 1). The number of interviews on November 1st, 2nd and 3rd are assumed to be representative (respectively 98%, 55% and 40%) for the tourist community present (Figure 3, Table 9). The interviews on the other two days are more restricted in their representation of the tourist community present, being 13 and 11% of the total of tourist counts and are, therefore, not included in the overall figures.

Tourists on Sorobon were both stay-over tourists (111) and cruise tourists (176). However, the relative numbers per type of tourist varied per day. On T2 (Thursday Nov 2) relatively high number of cruise tourist were present compared to the other days (Table 8 and Figure 4)

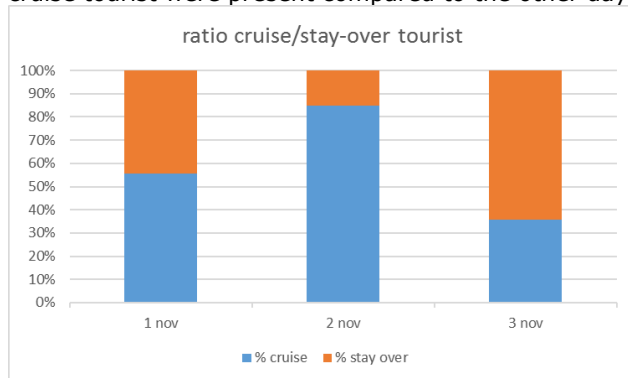


Figure 4 Tourist type

Table 8 Overview of the number of absolute and relative contribution of cruise and stay-over tourists during in the survey

	Number of cruise tourists	Number of stay over tourists	% cruise tourists	% stay over tourists
Wednesday Nov 1	54	43	56%	44%
Thursday Nov 2	79	14	85%	15%
Friday Nov 3	14	25	36%	64%
Tuesday Nov 14	13	17	43%	57%
Wednesday Nov 15	16	12	57%	43%

Specifications on number and type of tourist per origin/day interviewed are presented in Table 9 and Annex 2. Cruise tourists mainly originate from the US (57%), followed by EU (17%- mainly UK residents (66%)). Stay over tourists were mainly European (80%- mainly Dutch (83%)), or from the Antilles (10%).

Interviewed tourists originated from 17 countries. In general (Table 9), most people came from USA (125) and the EU (125). EU tourists were mainly Dutch (75), UK (24) and German (19). However, over the days the relative number of tourists per country varied largely (Table 9), meaning that the monitoring results could depend on these observations too.

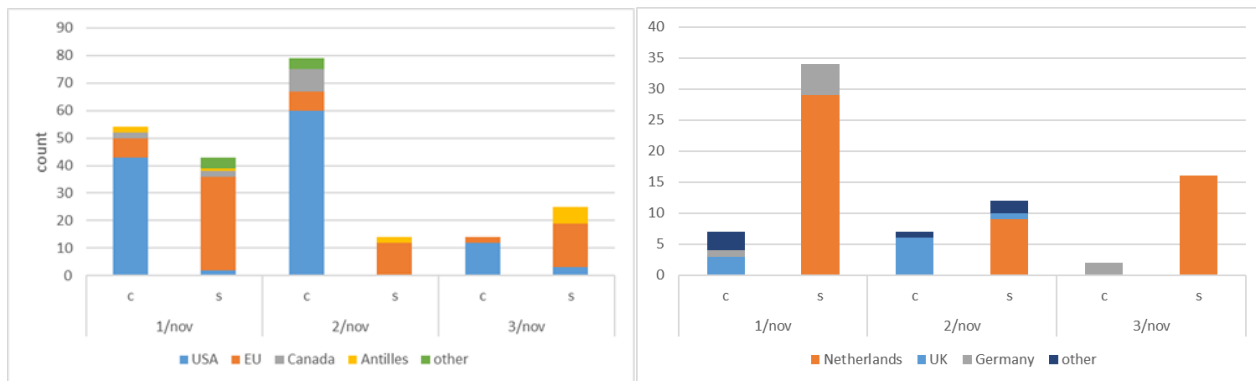


Figure 5 Origin of tourist surveyed, only for T1-2-3, since those data are most representative for the total tourist community present. Left: all. right: EU tourist split up.

Table 9 Origin per interviewee (count) and type of tourist per survey day.

		USA	EU	Canada	Antilles	other	Total
Nov 1	subtotal	45	41	4	3	4	97
	c	43	7	2	2		54
	s	2	34	2	1	4	43
Nov 2	subtotal	60	19	8	2	4	93
	c	60	7	8		4	79
	s		12		2		14
Nov 3	subtotal	15	18		6		39
	c	12	2				14
	s	3	16		6		25
Nov 14	subtotal	5	21	4			30
	c	5	4	4			13
	s		17				17
Nov 15	subtotal		26		2		28
	c		16				16
	s		10		2		12
	Total	125	125	16	13	8	287

3.2.2 Products and oxybenzone

Of all interviewed people, 267 used sunscreen products, 20 did not. In total, 69 brands were registered during the interviews, of which 27 (39%) contained oxybenzone. Products (within a brand) were noted, but not consequently and, therefore, not analysed separately. On average (all days together) 28% of the people used oxybenzone sunscreens- meaning that almost 1 out of 3 people apply sunscreens that contains some % oxybenzone. The average content of oxybenzone was 3.6% (ranging from 0.5% to 6%).

Survey data indicate that much more oxybenzone products were used on the second day of the survey (Figure 6). This observation relates to the findings of the monitoring study, which showed that levels of oxybenzone in the surface water of Sorobon were much higher at the second day compared to the other days (Figure 2).

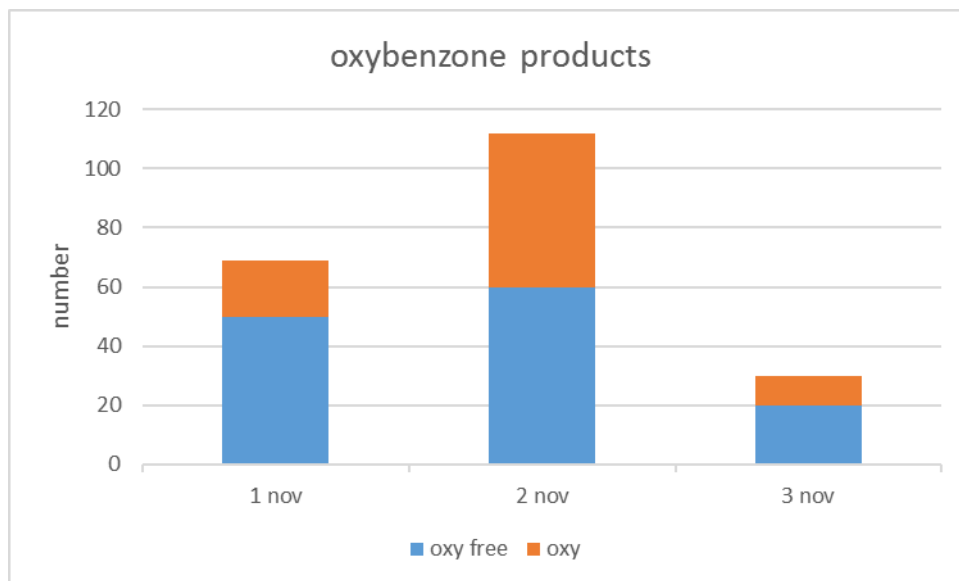


Figure 6 Number of products listed in the survey, divided by oxybenzone free products, and products containing oxybenzone. Note that the absolute numbers depend on the number of interviewees too. These data are steered by the survey density, see Table 1.

Beachvisitors were also asked where they purchased their product. This information would help to further determine the target groups for sunscreen awareness communication. The majority (~85%) brought their product from home. For the remainder of the results, larger "user groups" were distilled from the data, being so-called cruise tourist vs stay-over tourist, and EU or US origin.

Whether or not a product contains oxybenzone largely depends on the type of tourist (cruise or stay-over), and where the tourist lives. Of the US tourists using sunscreen, ~53% use products containing oxybenzone, whereas only 12% of the sunscreens used by EU tourists contain oxybenzone. Of all cruise tourists that use a sunscreen product, approximately² 45% of the products contained oxybenzone (concentration 3.6 % on average), whereas only 10% of the sunscreen products used by stay-over tourists contained oxybenzone (concentration 4% on average, out of 9 products).

The majority of products containing oxybenzone used by US tourists (56) were purchased at home (87%) and 13% bought the products during the trip. In contrast, EU tourists that use oxybenzone products purchase this product both from home (75%) and during the trip (25%), but the group size is too small (12) to conclude on a clear pattern in this buying behaviour, especially since the 12 interviewees came from 4 different countries.

Within the sunscreen awareness project, sunscreen lotions are preferred over aerosol sprays because it is assumed that aerosol sprays might also disperse to the environment during application. Therefore, it was noted whether the product was a spray or lotion.

From this survey, no clear distinction between "user groups" was observed in the preference for lotion or spray-sunscreens. Of all sunscreen products used by EU and US tourists, resp. 38% and 42% were sprays. No difference between cruise ship tourist and stay over tourist became clear from this survey. However, a rather large proportion of the interviewed tourists used sprays, indicating that this is an important focus point for the awareness project.

Application behaviour does not show differences in tourist origin in this survey. On average, sunscreen users apply sunscreen 2.6 times per beach visit. A small difference in bathing frequency was observed between EU and US tourists; US tourist tend to go into the water more often (2.8/day) than EU tourists (2.5/day). This information can be of interest when estimating loads of sunscreens from bathing tourists, which is not part of this current study.

3.2.3 Awareness

The awareness of the potential problem with oxybenzone suncare products among the visiting tourist in Sorobon is limited, and does not depend on the type of tourism. On average 13% of both stay over tourists and cruise tourist are aware of the topic.

The awareness of oxybenzone-risks among tourists varied with the origin of the tourist. Although total number of interviewed tourists varied per region, the results indicated that tourist from Antilles are relatively well informed. Up to 40% was aware of the potential problems of oxybenzone. In contrast, only 20-22% of US and Canadian tourists are informed, and ~10% of the EU tourists was aware of the potential pollution by oxybenzone.

Out of the interviewed tourists, only 2 (1 EU, 1 US) were not willing to change to a product that does not contain oxybenzone. It can be concluded from this first assessment that people are willing to change products. However, conditions to change or not to change were not asked for. On occasion, some did add restrictions, which might be in price, effectivity or skin sensitivity.

² Not all info was noted or available on site

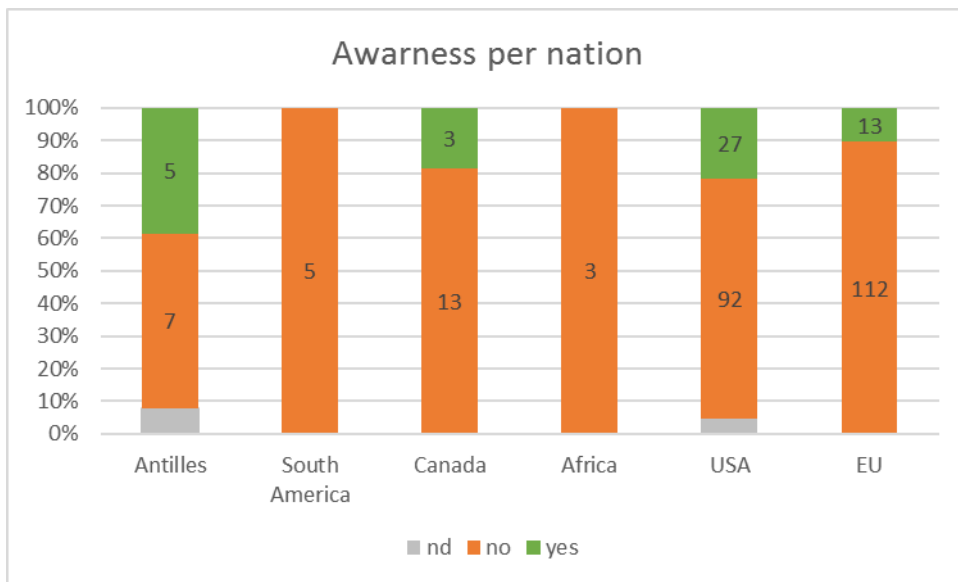


Figure 7 Awarness of Oxybenzone in the environment

4 Awareness raising- Stakeholder involvement

Stakeholder involvement is part of the awareness project coordinated by BD, and supported with scientific advice by WMR.

In this chapter a brief overview is presented on the stakeholder actions taken, including first observations and conclusions. Stakeholder involvement so far comprised two main actions: Shop surveys and a Sunscreen Awareness Conference.

4.1 Shop surveys

Main goal for the project team was to introduce the project to shops, and to provide basic information on the subject. In addition, shop surveys were conducted to get preliminary input for the conference. Shop owners were questioned about how they feel about ownership and responsibility, customer and sunscreen-selling experiences. In total 9 shop surveys were done, including 5 dive shops and 4 retail-shops. This number is an under-representation of the total number of shops on the island, but provides a first impression.

Qualitatively, the main results included the following:

- Dive shop owners were to a variable extent aware of the subject, whereas retailers were not.
- Dive shop owners sell a limited number of sunscreen brands, including oxybenzone-free brands to provide an eco friendly sunscreen. Sunscreen sales are not their largest turn-over and do not add much to the margins in the shops. In contrast, retailers provide large variations of brands and products, targeted on customer demands who want to buy the brand known from home. Eco-friendly products did not sell enough, and were discarded from the supply.
- Dive shops in general want to provide advice and environmentally friendly options to customers, but this can conflict with customer-friendliness. Know-how on how to communicate on the subject, how to advise the customer without being offensive towards the client is a concern in terms of shop competition and getting good shop reviews.
- Ownership of the subject/advise is difficult to communicate since no overall communication framework exists on the island. Dive shop owners plea for island wide instructions and mention TCB or STINAPA to provide an island rule or management plan to which they can refer to.
- Options in eco-friendly products are numerous. It is difficult for shop owners to choose the best options (price, user friendliness and preference, brand criteria)
- In general, a willingness to (better) communicate to customers and tourists exist among most dive shop owners and some retailers. Factsheet poster and flyers are optional education tools for shop owners (and customers).

4.2 Awareness conference

Wageningen Marine Research (WMR) and Boneiru Duradero (BD) organised a Sunscreen Awareness Conference, on March 21st 2018, inviting stakeholders from the government, NGO's and tourism sector on Bonaire to participate. The goal of the conference was twofold:

1. Educate participants about international sunscreen research and the studies that were implemented on Bonaire.
2. Create "buy-in" and create partnerships by engaging stakeholders to develop an island wide sunscreen strategy for Bonaire. A summary of the workshops is presented below. In annex 3 an overview of participants is provided.



Within the conference, two meetings were scheduled. During the morning meeting, government officials (OLB, RCN), Tourism business representatives (Bonhata) and representatives of NGO's (Stinapa, STCB, Coral reef foundation) were present. The evening session was visited by tourism private sector (dive shop managers and tour managers). In total 25 people attended the workshops.

The conference started with a presentation by WMR, to inform participants on international sunscreen research and the studies that were implemented on Bonaire. Sunscreen research is relatively new and still ongoing, but one thing is very clear: oxybenzone has been identified as the major "culprit" harming corals. Participants of the sunscreen conference agreed that there is a positive and clear action perspective. When we convince tourists on Bonaire to use sunscreens without oxybenzone, every swimmer, snorkeler and diver can add to the improvement of water quality.

There was a general consensus among all participants that action should be taken on Bonaire concerning potentially harmful sunscreens. The attendees of the conference participated in a lively discussion, and the following paths forward were identified:

1. Legal ban of oxybenzone-containing products.
2. Changing consumer behaviour.
3. An environmental tax for cruise tourist.

4.2.1 Legal ban

Representatives from the tourism sector were mostly in favour of a legal ban. Tourism operators feel that a legal ban on the UV-filter oxybenzone, will make it easier to convince their customers of the harmful impact of sunscreens to our reef. In contrast, most NGO's and members of the government are opposed to a ban. They have concerns about the feasibility. In the first place, it would be very difficult to build a legal framework that covers all arguments (see con's list in box 1). Enforcement would also be an issue: "We could try to prohibit the sale of sunscreens with oxybenzone on Bonaire, but it is impossible to control the sunscreen products tourists bring from home". A rule in the Marine Park management plan could, however, strengthen the communication about the subject.

Box 1: Arguments with regard to a Legal Ban

PRO	<ul style="list-style-type: none"> • A ban is necessary for local enforcement. • Local government mandates the Marine Park (MP) for marine park management. This enables the MP to include specific rules against the use of certain sunscreens in their management plan. • It is already illegal to bring chemicals into the marine park, although the interpretation of the law does not cover the emissions though sunscreen. However, it is worth exploring if the law could lead to a rule for restricted use of sunscreens in the MP. • Cooperation of resellers of sunscreens depends on rules and laws. • The process towards a legal ban will create awareness too, even if it does not reach final destination in law. It has communication value. • It is important for Bonaire to take a stand and lead by example, so that others in the Caribbean region may follow.
CON	<ul style="list-style-type: none"> • The need for a change is NOW! The process of introducing a new law takes a lot of time, effort, budget and capacity. • The process of a new law with regard to sunscreen is bound to fail. • Practical enforcement would be a problem, requiring capacity, budget and a fining system. • Introduction of this law could create negativity, seeming inhospitable to visitors, ultimately leading to bad publicity. • Education & Awareness is considered to be more effective. It is assumed that an appeal to morality will work better. Invest energy on what works. • It is yet unclear what should be banned: formulation, brands, import, selling, consumption?

4.2.2 Changing consumer behaviour

The solution for reducing impact of sunscreens on the reef is largely connected to behavioural change. It is as simple as avoiding sunscreens with oxybenzone and choosing Zinc and Titanium based products instead. That is why most participants of the sunscreen conference viewed Awareness as the best way to move forward. Moreover, an awareness campaign can be implemented much faster than a law. Another advantage of sunscreen awareness is that it can help to reinforce Bonaire's positioning on the "vacation market". After all, we are striving to be a sustainable island.

Participants of the sunscreen conference agreed unanimously that there is a positive and clear action perspective. WMR and BD are in the process of developing communication materials for an island wide awareness campaign.

The constructive feedback of all conference participants was essential to further shape the central messaging and the call for action: "Help save our reefs!" A number of NGO's and businesses have agreed to provide their logo in support of a Sunscreen Awareness poster. The informative poster asks tourists to change their sunscreen behaviour and will be provided for free to all tourism operators and resellers of sunscreens.

4.2.3 Environmental Tax for cruise tourists

Passengers of cruise ships currently do not pay for non-SCUBA water activities. Other persons pay an annual fee of 10 USD for water activities such as swimming or bathing. Since cruise tourists that swim seems to attribute to the problem too, a fee should be considered. Participants of the conference discussed the possibility of an Environmental Tax for cruise ship visitors. This tax would allow Bonaire to continually fund awareness campaigns, educating tourists about the use of sunscreens and the unique value of Bonaire's coral reefs.

Another advantage of sunscreen awareness via an environment tax for all tourists is that it can help to reinforce Bonaire's positioning on the "vacation market". After all, Bonaire is striving to be a sustainable island.

4.3 Stakeholder remarks

During the conference, the following remarks and questions were raised (not ranked in order of importance):

- Doesn't the current law already provide us the ability to prevent the use of oxybenzone inside Marine Park via a revision/addition in the marine park management plan.
- Sunscreen Awareness can become a Unique Selling Point to Bonaire, because it links to the existing perception that Bonaire is a green destination.
- The cruise sector has to be engaged, both on a strategic an island level. Cruise tourist are not made aware of the quality of Bonaire's nature and the fact that they are visiting protected areas.
- The impact of snorkelers on the reef might be bigger than that of divers. Snorkelers use more sunscreen than divers, because they do not wear wet suits. The number of snorkelers also exceeds the number of divers, especially during cruise season.
- There is a need for additional water monitoring, especially with regard to other tourist hot spots, such as Klein Bonaire and popular beaches on the west coast that receive high number of swimmers during cruise season.
- We need to identify the right alternatives very soon, because it would be disastrous if future research would show that Zinc and Titanium prove also to be harmful to the reef.
- There is a need to involve local resellers of sunscreens, so that oxybenzone products are at least not being sold on Bonaire.
- Are sustainable sunscreens more expensive than oxybenzone products and does that form an obstacle? Is there a willingness to change products, and under what conditions?
- Tourists visiting Bonaire are relatively well off and can therefore afford sustainable sunscreens.
- Should we work together with other islands?
- Budget and capacity has to be allocated in order to speed up research and raising awareness

4.4 Research questions from stakeholders

During the workshops, several additional research questions were listed.

- What are the UV filter concentrations at the reef rim at Lac bay?
- What are the concentrations of UV filters at hotspots at the west coast?
 - Klein Bonaire with ~1000 snorkelers/day during cruise days
 - Coco beach, Eden beach, reference/ow intensity locations, upstream?
- Are the concentrations related to number of tourists, origin, and products they use?
- What is the contribution at hotspots with kites+ surfers, snorkelers, divers?
- What is the contribution of the open sewers on the west coast of Bonaire in terms of UV filters?
- What is the relative contribution of sunscreen pollution to the effects on the reef compared to the other negative drivers?
- What is the degradation rate of harmful compounds?
- How did Mexico and Palau achieve a legal ban on oxybenzone?

4.5 Opportunities for on-island cooperation

All participating organizations were willing to support sunscreen awareness through their own on-line platforms. The following stakeholders have given a commitment to actively support the project:

Partner	Support offered
Dive Friends	Social media expertise
BONHATA	Willing to become a project partner, although no financial support
OLB and STINAPA	Willing to explore option for park management rule
STINAPA Junior Rangers	Working on Teens for Oceans program focussed on awareness
CURO Council of Underwater Resort Operators	Spreading message

The following marketing & promotion ideas are to be considered in cooperation with stakeholders:

- Develop flyer in addition to the poster and the animation video that are already in production.
- Booth at DEMA (Diving Equipment & Marketing Association) trade show.
- Instore marketing in the two largest supermarkets.
- Free eco-safe sunscreen dispensers in shops.
- Integrating sunscreen awareness in PADI dive course and as part of general instruction before each dive.
- Promotion on Tourist TV and TV screens at airport, in hotel lobbies and restaurants

4.6 Conclusions and steps forward

Wageningen Marine Research and Boneiru Duradero have succeeded to achieve the following goals through the Sunscreen Awareness Conference:

1. Participants have gained understanding of the relatively complex issue of sunscreens as a potential threat to corals.
2. Participants have gained a perspective on the local threat of the UV-filter Oxybenzone in relation to the water quality in Lac Bay on Bonaire.
3. Participants have gained insights with regard to the sunscreen behavior, origin and the type of tourists (stay-over versus cruise).
4. The organizers have gained valuable input and feedback on their preliminary sunscreen strategy and partly developed communication materials.
5. The organizers have gained partners who are willing to actively contribute and support the Sunscreen Awareness Bonaire project.
6. The organizers have gained a new insight with regard to existing local law prohibiting the use of chemicals in the marine park, thereby opening up the possibility of adapting Park Management rules in order to ban Oxybenzone.
7. Overall the conference has been received very positive by all participants and WMR and BD were thanked for the organization of the event and the progress made so far

The following steps forward were identified:

Short term:

- Education & Awareness: further development of communication materials by BD and WMR.
- Create buy in with local dive/tour operators and resellers of sunscreen.
- Further define relevant research questions.
- WMR and BD will write up new research proposals and acquire new funding.

-
- Form concrete alliances with local partners that are willing to support sunscreen awareness.
 - Explore cooperation with CURO.
 - Continue with scientific and generic publications.

Medium term

- Targeted awareness for cruise tourists, reaching them through a “pre-cruise information package”, so that they are informed before coming to Bonaire.
- Influence local policy makers to investigate if the current law offers concrete possibilities to adapt the rules and regulation of Marine Park Management

Longer term

- Push for nature tax cruise visitors.
- Engage local government.

5 Overall conclusions and recommendations

5.1 Monitoring

The field visit of November 2017 showed that oxybenzone and octocrylene are detected in concentrations that pose a risk to the environment. Levels are in the same levels that were observed in 2016, indicating that UV filters are emitted on a chronic basis to Lac Bay.

In 2017, a clear relation with beach-goers and the products used is observed. The detected concentrations indicate that Lac Bay faces a chronic emission of UV filters at levels raising environmental concern. UV filters emitted at Sorobon beach are diluted with the tide. However, they are detected up to hundreds of metres downstream near the mangrove ridge in levels that notwithstanding the dilution, still indicate risk for the environment.

Additional monitoring at the reef rim, within species and/or ecosystem compartments, and at locations at the west coast should make more clear how wide spread the pollution of UV filters can be. Additional research on the actual impact and effects of the pollution levels towards the ecosystem should be included in upcoming studies.

5.2 Tourist beach survey

Since pollution by sunscreens can be mitigated directly by changes in both buying and application behaviour, a survey was done to get more information on sunscreen use. The survey showed that the public awareness of oxybenzone is still limited. From this survey it became also clear, that oxybenzone products were mostly used by the US cruise tourist. This group mostly purchases the product at home. This means that when communicating about the topic and creating awareness to make a voluntary change in product choice and use, tourists should be informed already when booking their holiday. While on holiday, tourists can be informed during their trip about the more eco-conscious alternatives they can purchase instead, when they visit vulnerable ecosystems.

5.3 Awareness raising/Stakeholder involvement

Among all stakeholders, there is a large commitment to the project, and a large will to change tourist sunscreen behaviour.

The question rises what eco-friendly alternative products are best to provide to the public whilst protecting the reef from other unknown alternative ingredients. To continue and strengthen the awareness-process on Bonaire and in order to provide suitable advice, more knowledge is needed on the so-called eco claims that products express. Since research in this field in developing recently, more information is expected to become available in coming years. Supplementary research in the meantime should focus on the most suitable alternative, not only on oxybenzone, but also on other UV filters including zinc and titanium.

Furthermore, rules in the marine park management plan on oxybenzone would help stakeholders to communicate about the topic. See the extensive list in chapter 4 for specific follow up actions. Together with relevant stakeholders on Bonaire most suitable communication channels are discussed. Within the sunscreen awareness project, in the coming two years tasks can be allocated within BD, but follow-up on next responsibility should be included in next years evaluation.

6 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2008 certified quality management system (certificate number: 187378-2015-AQ-NLD-RvA). This certificate is valid until 15 September 2018. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V.

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Justification

Report C023/18

Project Number: 4318100183, 4315100093, 4318300042, 4318100167

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: dr. N.H.B.M. Kaag
Senior research scientist

Signature:

Handwritten signature of dr. N.H.B.M. Kaag in black ink.

Date:

7 mei 2018

Approved: drs. J. Asjes
Manager integration

Signature:

Handwritten signature of drs. J. Asjes in blue ink.

Date:

7 mei 2018

Annex 1 Field monitoring and risk assessment

Table 1 Annex 1 Recovery % of the spiked samples

Spike	High	Low	% recovery High	% recovery Low	average
Oxybenzone	0.85	0.07	79%	76%	77%
Octocrylene	0.4	0.06	39%	68%	x

Table 2 Annex 1 PNEC values derived according to ECHA (2008), based on corresponding assessment factors (AF). Lowest test concentration and species is reported. More info in Schaap & Slijkerman (submitted)

UV filter	Data coverage criteria	AF	Lowest test concentration + species	PNEC (µg/L)
BP-3	Lowest EC10 or NOEC from three freshwater or saltwater species representing three trophic levels + two long-term results from additional marine taxonomic groups	10	Algae: <i>Isochrysis galbana</i> EC ₁₀ (growth) 3.7 µg/L Paredes et al. (2014)	0.37
OCT	EC10 or NOEC from freshwater or saltwater species representing two trophic levels	500	Mussel: <i>Mytilus galloprovincialis</i> NOEC (growth) 20 µg/L Giraldo et al. (2017)	0.04

Annex 2 Beach survey information

A. Questions in the beach survey were:

General

- Origin (which country)
- Male/female
- Stay-over or cruise tourist or resident
- Days on Bonaire
-

Sunscreen use

- Yes/no
- Lotion or aerosol spray
- Brand
- Oxybenzone (y/n)
- If yes, which %
- Shirt (y/n)
- Application tiems/day
- Times/day in water
- Purchase (home or trip)

Awareness

- Known about oxybenzone discussion
- Willingness to change (y/n)

B. Additional data

Origin of interviewees/day

Origin	1/nov	2/nov	3/nov	14/nov	15/nov	total
Netherlands	29	9	16	10	10	74
UK	3	7		2	12	24
Germany	6		2	9	2	19
Norwegian	2					2
Belgium		1				1
Slovenia	1					1
France					1	1
Macedonia		1				1
Ireland					1	1
Switzerland		1				1
sub total EU countries	41	19	18	21	26	125
USA	45	60	15	5		125
Canada	4	8		4		16
Antilles	3	2	6		2	13
South America	4	1				5
Africa		3				3
Eindtotaal	97	93	39	30	28	287

Annex 3 Additional stakeholder involvement

A. Interview question shop surveys

- Which products are being sold mostly?
- Could you give a top 3-5?
- What is the biggest group of buyers? (tourists cruise/divers, locals, surfers, random passengers).
- Are you aware of the effects that sunscreen can have on coral reefs? (Please explain)
- Have you ever heard of Oxybenzone, a harmful ingredient in many sunscreen products?
- What are the main reasons to offer the specific selection of products that is sold in this shop?
- Do special product properties play a role? (If yes please explain.)
- Is it profitable to sell or is it a service to your customer.
- Does the profit margin differ between products?
- Can you import all products you want?
- What aspects influence or determine the selection of supplied products in this shop mostly?
- Would you recommend reef safe products?
- Which ones would you recommend?
- Would you discourage your customers to use products that are harmful to the reef?
- How important is the health of the reef to you?
- Do you have ideas how to raise awareness for safe sunscreen usage?
- What would be your approach to raise awareness on the effects of sunscreen on the reef or to start a movement towards oxybenzone free sunscreens only on this island?
- Would you be willing to change the selection of products in this shop for reef safe purposes?
- Would you support a voluntary movement towards oxybenzone-free shops on Bonaire?
- Would you therefore sign a voluntary covenant restricting the sale of sunscreen to oxybenzone-free products only?

B. Participants Sunscreen Awareness Conference

WMR and BD have invited government officials, representatives from nature members from the tourism sector. The organizers were content with the turnout. But more important with the enthusiastic contribution of participants, who were very much involved in the discussion rounds and shared their views and ideas with WMR and BD. The organizers of the conference are however aware of the fact that participants were already interested and/or somewhat cognizant of the topic of harmful sunscreens.

Name	Organisation
Yoeri De Vries	RCN/EZ
Frank van Slobbe	OLB/DROB
Anouschka van de Ven	STINAPA
Caren Eckrich	STINAPA
Sabine Engel	STINAPA
Kaj Schut	STCB
Irene Dingjan	BONHATA
Daphne Nossels	BONHATA
Carolyn Caporusso	Citizen Science
Francesca Viridis	Coral Reef Restoration
Bridget Hickey	Coral Reef Restoration
Rudolf Wout	Extra Bonaire (pers)
Koen Moons	Freelance reporter
Laurien Holtjer	Communication VIP diving
Caitlin Hale	Dive Friends
Eva Mudde	Dive Friends

Name	Organisation
Elly Albers	Mangrove Center
Kim van Vaardigem	Mangrove Center
Sarah Wilner	Freelance reporter
Norman van Holst	Bon Solo
Christine Ball	Harbor Village/Junior Rangers leader
Bonnie Eckrich	Junior Ranger
Brandon Schreiner	Junior Ranger
Deb Schwackhammer	Professor of Science/ Junior Rangers leader
Menno de Bree	Goodive

C. Final poster

Sunscreens with the UV-filter Oxybenzone are BAD for corals

WHAT YOU CAN DO

1
BP-3
Oxybenzone
Benzophenone3
!

Avoid sunscreens with Oxybenzone

2
ZnO
TiO₂

Use sunscreens with a combination of zinc and titanium

3

Use lotions not sprays

4

Apply at least 30 min. before entering the water

5
UPF

Wear protective clothing

6
SPF 50

Avoid Sunscreen Protection Factor above 50

6 tips

HELP SAVE OUR REEF

April 2018

Sunscreen Awareness Bonaire is a project of:



the reef

Sunscreen Awareness Bonaire

Supported by:



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Wageningen Marine Research is the Netherlands research institute established to provide the scientific support that is essential for developing policies and innovation in respect of the marine environment, fishery activities, aquaculture and the maritime sector.

Wageningen University & Research:

is specialised in the domain of healthy food and living environment.

The Wageningen Marine Research vision

'To explore the potential of marine nature to improve the quality of life'

The Wageningen Marine Research mission

- To conduct research with the aim of acquiring knowledge and offering advice on the sustainable management and use of marine and coastal areas.
- Wageningen Marine Research is an independent, leading scientific research institute

Wageningen Marine Research is part of the international knowledge organisation Wageningen UR (University & Research centre). Within Wageningen UR, nine specialised research institutes of the Stichting Wageningen Research Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment.
