Monitoring and Assessment of Beach Litter in Bonaire (The Caribbean Netherlands) 2018 – 2023

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CLEAN COAST BONAIRE

Cover photo: Boka Onima beach (bottles and floats) – March 2021

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Summary

Marine litter is a pervasive and persistent issue in marine and coastal environments worldwide, of increasing concern due to the growing amount of litter, its potential impact on marine ecosystems, and the lack of adequate disposal and management practices. It is particularly prevalent in island environments. This is often due to the fact that the source of litter is not the island itself but rather the surrounding ocean, which carries debris from distant sources.

A small Caribbean island located in the southern part of the Dutch Caribbean is the island of Bonaire in a protected marine area. In the recent years, the island has experienced an increase in beach litter, which has led to concerns about the impact on its marine ecosystem and tourism industry. A monitoring program was therefore initiated in 2018 by the WWF in collaboration with Clean Coast Bonaire.

This report presents a first (trend) analysis of the macro-litter data collected on Bonaire between 2018 and 2023 on three beaches (Te Amo, Boka Onima and Piedra Pretu) and includes a preliminary source identification. The report could be used as a first beach litter baseline for the Dutch Caribbean. In order to better compare the Bonaire beach litter data with the data assessments of OSPAR and EU countries, the original 50 m beach litter data collected have been extrapolated to 100 m.

The median total count for the island in the period 2018-2023 is 1792 counts/100 meter of beach and shows significant increasing trend of +461 counts/100 meter of beach per year. All beaches show increasing slopes. Te Amo and Boka Onima beaches show significant increasing slopes with the highest increasing slope of 560 counts/100 m per year on Te Amo beach. The median indicative weight of marine litter per 100 m beach on island level is 10.6 kilogram. Trend analysis for the period 2018-2023 shows an increasing significant trend for the whole island. In comparison with data collected in the Wider Caribbean Region, the total counts are comparable.

In comparison with the beach litter counts in the OSPAR region and The Netherlands, the median counts are much higher. In the OSPAR region the median count is 252 counts per 100 meter beach in the period 2015-2020, the Dutch North Sea beaches have a median count of 144 per 100 meter beach in the period 2017-2022. This means that the median count on Bonaire is more than 12 times higher as in the Netherlands.

The Bonaire top 10 most found litter types for the period 2018-2023 shows plastic/polystyrene pieces 2.5-50 cm as the most found litter type, which is mainly the remains of the breakdown of large pieces with no identifiable source. They are mostly found on the eastern beaches. Its origin is most probably a transboundary pollution (transported from the east via ocean currents and prevailing wind direction). Glass ranks as the number two most found litter type at country level, plastic caps as number three. The median count of meso-plastic fragments 0.5-2.5 cm (analyzed separately) in the period 2018-2023 is 2380 counts per 100 meter beach.

Cigarette butts are most found on the recreational Te Amo beach on the western side. Also, metal caps (bottle caps; metal bottle caps, lids & pull tabs from cans), single use plastics and the very diverse “paper other” items are found here which are sources or beach recreation. The introduction of single use plastics ban on Bonaire in June 2022 seems to have effect on single use plastics found, although the trend is not yet significant. The main sources of marine litter are 1) transboundary pollution; 2) maritime (shipping and fisheries) 3) coastal recreational and tourism.

The report shows a clear picture of the abundance of marine litter on the island of Bonaire. It is therefore crucial to continue the monitoring. The insights that can be obtained from the monitoring program can be used to develop measures to tackle pollution at a local, regional (through the Cartagena Convention) and even international level.

List of abbreviations

ALDFG Abandoned, lost, or otherwise discarded fishing gear
BES Bonaire, St. Eustatius and Saba
BLM Beach Litter Monitoring
CCB Clean Coast Bonaire
CEMP (OSPAR) Coordinated Environmental Monitoring Programme
CEP Caribbean Environmental Programme (one of 18 UN Regional Seas Programmes)
CLME Caribbean Large Marine Ecosystem
D10 MSFD Descriptor 10, marine litter
FISH Fishing related litter types
ICGML OSPAR Intersessional Correspondence Group on Marine Litter
LBS Cartagena Convention's Land-Based Sources Protocol
MSFD European Marine Strategy Framework Directive (MSFD)
NL Netherlands
OSPAR the organization in which 15 Governments & the European Union cooperate to protect the marine environment of the North-East Atlantic.
RAP (OSPAR) Regional Action Plan for Marine Litter
SEA Sea related litter types
SIDS Small Island Developing States
SUP Single Use Plastics
TC Total Count
TV Threshold value
UNEP United Nations Environmental Programme
WAXPOL Other pollutants category
WCR Wider Caribbean Region

1. Introduction

1.1 General introduction

Marine litter is a pervasive and persistent issue in marine and coastal environments worldwide, of increasing concern due to the growing amount of litter, its potential impact on marine ecosystems, and the lack of adequate disposal and management practices. It is particularly prevalent in island environments. This is often due to the fact that the source of litter is not the island itself but rather the surrounding ocean, which carries debris from distant sources, which can be challenging for waste management and resource allocation. To address this issue, there is a need for baseline studies that establish the current status of litter, including beach litter, in the marine environment. These studies involve regular monitoring and statistical analysis of the data using standardized protocols.

Studies on beach litter in Caribbean islands have been conducted in recent years (Nagelkerken et al, 2001; de Scisciolo et al, 2016; Botero et al, 2017; Perez-Alvelo et al, 2021) but there is still a significant gap in knowledge regarding the extent and sources of marine litter in this region. One example of an island community facing this issue is Bonaire, a small Caribbean island located in the southern part of the Dutch Caribbean. Despite its location in a protected marine area, the island has experienced an increase in beach litter in recent years, which has led to concerns about the impact on its marine ecosystem and tourism industry (Debrot et al, 2013; Diez et al, 2019; Kanhai et al 2022). Understanding the sources and extent of litter in Bonaire is crucial for effective waste management and conservation efforts.

Since 2018 Clean Coast Bonaire started with the monitoring of beach litter on Bonaire. Currently three sites are routinely monitored. Clean Coast Bonaire is a project that is managed by Seven Seas Care Consultancy with financial support from WWF-NL. [1] However, no trend analyses were carried out yet due to limited budget.

In October 2023 a “proposal to implement routine beach litter monitoring as an official Caribbean Netherlands monitoring scheme” in Bonaire, St Eustatius and Saba (the three BES islands) was approved by the Dutch Ministry of Infrastructure and Water management. Thus funding is secured for three years (2024-2026) for structural beach litter monitoring using the (modified) OSPAR beach litter monitoring protocol.

To get a first insight in amounts and trends of macro-litter on Bonaire, the Dutch Ministry of Infrastructure and Watermanagement contracted H2Oosterbaan in close collaboration with Clean Coast Bonaire to assist to carry out a (trend) analysis[2] of the macro-litter data on three beaches of Bonaire and to include a preliminary source identification.

[1] Clean Coast Bonaire was initiated by WWF-NL in August 2018 to pilot the OSPAR Marine Litter Monitoring survey protocol on Bonaire. Merijn Hougee, a trained surveyor who regularly conducted OSPAR monitoring in the Netherlands on behalf of Stichting Noordzee, visited Bonaire to establish the pilot program and conduct the initial training. Stakeholders such as marine park management and government were consulted. The stakeholders, general public, NGOs and community groups were invited to training workshops. The workshops consisted of a classroom session to explain the OSPAR purpose and methodology followed by a hands-on beach clean-up and survey. The workshops were well attended, with over 30 participants from various organizations. The pilot became an ongoing program that is managed by Seven Seas Care Consultancy with support from WWF-NL.

[2] Using LitteR Programme

1.2 What is known already?

In 2019 the World Bank published a report that includes an assessment of the status and impacts of marine pollution in the Caribbean and provides 12 recommendations to enhance the region's resilience as it steers toward a Blue Economy (Diez, S.M. et al, 2019). According to the report, 80 percent of all marine pollution in the Caribbean region comes from land-based sources, mostly untreated wastewater, public littering, and agricultural run-off. Solid waste and wastewater are assessed as being the most pervasive sources of marine pollution in the region.

Marine litter is accumulating in the Caribbean Sea, originating both in the region as well as distant countries overseas through the ocean currents. As marine litter accumulates in the ocean, Small Island Developing States (SIDS) are often exposed to concentrations of litter that are disproportionate to their own consumption and population. A snapshot of the level of litter in coastal areas shows that an average of 2014 litter items per kilometer were found on beaches and coastal areas as compared to a global average of 573 items per km (Ocean Conservancy, 2017 as mentioned by Diez et al, 2019).

Plastic has been found to be a key component of marine litter in the Caribbean. While plastic represents only 12 percent of the solid waste that is generated in the Caribbean[3], it is a component of marine and coastal litter. Approximately 80 percent of marine litter is composed of plastic. Within the Caribbean region it is proving to be a key component of marine and coastal litter.

According to the World Bank report, the most common marine litter found in Caribbean are plastic bottles, in addition to other single-use plastic items, and foam containers. Regional coastal clean-up survey data from 2017 show that 21 percent of items collected were plastic beverage bottles alone and 35 percent of all items are single use plastic. Abandoned, lost, or otherwise discarded fishing gear (ALDFG) is another critical type of marine litter and is considered the main source of plastic waste in the marine environment coming from the fisheries and aquaculture sector.

In paragraph 3.10, the present beach litter assessment on Bonaire will be compared with other studies on beach litter in the Caribbean region.

1.3 Marine litter and beach litter monitoring

For more than 25 years marine litter monitoring methodologies have been used, tested and improved. For various reasons beach litter monitoring is still one of the methodologies with a high level of confidence: easy to carry out (relatively cheap); use of (trained) volunteers; [some level of] source identification is possible; development of [open source] trend analysis and assessment software; follow-up of implementation of measures (adequacy and effectiveness).

One of the methodologies often used are the guidelines for monitoring and assessment of marine litter on beaches developed by OSPAR in 2010 and last updated in 2020 (OSPAR Agreement 2020-02[4]). These guidelines are under constant supervision of the Beach litter expert group (BLEG) and the Intersessional Correspondence Group Marine Litter (ICG ML) of OSPAR. This methodology is also used on the Island of Bonaire, but slightly modified.

Measures against marine litter require these quantitative data for the assessment of litter abundance, trends and distribution. The EU worked on the compilation and analysis of an EU beach litter dataset,

[3] Different sources, as summarized by Diez et al, 2019.
[4] OSPAR MEETING DOCUMENT

aiming to derive EU Marine Beach Litter Baselines at different spatial levels (Hanke et al., 2019). The resulting set of baselines enables within the EU the future monitoring of progress in reduction.

The Action Plan for Harmonized Marine Litter Monitoring in the Wider Caribbean Region (Caporusso, C. and Hougee, M., 2021) defines an effective strategy and a roadmap for a cost-effective and easily replicable means to collect high quality, harmonized marine litter data in the Caribbean region. Data that can be used for driving and verifying effectiveness of reduction policies. The plan builds on the earlier recommendations for a hybrid approach on beach litter monitoring (2019, Revised 2021) and incorporates regional and global assessments of marine litter frameworks, best practices of the established program for beach litter monitoring in the OSPAR region, and feedback from stakeholders within the WCR. The findings show that the OSPAR Beach Litter Monitoring program provides a centralized organizational structure involving participating country leads who supervise or conduct routine monitoring in their respective countries. In order to institutionalize a harmonized monitoring approach in the WCR, there is a need for commitment from authorities and increased communication and capacity for monitoring and for financial support. The strategy involves a number of key regional actions (e.g., designate regional coordinator; designate national monitoring- and survey coordinators; build a regional database; establish training program and conduct pilot testing) to secure commitment from the contracting parties.

1.4 Relevant policies and measures to reduce marine litter in the Caribbean

1.4.1 The Nature and Environmental Policy Plan Dutch Caribbean 2020-2030

The Natuur- en milieubeleidsplan Caribisch Nederland 2020-2030 | Beleidsnota | Rijksoverheid.nl is policy plan that contains action plans for nature and environmental policies on Bonaire, St Eustatius and Saba. The main objective is good management of the natural environment in order to obtain a responsible and sustainable use of natural resources. This should also lead to guarantee and recover ecological processes and functions by dealing with pressures from human activities. Waste management is one of these pressures. The recent initiative to implement routine beach litter monitoring as an official Caribbean Netherlands monitoring scheme" in Bonaire, St Eustatius and Saba fits in this plan and responsibilities.

1.4.2 Single-use plastic policies on Bonaire

Starting in October 2018, the Island Council of the Bonaire Public Body approved and adopted a proposal to ban the most harmful plastic disposable items by 1 January 2020. In July 2019, this was reinforced when Dutch Minister of Environment Stientje van Veldhoven and Bonaire Commissioner James Kroon signed a letter of intent to place a plan on single-use plastics. After consultation with stakeholders, a proposal was drafted that included several items on the EU Single-Use Plastic Directive. On 29 April 2021, the Island Council approved a ban (Openbaar Lichaam Bonaire (OLB), 2021) on plastic and bioplastic stirrers, straws, shopping bags and cutlery (effective 1 June 2022) and Expanded Plastic Styrofoam (EPS) takeaway food packaging (effective 1 August 2022). Entrepreneurs are no longer allowed to sell, stock, or give away any of these items. Violations of this prohibition may result in a warning or an order subject to penalty. In the near future other items might be banned as well.

1.4.3 Cartagena Convention

The Caribbean Environment Program (CEP) is one of 18 UN Environment administered Regional Seas Programs. The CEP and its Caribbean Action Plan (1981) were established by governments of the Wider Caribbean Region (WCR) to develop regional cooperation and national action for the sustainable

management and use of the coastal and marine environment. The Action Plan led to the 1983 adoption of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (**the Cartagena Convention**). This is the most comprehensive umbrella environmental agreement for the region and provides the operative legal framework for much of the ocean governance activity in the Wider Caribbean Regio (Caporusso, C., 2021).

The Cartagena Convention's Land-Based Sources Protocol (LBS) is a key instrument for addressing land-based pollution in the Wider Caribbean Region. It aims to prevent, reduce, and control pollution and to ensure sound environmental management. Requirements for assessment and monitoring are an important component, as well as public participation in the review of possible benefits and risks of any major project likely to have an important impact on the marine environment (Diez, et al. 2019).

The Netherlands is a member state of the Cartagena Convention and ratified the Specially Protected Areas and Wildlife (SPAW) Protocol in 1992 and the Oil Spills Protocol in 1984. As of July 2018, the Cartagena Convention and its LBS Protocol has been ratified by fourteen (14) WCR countries. However, the Netherlands has not yet ratified the Land-Based Sources protocol (LBS).

The Caribbean Node of the Global Partnership on Marine Litter and Plastic Pollution (GPML-Caribe) is co-hosted by Gulf and Caribbean Fisheries Institute (GCFI) and the Secretariat for the Cartagena Convention as a regional platform for implementing the Regional Action Plan and supporting the objectives of the Global Partnership on Marine Litter. The Regional Action Plan for Marine Litter (RAPMaLi) serves to set priorities and achieve the objectives of the LBS Protocol.

In June 2017, the United Nations Conference to Support the Implementation of Sustainable Development Goal 14, OSPAR Commission (OSPAR) and the Cartagena Convention (CEP) registered a voluntary commitment to collaborate across the Atlantic. Several initial areas for cooperation among the Wider Caribbean Region and the North-East Atlantic have been identified where OSPAR and CEP can partner to provide technical and programmatic support to member states. See the 2021 MoU between OSPAR and Cartagena Conventions[5].

1.4.4 Single-Use Plastic Bags and Expanded Polystyrene

The World Bank report (2019) mentions that many Caribbean countries have started education campaigns, public awareness, and introduced new legislation to reduce persistent marine litter items. A total of 14 Caribbean SIDS [status in 2019] has banned the use of litter such as single-use plastic bags and Expanded Polystyrene. Countries that manage and plan for prevention and abatement of waste will benefit from a cleaner environment which can in turn improve international investment, tourism, and economic growth.

1.4.5 Marine Strategy Framework Directive

Within the European Marine Strategy Framework Directive (MSFD) marine litter is one of the descriptors (DG10) to assess the 'Good Environmental Status' of the marine environment. At EU level, the MSFD is the dedicated binding legal instrument for assessing, monitoring, setting targets and reaching good environmental status with regard to marine litter. The Directive obliges Member States to monitor marine litter (Boonstra and Hougee, 2022). The MSFD goal for Descriptor 10 (D10/marine litter) is defined as follows: "Properties and quantities of marine litter do not cause harm to the coastal and marine environment by 2020".

[5] https://www.ospar.org/documents?v=46467

The revised European Commission Decision 2017/848 requires EU Member States to establish threshold values (TVs) for criteria of Descriptor 10 on marine litter. TVs which are now mandatory through the new provisions, are intended to contribute to Member States determination of a set of characteristics for GES and enable their assessment of the extent to which GES is being achieved. The threshold value for marine litter has been set by the European Commission at a median of 20 litter counts per 100 meter of beach. This excludes meso-plastic fragment 0.5-2.5 cm and waxes.

1.4.6 OSPAR Regional Sea Convention

OSPAR presented the Quality Status Report (on the status of the marine environment of the North East Atlantic Ocean) including a thematic assessment on marine litter in 2023 (Marine Litter Thematic Assessment (ospar.org) . It looks at the progress made by assessing the trends of a number of common indicators in relation to the implementation of measures such as OSPAR's Regional Action Plan Marine Litter. The beach litter common indicator assessment (Abundance, Composition and Trends of Beach Litter (ospar.org) plays a key part in the overall marine litter assessment.

Main conclusion of the beach litter assessment: beach litter levels remain high (252 items per 100 meter) with plastic items predominating. Over 2015-2020, significant decreases in litter and plastic abundance have been observed at the OSPAR Maritime Area scale and in four OSPAR Regions. To substantially reduce marine litter, it is necessary to continue current efforts and take additional measures.

One of the identified science needs for the beach litter assessment is on transboundary pollution: " … transboundary pollution is known to occur in the OSPAR Maritime Area, however this phenomenon is not well quantified. More studies should be performed to identify litter sources and assess transboundary pollution." [6]

1.4.7 United Nations

The UN is working on a Global Instrument to reduce marine litter. In parallel, UN organizations like IMO (International Maritime Organization) and FAO (Food and Agriculture Organization) work on worldwide level, to reduce marine litter from the shipping and fisheries & aquaculture sectors, respectively via the development of regulations and guidelines.

The Caribbean Sea is a Special Area under IMO/MARPOL Annex V relating to discharge of ship-generated waste leading to additional measures for the shipping sector[7].

1.5 Sources of marine litter

A crucial step in monitoring and effectively addressing marine litter is the identification of the origin and the pathways that lead to litter entering the marine environment. Marine litter sources can be classified under three main groups of sources (Veiga et al, 2016):

1. Land based sources, such as public littering; poor waste management practices; industrial activities; sewage related debris and storm water discharge.
2. Riverine sources (same as sources above - transported by rivers to the ocean)

[6] document 23/05/1 for OSPAR ICG ML (3) 2023

[7] Under Annex V Prevention of Pollution by Garbage from Ships, MARPOL defines certain sea areas as "special areas" in which, for technical reasons relating to their oceanographical and ecological conditions and to their sea traffic, the adoption of special mandatory methods for the prevention of sea pollution is required. Under the Convention, these special areas are provided with a higher level of protection than other areas of the sea. Special Areas under MARPOL (imo.org)

3. Ocean based sources, such as fishing activities (particularly abandoned, lost or discarded fishing gear); shipping; marine leisure industry; offshore oil and hydrocarbon industry

A given site or region can be subject to litter pollution from a number of sources, which can be local, regional or even distant, as litter can be transported to a specific area by ocean currents and wind drift. For this reason, pinpointing the origin of the different items that make up marine litter is a difficult task and will always have an inherent degree of associated uncertainty. For example, plastic drinks bottles can be left on beaches by tourists locally, thrown overboard by merchant shipmen, disposed of improperly in-land and washed into the sea through storm water overflows. They can also enter the sea via rivers and, because they are buoyant, can be easily transported into a given area by water currents and prevailing winds.

Microplastics are small pieces of litter < 5mm in diameter. Major sources include fragmentation of larger items in the environment, release of abrasive additives from cosmetic and other products, release of fibres from the washing of textiles, the spillage of pre-production pellets or powders (that are in transit or process prior to being made into everyday plastic items) and other synthetic particles, for example as a consequence of tyre wear on roads (Veiga et al, 2016).

In Figure 1 the multiple (path)ways a number of common items could end up in the marine environment are presented.

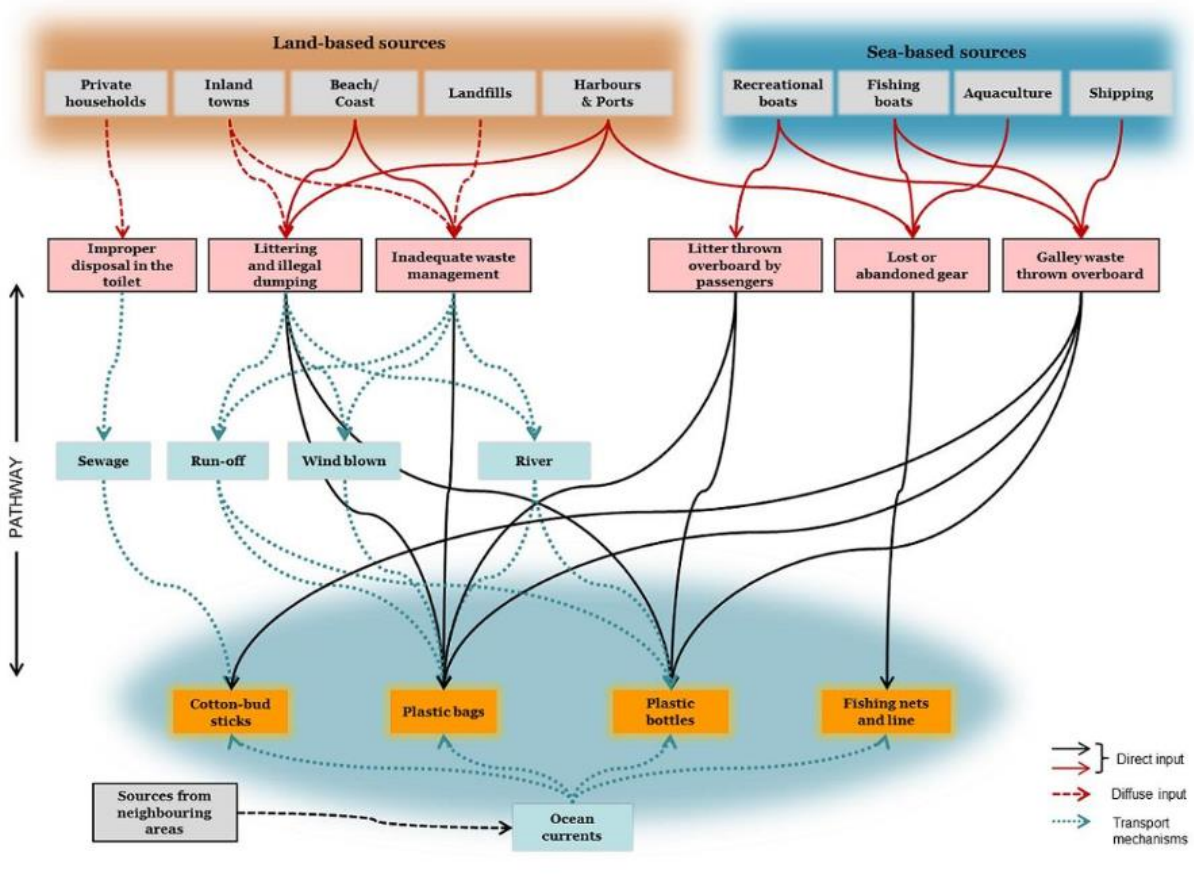

Figure 1 – Multiple (path)ways a number of common items could end up in the marine environment (Veiga et al, 2016)

It is extremely difficult to allocate a specific source to **microplastic particles** once they enter the wider environment. However, rivers are likely to represent substantial pathways to the marine environment.

A wide variety of methods have been used over the years to determine the sources of marine litter, ranging from simple counts of items to more complex statistical methods: 1. Attribution to sources according to the type of item including use of Indicator items; 2. Barcodes and container information; 3. Attribution of sources based on likelihood (Matrix Scoring Technique) and 4. Litter transport dynamics and models.

The use of indicator items, i.e. a selection of items which certainly originate form a given source, can help identify sources, and the general mix of items occurring in a given compartment of the marine environment (seabed, beach etc.), can give an indication of the main source of litter in that compartment[8]. However, although they provide an important indication of the sources involved, both will not supply information on the relative amounts of litter originating from different sources.

The Matrix Scoring Technique is an approach that considers the likelihoods of a single litter category originating for a series of potential sources. Compared to the use of indicator items, this methodology is likely to give a more accurate picture of sources and the relative importance of each type of source, in a certain area. However, in order to be able to use the Matrix Scoring Technique effectively a sound knowledge of the litter items found in the marine environment in the region is essential. The use of local knowledge of where, how and when which types of litter are being lost or disposed of into the marine environment and which socio-economic processes are generating marine litter is indispensable. These data should therefore form the basis of discussions with people from key sectors that may generate or influence the generation of marine litter.

Dedicated Litter ID sessions, aimed at in-detail investigations of the litter collected on a specific beach will contribute to high-quality source allocation information (Strietman et al, 2023).

1.6 Aims of this assessment

The aims of this report are (a) to carry out a status and trend analysis of the macro-litter data (including identifiable meso-plastic items) on three monitoring beaches of Bonaire and (b) to include a preliminary source identification. The report is a first beach litter baseline and trend study, and can be used to approach relevant authorities (regional but also in the Netherlands) and inform the on any measures that can help to reduce marine litter on Bonaire.

This report does not deal with the ecological and socio-economic effects on beach litter in the Caribbean Netherlands. However, there is no doubt that beach litter is ecologically harmful, often due to ingestion of smaller ingestible plastic items.

[8] E.g., marine litter source classification presented in Annex I EU source identification rapport (Veiga et al, 2016): Public litter; fishing; sewage-related debris; shipping; fly-tipping; medical; non-sourced

2. Methods

2.1 Monitoring method

The monitoring protocol being used is the OSPAR Beach Litter Monitoring Guidelines (OSPAR, 2020[9]). These guidelines have also been used successfully in the wider EU to monitor marine litter on beaches and assist with marine management decisions and policy development. The program was modified for Bonaire to accommodate (a.o.) for the heat and sun exposure for volunteers, in addition to time taken to conduct surveys due to the large amounts of marine litter. The modified OSPAR methodology includes supplemental information and incorporates minor differences as required by the region:

1. modified litter collection forms are enhanced versions of the OSPAR forms, and include Joint List litter items (Fleet et al, 2021)
2. additional metadata with respect to sampling site and survey conditions (i.e. presence of sargassum)
3. total weight of items is recorded
4. survey sites have been reduced to 50 meters in length rather than 100 meters. These 50 meter beach length counts could later be standardized to 100 meter beach length counts.
5. volunteers are utilized to assist in the survey process (manual collection and counting) under the direct supervision of a trained surveyor to accommodate the large volume of litter

As a pilot program, the methodology has been evolving and supplemental data has been included over time. The following is an explanation of each of the modifications to the OSPAR methodology and an indication of when the modifications took place (the 2021 Edition of "Harmonized Marine Litter monitoring in the Wider Caribbean Region: a hybrid approach" provides a description of the modified OSPAR methodology. Adopting this protocol for the Wider Caribbean is something that should be discussed and considered at Cartagena Convention level).

Reduction in Length

The time required for a high-resolution survey combined with the volume of debris and requirement for complete clearance, made it difficult for volunteers to complete the 100 meter survey within a realistic amount of time. During the pilot program training, it was determined that 50 meter can be cleared within two hours, so the sampling unit was reduced. Although a minimum of 100 meter is recommended in *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter* (Cheshire et al, 2009) to ensure variety of litter items, early surveys of 50 m are yielding between 55 to 72 unique litter items so the variety to length ratio was deemed acceptable (from program inception). [10] In the OSPAR CEMP guidelines (2.3.2.) it is allowed to use a minimum beach length of 50 meter when longer beaches are not available, but the litter counts then have to be normalized to 100 meter for data storage and reporting. The reason for WNF to use 50 meter is different, but the same method of data standardization to 100 meter can be used.

Supervised Volunteers

Clean Coast Bonaire encourages volunteers to participate as citizen scientists. Carolyn Caporusso (the CCB coordinator) is present at every survey to supervise. New volunteers are given a detailed briefing about how to use the survey form and paired up with more experienced surveyors. The 50 meter beach area also makes it so the coordinator is immediately accessible for any questions from volunteers. The CCB coordinator is present at every survey to supervise. Untrained volunteers are given a detailed

[9] OSPAR MEETING DOCUMENT

[10] in OSPAR and EU beach assessments the minimum beach length allowed/used is 50 m. The determined amounts must then be converted to 100 m (x2).

briefing and paired up with more experienced surveyors. The 50 meter beach area also makes it so the coordinator is immediately accessible for any questions from volunteers. The total number of participants (including the coordinator) is recorded on the *Modified OSPAR Survey Data Form* [11] each survey (from program inception).

Modifications to metadata

Width of survey site

A stakeholder requested that the width of the beach be recorded to monitor sea-level rise. A measurement from the waterline to the designated back of the beach is recorded on the *Modified OSPAR Survey Data Form* at each survey (starting January 2019).

Weight of collected items

To align with the *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter* (Cheshire et al, 2009), the weight of the items collected is recorded (with estimates for large items) on the *Modified OSPAR Survey Data Form* at each survey (starting February 2019).

Presence of sargassum

Due to an increase in events and concern regarding this transboundary issue, a stakeholder suggested that collection of regular data regarding sargassum presence would be useful. If sargassum is present, the maximum depth of the accumulation and maximum distance from the high-water mark is recorded on the *Modified OSPAR Survey Data Form* at each survey (from program inception).

During surveys when there are heavy accumulations of sargassum present, litter items are collected from on top of the seaweed mat as well trapped within the sargassum. However, although most macro-litter items are collected to the best of the survey team's ability, the presence of sargassum may impede full clearance of the survey site, particularly with respect to items smaller than 2.5 cm. In the subsequent survey, items smaller than 2.5 cm are frequently found under the dried patches of sargassum. For this reason the presence of sargassum is also monitored.

Figure 2 - Sargassum on Boka Onima, July 2019.

[11] created by CCB coordinator and adapted over time.
https://www.cleancoastbonaire.org/_files/ugd/12c02f_fe7fae95969c4f4498d13394a5dcc205.pdf
It currently incorporates the OSPAR list, common write-ins, and most items on the J-List (as of June 2021). Not yet officially adopted by any other (regional) organization.

Modifications to litter data

The OSPAR beach litter item list was modified for ease of use. On the *Modified OSPAR Beach Litter Data Form* similar items are grouped together within composition categories (i.e., bags, bottles, eating and drinking, fisheries) CCB engages in periodic reviews and updates with feedback from users.

Write-ins

Identifiable items without a litter category on the *Modified OSPAR Beach Litter Data Form* are written in. All write-in items are included on the spreadsheet housing the data and prolific items are periodically included on the form to increase ease of use. For example, food waste, plastic firework remains, and plastic decorations (ongoing).

OSPAR CEMP Updates

In April 2021, OSPAR's Coordinated Environmental Monitoring Programme launched the updated beach litter survey list dividing items between plastic and expanded polystyrene (Table 1), adding new related items (Table 2), and moving cigarette butts into the Plastic/Polystyrene category (OSPAR CEMP Guidelines, 2020[12]). In anticipation of the launch, the updates were included in the *Modified OSPAR Beach Litter Data Form* and spreadsheet housing the data (starting January 2021).

Table 1- Divided items of OSPAR CEMP for beach litter

OSPAR Category	OSPAR ID (old)	OSPAR ID (New)	J Code	Item Description
Plastic/Polystyrene	6	610	J225	Food containers incl. fast food containers (PLASTIC)
Plastic/Polystyrene		620	J224	Food containers incl. fast food containers (EPS)
Plastic/Polystyrene	21	211	J227	Cups (PLASTIC); cups and lids of hard plastic
Plastic/Polystyrene		212	J226	Cups (EPS); cups and cup lids of foamed polystyrene
Plastic/Polystyrene	32	321	J242	String and cord (diameter less than 1 cm) - not from dolly ropes/unidentified
Plastic/Polystyrene		322	J232	String and cord (diameter less than 1 cm) - exclusively from dolly ropes
Plastic/Polystyrene	33	331	J234	Tangled nets/cord/rope and string - without dolly rope/mixed with dolly rope
Plastic/Polystyrene		332	J235	Tangled dolly rope
Plastic/Polystyrene	34	341	J57	Fish boxes (Plastic)
Plastic/Polystyrene		342	J58	Fish boxes (EPS)
Plastic/Polystyrene	117	1171		Plastic pieces 0 - 2,5 cm
Plastic/Polystyrene		1172		Polystyrene pieces 0 - 2,5 cm
Plastic/Polystyrene	46	461	J79	Plastic pieces 2,5 cm > < 50 cm
Plastic/Polystyrene		462	J82	Polystyrene pieces 2,5 cm > < 50 cm
Plastic/Polystyrene	47	471	J80	Plastic pieces > 50 cm
Plastic/Polystyrene		472	J83	Polystyrene pieces > 50 cm
Sanitary waste	98	981	J95	Cotton bud sticks (Plastic)
Sanitary waste		982	J246	Cotton bud sticks (Cardboard)

[12] OSPAR_MEETING_DOCUMENT

Table 2 - New items OSPAR CEMP for beach litter

OSPAR Category	OSPAR ID	J Code	Item Description
Plastic/Polystyrene	481	J91	Biofilm support media
Medical waste	1051	J253	PPE Mask
Medical waste	1052	J252	Latex gloves
Sanitary waste	1021	J237	Wipes (wet wipes, hygenic wipes)

Inclusion of Joint List (J-List) Items

The 2021 *Joint List of Litter Categories for Marine Macro-litter Monitoring* by the Joint Research Centre (Fleet et al, 2021), combined the litter types from different marine litter monitoring lists (including OSPAR and UNEP) into one list with unique reference numbers for the purposes of global scale harmonization.

The spreadsheet housing the Bonaire beach litter data was updated to include all J-List items and the *Modified OSPAR Beach Litter Data Form* and was updated to include all regionally relevant items from the Joint List. In many cases, the J-List matches the OSPAR list, however, some J-List items add sub-categories to existing OSPAR items (Table 3), some are entirely new and even provided a unique code for Bonaire's frequently found write-in items (starting June 2021).

The lower resolution data will be analysed in the report, higher resolution data can be analysed once the number of surveys ('n') is considered sufficient for these subcategories. In some cases, a further in-depth analysis could indicate which sub-items seem to be most prominent.

2.2 Selection of reference beaches

The following criteria have been identified by OSPAR for selecting the reference beaches: the beaches should be a) composed of sand or gravel and exposed to the open sea; b) accessible to surveyors all year round; c) accessible for ease of marine litter removal; d) have a minimum length of 100 metres; e) free of 'buildings' all year round; f) not subject to any other litter collection activities.

Bonaire has a total coastline of 399 km. The western, leeward shore is characterized by calm sea conditions and the eastern, windward shore is characterized by rough sea conditions. Bonaire's coastline primarily consists of coral-rubble beaches, rocky shores and low limestone cliffs. There are a few popular sandy beaches that are located on the leeward shore, and there are several pocket beaches that have accumulated in small coves (known locally as bokas).

Three geographically separate locations were selected on Bonaire and designated as survey sites (see Figure 3). The sites are representative of the coastline of Bonaire. Bonaire has a scarcity of sand beaches, therefore a divergence from criterion a was required. Te Amo beach is a popular tourist beach, Boka Onima and Piedra Pretu are more-secluded, less/non-tourist beaches. Some characteristics are given in Table 3.

Table 3 – Characteristics of the survey beaches

Site name	Coordinate N-latitude	Coordinate W-longitude	Site description
Boka Onima	12.253129	68.311039	- windward east coast - Coral rubble/rocks 40%; Sand 60% - prevalent wind direction: east - current along the coast: south to north - nearby potential pollution sources: fishing/shellfish foraging/dog-walking (residents); sightseeing (tourists)
Piedra Pretu	12.067273	68.227988	- windward east coast - Rocky shore 40%; Sand 60% - prevalent wind direction: east - current along the coast: north to south - nearby potential pollution sources: fishing/shellfish foraging/dog-walking (residents); sightseeing (tourists)
Te Amo Beach	12.134766	68.279593	- leeward west coast - Sand (90%); Pebbles (5%); Scrub vegetation (5%); - prevalent wind direction: east - current along the coast: south to north - nearby potential pollution sources: town of Kralendijk; recreational use (residents/tourists); tourists on the beach (< 10000 per year); food trucks on the beach; immediately adjacent to Plaza Marina (recreational and charter vessels); 1.35km from South Pier (main offloading point for cargo shipments to Bonaire); 185 m from fuel pier for airport

Figure 3 - Locations of beach litter survey sites

Site #1 - Boka Onima is non-recreational, low-slope, sandy pocket beach located in the north-east with a large degree of rocky/coral rubble.

Figure 4 - Boka Onima

Site #2 - Piedra Pretu is a non-recreational, medium-slope rocky shore with a mix of gravel and sand and some coral rubble that is very typical of the south-east coast.

Figure 5 - Piedra Pretu

Site #3 - Te Amo Beach is on the western, leeward coast and is a low-slope, sandy beach. It is a popular recreational beach.

Figure 6 - Te Amo Beach

The Bonaire monitoring beaches are composed of sand but the two eastern beaches (Boka Onima and Piedra Pretu) also have a large degree of rocky/coral rubble. They are accessible all year round, are easily accessible for marine litter removal, have a length of 50 metres, are free of buildings all year round and comply with the OSPAR criteria a (to a certain degree), b, c, e and f. With respect to Te Amo Beach: between May to December (during sea turtle nesting season) volunteer nest surveyors may remove larger items of litter on daily nest surveys.

There is no regularly scheduled beach cleaning by Selibon NV (Bonaire's municipal waste management agency). Although litter bins are available on Te Amo Beach, these are frequently found to exceed capacity on weekends. It is also noteworthy that even during a March survey large amounts of (New Years Eve?) firework remains can be found on this beach. Boka Onima has one bin adjacent to the survey area that does not appear to be used and/or emptied with any degree of regularity.

Figure 7 - Waste receptacles on a Sunday morning at Te Amo Beach

Additional information in regards to physical and geographical characteristics e.g. proximity of shipping lanes, river mouths, waste water outlets of each site are available and updated when changes occur.

2.3 Monitoring frequency and period

The reference beaches are surveyed four times a year. However, the Caribbean does not experience the same seasons as Europe/the OSPAR Region. The seasonal cycle can be generally divided into two - wet season (Feb-June) and dry season (July-January). Hurricane season is June to November. The survey schedule has been arranged as follows:

- Boka Onima: January, April, July, October
- Piedra Pretu: February, May, August, November
- Te Amo Beach: March, June, September, December

Note that for best trend analysis results, it is important to monitor within these specified months per beach.

2.4 Reporting period

The beaches have been monitored according to the OSPAR protocol between September 2018 and October 2023. During this period, 60 surveys were performed by the teams of (trained) volunteers under supervision of Seven Seas Care Consultancy. The four surveys of 2018 on the east coast (Boka Onima and Piedra Pretu beaches) were for training and clearance purposes only and have been excluded from the analyses. All paper copies of survey and litter data forms are retained.

2.5 Data Management

The beach litter monitoring data are collected from September 2018 and entered in an Excel file by Clean Coast Bonaire (CCB), to have a good record of the results and circumstances.

2.5.1 Survey dates and special circumstances

Survey dates and relevant special circumstances, such as extreme weather conditions, beach events, recent beach replenishments and cleanings or any other activities that may influence the monitoring, are listed and registered in the data file.

2.5.2 Data clean-up

The beach litter data files from CCB have been cleaned and prepared for analysis with LitteR software. This is automated using a Python script that removes any redundant (comments) columns and transforms the data to a form that is required for and recognized by LitteR. Subsequently, an automatic performance via the LitteR type file ensures that meso-plastic fragments 0.5-2.5 cm (type 117), wax types (types 108-110) and other pollutants (type 111) are excluded (not selected) in the Total Count and the other groups. The presence of meso-plastics, waxes, pellets, weights comments are analysed separately (see sections 2.9.5-2.9.8).

In line with a change in the OSPAR CEMP Guidelines, CCB has made subdivisions for certain types from May 2021 onwards to further specify a category. For the analysis, these subs have been aggregated to their ‘mother’ group, e.g. 1171 and 1172 to 117. Once the number of surveys (‘n’) is considered sufficient for these subcategories, they can be included in the analysis.

2.6 LitteR software

LitteR software has been used, developed by Rijkswaterstaat (the Netherlands) for OSPAR beach litter data analysis, a tool to perform statistical analysis of litter data (e.g. beach, riverine, seafloor litter). This software package is based on robust statistics, such as the use of median values and Theil-Sen and Mann-Kendall trend analysis. These robust statistics are very suitable for the skewed (non-normal) litter data distributions. The software is freely available on the CRAN website.

2.7 Overview of analyses performed

In Table 4, the overview of analyses performed for this report is presented. These analyses are performed both on beach and on Bonaire Island assessment level. To give clarity in the differences of the assessments, the table gives the overview of the analysis groups, type of analysis, periods and on which level the analyses are performed. The descriptive statistics are explained in more detail in section 2.9. A threshold value (TV) assessment and trend analysis are explained in section 2.10 and 2.11.

Table 4 Overview of analyses performed in this annual report

Analysis group	Analysis performed	Period	Spatial level
Status analysis	Outlier analysis	Sept 2018-Sept 2023	Beach
	Total count (median)	Sept 2018-Sept 2023	Bonaire, beach
	Total weight (median)	Feb 2019- Sept 2023	Bonaire, beach
	Material groups (medians, median-based percentages)	Sept 2018–Sept 2023	Bonaire, beach
	SUP, FISH and OTHER groups	Sept 2018–Sept 2023	Bonaire, beach
	Top-10 (median-based)	Sept 2018-Sept 2023	Bonaire, beach
	Cigarette butts	Sept 2018-Sept 2023	Bonaire, beach
	Mesoplastics (0.5-2.5cm)	Sept 2018-Sept 2023	Bonaire, beach
	Presence of Waxes	Sept 2018-Sept 2023	Bonaire, beach
	Presence of Pellets	Sept 2018-Sept 2023	Bonaire, beach
	Presence of sargassum	Sept 2018-Sept 2023	Bonaire, beach
Trend analysis	Total count trend	Sept 2018-Sept 2023	Bonaire, beach
	Total weight trend	Feb 2019-Sept 2023	Bonaire, beach
	Material group trends	Sept 2018-Sept 2023	Bonaire, beach
	SUP, FISH and OTHER groups	Sept 2018-Sept 2023	Bonaire, beach
	Top-10 trends	Sept 2018-Sept 2023	Bonaire, beach
	Mesoplastics (0.5-2.5cm)	Sept 2018-Sept 2023	Bonaire, beach
	Waxes	Sept 2018-Sept 2023	Bonaire, beach
	Cigarette butts[13]	Sept 2018-Sept 2023	Bonaire, beach

[13] In this report the term cigarette butts is used instead of cigarette stubs

2.8 Outlier analysis

For data quality control purposes, the outlier analysis is performed with LitteR. This analysis detects outliers in the surveys selected for the data analysis. In statistics, an outlier is a data point that differs significantly from other observations. The outliers are presented in box- and whisker plots. Meso-plastics, waxes and other pollutions are excluded from the outlier values (dealt with in separate analyses). The outlier surveys are checked by the lead surveyor (Seven Seas Care Consultancy) to ensure the registration of the surveys is correct and whether there were special circumstances that could explain the outlier. These explanations are included in the report.

2.9 100 m beach length normalization

In order to better compare the Bonaire beach litter data with the normalized data in OSPAR and EU countries, the 50 m beach level is extrapolated to a 100 m beach level. This extrapolation, with a limited factor of 2 (from 50 to 100 m), is allowed by the CEMP guidelines for beach litter. This has been included in the Python script (see paragraph 2.5.2).

2.10 Status analysis

The following descriptive statistics are performed by LitteR software 1) median count, i.e., the median of the counts for each litter type 2) Theil-Sen slope (slope): a robust non-parametric estimator of slope (litter counts/100m per year) 3) p-value to show if a slope presents a significant trend. The descriptive statistics that are included in Results & Discussion chapter are further explained in the sections below.

2.10.1 Median total litter count

The median total litter count is calculated for 5 years. The medians are first calculated at the beach level using the indicated periods, and then aggregated to the country level using the median beach value (blocking method, see CEMP guidelines (OSPAR, 2022)). The litter types of meso-plastic fragments 0.5-2.5 cm [117], wax types [108-110] and other pollutants [111] are excluded from the total count calculation and are analysed separately.

2.10.2 Material analysis

A material analysis is performed for the 5-year period of the total abundances of litter groups which have been assigned to any of the following categories: Plastic/polystyrene, Rubber, Paper/cardboard, Wood, Glass, Cloth/textile, Metal and Ceramic/pottery. The litter composition percentages are calculated based on the calculated medians of each material type.

2.10.3 Functional group analysis

A specific litter group analysis is performed for the 5-year period using the combined total counts for following material group types: Single Use Plastics (SUP); Fishing related items (FISH); All other items (OTHER). The categorisation of the OSPAR litter types per specific litter group is included in Appendix V.

2.10.4 Top 10 litter types

The top 10 most found litter types is calculated for the 5-year period. A top-10 list of most found litter types on individual beaches is constructed. These top-10 litter types per beach are then aggregated at the country level and the top 10 list with the highest aggregated median values are selected.

2.10.5 Indicative assessment of meso-plastics fragments

All beach litter items > 5 mm are surveyed. However, meso-plastic fragments (0-2.5 cm) are not included in the total count calculation. The CEMP guidelines prescribe they are monitored less accurately comparably within the OSPAR area due to their small size and the occurrence of very high numbers on some beaches. For this report, the same approach is applied, the fragments are descriptively analysed only at the country level for the 5-year period.

2.10.6 Indication of waxes presence

During each monitoring, the presence of paraffin is registered under OSPAR codes 108 (size 0-1 cm), 109 (size 1-10 cm) and 110 (size > 10 cm). Monitoring does not take place in line with the OSPAR guidelines. However, waxes are not very prevalent and any solid items that are found are collected and counted.

2.10.7 Indication of pellets presence

Each monitoring the presence of pellets is registered with a yes/no on the OSPAR form. The median presence percentage of pellets for the period 2018-2023, analysed using the blocking method (first beach aggregation for 2018-2023, then calculate median beach result) is included in the report.

2.10.8 Indication of sargassum

Plastic litter is often collected by sargassum. This may especially affect the number small plastic pieces found on such a beach (bigger litter items are picked out of the sargassum). It is not clear how the litter gets into the sargassum: while floating or on the beach. A preliminary sargassum analysis will be performed for Boka Onima and Piedra Pretu beaches. On Te Amo no sargassum was encountered. Excluding the 2018 surveys (for training purposes only), a total of 39 surveys were taken into account. A distinction will be made between “no sargassum”, “small patches of sargassum” and “large patches of sargassum”. Six surveys containing quantitative information on thickness and surface and (only) one survey with “medium patches” have all been classified as “large patches”. Furthermore, the data have been cross-checked with Total Counts and with meso-plastics to see if any correlation exists between sargassum occurrence and number of items counted (litter caught by sargassum leading to lower counts).

2.10.9 Indicative monitoring of total weight

From February 2019 onwards, supplementary research has been conducted by weighing the marine litter gathered after each survey. Larger litter types are collected in re-usable mesh bags and smaller items in buckets and sand, biofouling and seaweed are removed. The items are weighed with a handheld luggage scale (see Appendix III for the overview). The aim is to get a better insight in the weight of marine litter washing ashore. The weights per survey are reported and the average and median weight for the 4-year period 2019-2023 is calculated and included in the report.

2.11 Threshold value

A Total Count (TC) value is calculated based on the period 2018-2023. The median TC value for a 100 m beach is calculated of 60 surveys by converting the 50-meter beach results to 100-meter beach lengths. Meso-plastic fragments 0.5-2.5 cm [117] and waxes/other pollutants [108 until 111] are excluded. By converting the 50-meter results to 100-meter, the values could be compared to for example total counts on Dutch and other OSPAR beaches and to the EU threshold value (median of 20 litter counts per 100-meter coastline). More on this conversion in paragraph 2.9

2.12 Trend analysis

In the annual report trend analyses are performed on the total count of all litter items, all material groups, the SUP, FISH and OTHER groups, and the top 10 types. The trend period used is 5 years, in order to show relatively recent trends. Trends are analysed by non-parametric Theil-Sen analysis, and p-values are calculated using the Mann Kendall analysis. A p-value less than 0.05 is considered significant. If the p-value is greater than this significance level, then no trend can be concluded. The only conclusion can be that the data do not show evidence for a significant trend (e.g. due to lack of data, noise, etc.).

2.13 Environmental situation and source identification

In order to assess the origin of the beach litter items, it is important to know about 1) the direction of oceanographic currents around the island; 2) prevalent wind direction; 3) (potential) pollution sources on and around the island. A summary of the environmental situation is presented in Appendix III.

3. Results

This chapter includes the beach litter monitoring results of the descriptive statistics and the trend analysis. Both analyses included the aggregated total count on island level and beach level, material analysis on island and beach level, specific litter group analysis on island and beach level, top 10 most found litter types on island and beach level and selected trend plots, trend plots on island and beach level on total count, materials, and specific litter groups.

The original data containing all litter data have been added in Appendix I. The LitteR files and reports are provided in Appendix II and the survey dates and weights overview are included in Appendix III.

3.1 Outlier analysis

The outlier analysis was performed for the 5-year period September 2018 – September 2023. The boxplot of the outlier analysis is presented in Figure 8. Table 5 includes the overview of specific outlier per location together with a (possible) explanation of the outlier. All outliers were checked before further analysis.

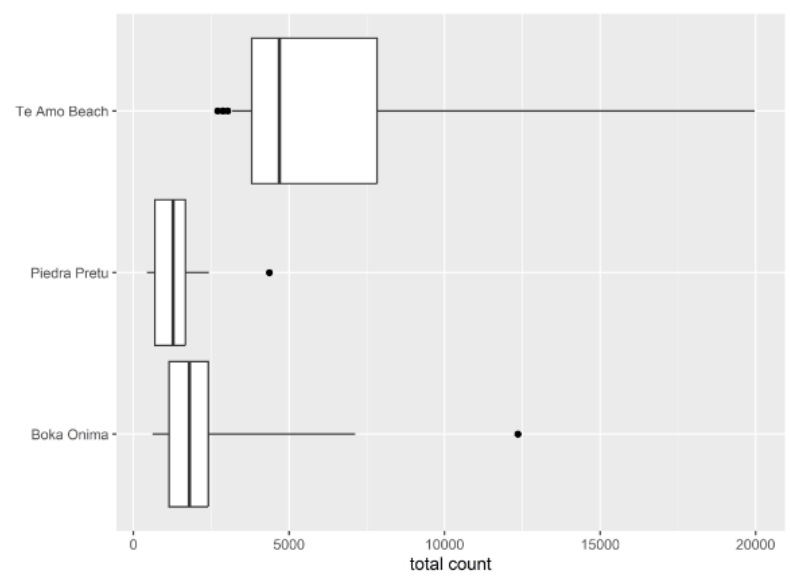

Figure 8 - Outlier boxplot 2018-2023 per location. Outliers are given as dots.

Table 5 Overview of outlier in the period 2018-2023.

5-year outlier analysis				
Location	**date**	**N**	**total count**	**Possible explanation**
Boka Onima	2023-01-08	18	12358	Very high numbers of plastic lids/ cans/ bottles; Whole east coast large amounts washed ashore. [14]
Piedra Pretu	2023-08-13	19	4366	Too much to collect in one session, 2 people returned for more on 16 Aug. Windy day.
Te Amo Beach	2018-12-08	21	2702	This location is located close to the more densely populated part of Bonaire and is popular for after-hours parties. This outlier shows a lower total count than the median on this beach. This is mainly due to the relatively few cigarette butts and metallic caps that are collected on this day. Due to the large share that cigarette butts have in the total count calculation on this beach, a lower count of this litter type has a great influence on the outlier analysis.
Te Amo Beach	2019-12-14	21	2862	This outlier shows a lower total count than the median on this beach. This is mainly due to the relatively few cigarette butts and metallic caps that are collected on this day. Due to the large share that cigarette butts have in the total count calculation on this beach, a lower count of this litter type has a great influence on the outlier analysis. Due to the presence of two large party tents on the beach, the participants were not able to clean the full area.
Te Amo Beach	2019-09-14	21	2890	This outlier shows a lower total count than the median on this beach. This is mainly due to the relatively few cigarette butts, metallic caps and zero bottles that are collected on this day. Due to the large share that cigarette butts have in the total count calculation on this beach, a lower count of this litter type has a great influence on the outlier analysis.
Te Amo Beach	2020-12-13	21	3032	This outlier shows a lower total count than the median on this beach. This is mainly due to the relatively few cigarette butts and metallic caps that are collected on this day.

[14] No clear origin. However, seems NOT to be directly linked to heavy rain period October/November 2022 (also on northern coast South America that might have generated trash gullies there). See paragraph 3.11.

3.1.1 Other special circumstances

In 2020 the worldwide COVID-19 pandemic begun and ended in 2022. In the general discussion section, other developments that could have been an influence on the beach litter monitoring results are explained in more detail.

3.2 Status analysis (September 2018 - September 2023)

This section includes the 5-year analysis on country (island) and local beach level of the aggregated total count, material analysis, specific litter group analysis, the top 10 most found litter types.

3.2.1 Overview results descriptive analysis

3.2.1.1 Country (island) level

The results of the descriptive analysis on country (island) level are included in Table 6. The trends for all the groups and types in this table are presented in Table 10. All median percentages are based on the sum of all group medians.

Table 6: Overview state analysis results for the period 2018-2023 on country (island) level

Total count on country (island) level				
Region	Name/ group code	N	median	
Bonaire	TC	60	1792	
Region	type name/ group code	N	Median	%
Bonaire	PLASTIC	60	1547	86.3
Bonaire	GLASS	60	170	9.5
Bonaire	METAL	60	28	1.6
Bonaire	WOOD	60	18	1.0
Bonaire	RUBBER	60	13	0.7
Bonaire	PAPER	60	8	0.4
Bonaire	CLOTH	60	6	0.3
Bonaire	POTTERY	60	2	0.1
Region	type name/ group code	N	Median	%
Bonaire	OTHER	60	1185	65.0
Bonaire	SUP	60	610	33.4
Bonaire	FISH	60	29	1.6
Region	type name/ group code	N	median	
Bonaire	PLASTIC: 2.5 <>50cm [46]	60	256	
Bonaire	GLASS: OTHER [93]	60	140	
Bonaire	PLASTIC: CAPS [15]	60	124	
Bonaire	PLASTIC: CUTLERY [22]	60	49	
Bonaire	PLASTIC: FOAM_SPONGE [45][15]	60	32	
Bonaire	PLASTIC: OTHER [48]	60	31	
Bonaire	PLASTIC: CRISP [19]	60	27	
Bonaire	PLASTIC: STRING [32]	60	15	
Bonaire	PLASTIC: CUPS [21]	60	14	
Bonaire	PLASTIC: FOOD [6]	60	12	

Total weight on country level				
Region	type name/ group code	N	Mean	median
Bonaire	Total weight	57	21.2	10.6

[15] Lightweight cellular foam (mainly foamed PU and PE materials) used especially for insulation (i.e., in walls, roofs, and foundations as thermal insulation and water barrier). Includes spray foam.

3.2.1.2 Beach level: Te Amo Beach

The results of the descriptive analysis of Te Amo Beach are included in Table 7. The trends for all the groups and types in this table are presented in Table 11.

Table 7: Overview state analysis results for the period 2018-2023 on beach level: Te Amo Beach

Total count on beach level: Te Amo Beach				
Beach	Name/ group code	N	median	
Te Amo Beach	TC	21	4690	
Beach	type name/ group code	N	median	%
Te Amo Beach	PLASTIC	21	3378	70.1
Te Amo Beach	METAL	21	774	16.5
Te Amo Beach	PAPER	21	258	6.9
Te Amo Beach	GLASS	21	170	3.5
Te Amo Beach	WOOD	21	58	1.3
Te Amo Beach	RUBBER	21	40	0.9
Te Amo Beach	CLOTH	21	12	0.3
Te Amo Beach	POTTERY	21	2	0.1
Beach	type name/ group code	N	median	%
Te Amo Beach	SUP	21	3084	64.5
Te Amo Beach	OTHER	21	1842	35.3
Te Amo Beach	FISH	21	16	0.4
Beach	type name/ group code	N	median	
Te Amo Beach	PLASTIC: CIG_STUBS [64]	21	2480	
Te Amo Beach	METAL: CAPS [77]	21	716	
Te Amo Beach	PAPER: OTHER [67]	21	238	
Te Amo Beach	GLASS: OTHER [93]	21	140	
Te Amo Beach	PLASTIC: CAPS [15]	21	124	
Te Amo Beach	PLASTIC: OTHER [48]	21	116	
Te Amo Beach	PLASTIC: CUTLERY [22]	21	112	
Te Amo Beach	PLASTIC: CRISP [19]	21	50	
Te Amo Beach	PLASTIC: 2.5 <>50cm [46]	21	32	
Te Amo Beach	METAL: FOIL [81]	21	30	

Total weight on beach level: : Te Amo Beach				
Beach	type name/ group code	N	Mean	median
Te Amo Beach	Total weight	21	17	10.2

3.2.1.3 Beach level: Boka Onima

The results of the descriptive analysis of Boka Onima are included in Table 8. The trends for all the groups and types in this table are presented in Table 12.

Table 8: Overview state analysis results for the period 2018-2023 on beach level: Boka Onima

Total count on beach level: Boka Onima				
Beach	Name/ group code	N	median	
Boka Onima	TC	20	1792	
Beach	type name/ group code	N	median	%
Boka Onima	PLASTIC	20	1547	85.0
Boka Onima	GLASS	20	134	8.6
Boka Onima	METAL	20	28	1.7
Boka Onima	WOOD	20	18	1.4
Boka Onima	RUBBER	20	13	0.9
Boka Onima	PAPER	20	8	0.6
Boka Onima	CLOTH	20	6	0.4
Boka Onima	POTTERY	20	2	0.1
Beach	type name/ group code	N	median	%
Boka Onima	OTHER	20	1185	62.5
Boka Onima	SUP	20	610	36.3
Boka Onima	FISH	20	29	1.8
Beach	type name/ group code	N	median	
Boka Onima	PLASTIC: 2.5 <>50cm [46]	20	595	
Boka Onima	PLASTIC: CAPS [15]	20	189	
Boka Onima	GLASS: OTHER [93]	20	118	
Boka Onima	PLASTIC: DRINKS [4]	20	110	
Boka Onima	PLASTIC: FOAM_SPONGE [45]	20	80	
Boka Onima	PLASTIC: FOOD [6]	20	52	
Boka Onima	PLASTIC: CUTLERY [22]	20	49	
Boka Onima	PLASTIC: OTHER [48]	20	31	
Boka Onima	PLASTIC: CRISP [19]	20	27	
Boka Onima	PLASTIC: STRING [32]	20	15	
Total weight on beach level: Boka Onima				
Region	type name/ group code	n	Mean	median
Boka Onima	Total weight	20	39	22.6

3.2.1.4 Beach level: Piedra Pretu

The results of the descriptive analysis of Piedra Pretu are included in Table 9. The trends for all the groups and types in this table are presented in Table 13.

Table 9: Overview state analysis results for the period 2018-2023 on beach level: Piedra Pretu

Total count on beach level: Piedra Pretu				
Beach	Name/ group code	N	median	
Piedra Pretu	TC	19	1266	
Beach	type name/ group code	N	median	%
Piedra Pretu	PLASTIC	19	506	65.3
Piedra Pretu	GLASS	19	288	28.1
Piedra Pretu	METAL	19	14	1.5
Piedra Pretu	RUBBER	19	12	1.4
Piedra Pretu	WOOD	19	6	0.8
Piedra Pretu	PAPER	19	6	0.7
Piedra Pretu	CLOTH	19	4	0.5
Piedra Pretu	POTTERY	19	0	0.2
Beach	type name/ group code	N	median	%
Piedra Pretu	OTHER	19	876	72.2
Piedra Pretu	SUP	19	204	24.0
Piedra Pretu	FISH	19	50	4.6
Beach	type name/ group code	N	median	
Piedra Pretu	GLASS: OTHER [93]	19	264	
Piedra Pretu	PLASTIC: 2.5 <>50cm [46]	19	256	
Piedra Pretu	PLASTIC: CAPS [15]	19	98	
Piedra Pretu	PLASTIC: FOAM_SPONGE [45]	19	32	
Piedra Pretu	PLASTIC: STRING [32]	19	24	
Piedra Pretu	PLASTIC: CRISP [19]	19	16	
Piedra Pretu	PLASTIC: CUTLERY [22]	19	14	
Piedra Pretu	PLASTIC: FOOD [6]	19	12	
Piedra Pretu	PLASTIC: CIG_STUBS [64]	19	10	
Piedra Pretu	PLASTIC: OTHER [48]	19	10	
Total weight on beach level: Piedra Pretu				
Region	type name/ group code	n	Mean	median
Piedra Pretu	Total weight	19	7.6	5.6

3.3 Trend analysis

This section includes the 5-year trend analysis (September 2018 – September 2023) of the aggregated total count on country (island) and local beach level, material analysis, specific litter group, top-10 most found litter and trend plots.

3.3.1 Overview trend plots

The results of trend analysis for 2018-2023 are included in the tables in the following sections. Every table then followed by the presentation of (selected) trend analysis plots. All trend plots can be found in Appendix II. In each plot, the black dots are the observations, the thin gray line segments connect the dots and guide the eye, and the red line is the Theil-Sen slope.

3.3.1.1 Country (island) level

The results of the trend analysis on regional level are included in Table 10 (next page), followed by the time-series plots.

Table 10: Overview of trend analysis results on country (island) level for the period 2018-2023 (p-values of significant trends are printed bold. Slope given in counts per year. All slopes are positive (increase) unless otherwise indicated)

Total count at country (island) level					
Region	type name/ group code	n	median	slope	p value
Bonaire	TC	60	1792	460.7	**<0.001**
Material trends at country level					
Region	type name/ group code	n	median	slope	p value
Bonaire	PLASTIC	60	1547	341.7	**<0.001**
Bonaire	GLASS	60	170	12.4	0.127
Bonaire	METAL	60	28	3.5	**0.010**
Bonaire	WOOD	60	18	1.4	**0.013**
Bonaire	PAPER	60	8	1.3	**0.037**
Bonaire	CLOTH	60	6	0.7	0.702
Bonaire	POTTERY	60	2	0	0.500
Bonaire	RUBBER	60	13	0	0.455
Functional group trends at country level					
Region	type name/ group code	n	median	slope	p value
Bonaire	OTHER	60	1185	312.6	**<0.001**
Bonaire	SUP	60	610	123.5	**0.003**
Bonaire	FISH	60	29	1.29	0.500
Top 10 trends country level					
Region	type name/ group code	n	median	slope	p value
Bonaire	PLASTIC: 2.5 <>50cm [46]	60	256	82.7	**0.017**
Bonaire	GLASS: OTHER [93]	60	140	18.3	**0.008**
Bonaire	PLASTIC: CAPS [15]	60	124	7.4	0.233
Bonaire	PLASTIC: CUTLERY [22]	60	49	6.5	0.083
Bonaire	PLASTIC: FOAM_SPONGE [45][16]	60	32	0	0.557
Bonaire	PLASTIC: OTHER [48]	60	31	13.6	**<0.001**
Bonaire	PLASTIC: CRISP [19]	60	27	8.6	**<0.001**
Bonaire	PLASTIC: STRING [32]	60	15	0	0.646
Bonaire	PLASTIC: CUPS [21]	60	14	3.7	**0.002**
Bonaire	PLASTIC: FOOD [6]	60	12	2.2	0.107

Total weight on regional level						
Region	type name/ group code	N	mean	median	slope	p value
Bonaire	Total weight	57	21.2	10.6	1.1	**0.028**

[16] Lightweight cellular foam (mainly foamed PU and PE materials) used especially for insulation (i.e., in walls, roofs, and foundations as thermal insulation and water barrier). Includes spray foam.

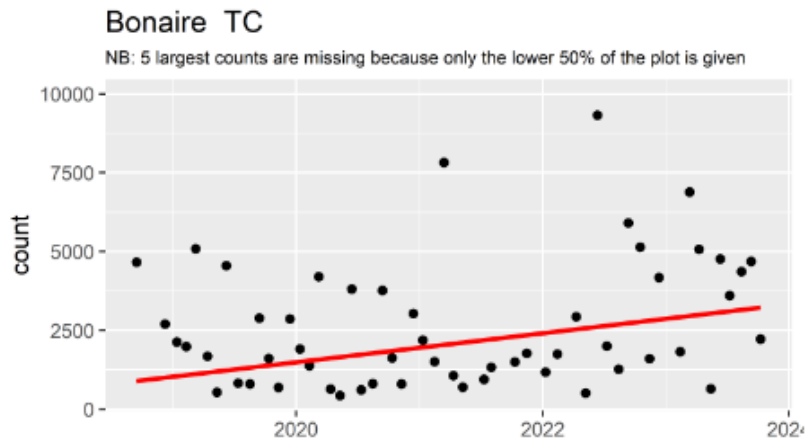

Figure 9: Trend plot 2018-2023: 5-year plot total count aggregated results for all beaches on Bonaire – significant upward trend per 100 m beach

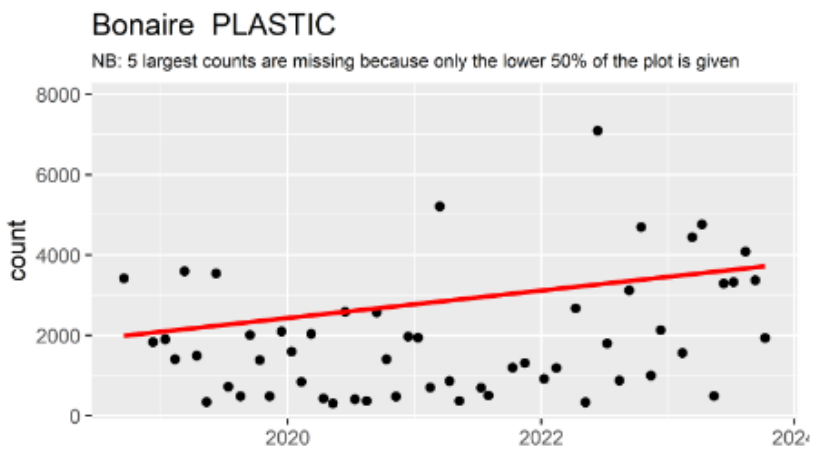

Figure 10: Trend plot 2018-2023: 5-year plot litter group "Plastics" aggregated results for all beaches on Bonaire – significant upward trend per 100 m beach

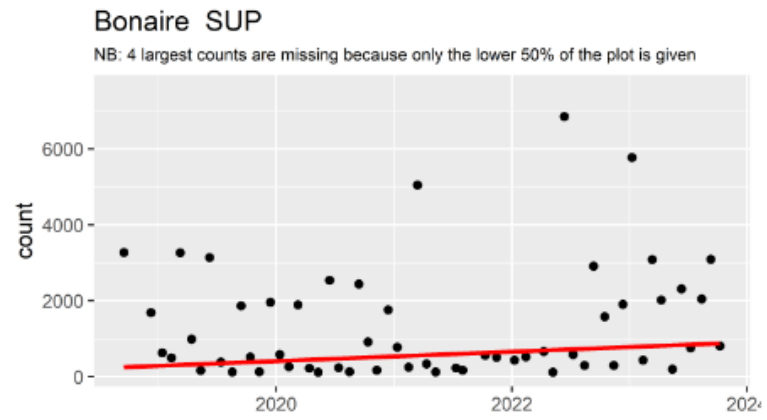

Figure 11: Trend plot 2018-2023: 5-year plot specific SUP litter group aggregated results for all beaches on Bonaire - significant upward trend per 100 m beach

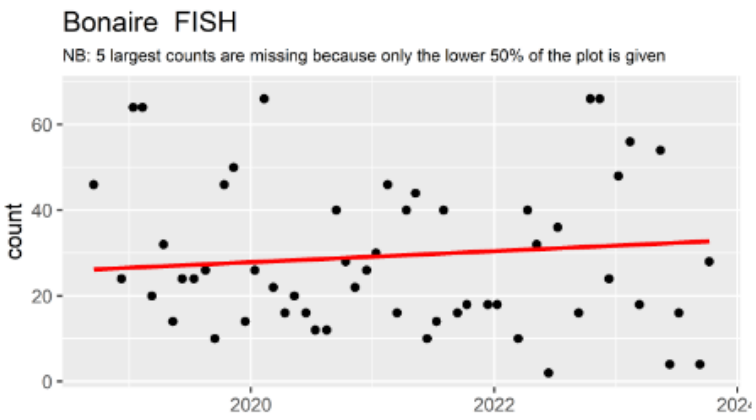

Figure 12: Trend plot 2018-2023: 5-year plot specific FISH litter group aggregated results for all beaches on Bonaire – non-significant upward trend per 100 m beach

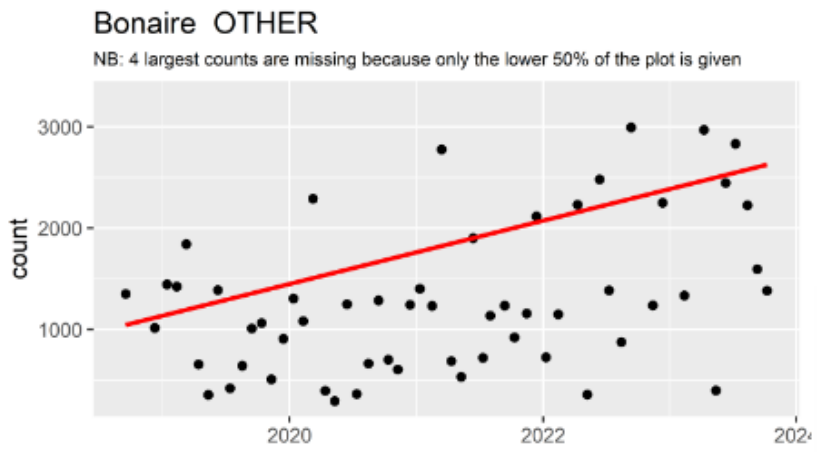

Figure 13: Trend plot 2018-2023: 5-year plot specific OTHER litter group aggregated results for all beaches on Bonaire – significant upward trend per 100 m beach

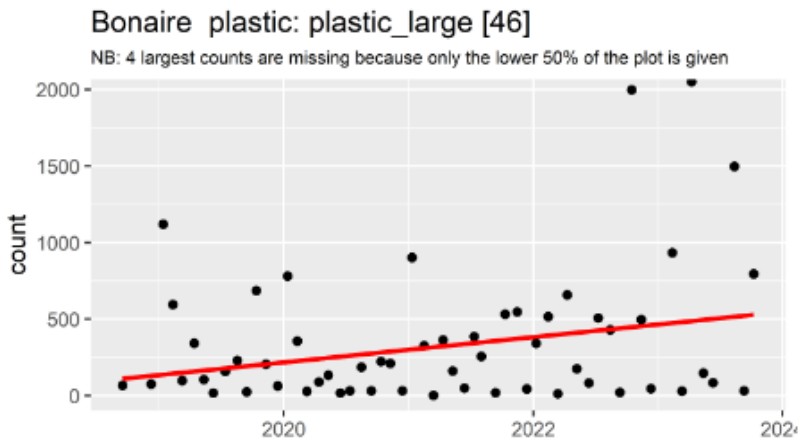

Figure 14: Trend plot Plastic/polystyrene pieces 2.5 cm >< 50 cm [46] 2018-2023: 5-year plot litter aggregated results for all beaches on Bonaire – significant upward trend per 100 m beach

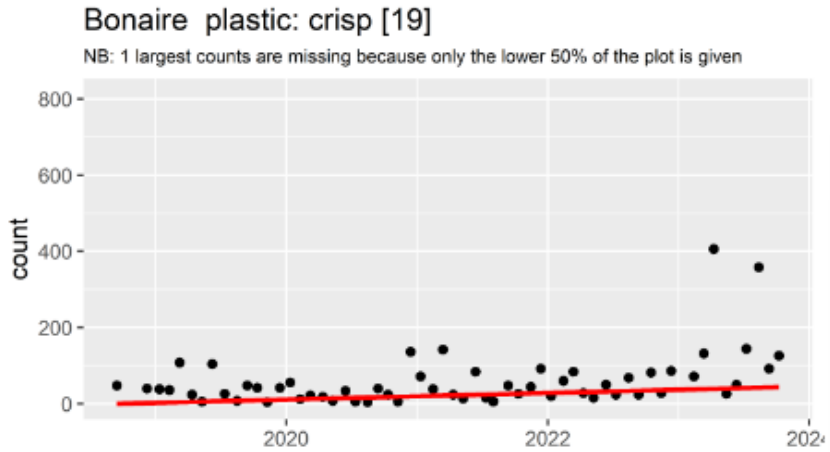

Figure 15: Trend plot Plastic crisp/sweet packets and lolly sticks [19] 2018-2023: 5-year plot litter aggregated results for all beaches on Bonaire – significant upward trend per 100 m beach

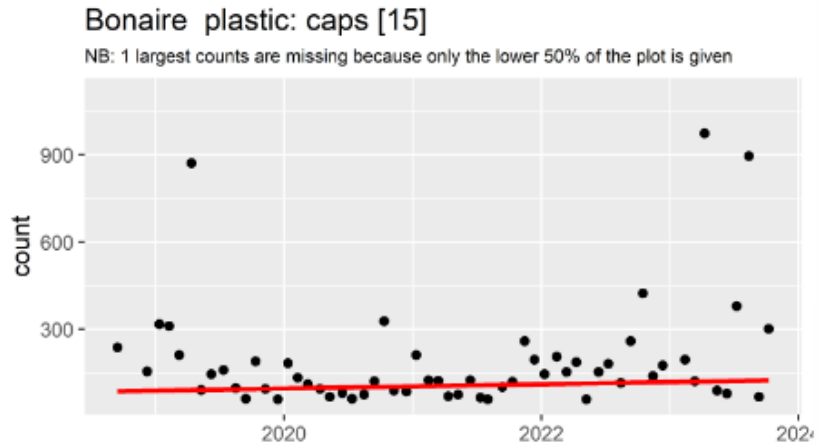

Figure 16: Trend plot Plastic caps [15] 2018-2023: 5-year plot litter aggregated results for all beaches on Bonaire – non-significant upward trend per 100 m beach

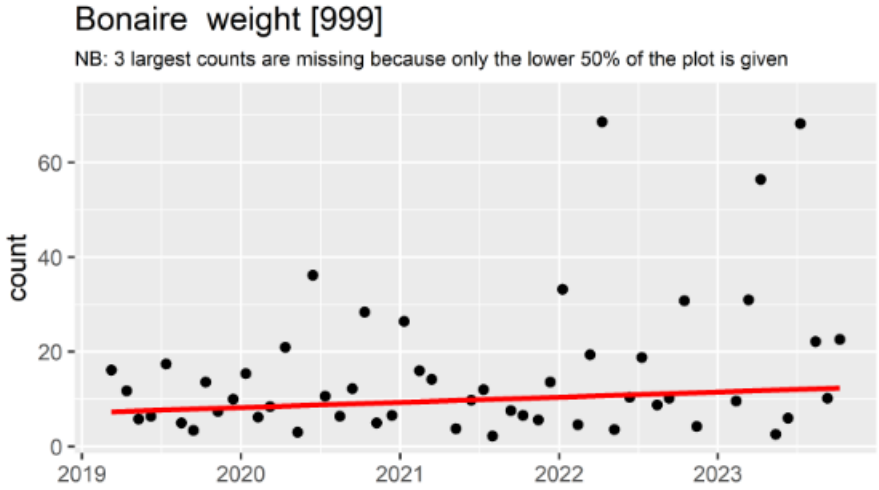

Figure 17: Trend plot weight 2018-2023: 5-year plot litter aggregated results for all beaches on Bonaire – small significant upward trend per 100 m beach. KG's on the y-axis.

3.3.1.2 Beach level: Te Amo Beach

The results of the trend analysis on Te Amo Beach are included in Table 11, followed by the time-series plots. The lines and dots have the following meaning:

- coloured dots: observations;
- red line: Regional Theil-Sen trend line (its slope is given in the tables above).

Table 11: Overview of trend analysis results of Te Amo Beach for the period 2018-2023 (p-values of significant trends are printed bold. Slope given in counts per year. All slopes are positive (increase) unless otherwise indicated)

Total count at beach level: Te Amo Beach					
Beach	type name/ group code	n	median	slope	p value
Te Amo Beach	TC	21	4690	559.5	**0.033**
Material trends at beach level					
Beach	type name/ group code	n	median	slope	p value
Te Amo Beach	PLASTIC	21	3378	341.7	0.062
Te Amo Beach	METAL	21	774	180.8	**0.002**
Te Amo Beach	PAPER	21	258	44.2	**0.033**
Te Amo Beach	GLASS	21	170	24.0	0.228
Te Amo Beach	WOOD	21	58	11.4	**0.010**
Te Amo Beach	RUBBER	21	40	3.8	0.091
Te Amo Beach	CLOTH	21	12	0	0.488
Te Amo Beach	POTTERY	21	2	0	0.387
Functional group trends at beach level					
Beach	type name/ group code	n	median	slope	p value
Te Amo Beach	SUP	21	3084	228.7	0.147
Te Amo Beach	OTHER	21	1842	312.6	**0.005**
Te Amo Beach	FISH	21	16	-3.38	**0.010**
Top 10 trends beach level					
Beach	type name/ group code	n	median	slope	p value
Te Amo Beach	PLASTIC: CIG_STUBS [64]	21	2480	277.9	0.098
Te Amo Beach	METAL: CAPS [77]	21	716	190.6	**0.002**
Te Amo Beach	PAPER: OTHER [67]	21	238	45.5	**0.015**
Te Amo Beach	GLASS: OTHER [93]	21	140	29.9	0.055
Te Amo Beach	PLASTIC: CAPS [15]	21	124	-1.6	0.381
Te Amo Beach	PLASTIC: OTHER [48]	21	116	47.0	**<0.001**
Te Amo Beach	PLASTIC: CUTLERY [22]	21	112	-6.1	0.285
Te Amo Beach	PLASTIC: CRISP [19]	21	50	2.8	0.174
Te Amo Beach	PLASTIC: 2.5 <>50cm [46]	21	32	-0.7	0.428
Te Amo Beach	METAL: FOIL [81]	21	30	-4.8	0.065

Total weight on beach level						
Beach	type name/ group code	N	mean	median	slope	p value
Te Amo Beach	Total weight	21	17	10.2	1.1	0.164

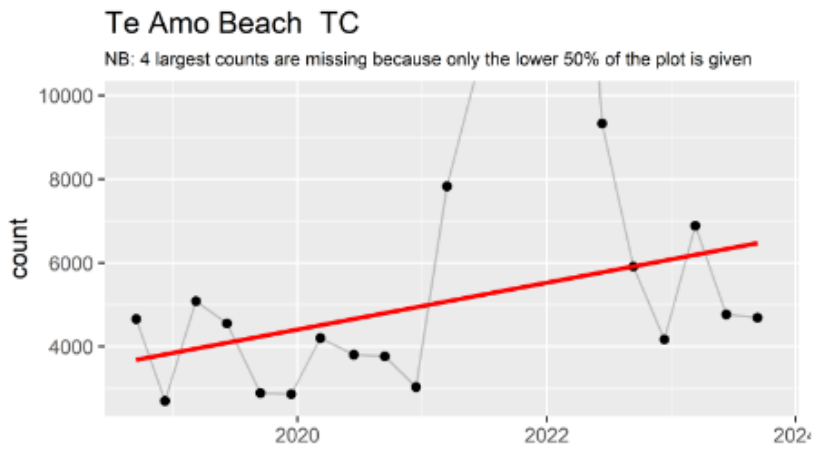

Figure 18: Trend plot 2018-2023: 5-year plot total count for Te Amo Beach – significant upward trend per 100 m beach

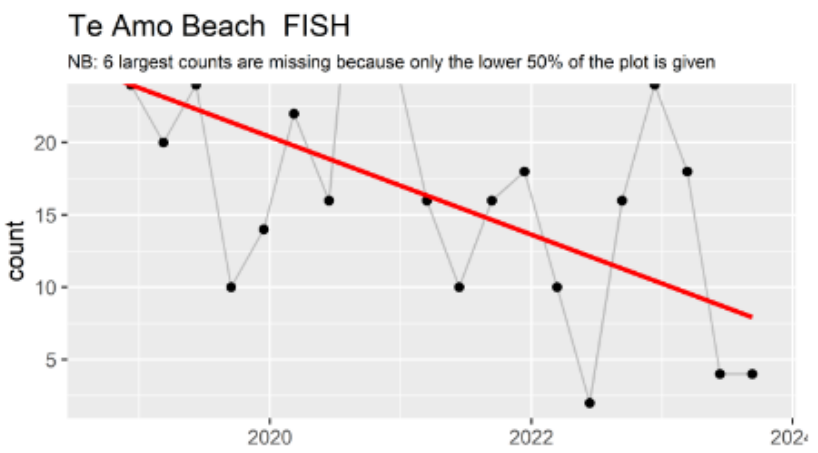

Figure 19: Trend plot 2018-2023: 5-year plot specific FISH litter group for Te Amo Beach – significant downward trend per 100 m beach

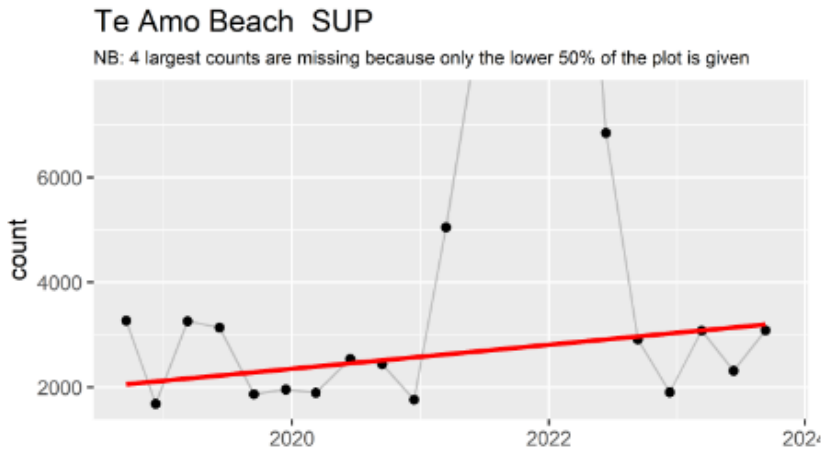

Figure 20: Trend plot 2018-2023: 5-year plot specific SUP litter group for Te Amo Beach – non-significant upward trend per 100 m beach

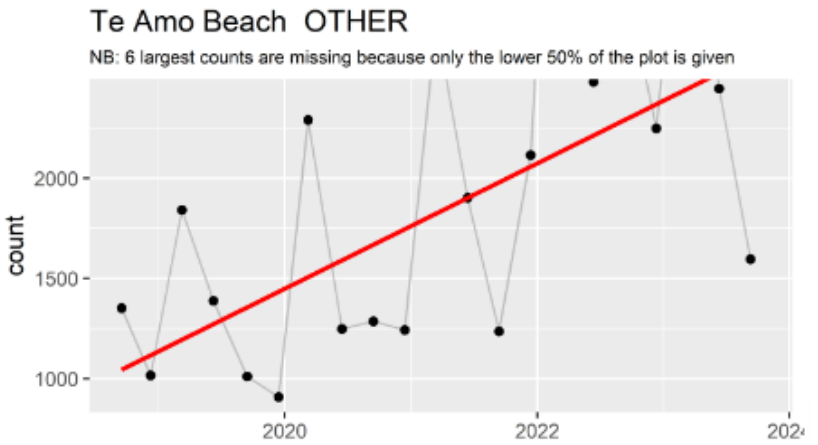

Figure 21: Trend plot 2018-2023: 5-year plot specific OTHER litter group for Te Amo Beaches – significant upward trend per 100 m beach

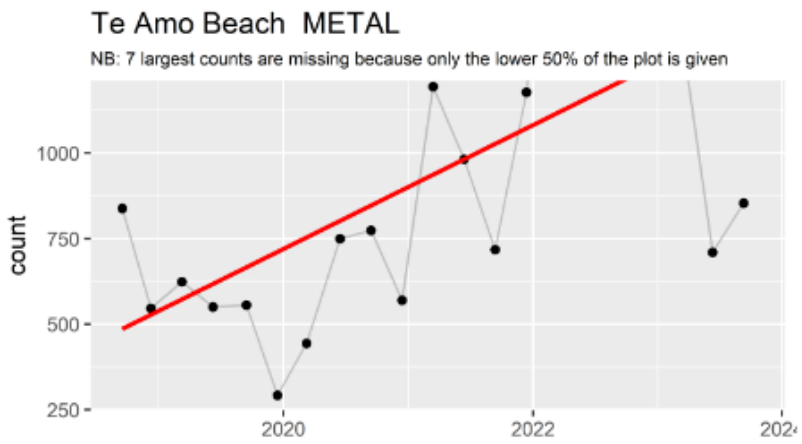

Figure 22: Trend plot 2018-2023: 5-year plot litter group "Metal" for Te Amo Beach – significant upward trend per 100 m beach

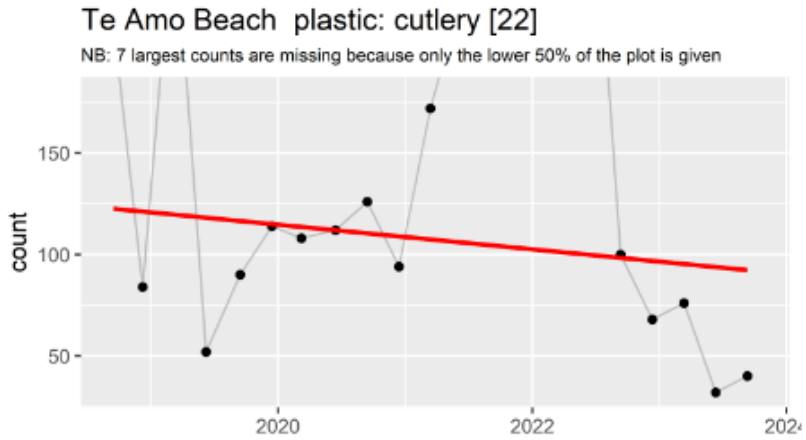

Figure 23: Trend plot 2018-2023: 5-year plot litter group "cutlery" for Te Amo Beach – non-significant downward trend per 100 m beach

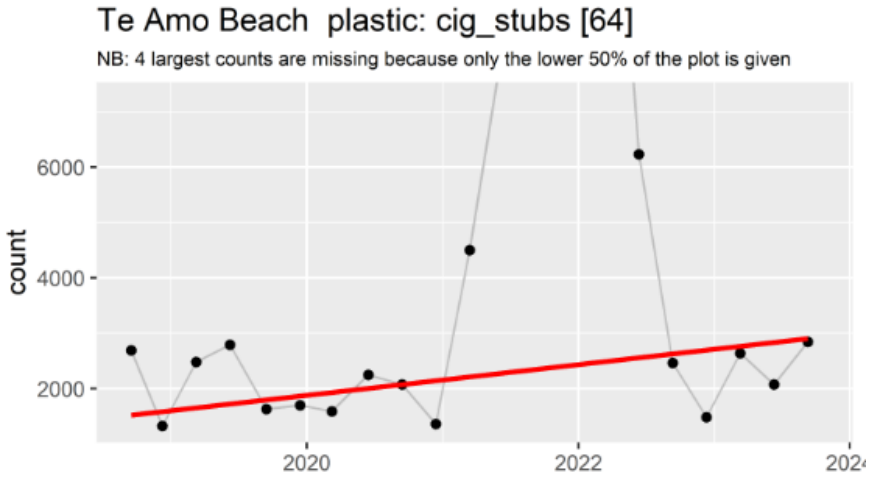

Figure 24: Trend plot September 2018 – September 2023: 5-year plot cigarette butts (stubs) for Te Amo beach –non-significant upward trend per 100 m beach

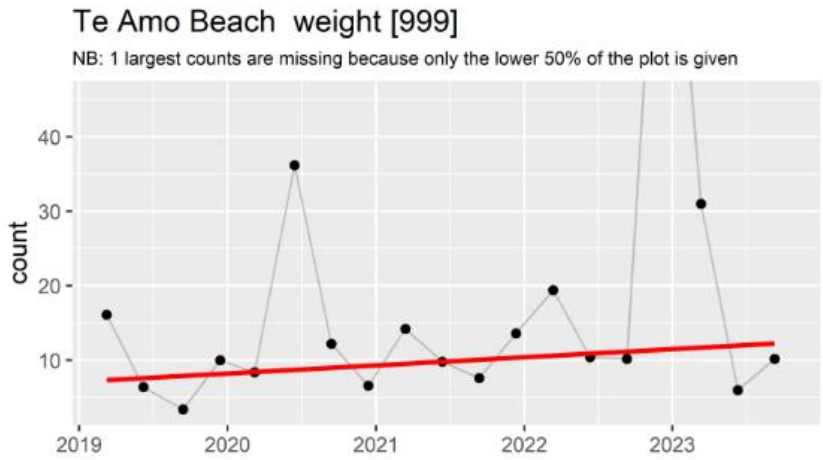

Figure 25: Trend plot weight 2018-2023: 5-year plot litter aggregated results for Te Amo Beach – small upward trend per 100 m beach. KG's on the y-axis.

3.3.1.3 Beach level: Boka Onima

The results of the trend analysis on Boka Onima are included in Table 12, followed by the time-series plots. The lines and dots have the following meaning:

- coloured dots: observations;
- red line: Regional Theil-Sen trend line (its slope is given in the tables above).

Table 12: Overview of trend analysis results of Boka Onima for the period 2018-2023 (p-values of significant trends are printed bold. Slope given in counts per year. All slopes are positive (increase) unless otherwise indicated)

Total count at beach level: Boka Onima					
Beach	type name/ group code	n	median	slope	p value
Boka Onima	TC	20	1792	460.7	**0.010**
Material trends at beach level					
Beach	type name/ group code	n	median	slope	p value
Boka Onima	PLASTIC	20	1547	447.8	**0.012**
Boka Onima	GLASS	20	134	12.4	**0.040**
Boka Onima	METAL	20	28	3.5	**0.014**
Boka Onima	WOOD	20	18	1.4	0.189
Boka Onima	RUBBER	20	13	0	0.423
Boka Onima	PAPER	20	8	0	0.526
Boka Onima	CLOTH	20	6	1.5	0.093
Boka Onima	POTTERY	20	2	0	0.936
Functional group trends at beach level					
Beach	type name/ group code	n	median	slope	p value
Boka Onima	OTHER	20	1185	369.5	**0.004**
Boka Onima	SUP	20	610	123.5	**0.037**
Boka Onima	FISH	20	29	1.3	0.279
Top 10 trends beach level					
Beach	type name/ group code	n	median	slope	p value
Boka Onima	PLASTIC: 2.5 <>50cm [46]	20	595	232.4	**0.009**
Boka Onima	PLASTIC: CAPS [15]	20	189	33.2	0.144
Boka Onima	GLASS: OTHER [93]	20	118	18.3	**0.008**
Boka Onima	PLASTIC: DRINKS [4]	20	110	48.2	**0.002**
Boka Onima	PLASTIC: FOAM_SPONGE [45]	20	80	29.2	0.064
Boka Onima	PLASTIC: FOOD [6]	20	52	11.9	**0.040**
Boka Onima	PLASTIC: CUTLERY [22]	20	49	8.0	0.076
Boka Onima	PLASTIC: OTHER [48]	20	31	13.6	**<0.001**
Boka Onima	PLASTIC: CRISP [19]	20	27	14.7	**0.023**
Boka Onima	PLASTIC: STRING [32]	20	15	0	0.474

Total weight on beach level						
Beach	type name/ group code	N	mean	median	slope	p value
Boka Onima	Total weight	20	39	22.6	7.8	**0.010**

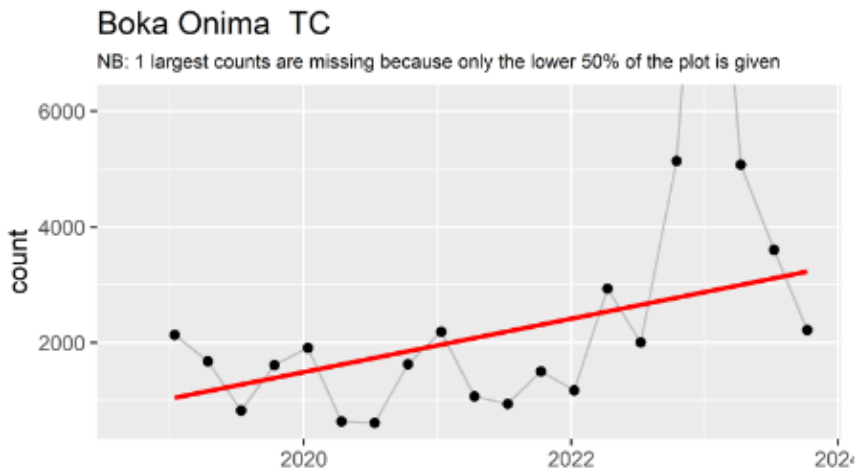

Figure 26: Trend plot 2018-2023: 5-year plot total count for Boka Onima – significant upward trend per 100 m beach

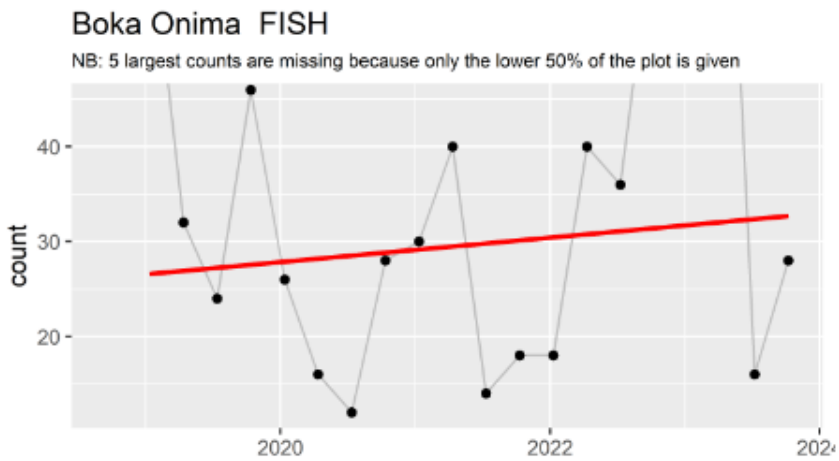

Figure 27: Trend plot 2018-2023: 5-year plot litter group FISH for Boka Onima – non-significant upward trend per 100 m beach

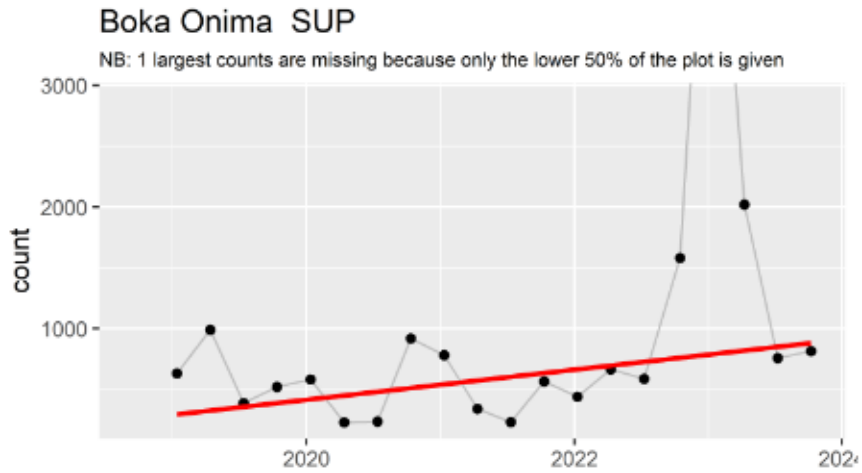

Figure 28: Trend plot 2018-2023: 5-year plot specific SUP litter group for Boka Onima – significant upward trend per 100 m beach

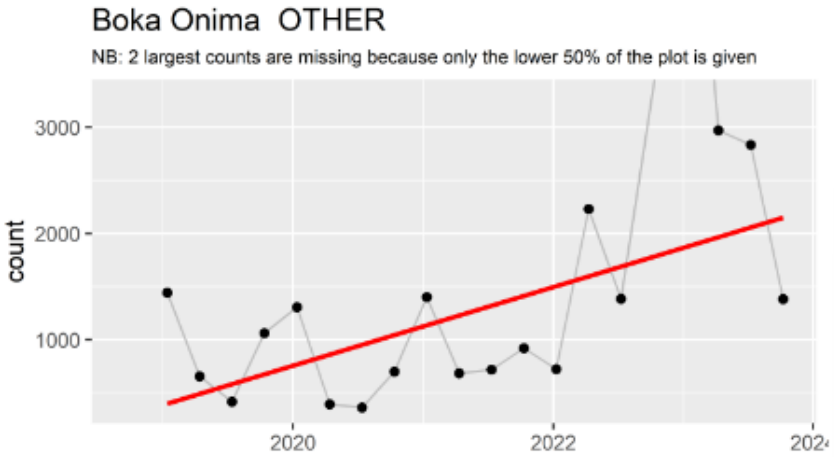

Figure 29: Trend plot 2018-2023: 5-year plot specific OTHER litter group for Boka Onima– significant upward trend per 100 m beach

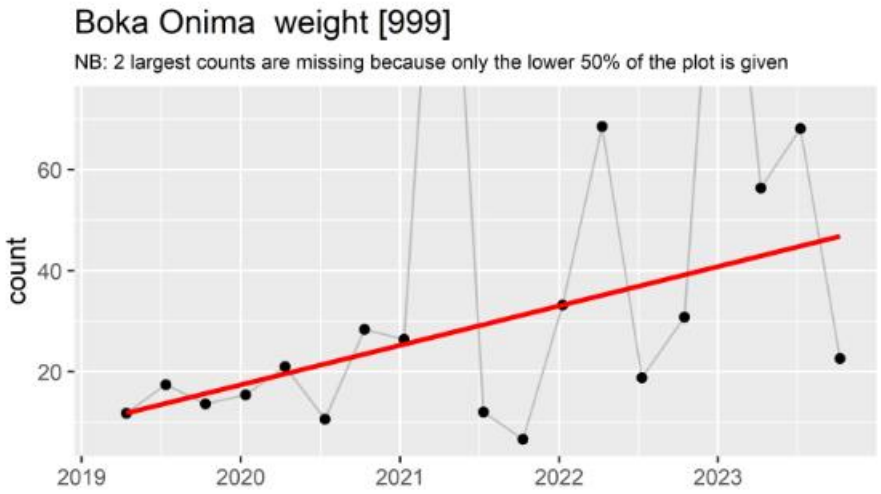

Figure 30: Trend plot weight 2018-2023: 5-year plot litter aggregated results for Boka Onima – small significant upward trend per 100 m beach. KG's on the y-axis.

3.3.1.4 Beach level: Piedra Pretu

The results of the trend analysis on Piedra Pretu are included in Table 13, followed by the time-series plots. The lines and dots have the following meaning:

- coloured dots: observations;
- red line: Regional Theil-Sen trend line (its slope is given in the tables above).

Table 13: Overview of trend analysis results of Piedra Pretu for the period 2018-2023 (p-values of significant trends are printed bold. Slope given in counts per year. All slopes are positive (increase) unless otherwise indicated)

Total count at beach level: Piedra Pretu					
Beach	type name/ group code	n	median	slope	p value
Piedra Pretu	TC	19	1266	209.2	0.072
Material trends at beach level					
Beach	type name/ group code	n	median	slope	p value
Piedra Pretu	PLASTIC	19	506	157.9	**0.034**
Piedra Pretu	GLASS	19	288	-17.4	0.264
Piedra Pretu	METAL	19	14	-1.8	0.102
Piedra Pretu	RUBBER	19	12	-2.3	0.055
Piedra Pretu	WOOD	19	6	0.7	0.286
Piedra Pretu	PAPER	19	6	1.3	0.122
Piedra Pretu	CLOTH	19	4	0	0.361
Piedra Pretu	POTTERY	19	0	0	0.079
Functional group trends at beach level					
Beach	type name/ group code	n	median	slope	p value
Piedra Pretu	OTHER	19	876	120.4	0.062
Piedra Pretu	SUP	19	204	39.9	**0.029**
Piedra Pretu	FISH	19	50	11.6	**0.021**
Top 10 trends beach level					
Beach	type name/ group code	n	median	slope	p value
Piedra Pretu	GLASS: OTHER [93]	19	264	4.6	0.473
Piedra Pretu	PLASTIC: 2.5 <>50cm [46]	19	256	82.7	0.054
Piedra Pretu	PLASTIC: CAPS [15]	19	98	7.4	0.288
Piedra Pretu	PLASTIC: FOAM_SPONGE [45]	19	32	-3.2	0.264
Piedra Pretu	PLASTIC: STRING [32]	19	24	6.0	**0.012**
Piedra Pretu	PLASTIC: CRISP [19]	19	16	8.6	**0.002**
Piedra Pretu	PLASTIC: CUTLERY [22]	19	14	6.5	**0.037**
Piedra Pretu	PLASTIC: FOOD [6]	19	12	2.2	0.146
Piedra Pretu	PLASTIC: CIG_STUBS [64]	19	10	0	0.612
Piedra Pretu	PLASTIC: OTHER [48]	19	10	8.6	**<0.001**
Total weight on beach level					
Beach	type name/ group code	N	mean	median	slope	p value
Piedra Pretu	Total weight	19	7.6	5.6	-0.1	0.470

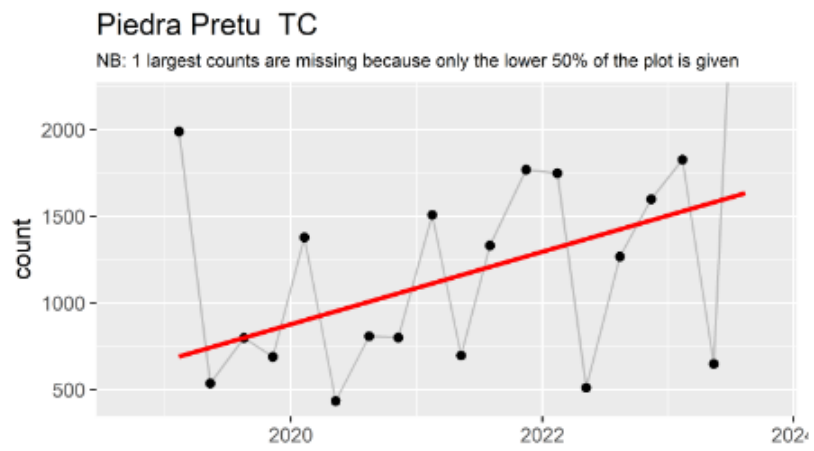

Figure 31: Trend plot 2018-2023: 5-year plot total count for Piedra Pretu – non-significant upward trend per 100 m beach

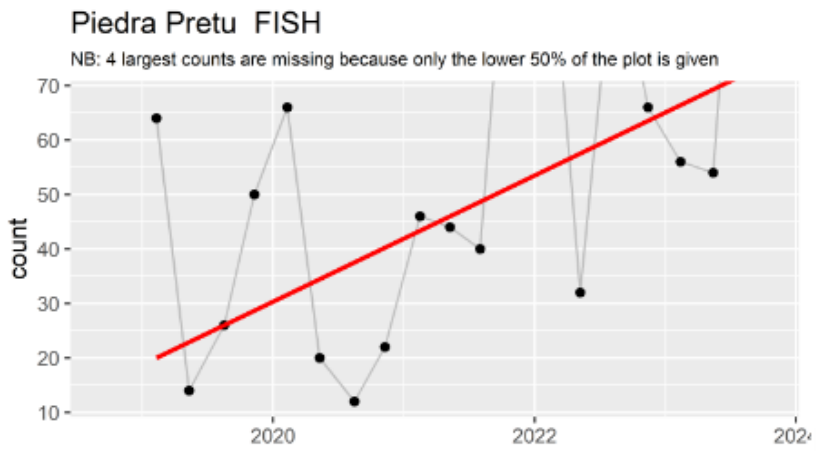

Figure 32: Trend plot 2018-2023: 5-year plot litter group FISH for Piedra Pretu – significant upward trend per 100 m beach

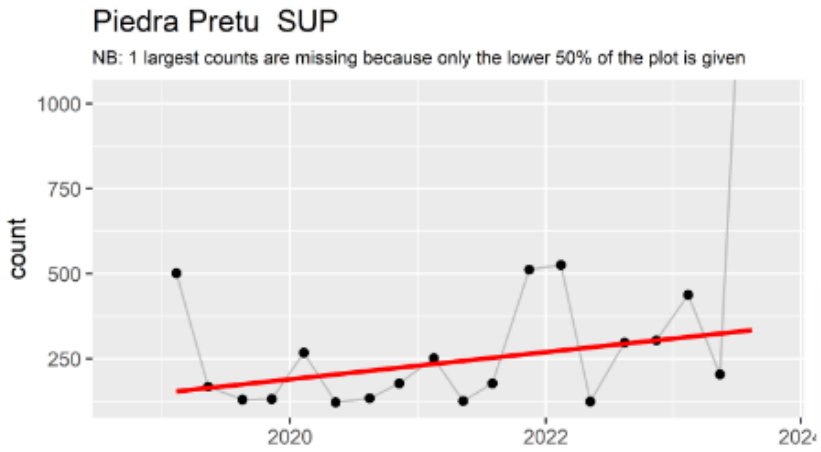

Figure 33: Trend plot 2018-2023: 5-year plot specific SUP litter group for Piedra Pretu – significant upward trend per 100 m beach

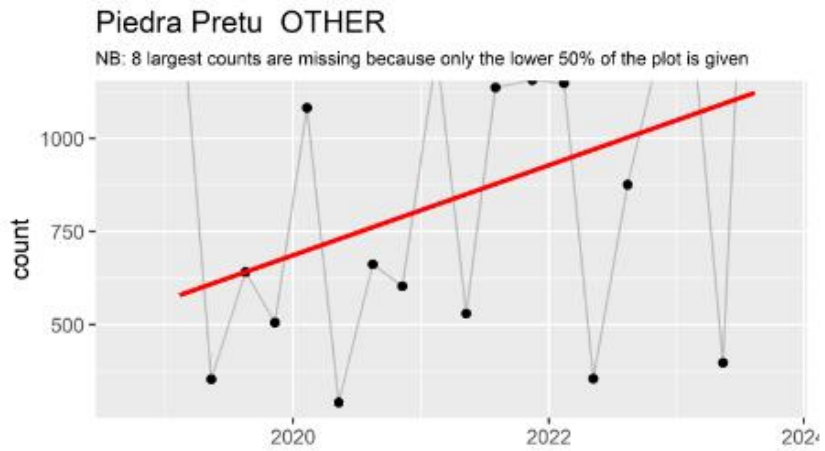

Figure 34: Trend plot 2018-2023: 5-year plot specific OTHER litter group for Piedra Pretu – non-significant upward trend per 100 m beach

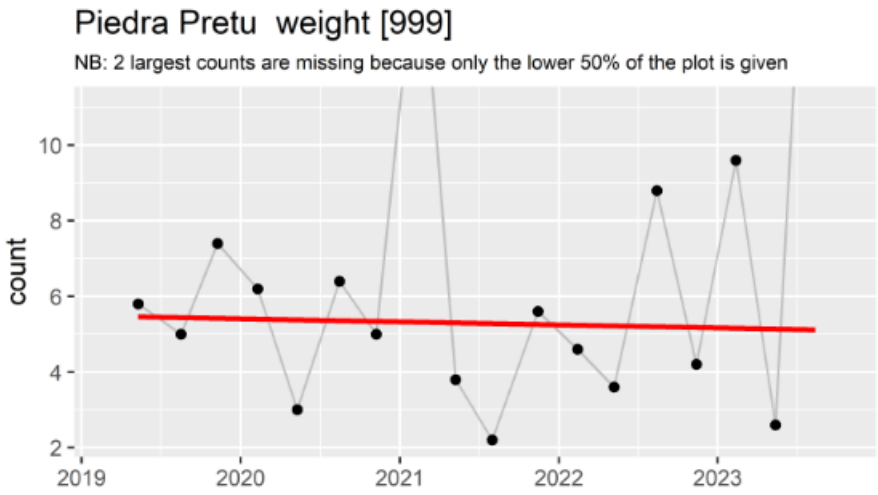

Figure 35: Trend plot weight 2018-2023: 5-year plot litter aggregated results for Piedra Pretu – small downward trend per 100 m beach. KG's on the y-axis.

3.3.2 Total count

The aggregated country (island) total count for the period September 2018 – September 2023 shows a significant upward trend. The median total count for this period is 1792 counts per 100 meter with a positive slope of 461 counts per 100 meter per year.

Median total count (count per 100 meter) for the individual beaches is 4690 (Te Amo), 1792 (Boka Onima) and 1266 (Piedra Pretu). All beaches show increasing total counts. Te Amo Beach and Boka Onima beaches show significant positive slopes with the highest slope of 560 counts per 100 meter per year on Te Amo Beach.

The category cigarette butts [64] is included in the total count calculation. The indicative 5- year trend analysis does not show any slope on national level, as it is mainly found on Te Amo Beach. For this beach the analysis shows a non-significant positive steep trend slope (278 counts per 100 meter per year), with a median count of 2480 per 100 meter beach (against approx. 10 counts per 100 meter beach for Boka Onima and Piedra Pretu). This accounts for nearly 50% of the litter recorded on Te Amo Beach in the period 2018-2023. Especially in March 2022, very high levels have been counted (7,233). See Figure 24. This skewed distribution does not affect the median total count values at country level much (1792 items per 100 meter), as the cigarette butts are mainly found at Te Amo Beach (it also does not change the top-10 at country level). However, SUP values are higher at both country- and Te Amo Beach-level. Only very small changes can be seen for Boka Onima and Piedra Pretu beaches.

3.3.3 Material group analysis (country level)

The litter types are categorized in following material categories: plastic/polystyrene, rubber, wood, paper/cardboard, glass, ceramic/pottery, metal and cloth/textile.

In the period September 2018 – September 2023 on country (island level, plastic is the most found type of material (86%) followed by glass (10%), metal (2%) and wood (1%). The other materials are rubber, paper, cloth and pottery.

Plastic has a median value of 1547 counts per 100-meter beach.

The trend analysis results show significant upward trends for plastic/polystyrene (342 counts per 100 meter per year), metal (four counts per 100 m per year), wood and paper (both one count per 100 meter per year) and a non-significant downward trend for glass (12 counts per 100 meter per year) and cloth (one count per 100 meter per year). The other materials show no trend slopes.

3.3.4 Functional group analysis (country level)

The litter types are categorized in the specific litter group types: SUP, FISH and OTHER. At country level, the specific litter groups OTHER and SUP show significant upward trends of 313 and 124 litter counts per 100 meter per year, respectively. FISH shows a small upward trend of 1 count per 100 meter per year, but is considered non-significant.

Although the Te Amo SUP trend plot does not show yet a downward (significant) trend, the graph itself seems to indicate lower values since the introduction of the SUP ban on the island in June 2022.

3.3.5 Top 10 litter types

The Bonaire top 10 most found litter types for the period September 2018 – September 2023 shows plastic/polystyrene pieces 2.5 cm >< 50 cm [46] as the most found litter type, which are mainly the

remains of the breakdown of large pieces with no specific source. It has a median of 256 litter counts per 100 meters of beach with a significant upward trend of 83 counts per 100 meter per year.

Remarkable is that this group [46] is not part of the top 10 of Te Amo Beach, although this beach has the highest median total count (4690) of the three beaches. The high numbers of [46] at country level are due to both Boka Onima and Piedra Pretu and its origin is most probably a transboundary pollution (transported from the east via ocean currents and prevailing wind direction).

The high median total count (4690) at Te Amo Beach is mainly caused by cigarette butts [64], metal caps [77] (bottle caps; metal bottle caps, lids & pull tabs from cans), and "paper: other" [67] items. The "paper: other" group is quite diverse and consists of subgroups like paper towels/napkins, firework remains, paper food trays, food wrappers, drink containers, straws, labels, receipts, and unidentifiable fragments of paper. Obviously, beach recreation is clearly the main source of litter on Te Amo Beach.

Glass Other [93], basically smaller and larger glass pieces, ranks as the number two most found litter type at country level with a median of 140 counts per 100 meter beach and a significant positive trend slope of 18 counts per 100 meter per year. Also, on all individual beaches glass is one of the top 3 items, and on Piedra Pretu even the main item.

At country level Plastic Caps [15] ranks as third most found litter type with a median value of 124 counts per 100 meter beach and positive slope of seven counts per 100 meter per year.

Also on country level: Plastic Cups [21], Crisp [19], and "Plastic: other" [48] in the top 10, all show significant upward trends.

The "other plastic" group [48] is a very mixed group of items: main subgroups are:

- personal hygiene/ care products (toothbrush, razor, etc) on all beaches;
- fire work remains on Te Amo Beach;
- plastic/pvc pipes on Boka Onima and Piedra Pretu;
- tobacco pouches/ cigarette package wrappings on Te Amo Beach;
- decorations (beads, ribbons, flowers) on Te Amo Beach;
- labels and tie-wraps on Te Amo Beach;
- dive/snorkel items on Te Amo Beach.

Other noteworthy individual categories are item [5]: plastic cleaner bottles (+containers/drums); item [8]: engine oil containers; item [12]: other plastic bottles, containers, drums and item [13]: plastic crates. All these groups are found in high numbers (but not yet reflected in top 10) on the east coast, and probably originate from shipping/fisheries sector.

Figure 36: Monitoring on Boka Onima

Figure 37: Monitoring on Piedra Pretu

Figure 38: First Survey team

Figure 39: Te Amo Beach litter (mostly cigarette butts and caps)

Figure 40: small pieces Piedra Pretu

Figure 41: Bottles on the East coast

Figure 42: paraffin wax pieces

Figure 43: counting cigarette butts on Te Amo Beach

3.4 Indicative assessment of meso-plastics fragments

The category meso-plastic fragments 0.5-2.5cm [117] has been analyzed separately. The indicative 5-year trend analysis shows a non-significant decreasing trend slope (-13 counts per 100 meter per year) on island level. The median count for this period is 2380 litter items per 100 meter beach in the period 2018-2023. The statistics of meso-plastics fragments, also on beach level, are shown in Table 14.

Table 14: State and trend analysis of meso-plastic fragments in period September 2018 – September 2023.

Beach level					
Beach	type name/ group code	n	median	slope	p value
Te Amo Beach	PLASTIC: PLASTIC_SMALL [117]	21	182	-12.8	0.228
Boka Onima	PLASTIC: PLASTIC_SMALL [117]	20	2380	-208.2	0.250
Piedra Pretu	PLASTIC: PLASTIC_SMALL [117]	19	3846	220.8	0.245
Island level					
Beach	type name/ group code	n	median	slope	p value
Bonaire	PLASTIC: PLASTIC_SMALL [117]	60	2380	-12.8	0.314

3.5 Indication of waxes presence

Since the beginning of the beach litter monitoring (2002), the presence of pollutants, such as paraffin, has been separately recorded on the OSPAR Marine Litter Monitoring Survey Form. This included three waxes size categories. Paraffin waxes are recorded per size category which are 0-1 cm [108], 1-10 cm [109] and > 10 cm [110] and the frequency of paraffin.

In the period September 2018 – September 2023 small and medium wax pieces (size 0- 1 cm [108] and 1 – 10 cm [109]) were most found, together with Other Pollutants [111]. Dozens of wax pieces are found from the summer of 2020 until spring of 2022 on Boka Onima and few are found on Piedra Pretu. The count of waxes on Te Amo Beach is near-zero, so the origin seems linked to shipping activities, east of Bonaire, and/or coming from further away (transboundary transport). However, the exact source is still unknown, and the chemical content has never been analysed. Some of the waxes on Boka Onima appear to be the remains of candles (see figure 43, below).

Figure 44: candle waxes on Boka Onima beach

The category Pollutants: Other [111] is mainly found as tar (unidentified generally dark-coloured oil-like chemicals, i.e. no chemical analysis carried out) on Piedra Pretu and as charcoal on both Te Amo Beach and Piedra Pretu. Also, food waste like bones (i.e. BBQ rib/chicken) is part of this category and is found on Te Amo Beach.

The indicative 5-year trend analysis on country level shows no significant trends. However, on beach level, some trends (of which two significant) are found:

- Te Amo Beach
  - Other pollutants [111] (charcoal and food waste as bones) show a significant positive trend of 22 counts per 100 meter per year.
- Boka Onima
  - Small waxes [108] show a small positive trend of one count per 100 meter per year.
- Piedra Pretu
  - Other pollutants [111] (tar and charcoal) show a non-significant downward trend of -10 counts per 100 meter per year.
  - Medium waxes [109] show a significant downward trend of -2 counts per 100 meter per year.

The tar presence on Piedra Pretu could be linked to the oil spill on Trinidad in April 2017, washed ashore on southeastern part of Bonaire in May 2017. Although clean-up activities took place, small occurrences might be found but should disappear over time (trend is decreasing but still non-significant).

Figure 45 and 45a: Clumps of the black substance washing up on the Bonaire's white sand beaches along the island's east coast after the Trinidad oil spill (May, 26, 2017; Petrotrin oil spill allegedly spreads to Bonaire | Loop Trinidad & Tobago (loopnews.com))

In addition, a tar globule, collected at Piedra Pretu beach during the February 2021 survey, shows a mixture of tar and plastics.


Figures 46 and 46a: tar/plastic globule found at Piedra Pretu beach, CCB survey February 2021 (left) and close-up of fibres embedded (right). Pictures by CCB.

3.6 Indication of pellets presence

An analysis was conducted on the median presence of pellets for the period September 2018 – September 2023. The results are included in Table 15. In the period 2018-2023, the median presence of pellets was that a 42% of surveys conducted pellets were found. There is no pellet production or processing on the island. Piedra Pretu is the location where in each survey pellets were found, probably originating from shipping/transboundary pollution. No pellets were found on Te Amo beach.

Table 15: Status analysis of indication of pellets presence in period September 2018 – September 2023. 2018 is excluded from the analysis.

	Status analysis Presence of pellets 2018-2023						
Location	2018	2019	2020	2021	2022	2023	% of surveys with pellets found per location in 2018-2023
Te Amo Beach	0	0	0	0	0	0	0%
Boka Onima	0	0	1	0	0	4	25%
Piedra Pretu	2	4	4	4	4	3	100%
% of surveys with pellets found per year							42%

3.7 Indication of sargassum

A preliminary analysis has been carried out on the sargassum data. Figure 48 presents the absence/presence of small/large patches of sargassum on Boka Onima and Piedra Pretu beaches, in relation to Total Counts (TC) and to meso-plastics [117]. No clear relations appear that show an influence of sargassum presence on either Total Counts or meso-plastics. More detailed research is needed to get a better grip on this phenomenon, also to verify if the litter gets stuck in the sargassum at sea or on the beach.

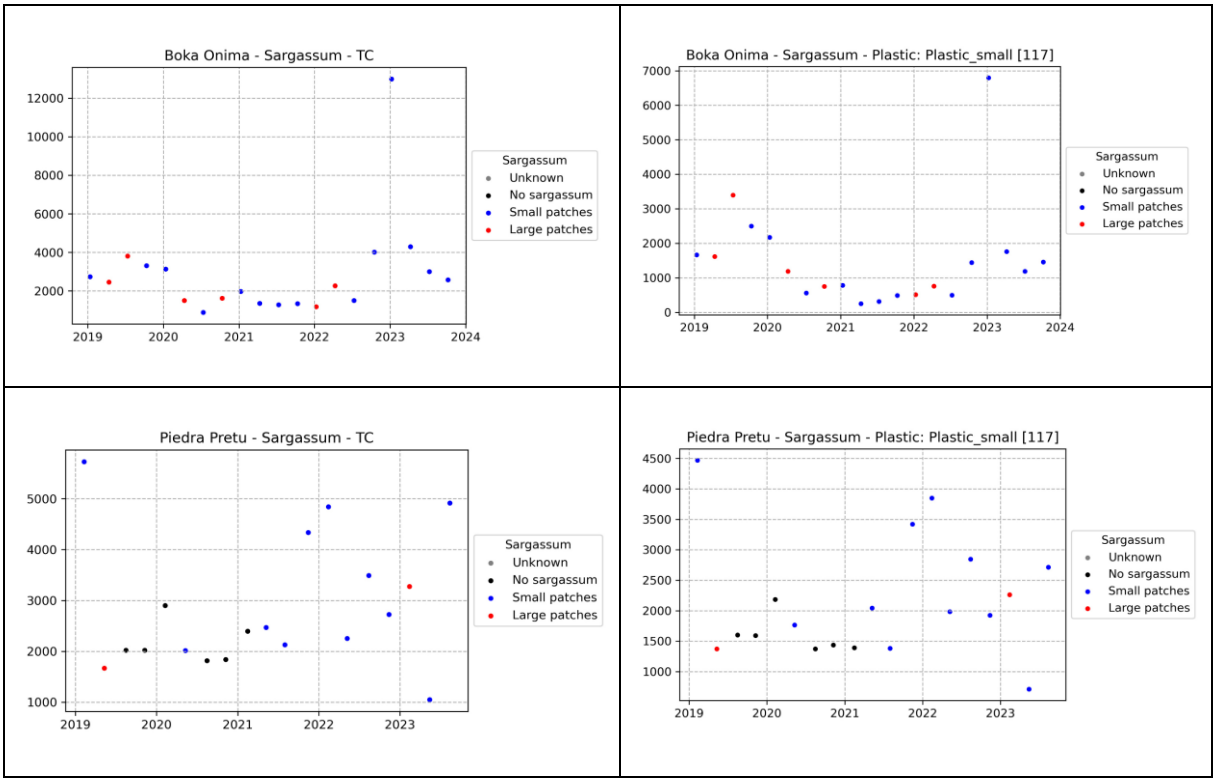

Figure 47: Sargassum plots 2019-2023 for Boka Onima and Piedra Pretu beaches, in relation to Total Counts and meso plastics values.

3.8 Indicative monitoring of total weight

The results of indicative monitoring of total weight in period February 2019 – September 2023 are included in the bottom of Tables 10-13 in chapter 3.3. The median indicative weight of marine litter per 100 meters of beach on island level is 10.6 kilogram (table 10). On beach level this matches the median weight found on Te Amo Beach (10.2 kilogram; Table 11). Boka Onima stands out with a median of 22.6 kilogram (Table 12). On Piedra Pretu the median weight found is 5.6 kilogram (Table 13).

Based on trend analysis conducted with data collected in the 4,5 years during 57 surveys, the results show a significant positive trend slope of 1.1 kilogram per year (see table 10). The trend found for Boka Onima is also considered significant and reaches 7.8 kilogram per year per 100 meter of beach. Piedra Pretu is the only beach that shows a non-significant downward trend of 0.1 kilogram per year per 100 meter of beach.

3.9 Threshold Value

The median Total Count value is calculated based on 5-year analysis period (September 2018 – September 2023) and is based on 60 surveys, where small meso-plastic fragments 0-2.5cm [117] and waxes/other pollutants are excluded. The median total count for this period is 1792 litter counts per 100 meter beach.

The total median count for macro-litter within OSPAR is 252 items per 100 meter (period 2015-2020). Along the Dutch Coast the total median count for macro-litter is 144 items per 100 meter (2017-2022). Trend analysis over this period shows a significant downward trend of -15 litter counts per 100 meter per year and a downward trend of -0.5 kilogram of litter per 100 meter per year. Both values (OSPAR and Dutch beaches) are both much lower than the counts found on Bonaire. And, for example, the European threshold of 20 counts per 100 meter beach would be way beyond reach.

3.10 Comparison with other studies

Chapter 1.2 mentioned the 2019 World Bank report (Diez et al, 2019) presented a snapshot of the level of litter showing an average of 2014 litter items per kilometer (200 items per 100 meter) found on Caribbean beaches and coastal areas and compared to a global average of 573 items per km (57 per 100 meter). Table 16 below, from Kanhai, LD.K. et al, 2022, presents a number of beach litter data in the Caribbean Large Marine Ecosystem between 1980-2020.

Table 16 – selected beaches in the Caribbean Large Marine Ecosystem (from Kanhai, LD.K. et al, 2022)

Country/region	**items/meter beach**	**Items/100 meter beach (converted from items/m)**
Whole region	< 15	< 1500
Aruba (windward side)	30	3000
Curacao	0.5 – 253	50-25300
Bonaire	0.1-1.640	10-164000
Jamaica	0-75	0-7500
Colombia	0.2.-37.8	20-3780
The Bahamas	<5 - 60	<500-6000

Other studies on beach litter in Caribbean islands that have been conducted in recent years show high levels of litter, however, the assessment methodologies differ each time, making it difficult to make a good comparison (de Scisciolo et al, 2016; Botero et al, 2017; Perez-Alvelo et al, 2021).

The results of this report are supported by previous studies carried out on the island. In 2018 and in 2020 two preliminary analyses were carried out on the same beach litter data collected by Clean Beach Bonaire (CCB/WWF (2018/19) – Year in Review; Caporusso, C. (2021) – Bonaire 2020 Plastic Baseline). Based on the data available at the time, the **average** litter amounts per meter have been determined. The average values for Piedra Pretu, Boka Onima and Te Amo Beach were respectively 49, 50 and 40 items per meter beach (or between 4000 and 5000 items per 100 meter beach). However, the major group meso-plastic/polystyrene fragments (0-2.5 cm) [117] was included, which has been excluded for the analysis of this report.

It should be noted that differences exist between average and median values (up to approximately 25%, higher and lower).

The top 15 most found items presented in the 2021 study are almost similar to the ones presented in the present study, taken into account the present exclusion of a few groups:

- at the two east coast sites, very similar in composition, the majority of the items were plastic or expanded polystyrene (EPS) but too degraded or fragmented to be identified. Common identifiable plastic/EPS items found are caps/lids, drink bottles, foam sponge, food containers, cutlery/trays/straws, chip/candy wrappers and lollypop sticks, cups and string or cord.
- at the Te Amo Beach, cigarette butts were by far the most common item. Other commonly found plastic/EPS items found here are unidentifiable pieces, cutlery/trays/straws, caps/lids, chip/candy wrappers and lollypop sticks, and decorations.

Also, Debrot presented data on beach litter and tar contamination for 21 beach sites in Bonaire. In total, a combined length of 991 m was sampled in March–May 2011. Highest litter and tar contamination were found on the beaches of the windward East coast of the island where average

litter concentrations were 115 ± 58 items per meter beach. Contamination levels for leeward west-coast beaches were generally two orders of magnitude less than windward beaches (this difference in litter contamination between windward and leeward beaches were statistically significant). Plastics were numerically the most important material component and represented 72% of all items collected followed by Expanded Polystyrene (EPS/16%) and wood (7%). The numerical differences in material distribution by coast differed significantly: while plastics followed by EPS fragments were thus numerically dominant on both beach categories, their contribution to the total weight of litter differed significantly (Debrot et al., 2013).

Debrot describes a good example of the contrast between windward and leeward beaches: (a) a higher preponderance of (small) plastic beverage bottle caps on leeward beaches and (b) a higher preponderance of plastic beverage and (large) household bottles on windward sites. While on wind-exposed windward beaches, light plastic bottles are blown up onto beaches, on leeward beaches where the wind direction is off-shore, plastic bottles seem to more often roll into the water and be carried away under conditions where bottle caps stay behind.

Debrot's study encountered tar only on two of the 11 leeward beaches and on five of the 10 windward beaches. Contamination levels averaged 223 gram per meter on windward beaches. In 2013 the level of tar contamination for Bonaire appeared to be in the same range or possibly less than it used to be in the early 1980s (Debrot et al, 2013). The present study only indicates presence of tar on windward beach of Piedra Pretu, partially linked to an oil spill incident on Trinidad in 2017.

3.11 Preliminary source identification

To date, no marine litter source identification analysis has been conducted in Bonaire. Using indicator items (Annex I, Veiga et al, 2016) gives a first, preliminary, analysis for most probable sources and originating sectors (country/island level).

Cigarette butts, although not in the top 10 (country level) table below are by far the most important group on the Te Amo (west coast) beach. This beach is very popular for daytime beachgoers (two food trucks are present) and unofficial parties at night. Dedicated local measures (policy, communication, enforcement) could or should be taken. Furthermore, the beach is also located at the mouth of Plaza Marina, susceptible for litter generated in that harbor.

Table 17: preliminary analysis for most probable sources and originating sectors (top 10 country/island level)

type name/ group code	median	Most probable source/sector	Possible measure(s)
PLASTIC: 2,5<>50 cm [46]	256	No specific source/sector: breakdown of large pieces from multiple sources Elevated on eastern beaches; transboundary pollution (washed ashore via currents/wind)	Regional (bilaterally with South American Countries; or via Cartagena Convention)
GLASS: OTHER [93]	140	Public litter/beach-recreation sector	Local policy: communication; deposit scheme
PLASTIC: CAPS [15]	124	Public litter/beach-recreation sector	Local policy: communication Retail sector: sell bottles with caps attached
PLASTIC: CUTLERY [22]	49	Public litter/beach-recreation sector	Included in local policy on SUP
PLASTIC: FOAM_SPONGE [45]	32	No specific source/sector: mostly foamed PU and PE materials used	IMO Environmental Awareness curriculum

		especially for insulation → shipping/fishing/construction sector	+ Local/regional fishing communities + local builders
PLASTIC: OTHER [48]	31	Various items: A) All beaches: personal hygiene/ care products (toothbrush, razor, etc); B) TA: fire work remains C) BO/PP: pipes D) TA: tobacco pouches/ cigarette package wrappings E) TA: decorations (beads, ribbons, flowers) F) TA: labels; tie-wraps; G) TA: dive/snorkel items A: public litter/beach-recreation sector and shipping/fishing sector B: public litter/beach-recreation sector C: shipping/fishing sector D-G: public litter beach-recreation sector	A; C: IMO Environmental Awareness curriculum + Local/regional fishing communities A; B; D; E; F; H: Local policy (incl beach cleaning; education; awareness activities; communication; enforcement)
PLASTIC: CRISP [19]	27	Public litter/beach-recreation sector	Local policy (incl beach cleaning; education; awareness activities; communication; enforcement) Could also be included in (local) policy on SUP
PLASTIC: STRING [32]	15	Fishing sector	Local/regional fishing communities
PLASTIC: CUPS [21]	14	Public litter/beach-recreation sector	Local policy (incl beach cleaning; education; awareness activities; communication; enforcement) Could also be included in (local) policy on SUP
PLASTIC: FOOD [6]	12	Public litter/beach-recreation sector	Local policy (incl beach cleaning; education; awareness activities; communication; enforcement) Could also be included in (local) policy on SUP

The top 10 items found most at island level often indicate maritime (shipping and fisheries) and transboundary related items on the east coast and coastal recreational and tourism activities on the west coast as the most predominant sources of beach litter. Potential measures are indicated in the last column and could be discussed with authorities and relevant stakeholders. Also internationally,

e.g. at the Intergovernmental Negotiating Committee on Plastic pollution, since the largest degree of the litter (on the east coast) appears to be coming from abroad.

This source identification assessment should be seen as a preliminary one and gives a feeling of type of potential sectors/sources to approach. At a later stage a more detailed source identification could/should be carried by using the Matrix Scoring Technique and/or dedicated LitterID sessions. This should be carried out using local/regional knowledge of stakeholders, and to develop measures with the best chances of success.

3.11.1 Source identification with labels

Identifying information from labels (and/or scanning bar codes) is the most straightforward method to get information on geographic origin of marine litter items. In the absence of a reliable and cost-effective method, this has not been tracked in a quantifiable way. However, based on more than 10 years of local coast cleaning experience, the majority of the readable labels are in Spanish or Portuguese indicating a South American manufacturing origin. The Caribbean Ocean Current flows along the South American coast westwards, passing the Bonaire windward east coast (see further below).

However, it should be noted that manufacture labels do not imply exactly the "location of entry into the marine environment", e.g. was it only produced in that country? was it bought in that country by a sailor and later disposed of it from a ship? did a tourist buy it and disposed of it somewhere along a beach or from a cruise ship, etc...). So some level of caution should be taken into account using this information.

Examples from Boka Onima (July 2019) present labels from China, Panama, Trinidad & Tobago and Surinam see figures 48-51 below.

Figure 48: China

Figure 49: Trinidad and Tobago

Figure 50: Panama

Figure 51: Surinam

Furthermore, a much larger than normal influx of litter (including more medical (syringes) and sanitary waste (cotton bud sticks)) seems to occur a few months after there have been heavy rains in the region, such as the January 2023 data at Boka Onima.

Something that could be explored further is OSPAR ID 37 Floats/Buoys that could be subdivided into manufactured and homemade. This could be considered to be added as another write-in category. It could have potential to indicate the socio-economic status of the source countries (3rd world vs 1st) and activities (subsistence vs commercial fisheries). See Figures 52 and 53.

Figures 52 and 53: examples of floats and buoys encountered on the beach

This source identification assessment should be seen as a preliminary one and gives a feeling of type of potential sectors/sources to approach. At a later stage a more detailed source identification could/should be carried by using the Matrix Scoring Technique and/or dedicated LitterID sessions. This should be carried out using local/regional knowledge of stakeholders, and to develop measures with the best chances of success.

4. General discussion

This beach litter assessment aims to gain insight into the quantities and types of litter that wash up and are left behind on the beaches of Bonaire. Providing insight into the presence of (floating) litter in the sea and the degree of pollution in the Caribbean Sea and providing insight in potential sources and potential measures.

Main conclusion for the Bonaire Beach litter data: the total counts are very high and the trend analysis of the aggregated Total Counts data set for 2018-2023 shows an increasing significant trend for the whole island.

There is a clear distinction between the monitoring beaches on the eastside and the westside. Boka Onima and Piedra Pretu, the two locations on the east coast, are more prone to the dominating onshore tradewinds, and the oceanic (Caribbean) Current, bringing relatively more amounts of (possible washed-up) large-sized plastics, a transboundary pollution. On Te Amo Beach, the west side of the island, more locally sourced litter types were found, like paper and metal. The offshore winds ensure less washed-up litter of relatively large-sized plastics. Obviously, beach recreation is the main source of litter on Te Amo beach.

The data collected by the surveyors seems to be of a consistent and good quality. OSPAR's guidelines (and the survey sheet) were slightly adapted to the local circumstances. Significancy values below 0.05 were often calculated by LitteR, given (some level of) trust in the data. However, future attention should be given in analysis of split data categories; look more into depth at the very wide ranging "other pollutants", "paper other" and "plastic other" categories; split weight into big/small items and on influence of sargassum on data set.

Where could the increase come from? Is it COVID related (more people going outside, to Te Amo and other, more secluded, beaches)? Is it due to more volunteers/participants collecting and counting the litter leading to higher amounts? A short analysis shows indeed collection of more smaller (< 2,5 cm) items with more participants; however, these items are excluded from the main assessment, and assessed separately. Overall, it seems that the number of items per participant roughly correlates to the total amount of litter collected (more litter → more litter per participant). Is it due to better monitoring, to more experienced surveyors with more eye for historic/old litter? Probably all these aspects are present in some way. Continuation of the monitoring would filter these aspects out. On the other hand: dealing with a lot of the litter on Te Amo Beach seems within reach of local authorities and communities.

The results point at many different types of item groups: on the one hand unidentifiable plastic, glass and paper pieces, difficult to manage, and on the other hand specific item groups that could be dealt with (cigarette butts/specific SUP items). At country level, smaller and larger glass pieces, plastic caps, plastic cups, crisps and "other plastics" all rank high and show significant increasing trends. The "other plastic" group is a very mixed group of items that requires further future analysis.

Some items related to (e.g.) Single Use Plastic are already targeted by Bonaire, and the beach litter monitoring can help to monitor the effectiveness of this measure and see if additional items might benefit from inclusion. The identification of country or regional specific items provides useful data to help identify unique problem areas within Bonaire and further provides evidence to prioritise actions (see also Briony Silburn et al (2022)). Although the Te Amo Beach SUP-trend plot does not show yet a downward (significant) trend, the graph itself seems to indicate lower values since the introduction of the SUP ban on the island in June 2022.

5. Conclusions and recommendations

This report provides a beach litter assessment on Bonaire on 2018-2023 monitoring data including status analyses and trend analyses at country (island) and beach level. The statistical analysis was conducted using LitteR software, according to the revised OSPAR CEMP guidelines, for conducting beach litter data analysis. The calculated medians are leading in presenting the results of the 5-year status and trend results for Bonaire beach litter.

In order to better compare the Bonaire beach litter data with the data assessments of OSPAR and EU countries, the original 50 m beach litter data collected have been extrapolated to 100 m. This extrapolation, with a limited factor of 2 (from 50 to 100 m), is allowed by the CEMP guidelines for beach litter.

The median total count for the island for this period is 1792 counts per 100 meter. The aggregated country (island) total count shows a significant increasing trend of 461 counts per 100 meter per year. Median total count (per 100 meter) for the individual beaches is 4690 (Te Amo Beach), 1792 (Boka Onima) and 1266 (Piedra Pretu). All beaches show increasing slopes. Te Amo Beach and Boka Onima beaches show significant increasing slopes with the highest increasing slope of 560 counts per 100 meter per year on Te Amo Beach.

Cigarette butts are encountered in very high numbers on Te Amo beach and are the number 1 item on this beach. At country level, however, cigarette butts do not come up in the Top 10 and they also do not affect the median total counts at country level. The impact on total counts is much less than expected because the median of the three locations is used for the aggregated Bonaire result. The other two beaches have low cigarette stub counts.

Main conclusion for the Bonaire Beach litter data: the median total counts are very high but in line with the overall levels within the Caribbean Large Marine Ecosystem: < 15 items/m (< 1500 items/100 m) although locally much higher levels are encountered (Kanhai et al, 2022)) and the trend analysis of the aggregated Total Counts data set for 2018-2023 shows a increasing significant trend for the whole island.

In comparison with the beach litter counts in the OSPAR region and The Netherlands, the median counts are much higher. In the OSPAR region the median count is 252 counts per 100 meter beach in the period 2015-2020, the Dutch North Sea beaches have a median count of 144 per 100 meter beach in the period 2017-2022. This means that the median count on Bonaire is more than 12 times higher as in the Netherlands. And, for example, the European Threshold of 20 counts per 100 meter beach would be way beyond reach.

The increase could be COVID related (more local tourists but also fewer international tourists) and partly linked to better monitoring. However, continuation of the monitoring would filter these aspects out.

Boka Onima and Piedra Pretu, the two locations on the east coast, are more prone to the dominating onshore trade winds, and the oceanic (Caribbean) Current, bringing relatively more amounts of (possible washed-up) large-sized plastics. Based on more than 10 years of coast cleaning experience, the majority of the readable labels are either in Spanish or in Portuguese, pointing to South American origins. On Te Amo Beach, the west side of the island, more locally sourced litter types were found, like paper and metal. The offshore winds ensure less washed-up litter of relatively large-sized plastics.

The results point at different types of item groups: on the one hand unidentifiable plastic, glass and paper pieces, difficult to manage, and on the other hand specific item groups that could be dealt with (cigarette butts/specific SUP items).

The Bonaire top 10 most found litter types for the period 2018-2023 shows plastic/polystyrene pieces 2.5 cm >< 50 cm as the most found litter type, which is mainly the remains of the breakdown of large pieces with no specific source. They are mostly found on the eastern beaches. Its origin is most probably a transboundary pollution (transported from the east via ocean currents and prevailing wind direction). Glass ranks as the number two most found litter type at country level, Plastic Caps as number three.

Meso-plastic fragments 0.5-2.5 cm have been analyzed separately. The median count for 2018-2023 is 2380 counts per 100 meter beach .The trend analysis shows a (non-significant) decreasing trend slope per 100 meter per year on island level.

The high median total count at the western beach of Te Amo is mainly caused by cigarette stubs, metal caps (bottle caps; metal bottle caps, lids & pull tabs from cans) and the very diverse "paper other" items. Obviously, beach recreation is the main source of litter on this beach. Although the Te Amo Beach SUP-trend plot does not show yet a downward (significant) trend, the graph itself seems to indicate lower values since the introduction of the SUP ban on the island in June 2022.

The "other plastic" group [48] is a very mixed group of items, mostly reflecting tourist items on Te Amo beach.

A number of individual categories (item [5]: plastic cleaner bottles (+containers/drums); item [8]: engine oil containers; item [12]: other plastic bottles, containers, drums and item [13]: plastic crates), mostly on the east coast, probably originate from shipping/fisheries sectors.

Also "other pollutants and plastic pellets" are found on the eastern beaches, thus indicating offshore sources like shipping: cleaning paraffin tanks; pellets loss; oil spills (although the current presence of tar seems to be linked to the 2017 Trinidad oil storage tank incident).

Recommendations

Monitoring

1) The beach litter monitoring surveys seem to yield good quality data. However, future attention should be given to:
   - analysis of split data categories;
   - additional data collection within the very wide ranging "other pollutants", "paper other" and "plastic other" categories;
   - split weight into big/small items;
2) further research and on influence of sargassum on data set[17]. Continuation of the monitoring, preferably under supervision with a dedicated (paid) team to direct any volunteers, is key to obtain longer data series with consistent quality.
3) In order to better compare the data with other beach litter data in the region, it would be useful to support expansion of harmonized structural, long-term OSPAR monitoring in all of the Dutch Caribbean support harmonized monitoring within the WCR and sharing of best practices from the OSPAR region. As is done in this study, data should preferably be normalized to 100 m.

[17] include recording total percentage of sargassum coverage also on *Modified OSPAR Survey Data Form*

4) Measures against marine litter require quantitative data for the assessment of litter abundance, trends and distribution. A set of baselines could enable the future monitoring of progress in reduction. The EU Technical report (Hanke et al, 2019) contains further guidance for this, a process closely related to top litter item identification and litter threshold values.
5) The preliminary source identification in this study, using indicator items, should be enhanced by using the Matrix Scoring Technique and/or a dedicated Litter ID sessions, aimed at in-detail investigations of the litter collected on a specific beach.

Reduction Measures

6) Based on the knowledge of amounts, composition and sources of marine litter, a follow-up step would be to start working on a two-part action plan that addresses both local and regional litter reduction measures and includes the following considerations:
    a. Address the diverse litter sources by involving cross-sector stakeholders and utilizing various approaches.
    b. Initially target litter items with the highest abundance (this does not necessarily imply the items with biggest impact and/or effects) and from sources that could be dealt with locally.
    c. Many specific ("other") category items outside the top 10 should/could also be dealt with: very often, measures dealing with the top 10 items can easily be expanded to include a great number of specific non-top 10 items, thus generating greater effectiveness.
7) Develop locally oriented measures to address litter from coastal recreational and tourism activities. Potential measures can include:
    a. (donkey-proof) Litter bins and management responsibilities;
    b. Role for authorities to clean up beaches after specific events;
    c. Communication and education;
    d. Enforcement;
    e. Inclusion of additional problematic plastic items (i.e. cigarette butts) in the Bonaire SUP policy. (In 2022, the Bonaire government (OLB Bonaire 2021) has agreed to ban the sale and provision of a number of Single-Use Plastic items: plastic bags, straws, stirrers, cutlery and EPS food packaging).
8) Cooperate regionally to address transboundary litter by ratifying the Cartagena Convention's LBS Protocol. The LBS Protocol is the only legally binding, regional agreement that incorporates general obligations to address land-based sources of pollution (including marine litter) in the Wider Caribbean. The UN Caribbean Environment Programme, as Secretariat for the LBS Protocol, provides support for Contracting Parties to implement essential marine litter measures, such as improving waste management programs, increasing public awareness and education, and providing a forum to facilitate regional cooperation. Ratification will allow the Netherlands to actively participate in the Caribbean in a manner similar to what they are already successfully doing to reduce marine litter in the OSPAR region.
9) Initiate the conversation to address maritime (shipping and fisheries) and transboundary related items. Potential measures for these sectors should be discussed with these stakeholders, local and regional shipping/ fishing communities and ideally also be addressed at a joint regional level (Cartagena Convention) and bilaterally with countries sharing the north-eastern coastline of South American from Venezuela to Brazil; results should be presented and potential solutions discussed.

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Appendices

Appendix I Clean Coast Bonaire (CCB) database beach litter monitoring 2018-2023

Separate file, available at carolyn@cleancoastbonaire.org

Appendix II LitteR reports and files 2018-2023

Separate (ZIP) folder, available at marijke.boonstra@minienw.nl

Appendix III Environmental situation and source identification

In order to assess the origin of the beach litter items, it is important to know more about the environmental situation: 1) the direction of oceanographic currents around the island; 2) prevalent wind direction;3) (potential) pollution sources on and around the island.

Plastic pollution in the Caribbean Large Marine Ecosystem (CLME) is a transboundary issue as sea surface currents are responsible for transporting plastic debris into, within and out of the region (see Figure A III-1). Water from the North and South Atlantic Ocean as well as the adjacent North Brazil Shelf LME is transported into the CLME via oceanic currents at its eastern and southern regions. Evidence for the off-island origins (regional or more distant) of marine debris and their potential transport to the CLME by oceanic currents were (i) beaches on certain SIDS (St. Lucia, Bonaire, Aruba, Bahamas) had higher quantities of marine debris reported on windward (east coast) beaches exposed to the Atlantic Ocean than leeward (west coast) beaches and, (ii) debris items stranded on beaches had foreign manufacturer labels whose origin could be pinpointed as being neighboring or distant countries (Kanhai, LD.K. et al, 2022).

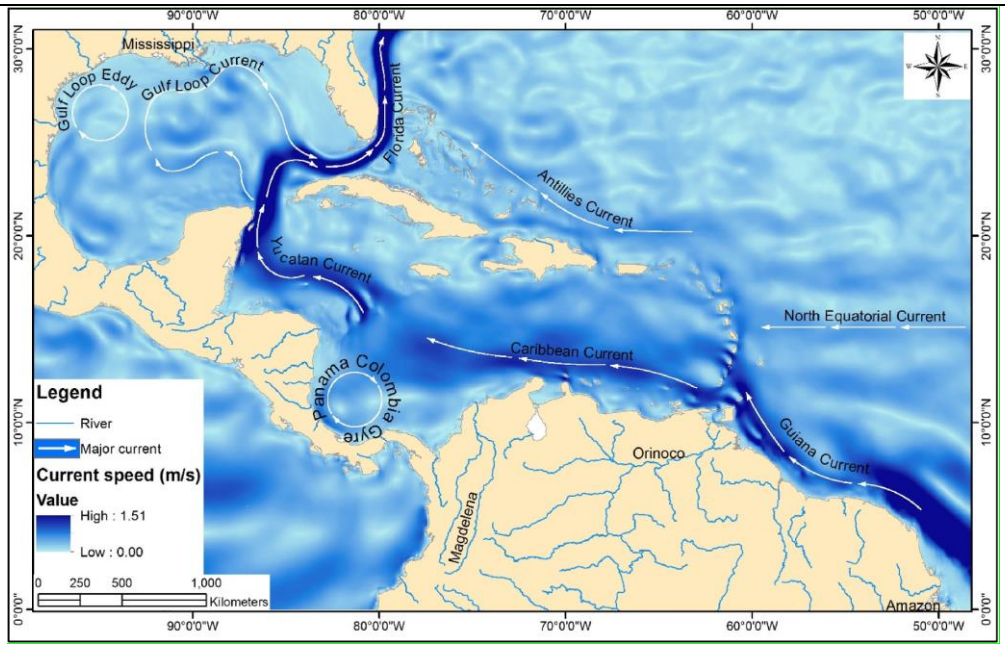


Figure A III-1. Major rivers and oceanic currents influencing the CLME. Average current speeds were based on Hybrid Coordinate Ocean Model (HYCOM) data from 2020. HYCOM generates 3 hourly current directions expressed as U (eastward velocity) and V vectors (westward velocity) for a number of vertical layers. For each vector coordinate location, the U and V values for the surface layer were averaged for 2020, and then the current speed calculated. The rivers were generated from data downloaded from Natural Earth. – from Kanhai et al (2022).

The current at Piedra Pretu (southeastern, windward) is most frequently North to South. Apparently, the current is deflected when it flows around the island. However, there is no scientific data to support this. Information from divers insists that in the southeast the current is more frequently north to south (C. Caporusso, pers. Comm.).

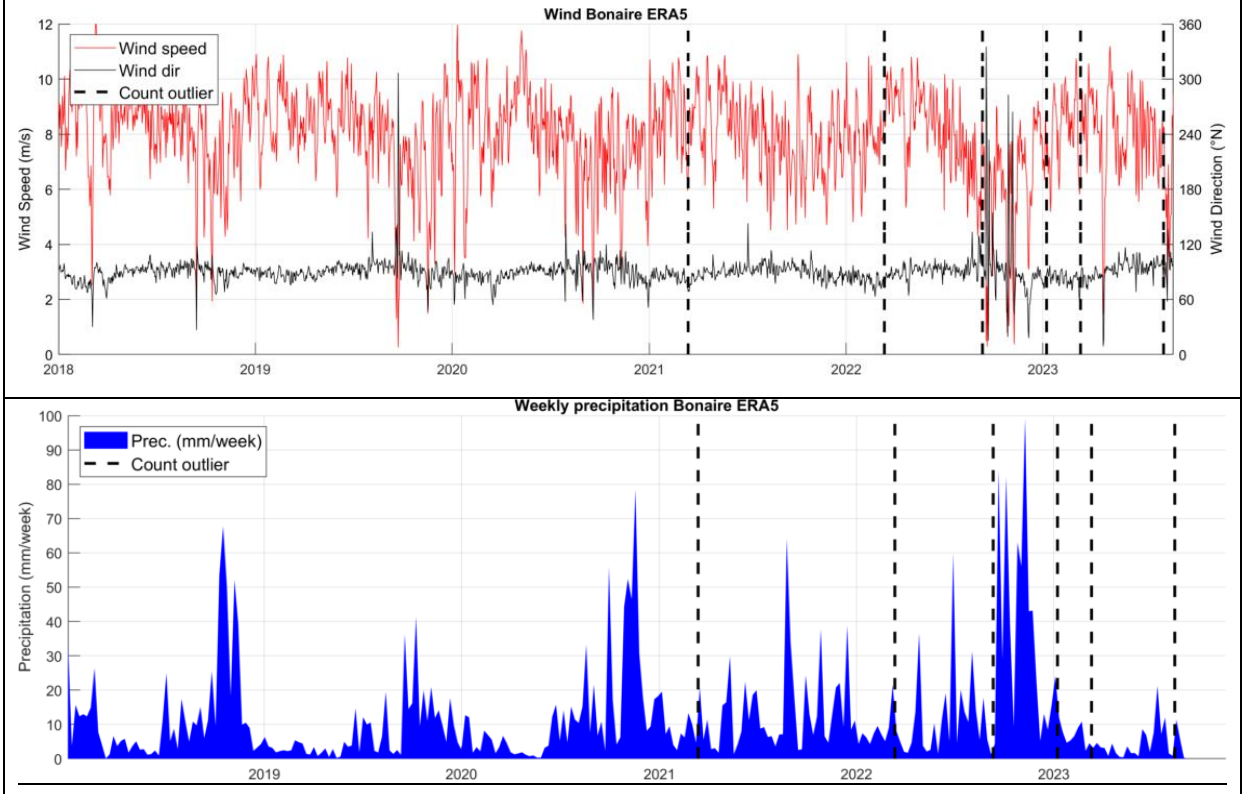
The ocean current reach Bonaire's east coast from the east/southeast. According to the Bonaire beach litter metadata the prevailing ocean currents off the two monitoring beaches, Te Amo (western, leeward) and Boka Onima (northeastern, windward) is South to North but is subject to variations. See also van der Geest et al (2020).

Beaches are an important source of debris to the shallow regions of reefs and wave action can transport debris from the reef terrace to deeper regions of coral reefs (Nagelkerken, 2021, as cited by Kanhai et al (2022). Submerged debris was also recorded in seagrass beds in Bonaire (Debrot et al., 2013b).

Prevalent winds and precipitation

The figures A III-2a and b below display, respectively, the wind speed and direction and precipitation over the whole period as given by the Copernicus Climate Change Service[18] in combination with the count outlier events.

The prevalent (trade)wind direction is east (approx. 90 degrees N), as is also clearly shown by data. The precipitation data clearly shows a yearly pattern with more rainfall towards the end of each year. There seems to be no clear correlation between neither the wind nor the precipitation and the outliers, but a more in-depth assessment could be needed (including data from South Amerca).



Figures A III 2a (upper) and 2b (lower): the wind speed and direction and precipitation over the whole period as given by the Copernicus Climate Change Service in combination with the count outlier events.

[18] https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview

Citing the data: Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2023): ERA5 hourly data on single levels from 1940 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), DOI: 10.24381/cds.adbb2d47 (Accessed on DD-MMM-YYYY)

DOI: 10.24381/cds.adbb2d47

Potential pollution sources

Bonaire is a small island (288 km2) with a permanent population of 24.090 [1/1/2023] inhabitants. It is a popular tourist destination: yearly approximately 173.000 tourists by plane (2022), 56.600 by cruise ship (2021) and 1.200 by sailing vessels (2021) tourists come to the island.[19]

Its geographical situation, off the north coast of Venezuela, in relation to the eastern currents and prevailing wind directions, makes it vulnerable for pollution coming from the North coast of South America. There is a number of coastal rivers flowing into the Caribbean Seas. The largest t river nearby Bonaire (river mouth is at 112 km) is the Hueque river. However, this river is located South West from Bonaire, so will, given the prevailing eastern currents/wind, probably not contribute to the marine litter washing ashore.

To illustrate to vulnerability of Bonaire for transboundary pollution is an incident in Trinidad and Tobago on 23 April 2017. An oil storage tank ruptured and 20.000 gallons of oil flowed into the Caribbean Seas reaching Bonaire's Southeast coast after a month where tar was washed ashore (near Sorobon). [20]

a) Watercourses

There are no real rivers on Bonaire itself but the following streams exist. All are intermittent streams, except Roi Kaohari.[2]

- Rooi Grandi, 12°16'00"N 68°18'00"W
- Roi Kaohari, 12°12'40"N 68°12'41"W
- Rooi Tuna, 12°11'45"N 68°13'07"W
- Rooi Promente, 12°10'56"N 68°13'29"W
- Rooi Huba, 12°14'49"N 68°22'24"W
- Camia, 12°18'00"N 68°23'00"W

b) Shipping, ports and marinas

Being an island, shipping is an important sector in Bonaire.

The oil terminal of BOPEC (NW coast) was frequently visited by oil tankers (229 in 2010 according to MARIN (2012) and 380 incoming and 60 outgoing loaded tankers per year according to Diana Slijkerman et al, (2016). The BOPEC terminal has been closed in 2021.

Another intense shipping industry is the cruise industry (Kralendijk port/town; 165 calls in 2022.[21]

Other smaller shipping activities are local cargo and supplies (e.g., containers to Kralendijk port), the CARGILL salt terminal (SW) and fuel trans-shipment for the airport, W, close to Te Amo beach (MARIN, 2012).

There are no specific shipping lanes around the island. "Through traffic" West – East lanes can be found at approx. 50 North and South of the island. Most shipping takes place on the western (leeward) side. A lot of traffic takes place towards/from Curacao. See maps below (Figures A III-3 and A III-4).

[19] https://www.cbs.nl/
[20] Trinidadian Oil Spill Reaches Bonaire's East Coast – InfoBonaire
[21] Preparing for the Upcoming 2023-2024 Cruise Season - InfoBonaire

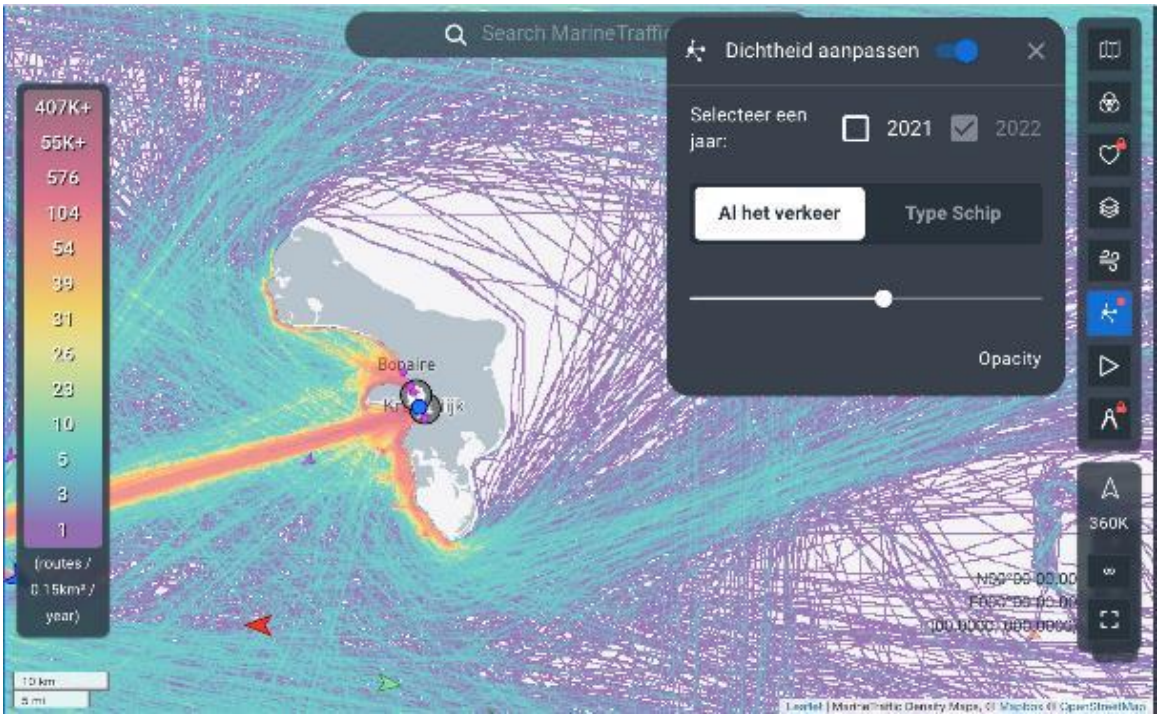


Figure A III-3: Marine traffic density in 2022 (all traffic). From: www.marinetraffic.com

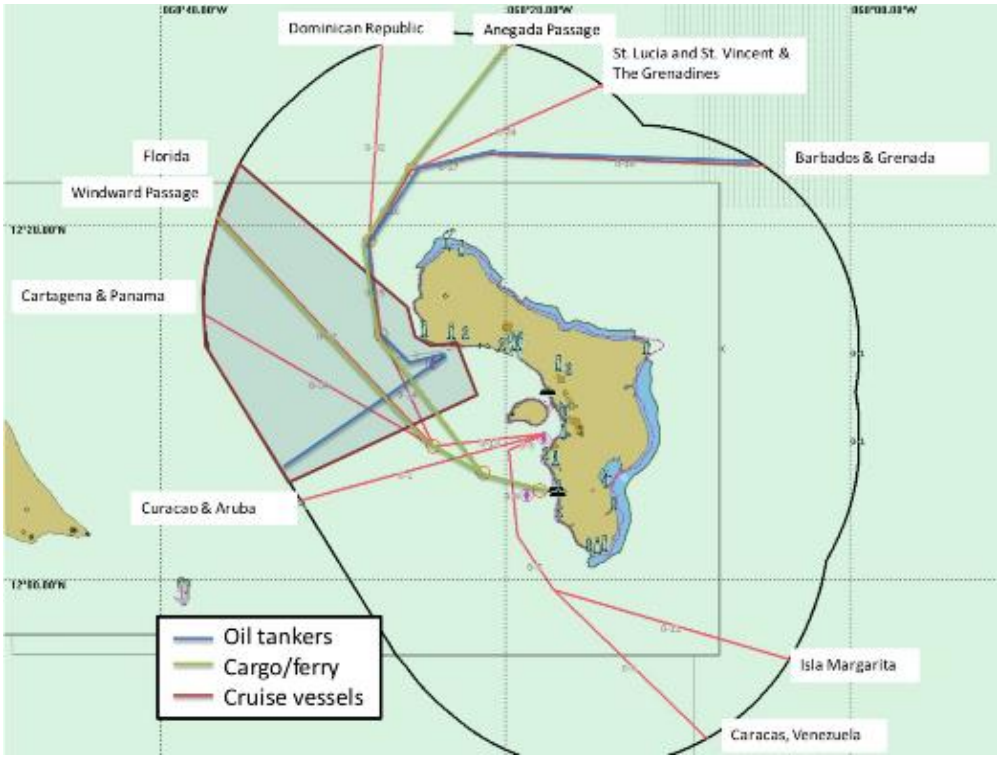


Figure A III-4: Shipping around Bonaire. From: MARIN – Qualitative nautical risk assessment for the Dutch Caribbean. Report nr 25478-1-MSCN-rev 3. 16 February 2012.

There are two marinas for pleasure crafts: Harbour Village (north of Kralendijk terminal) and Plaza Marina (south of Kralendijk Terminal; entry point directly north of Te Amo beach. In addition, there are mooring field for resident boat owners and visiting private yachts.

c) Towns

Main town is Kralendijk (19.011 inhabitants; 2020) on the Westcoast of the island. A smaller settlement is Rincon, in the North.

d) Sewage/stormwater outflows

The coastal area of Bonaire has a closed sewage system that goes to a wastewater treatment plant inland. Outside of the coastal area there are septic tanks and cesspools that are pumped out and trucked to the wastewater treatment plant, located inland. The treated water is stored in tanks and re-used for irrigation. [22]

e) Beaches

Besides Te Amo beach, one of the monitoring beaches, most of the western, leeward coastline (that is not walled off by private residences) is a public area utilized by divers, snorkelers, visitors, and residents to hang out. Areas that have more sand and shade are the most popular such as (besides Te Amo): Donkey Beach, Bachelor's Beach and Pink Beach typically attract the most recreational visitors. However, based on the strong and near-constant wind coming from the east, it is not expected that any litter found on Te Amo is coming from these other sites. However, standing crop surveys using the Ocean Conservancy CleanSwell App indicate similar litter composition to what is found at Te Amo Beach.

f) Fishing

Bonaire has a small-scale local fishing industry. Some recreational sport-fishing, subsistence and commercial deep sea fishing takes place on the leeward side. Some commercial fishing boats leave/arrive from Lac Cal/Sorobon. These boats fish on pelagic fish, mostly line fishing. The Bonaire National Marine Park restricts any fishing that is not using traditional methods such as lines and approved nets. Angling from the east coast is rare and shellfish foraging does take place. Illegal long-liners and trawlers occasionally enter Bonaire's territorial waters.

g) Waste management facilities

According to Debrot (2013), municipal dumping of domestic waste into the sea in Bonaire, at the west-coast dumpsite at Wecua, had already stopped by the mid-1970s, when the current landfill was opened. The island's landfill is centrally located on Kaminda Lagoon[23]. Currently, Selibon NV is the designated collection service responsible for collection, transshipment, transport, treatment and processing of waste.

[22] https://maps.app.goo.gl/Si5XMvRDmdVpw71K9; https://www.webbonaire.com/wastewater/?lang=en

[23] https://maps.app.goo.gl/RYeRhqyoaCYQDvYCA

Undocumented illegal dumping of waste on land does still (increasingly) occur and Selibon (municipality) is trying to address this by temporarily making the landfill free of charge and organizing a week of clean ups.[24]

There are no full-blown port waste reception facilities on Bonaire, being a small-island-state. Bonaire received IMO approval for ships to take their garbage/waste and their grey water to the next port-of-call. However, some small amounts of garbage/waste from smaller ships is collected and taken to the landfill. Also some grey water is collected, in some cases, and taken to the island's waste water treatment plant (pers. Comm. Harbormaster of Bonaire).

The maps below (Figure A III-5) present the locations of some pollution sources in relation to the location of the monitoring beaches.

Figure A III-5: selected potential pollution sources in relation to the locations of the monitoring beaches.

Boka Onima

Piedra Pretu

Te Amo Beach

[24] https://bes-reporter.com/joint-action-aims-to-make-bonaire-cleaner/

Appendix IV Survey dates and weights

#	Beach	Date	Weight (kilogram per 50 meter)	Normalized to 100 m
1	Te Amo Beach	9-3-2019	8.06	16.1
2	Te Amo Beach	8-6-2019	3.2	6.4
3	Te Amo Beach	14-9-2019	1.7	3.4
4	Te Amo Beach	14-12-2019	5	10.0
5	Te Amo Beach	8-3-2020	4.2	8.4
6	Te Amo Beach	14-6-2020	18.1	36.2
7	Te Amo Beach	13-9-2020	6.1	12.2
8	Te Amo Beach	13-12-2020	3.3	6.6
9	Te Amo Beach	14-3-2021	7.1	14.2
10	Te Amo Beach	13-6-2021	4.9	9.8
11	Te Amo Beach	12-9-2021	3.8	7.6
12	Te Amo Beach	12-12-2021	6.8	13.6
13	Te Amo Beach	13-3-2022	9.7	19.4
14	Te Amo Beach	12-6-2022	5.2	10.4
15	Te Amo Beach	11-9-2022	5.1	10.2
16	Te Amo Beach	11-12-2022	45.4	90.8
17	Te Amo Beach	12-3-2023	15.5	31.0
18	Te Amo Beach	11-6-2023	3	6.0
19	Te Amo Beach	10-9-2023	5.1	10.2
20	Boka Onima	13-4-2019	5.9	11.8
21	Boka Onima	13-7-2019	8.7	17.4
22	Boka Onima	12-10-2019	6.8	13.6
23	Boka Onima	12-1-2020	7.7	15.4
24	Boka Onima	12-4-2020	10.5	21.0
25	Boka Onima	12-7-2020	5.3	10.6
26	Boka Onima	11-10-2020	14.2	28.4
27	Boka Onima	10-1-2021	13.2	26.4
28	Boka Onima	11-4-2021	73.2	146.4
29	Boka Onima	11-7-2021	6	12.0
30	Boka Onima	10-10-2021	3.3	6.6
31	Boka Onima	9-1-2022	16.6	33.2
32	Boka Onima	10-4-2022	34.3	68.6
33	Boka Onima	10-7-2022	9.4	18.8
34	Boka Onima	16-10-2022	15.4	30.8
35	Boka Onima	8-1-2023	66.9	133.8
36	Boka Onima	9-4-2023	28.2	56.4
37	Boka Onima	9-7-2023	34.1	68.2
38	Boka Onima	8-10-2023	11.3	22.6

39	Piedra Pretu	9-2-2019	10.7	21.4
40	Piedra Pretu	11-5-2019	2.9	5.8
41	Piedra Pretu	17-8-2019	2.5	5.0
42	Piedra Pretu	9-11-2019	3.7	7.4
43	Piedra Pretu	9-2-2020	3.1	6.2
44	Piedra Pretu	10-5-2020	1.5	3.0
45	Piedra Pretu	15-8-2020	3.2	6.4
46	Piedra Pretu	8-11-2020	2.5	5.0
47	Piedra Pretu	14-2-2021	8	16.0
48	Piedra Pretu	9-5-2021	1.9	3.8
49	Piedra Pretu	1-8-2021	1.1	2.2
50	Piedra Pretu	14-11-2021	2.8	5.6
51	Piedra Pretu	13-2-2022	2.3	4.6
52	Piedra Pretu	8-5-2022	1.8	3.6
53	Piedra Pretu	14-8-2022	4.4	8.8
54	Piedra Pretu	13-11-2022	2.1	4.2
55	Piedra Pretu	12-2-2023	4.8	9.6
56	Piedra Pretu	14-5-2023	1.3	2.6
57	Piedra Pretu	13-8-2023	11.1	22.2

Appendix V List of OSPAR litter types and assignment litter groups

Source: TGML beach litter photo guide.
https://mcc.jrc.ec.europa.eu/main/photocatalogue.py?N=41&O=457&cat=all
Note: with some interpretation in the conversion of the Joint list codes to the OSPAR codes

type_name	included	SUP	FISH	OTHER
Plastic: Yokes [1]	x	x		x
Plastic: Bags [2]	x	x		
Plastic: Small_bags [3]	x	x		x
Plastic: Bag_ends [112]	x	x		x
Plastic: Drinks [4]	x	x		
Plastic: Cleaner [5]	x			x
Plastic: Food [6]	x	x		
Plastic: Toiletries [7]	x			x
Plastic: Oil_small [8]	x			x
Plastic: Oil_large [9]	x			x
Plastic: Jerry_cans [10]	x			x
Plastic: Injection_gun [11]	x			x
Plastic: Other_bottles [12]	x			x
Plastic: Crates [13]	x			x
Plastic: Car_parts [14]	x			x
Plastic: Caps [15]	x	x		
Plastic: Cigarettelighters [16]	x			x
Plastic: Pens [17]	x			x
Plastic: Combs [18]	x			x
Plastic: Crisp [19]	x	x		
Plastic: Toys [20]	x			x
Plastic: Cups [21]	x	x		
Plastic: Cutlery [22]	x	x		
Plastic: Fertiliser [23]	x			x
Plastic: Meshbags [24]	x			x
Plastic: Gloves [25]	x			x
Plastic: Gloves_pro [113]	x			x
Plastic: Lobsterpots [26]	x		x	
Plastic: Fish_tags [114]	x		x	
Plastic: Octopus_pots [27]	x		x	
Plastic: Oyster_nets [28]	x		x	
Plastic: Oyster_trays [29]	x		x	
Plastic: Mussel_sheeting [30]	x		x	
Plastic: Rope [31]	x		x	

Plastic: String [32]	x		x	
Plastic: Fishing_net_small [115]	x		x	
Plastic: Fishing_net_large [116]	x		x	
Plastic: Tangled [33]	x		x	
Plastic: Fishboxes [34]	x		x	
Plastic: Fishing_line [35]	x		x	
Plastic: Light_sticks [36]	x		x	
Plastic: Floats [37]	x		x	
Plastic: Buckets [38]	x			x
Plastic: Strapping [39]	x			x
Plastic: Industrial [40]	x			x
Plastic: Fibre_glass [41]	x			x
Plastic: Hard_hats [42]	x			x
Plastic: Shotgun [43]	x			x
Plastic: Shoes [44]	x			x
Plastic: Foam_sponge [45]	x			x
Plastic: Plastic_small [117]				
Plastic: Plastic_large [46]	x			x
Plastic: Plastic_vlarge [47]	x			x
Plastic: Other [48]	x			x
Plastic: Cig_butts [64]	x	x		
Rubber: Balloons [49]	x	x		
Rubber: Boots [50]	x			x
Rubber: Tyres [52]	x			x
Rubber: Other [53]	x			x
Cloth: Clothing [54]	x			x
Cloth: Furnishings [55]	x			x
Cloth: Sacking [56]	x			x
Cloth: Shoes [57]	x			x
Cloth: Other [59]	x			x
Paper: Bags [60]	x			x
Paper: Cardboard [61]	x			x
Paper: Purepak [118]	x			x
Paper: Tetrapak [62]	x			x
Paper: Cig_packets [63]	x			x
Paper: Cups [65]	x			x
Paper: Newspapers [66]	x			x
Paper: Other [67]	x			x
Wood: Corks [68]	x			x

Wood: Pallets [69]	x			x
Wood: Crates [70]	x			x
Wood: Lobsterpots [71]	x			x
Wood: Fish_boxes [119]	x			x
Wood: Lolly [72]	x			x
Wood: Brushes [73]	x			x
Wood: Other_small [74]	x			x
Wood: Other_large [75]	x			x
Metal: Aerosol [76]	x			x
Metal: Caps [77]	x			x
Metal: Drink [78]	x			x
Metal: Bbqs [120]	x			x
Metal: Electrical [79]	x			x
Metal: Fishing [80]	x			x
Metal: Foil [81]	x			x
Metal: Food [82]	x			x
Metal: Scrap [83]	x			x
Metal: Oil [84]	x			x
Metal: Paint_tins [86]	x			x
Metal: Lobsterpots [87]	x		x	
Metal: Wire [88]	x			x
Metal: Other_small [89]	x			x
Metal: Other_large [90]	x			x
Glass: Bottles [91]	x			x
Glass: Bulbs [92]	x			x
Glass: Other [93]	x			x
Pottery: Construction [94]	x			x
Pottery: Octopus_pots [95]	x		x	
Pottery: Other [96]	x			x
San: Condoms [97]	x			x
San: Buds [98]	x	x		
San: Towels [99]	x	x		
San: Tampons [100]	x	x		
San: Toilet [101]	x			x
San: Other [102]	x			x
Med: Containers [103]	x			x
Med: Syringes [104]	x			x
Med: Other [105]	x			x
Faeces: In_bags [121]	x			x

Pollutants: Wax_small [108]				
Pollutants: Wax_medium [109]				
Pollutants: Wax_large [110]				
Pollutants: Other [111]				
Plastic: Food_plastic [610]				
Plastic: Food_eps [620]				
Plastic: Cups_plastic [211]				
Plastic: Cups_eps [212]				
Plastic: Fishboxes_plastic [341]				
Plastic: Fishboxes_eps [342]				
Plastic: Plastic_s [1171]				
Plastic: Eps_s [1172]				
Plastic: Plastic_m [461]				
Plastic: Eps_m [462]				
Plastic: Plastic_l [471]				
Plastic: Eps_l [472]				
Plastic: String_cord [321]				
Plastic: Dolly_rope [322]				
Plastic: Tangled_string [331]				
Plastic: Tangled_dolly_rope [332]				
San: Buds_plastic [981]				
San: Buds_cardboard [982]				
Plastic: Biofilm [481]				
Glass: Jars [931]				
Survey: Old_rope_small [200]				
Survey: Old_rope_large [201]				
Survey: Old_plastic_pieces [202]				
Survey: Old_gloves [203]				
Survey: Old_cartons [204]				
Survey: Old_oildrums_new [205]				
Survey: Old_oildrums_old [206]				
Survey: Old_human_faeces [207]				
Survey: Old_animal_faeces [208]				
Survey: Old_cloth_rope [210]				