



UNIVERSITY
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OF APPLIED SCIENCES



USING CITIZEN SCIENCE IN MONITORING PLASTIC DEBRIS ON BEACHES ALONG THE EASTERN & WESTERN SCHELDT

Report project 2546

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Cover photo by Liliane Geerling: beach clean-up and monitoring session at Zoutelande November 2019

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Figure 2 – Beach at Zoutelande, one of the monitored beaches (own archive)



Plastic/polystyrene pieces
2,5 cm - 50 cm **46**



15 Caps/lids



Crisp/sweet packets and
lolly sticks **19**

Figure 3– Examples of pictures used in OSPAR list



Figure 4– Beach at Zoutelande, one of the monitored beaches (own archive)

1 Introduction

Marine litter can be defined as all persistent, manufactured, or processed solid material disposed of, or abandoned over coastal and marine environments (Tudor and Williams, 2018). This also includes litter entering the marine environment via rivers, canals and other surface waters, water treatment plants, sewage outlets and storm water outlets. Marine litter is sometimes also directly discarded at sea by fishing, aquaculture, and shipping activities (Lebreton et al., 2017; Horton et al., 2017). Its impact encompasses local, regional, national and global scales and includes adverse effects on human health, aesthetic quality, economy, public perceptions and biologic interactions.

A big part of the marine litter is plastic. A research by Hougee & Boonstra (2016) found that 90% of the amount of the litter on the beaches alongside the North Sea coast in the Netherlands is plastic waste. Only a handful of scientists are mapping the composition and the amount of plastic litter on beaches, as well as the locations where the highest quantities can be found, due to a limited amount of money available to do proper research into this topic. Therefore, estimates made by scientists about how much plastic is in the rivers and oceans are based on limited numbers of measurements. If the scientists want to better understand where the plastic stays in nature, and to develop policies and measures aiming to reduce marine litter as well as assess the effectiveness and efficiency of existing measures and monitoring tools, much more research is needed in many more places....

It was concluded by Van de Velde et al. (2016) that citizen science programmes can broaden the coverage and increase the sampling power of coastal litter without compromising the data. The increased use of citizen science can be viewed as a way for science to be informed by citizens, but at the same time, and very importantly for risk perception, as a means for citizens to obtain a better understanding of the scientific field in focus. A key challenge with any citizen science programme is to ensure standardized methods and quality control so that the samples and data can legitimately be compared and used in peer-reviewed research.

This report describes the results from various monitoring sessions on 5 beaches along the Eastern and Western Scheldt using citizen scientists to monitor the amount and type of plastic litter on these beaches. Next to that, two different monitoring methods are compared, The Oskar Beach Monitoring Guideline (OSPAR Commission, 2010) and Litterati app. These results will form a part of a bigger project executed for RWS-WVL, together with Rotterdam University of Applied Sciences and TU Delft.

2 Methods

2.1 Selection of monitoring methods.

According to the assignment we will test two different ways of monitoring the litter on the beaches; the OSPAR method and the Litterati app. We will execute all monitoring sessions around the same time (between 13:00-15:00 hrs. PM) to avoid the influence of the tides. We will focus mainly on macro litter which according to most definitions is >25mm.

2.1.1 OSPAR

The OSPAR Beach Monitoring Guideline (OSPAR Commission, 2010) describes how to select the reference beaches (see 2.2), how wide the monitoring sampling area on the beach should be, how to monitor within that stretch and how to identify the found litter objects. The monitoring sampling unit is a fixed section of beach covering the whole area between the water line to the back of the beach i.e. start of the dunes. We used 100-metres wide sampling areas and depending on the amount of volunteers we monitored 1, 2 or 3 stretches of 100 m wide within a stretch of 1 km. The monitoring sessions start at the back of the beach on the landside. A small strip of about 2-3 meters is monitored; walking distance between the two surveyors is about 2-3 meters. Two surveyors walk parallel with the beach towards the end of the 100 metre monitoring area and draw a line in the sand during monitoring of the litter items. After reaching the 100-metre border of the monitoring area, the surveyors make a turn and proceed with the next strip. All litter is collected in garbage bags. The drawn line is now the border of the monitoring strip. This method is repeated until the sea line is reached. See also the drawing below.

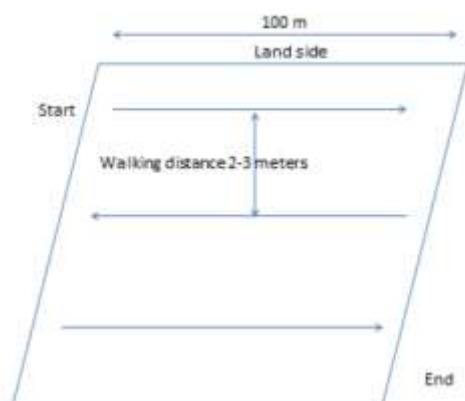


Figure 5 - Walking pattern used for the beach litter monitoring. A monitoring strip is typically 2-3 m wide.

The OSPAR method has an extensive list of litter objects which you can compare with your found litter object.



Figure 6 - Examples from the OSPAR list

2.1.2 Litterati app

The Litterati app (<https://www.litterati.org/>) which was started in 2017 is a free downloadable mobile app that allows participants to photograph, upload and tag litter in their own area. This project has citizen scientists photographing litter in their own area and categorising it in a standardised way. Data can then be downloaded, patterns discussed and potential actions to change littering behaviour put in place. Litter can be photographed offline during a clean-up session and tagged later when online. All tagged objects can be viewed on a worldwide map. For photographing and tagging all objects we will use the same 100-metres wide sampling areas from the water line to the dune area as well as the same walking pattern as used in the OSPAR method (see 2.1.1).

2.2. Selection of reference beaches

On the map below you can see all 5 beaches along the Eastern and Western Scheldt that have been surveyed, marked by the small blue spots. These spots have been picked accordingly to the indicators mentioned in the OSPAR Beach Monitoring Guideline (OSPAR Commission, 2010), which are:

- Be composed of sand or gravel and exposed to the open sea;
- Accessible to the surveyors all year around;
- Accessible for ease of marine litter removal;
- Have a minimum length of 100 meters and if possible over 1km in length;
- Free of buildings all year around;
- Not subject to any other litter collection activities.

Since it will not always possible to meet all of those indicators (e.g. many beaches in Zeeland have buildings on it) for each beach some minor adjustments will be made. These are described in the results chapter 3.

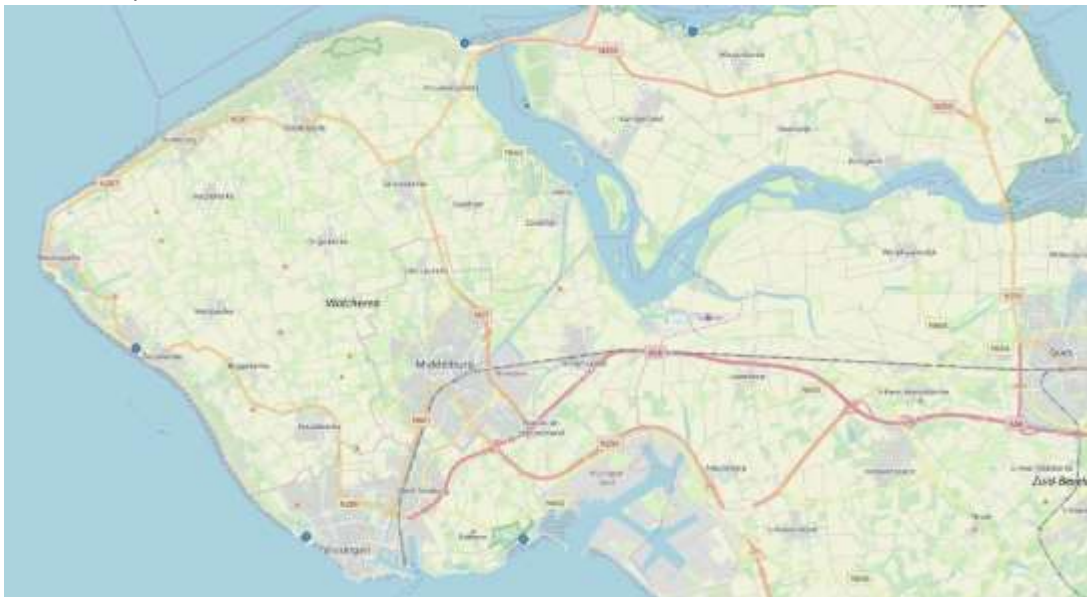


Figure 7- monitored beaches alongside Eastern and Western Scheldt

The monitored beaches alongside the Western Scheldt are Nolle beach, Vlissingen; Ritthem beach; Zoutelande beach. The monitored beaches alongside the Eastern Scheldt are De Banjaard at Breezand and De Roompot.

2.3 Selection of volunteers

The 'citizen scientists' or volunteers used for the monitoring and beach clean-up sessions are mainly students from HZ and some lecturers. HZ Green Office organizes beach and port clean-ups in Vlissingen on a regular base. Of course the group of students varies over the years (4 year Bachelor programme) but there is a 'core' of students who join most of the organized clean-ups. The monitoring of the litter is a new activity and was not executed before. Students can also gain study credits by joining the beach clean-ups. Clean-up sessions are announced via HZ Green Office Instagram and FB page, directly via email, and sometimes via lecturers during lectures.

2.4 Survey on user friendliness of monitoring methods

Because the monitoring of the beach litter is a new activity and two different methods will be tested, we have designed a small survey, which we will ask students to fill in after joining a monitoring session. The survey focusses on citizen science and user friendliness of the monitoring methods. In appendix 1 an overview of the survey can be found.



Figure 8- Instruction of OSPAR method to 'citizen scientists' of HZ University of Applied Sciences

3 Results

3.1. Nollestrand Vlissingen

The Nollestrand in Vlissingen is located North-west of the Vlissingen boulevard. The beach meets the following criteria of monitoring:

- It is composed of sand
- Accessible to the surveyors all year around
- Accessible for ease of marine litter removal
- Have a minimum length of 100 meters and if possible over 1km in length

The beach has a long row of small seasonal used beach houses and the Stichting Strandexploitatie Veere (SVV) is emptying the litter bins and collect the litter close to them once a week.



Figure 9 - sampling areas Nollestrand (Google maps)



Figure 10 – satellite view Nollestrand (Google maps)

3.1.1 Monitoring event 1

Date: 04-10-2019

Time: Between 13:00 and 15:00 hrs. PM.

Monitoring method: OSPAR list

Meteorological data (world weather online):

- 15c
- Wind speed: 35-36km/h with 51km/h
- Precipitation: 1.0mm



Figure 11- photo of Nollestrand (own archive)

For this beach clean-up and monitoring session the group of volunteers met at the beach post in Vlissingen Nollestrand. There was a lot of wind. After the group was complete with 12 persons the OSPAR method was explained and the research setup (why monitoring of the litter). Three groups of 4 people were formed. Every group got a picker and a sustainable trash bag from the HZ Green Office and the gemeente Vlissingen to use. Because it was raining heavily and cold, we decided to collect all the trash on the areas on the beach for around 1.5 h and then categorize the found materials inside the beach post where it would be dry and warm. This was not only because of the

comfort inside, but mainly because it was hard to collect the data on a sheet of paper with strong winds and rain.

Therefore, after we finished picking up the litter at the beach we went inside the beach post again, emptying the trash bags per bag on a black sorting cloth. Then one participant would handle the pen and paper while the others would call out the piece of trash they found. After a little bit of trying the most effective method would be to roughly sort the trash on the floor and then go by category. This sped up the whole process a bit. It was observable that especially those with pen and paper got more efficient over time, understanding quickly where on the list said item needs to be marked.



Figure 12- Sorting of the collected waste (photo own archive)

In general this approach is a more comfortable approach that is especially useful if there is a warm and dry place nearby that is accessible. It took more time to do this. So on top of the 1.5 h of monitoring we spend close to 1 h on categorizing the trash of two groups afterwards. Most participants could not stay longer which prevented us from evaluating the data of the last areas.

Area 1:

The pie chart on the next page gives an overview of found litter in the first observation area at the Nollestrand in Vlissingen using the Ospar Method for monitoring. The total amount of items monitored on the first stretch of 100 m wide is: 400.

The top 5 items found in area 1:

1. Strings and chords: 103 Items = 26%
2. Unidentified solid plastics : 80 items = 20%
3. Plastic bag ends: 56 items = 14%
4. Bottle caps and lids: 40 items = 10%
5. Cutlery and straws: 24 items = 6%

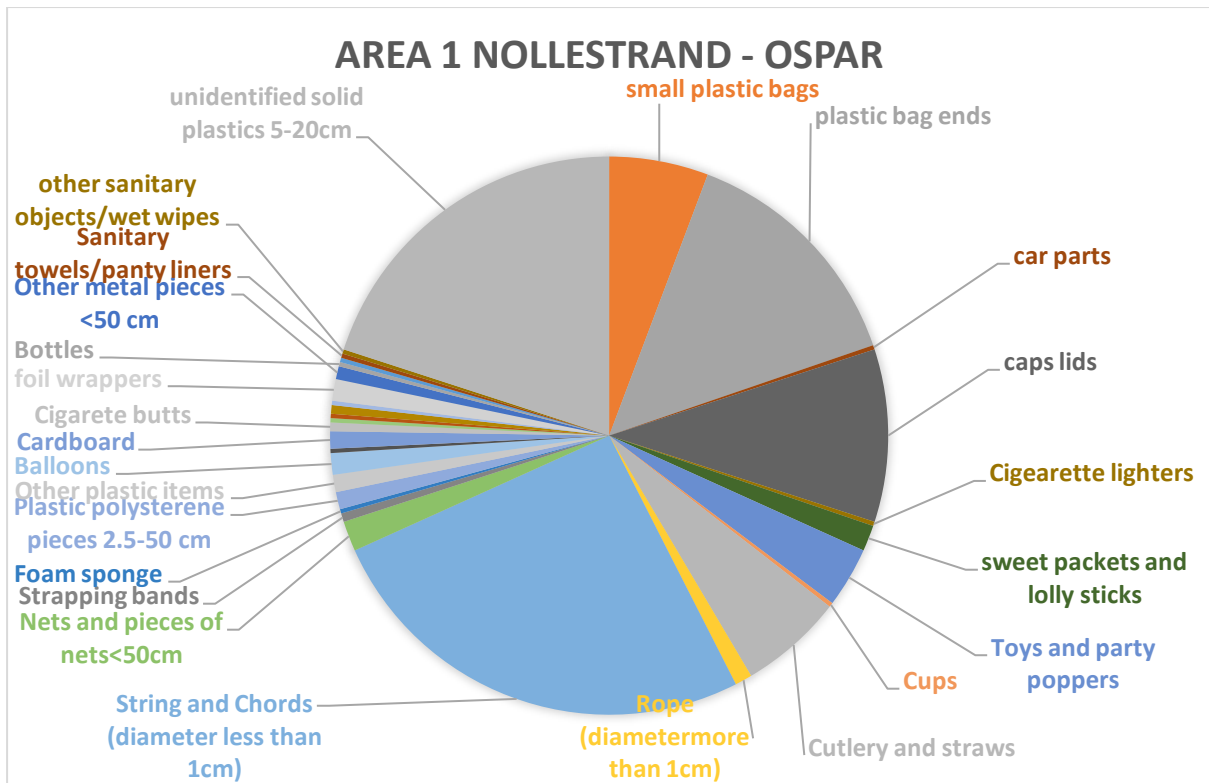


Figure 13 - Pie chart area 1 Nollestrand Vlissingen using OSPAR method

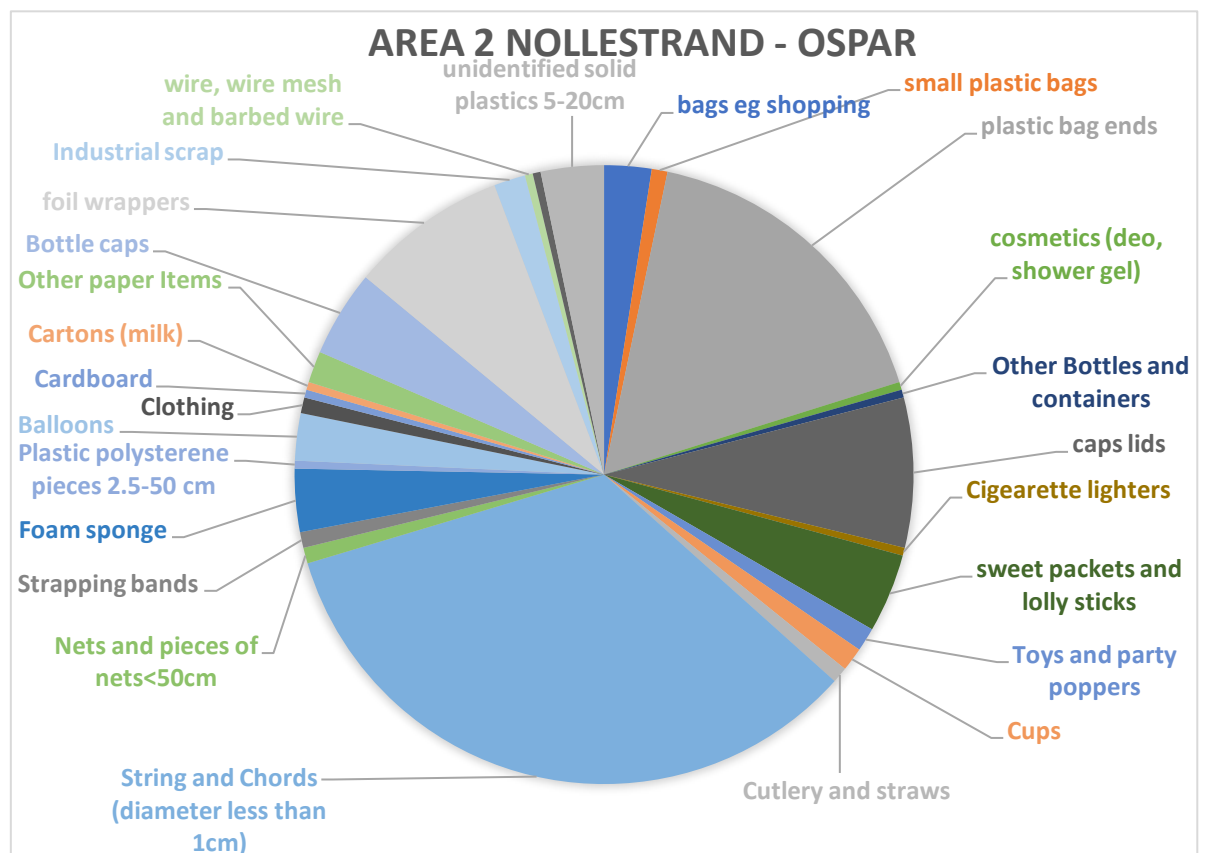


Figure 14 - Pie chart area 2 Nollestrand Vlissingen using OSPAR method

The second pie chart on the previous page represents the items we monitored in area 2 at the Nollestrand in Vlissingen using the Ospar Method for monitoring. The total amount of items monitored on the second stretch of 100 m wide is: 243.

The top 5 items found in area 2:

1. Strings and chords: 82 items = 34%
2. Plastic bag ends: 41 items = 17%
3. Bottle caps and lids: 20 items = 8%
4. Foil wrappers: 19 = 8%
5. Metal bottle caps: 11 items = 5%

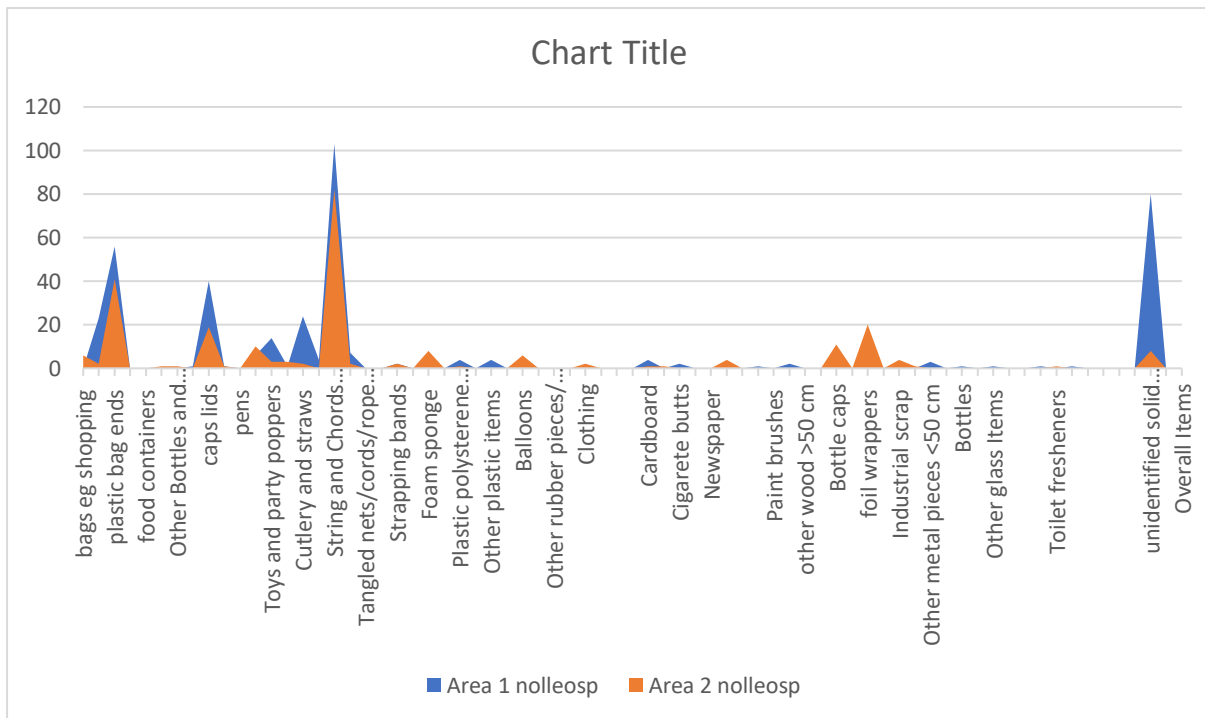


Figure 15- comparison area 1 and area 2 Nollestrand Vlissingen

3.1.2 Monitoring event 2

Date: 25-10-2019

Time: Between 15:00 and 17:00 hrs. PM.

Monitoring method: Litterati app.

Meteorological data:

- Temp: 15c felt like 14c
- Wind: 29-31km/h 50 km/h gusts
- Precipitation: 0mm

The second research event did also take place at the Nollestrand in Vlissingen. This time we tested the Litterati app. The functioning of this app was explained to the participants and then we formed groups. The group size was about the same as at the event before. We formed groups of at least 4 people. Two group members would walk, pick up trash and put it into the trash bag, while one group member would hold the trash bag and another member would take a picture of every piece of trash before it was tossed in. During this event the weather overall was good but it was windy and turned

cold pretty quick. However, the groups still managed to survey for around 2h. The preparation time was moderate but the participants have to come prepared with their phone charged, the app downloaded and a profile as well. The students chose to not tagging the data in the app immediately but do that later. Unfortunately the data of just one group was sent back, by making screenshots of the photographed items.

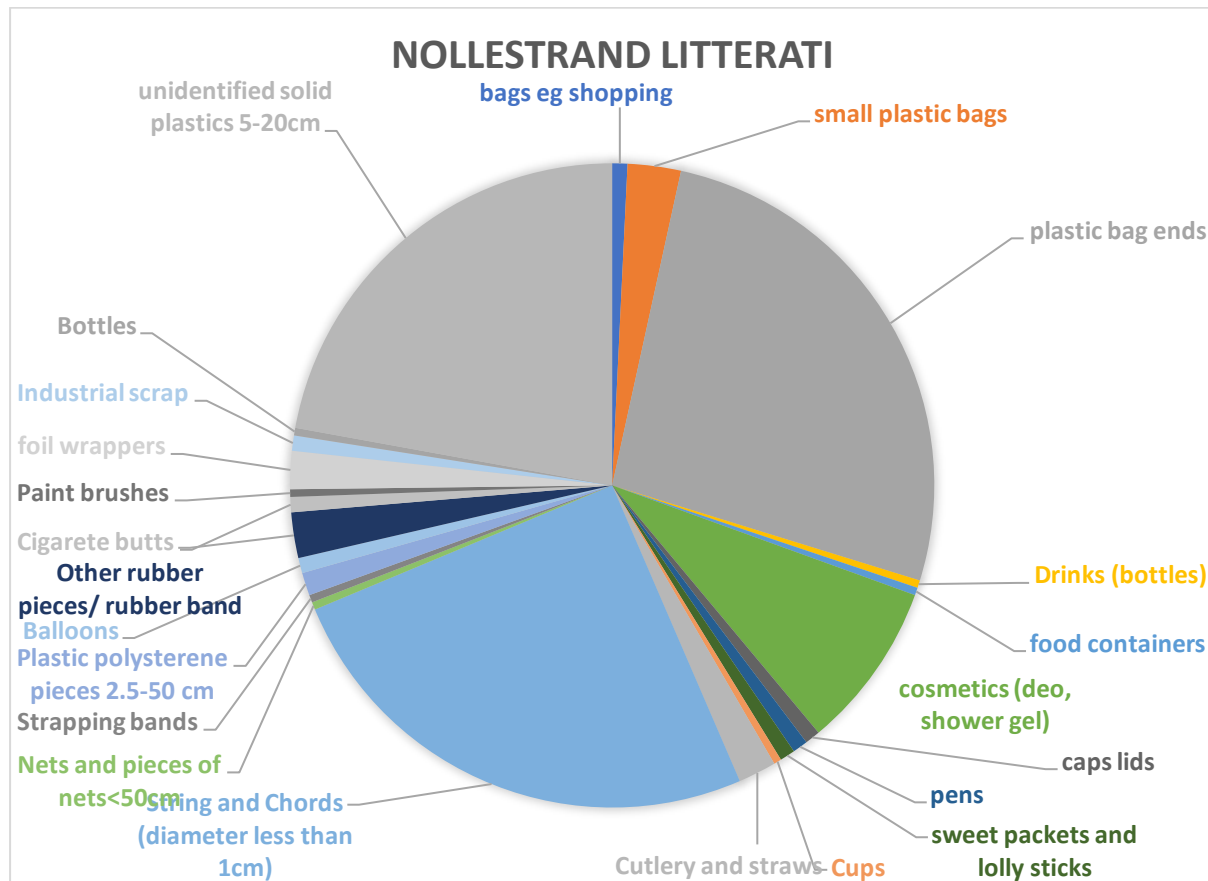


Figure 16- Pie chart of Nollestrand using Litterati app

The pie chart above represents the items that were monitored in one area of 100 m wide using the Litterati app. The overall amount of objects found is: 262.

The top 5 items found:

1. Plastic bag ends: 69 items = 26%
2. Strings and Chords: 66 items = 25%
3. Unidentified solid plastics: 58 items = 22%
4. Cosmetics (deo, shower gel etc): 22 items = 8%
5. Small plastic bags: 7 items = 3%

3.2 Ritthem beach

This beach in Ritthem is fulfilling all of the preconditions set by the OSPAR monitoring guidelines:

- Be composed of sand or gravel and exposed to the open sea
- Accessible to the surveyors all year around
- Accessible for ease of marine litter removal
- Have a minimum length of 100 meters and if possible over 1 km in length
- Free of buildings all year around
- Not subject to any other litter collection activities

The beach is mostly used for recreational purposes since it is one of the few beaches in the area where citizens can walk their dog all year around. It is closely located to the industrial zone in Ritthem.



Figure 17-sampling areas beach Ritthem



Figure 18- satellite image Ritthem beach (Google maps)

3.2.1. Monitoring event 1

Date: 08-11-2019

Monitoring method: OSPAR

Time: 13:00-15:00

Meteorological data:

- Temp: 8c felt like 6c
- Wind: 12km/h SSW 13km/h gusts

Precipitation: 0.0mm



Figure 19- Ritthem beach (own archive)

For this event we used a car to drive to the project location close to Ritthem. We had a group of 5 volunteers so we decided to only form one group and observe just one area. We started on the east side of the beach, walking west. At first we had two participants holding the bags, one participant writing down and the rest would gather data. During the observation we adapted a bit with two students writing down, coordinating who is responsible for what kind of item. For example student 1 would only write down the unidentified solid plastics so that the other student could concentrate on other items. This actually sped up the whole process. It also helped that some participants already knew a bit about the list from previous monitoring action. This way, finding items on the list did not take as much time as it did the first time using it. We managed to gather data from that area in about 1.5h.

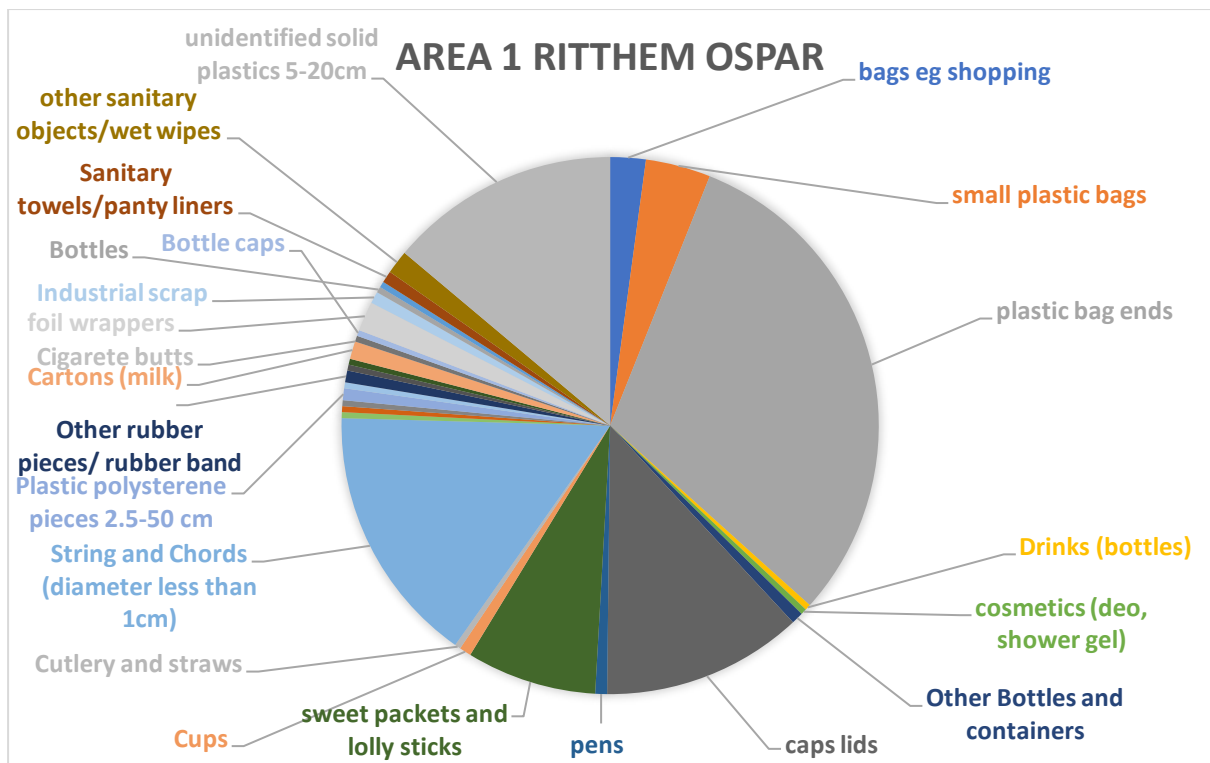


Figure 20 - Pie chart Ritthem beach of litter found using OSPAR method

The pie chart above represents the items that have been found in the first 100 meters wide stretch that was monitored. The overall amount of objects found is: 281.

The top 5 items found:

1. Plastic bag ends: 86 items = 31%
2. Strings and Chords: 44 items = 16%
3. Unidentified solid plastics: 39 Items = 14%
4. Bottle caps and lids: 34 items = 12%
5. Sweet packets and lolly sticks: 22 item = 8%

3.2.2. Monitoring event 2

Date: 29-11-2019

Monitoring method used: Litterati app.

Time: 13:00-15:00 hrs. PM

Meteorological data:

- Temp: 9c felt like 5c
- Wind: 22km/h NNW with 31km/h gusts
- Precipitation: 0.1mm

When we observed the beach of Ritthem again with the Litterati app there have been only 4 participants. The weather was calm and sunny. We decided to survey two areas but keep the group together so that we did the sections in sequence. Overall we observed the beach for around 1h and 50 mins. For this time we changed the method of taking the pictures slightly. Instead of taking the picture before tossing it into the bag we decided to collect a few items, place them in a line on the

floor for the participant with the camera. He/she would quickly take successive pictures while the collector started to toss the items in the bag after. This turned out to improve the pictures a lot due to camera focus, mostly the same distance to the item, etc.

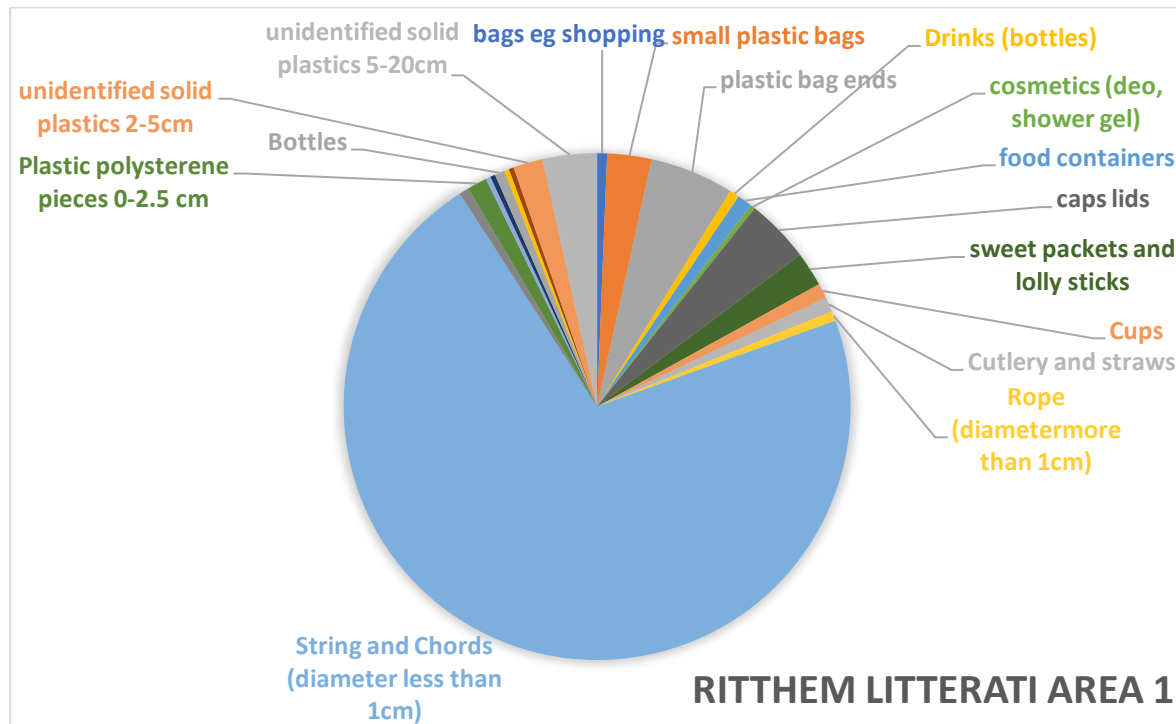


Figure 21 - Pie chart area 1 Ritthem beach of litter found using Litterati app

The pie chart above represents the items that have been found in the first 100 meters wide stretch that was monitored. The overall amount of objects found is: 316.

The top 5 items found:

1. Strings and Chords: 227 items = 71%
2. Plastic bag ends: 17 items = 5%
3. Bottle caps and lids: 13 items = 4%
4. Unidentified solid plastics: 11 items = 3%
5. Small plastic bags: 9 items = 3%

The pie chart on the next page represents the items that we found in area 2 in Ritthem using the Litterati method. The overall amount of objects found is: 281.

The top 5 items found:

1. Strings and chords: 224 items = 80%
2. Drinking bottles: 12 items = 4%
3. Unidentified plastics 5-20cm: 7 items = 2%
4. Cups: 6 items = 2%
5. Bottle caps/lids: 6 items = 2%

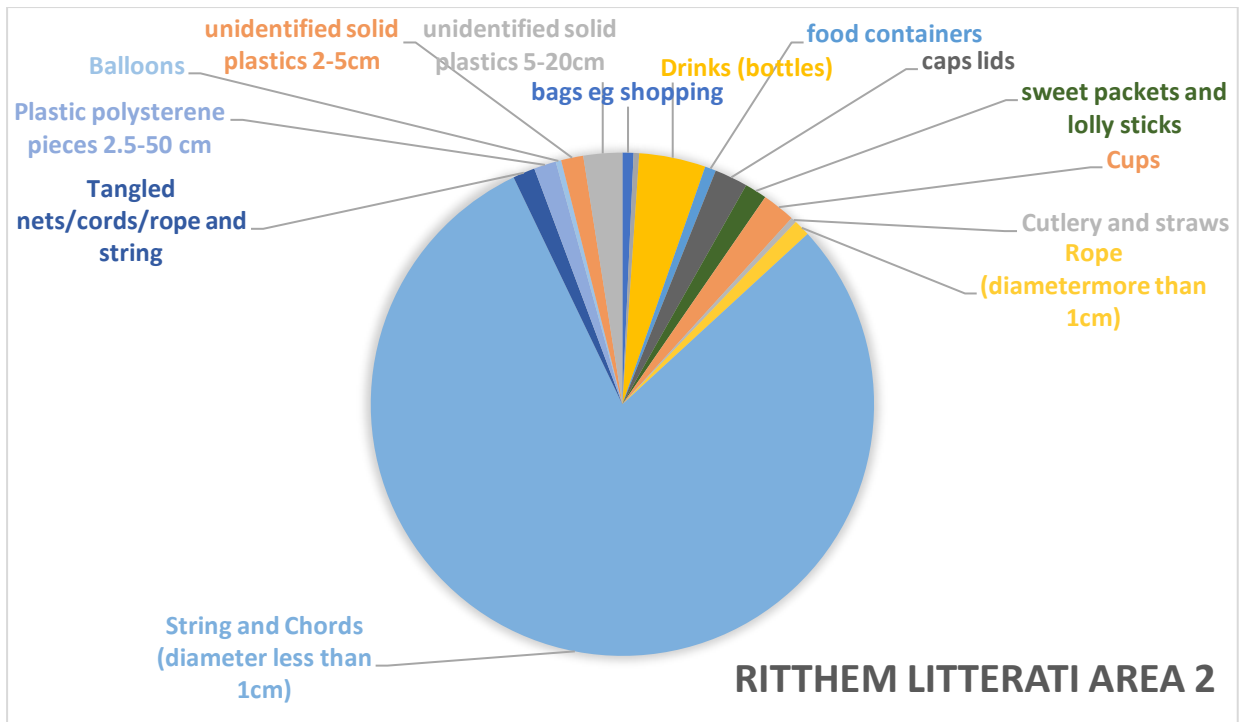


Figure 22 - Pie chart area 2 Ritthem beach of litter found using Litterati app

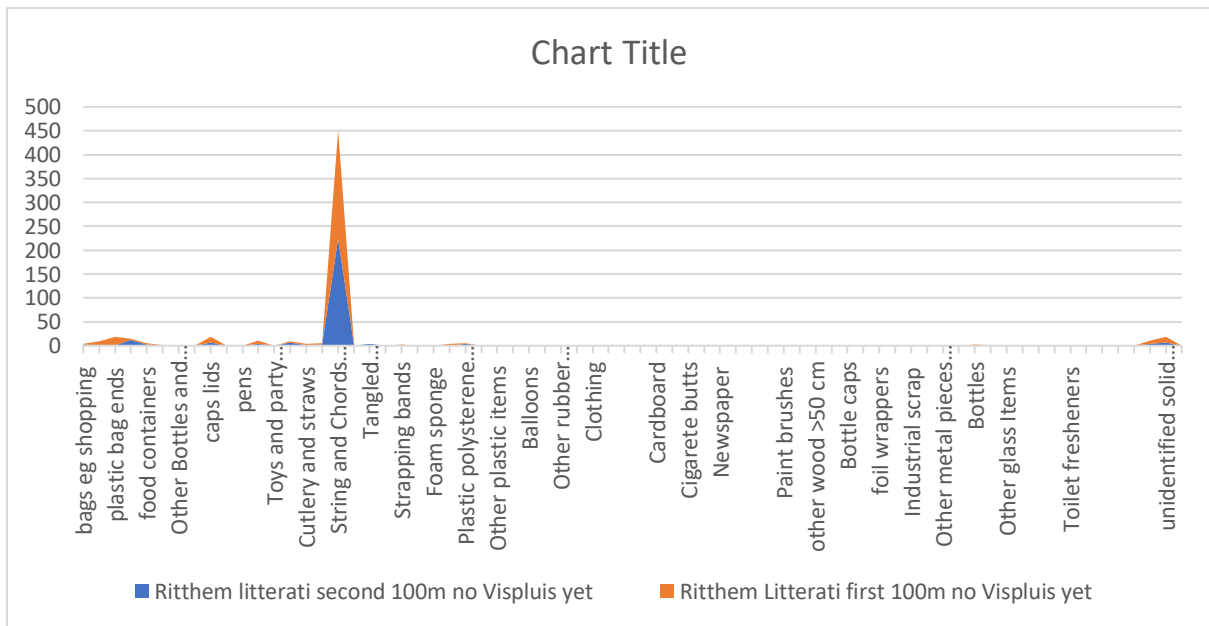


Figure 23 - Comparison area 1 and 2 Ritthem beach using Litterati app

3.3. Zoutelande beach



Figure 24 - sampling areas Zoutelande beach (Google maps) Figure 21-satellite image Zoutelande beach (GM)

The beach in Zoutelande almost adheres to the research principles of OSPAR. There is a pavilion though.

- Be composed of sand or gravel and exposed to the open sea
- Accessible to the surveyors all year around
- Accessible for ease of marine litter removal
- Have a minimum length of 100 meters and if possible over 1km in length
- Not subject to any other litter collection activities

3.3.1 Monitoring event 1

Date: 15-11-2019

Monitoring method: OSPAR

Time: 13:00-15:00 hrs. PM

Meteorological data:

- Temp: 5c felt like 1c
- Wind: 26km/h NE/ ENE, 33km/h gusts
- Precipitation: 0.0mm

During the first clean-up in Zoutelande we had a group of 4 people using the OSPAR method. Here the waterline was high up only leaving a relative small area with dry sand. Overall there has not been a lot of waste at this beach at that day. This might be because of the tides. The wind was cold. We had only one group member take the pictures while one other member held the bag and the two other members collected the litter. For this event we decided to not categorize the blue fishing chords (vispluis) at the beach, but collect it in a bag and count it afterwards. This was based on previous observations that participants would sometimes miss on categorizing items that are on the beach, specially the blue fishing chords, because there are so many. It improved a lot due to the increased effort. We continued this for the next event in Ritthem as well as the last event in Zoutelande to see if there is a difference in the results.

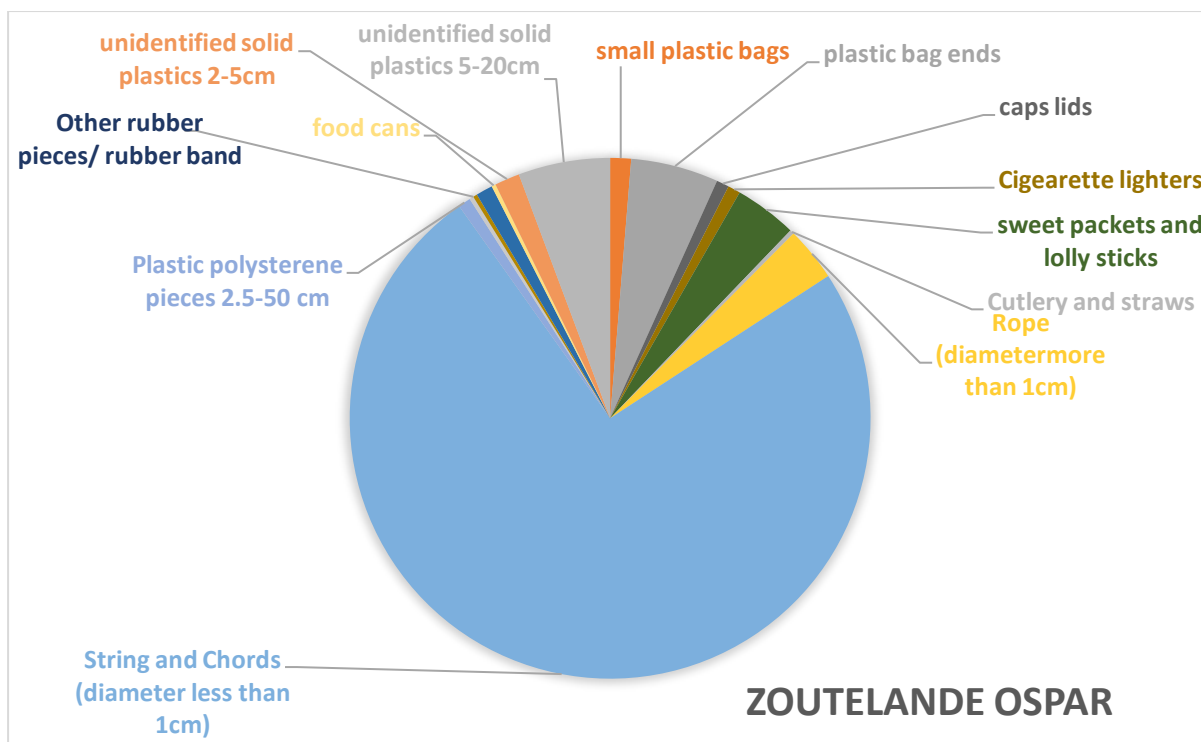


Figure 25 - Pie chart area 1 of litter found at Zoutelande beach using OSPAR method

The overall amount of objects found is: 386. The top 5 items found:

1. Strings and chords: 287 items = 74%
2. Unidentified solid plastics 5-10 cm: 22 items = 6%
3. Plastic bag ends: 21 items = 5%
4. Sweet packets and lolly sticks: 15 items = 4%
5. Rope diameter larger than 1cm: 13 items = 3%

3.3.2 Monitoring event 2

Date: 27-11-2019

Monitoring method: Litterati app.

Time: 13:00-15:00 hrs. PM

Meteorological data:

- Temp: 11c felt like 8c
- Wind: 35km/h SSW with 59km/h gusts
- Precipitation: 0.4mm

For this monitoring event we had 16 volunteers. We drove with two vans to the beach. We divided the beach into 3 areas, dividing groups so that there were always two people collecting and picking up the trash whilst one held the bag and one took the pictures for the Litterati app. It was a bit cold but overall perfect weather to survey. The whole group surveyed the 3 different areas for 1.5 h. One group tried to implement the same method as we have used in Ritthem for the pictures we took. We could only obtain the data from 2 groups monitoring, due to the fact that the photos in the Litterati app are private and only screenshots can be shared.



Figure 26 - Zoutelande beach, clean-up and monitoring session 2 using Litterati app

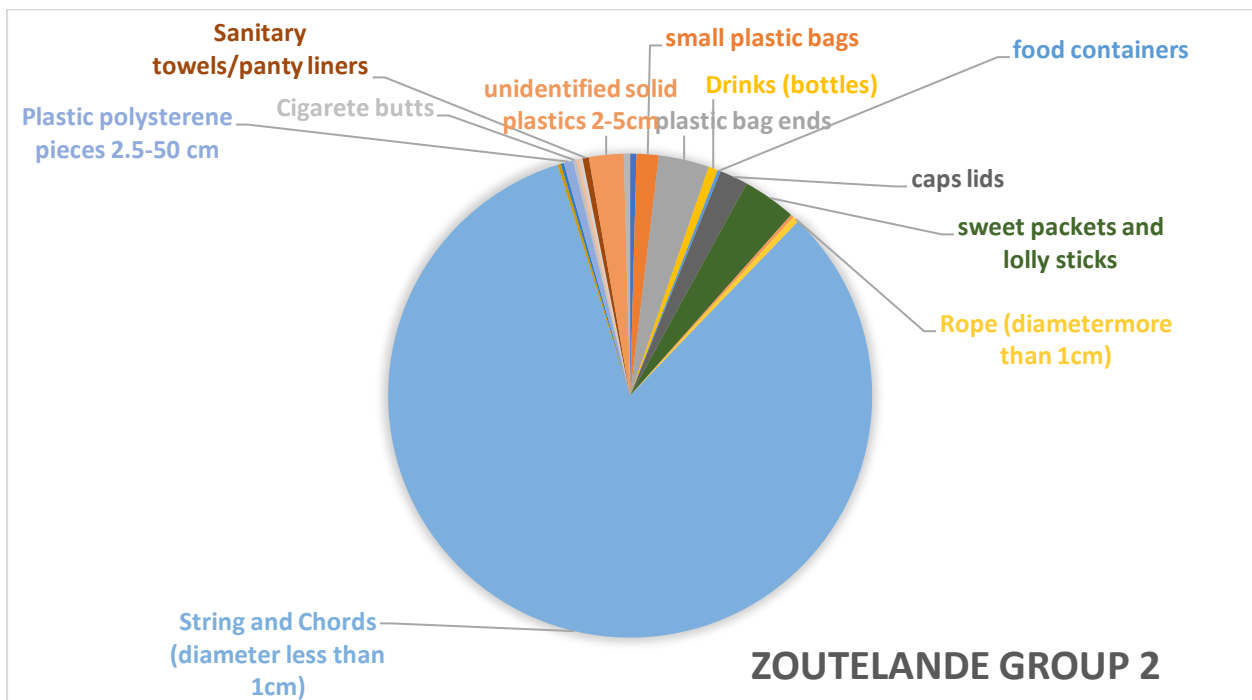


Figure 27 - Pie chart of litter found in area 2 at Zoutelande beach using Litterati app

The overall amount of objects found is: 486. The top 5 items found:

1. Strings and chords: 394 items = 83%
2. Sweet packets and lolly sticks: 17 Items = 4%
3. Plastic bag ends: 16 items = 3%
4. Unidentified solid plastics: 11 items = 2%
5. Bottle caps and lids: 9 items = 2%

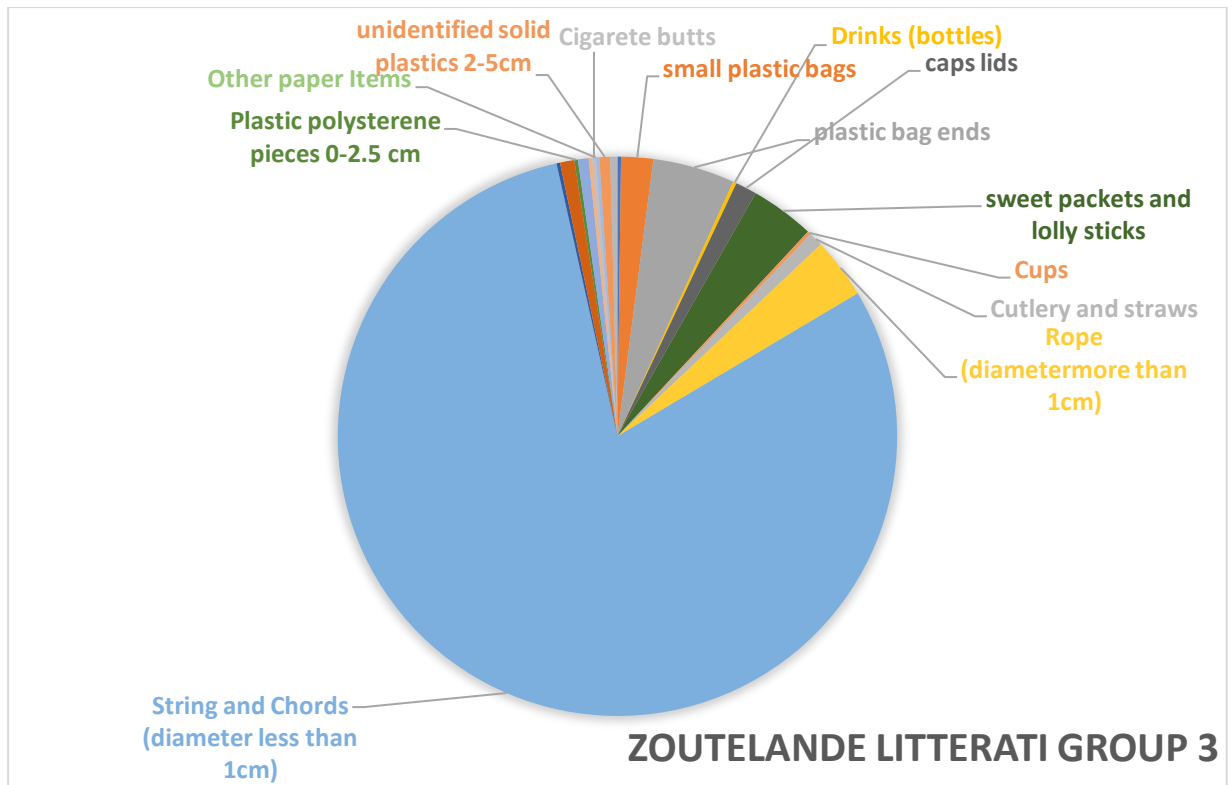


Figure 28 - Pie chart of litter found in area 3 at Zoutelande beach using Litterati app

The overall amount of objects found is: 475. The top 5 items found:

1. Strings and chords: 389 items = 80%
2. Plastic bag ends: 23 items = 5%
3. Sweet packets and lolly sticks: 18 items = 4 %
4. Rope diameter more than 1cm : 17 items =3 %
5. Small plastic bags: 9 items = 2%

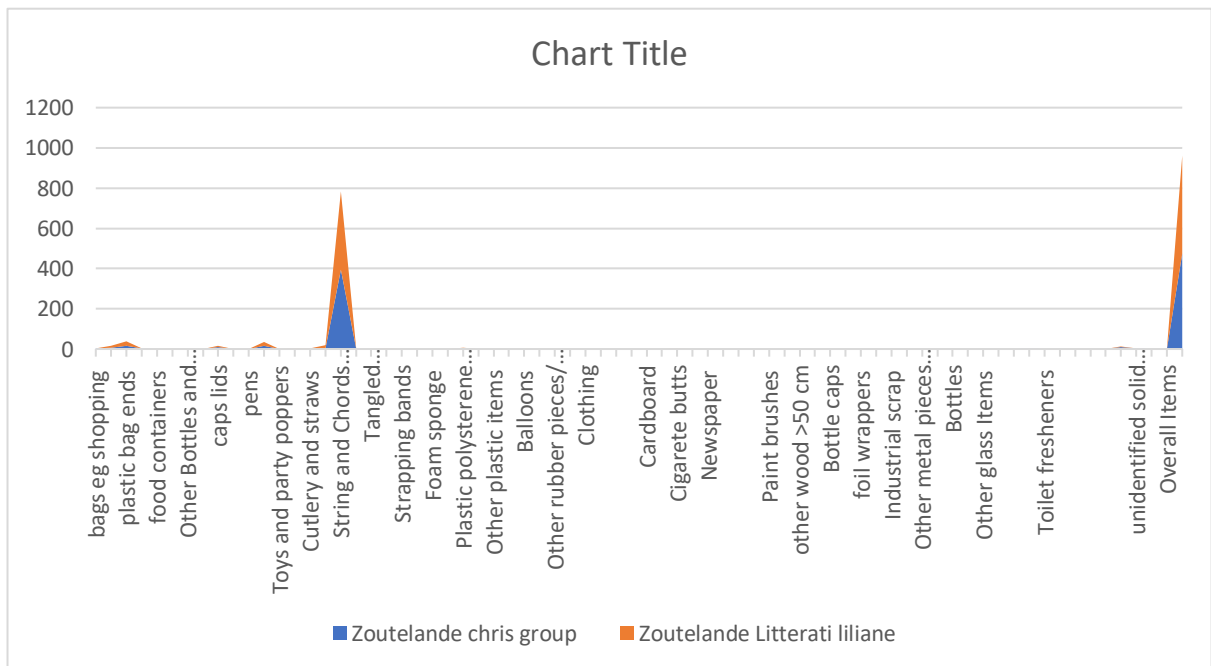


Figure 29- Comparison area 2 and 3 Zoutelande beach using Litterati app

3.4. Beach at Breezand



Figure 30- sampling areas beach at Breezand (Google maps)



Figure 31– Breezand (Google photo)

The beach of Breezand is as its name states indeed a very broad beach. As indicated in the map of figure 27 the monitoring areas were adjusted due to this (not until the dunes) and the lack of litter we could find far away from the water. As can be seen in the same map there are some structures and a beach pavilion on that part of the beach, however, most of the research principles of OSPAR are adhered to.

- Be composed of sand or gravel and exposed to the open sea
- Accessible to the surveyors all year around
- Accessible for ease of marine litter removal
- Have a minimum length of 100 meters and if possible over 1 km in length
- Not subject to any other litter collection activities

3.4.1. Monitoring event

Date: 04-12-2019

Monitoring method: OSPAR

Time 13:00-15:00

Meteorological data:

- Temp: 5c felt like 4
- Wind: 7km/h S/SE with 10km/h gusts
- Precipitation: 0,0mm

At this day there were 8 participants joining the event. We used 1 van and 1 car to drive to the beach. The weather was great. Since the beach was very wide we decided not to survey all the way from the dunes to the water but rather the other way around until we could not find any plastics anymore. Most of the found litter was at the tide line. We formed two groups but overall there was not much to find on these beaches. This could be because it is immensely broad. One student categorized while one held the bag and the rest picked up the litter. However since it was hard to find a lot of trash we placed the bag somewhere close and all of the members looked closely for 10 m of area and then take the bag to the next spot to do the same.

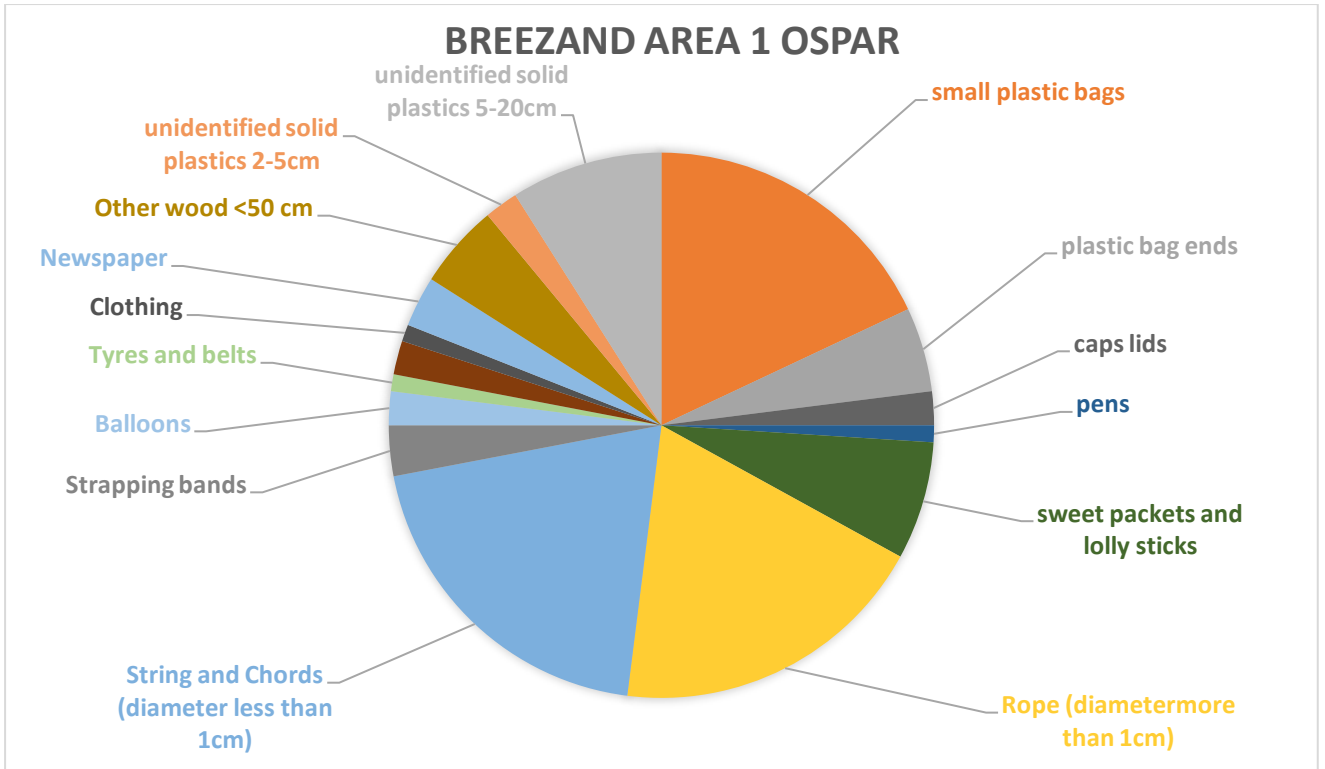


Figure 32 - Pie chart of litter found in area 1 at Breezand beach using OSPAR method

The overall amount of objects found is: 100. The top 5 items found:

1. Strings and chords: 20 items = 20%
2. Rope diameter more than 1 cm: 19 items = 19%
3. Small plastic bags: 18 items = 18 %
4. Unidentified solid plastics 5-10cm: 9 items = 9%
5. Sweets packages and lolly sticks: 7 items = 7 %

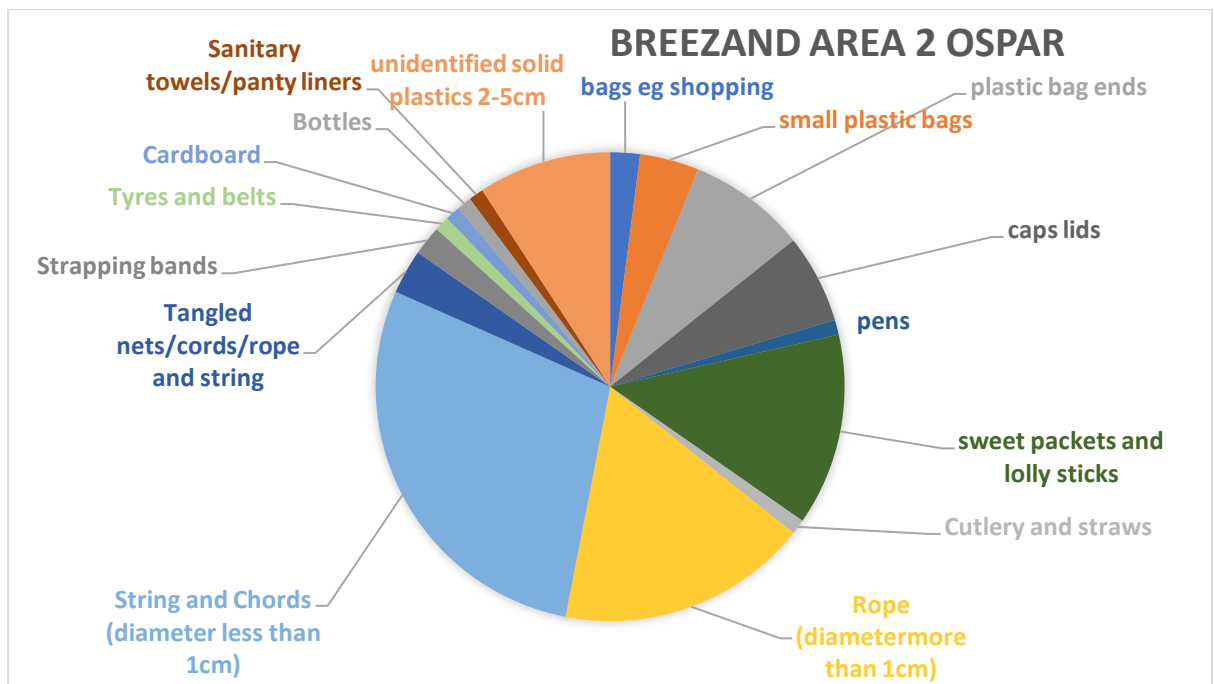


Figure 33 - Pie chart of litter found in area 2 at Breezand beach using OSPAR method

The overall amount of objects found is: 98. The top 5 items found:

1. String and chords: 28 items = 29%
2. Rope diameter more than 1cm: 17 items = 17%
3. Sweet packages and lolly sticks: 13 items = 13%
4. Unidentified solid plastics 2-5 cm: 9 items = 9 %
5. Plastic bag ends: 8 items = 8%

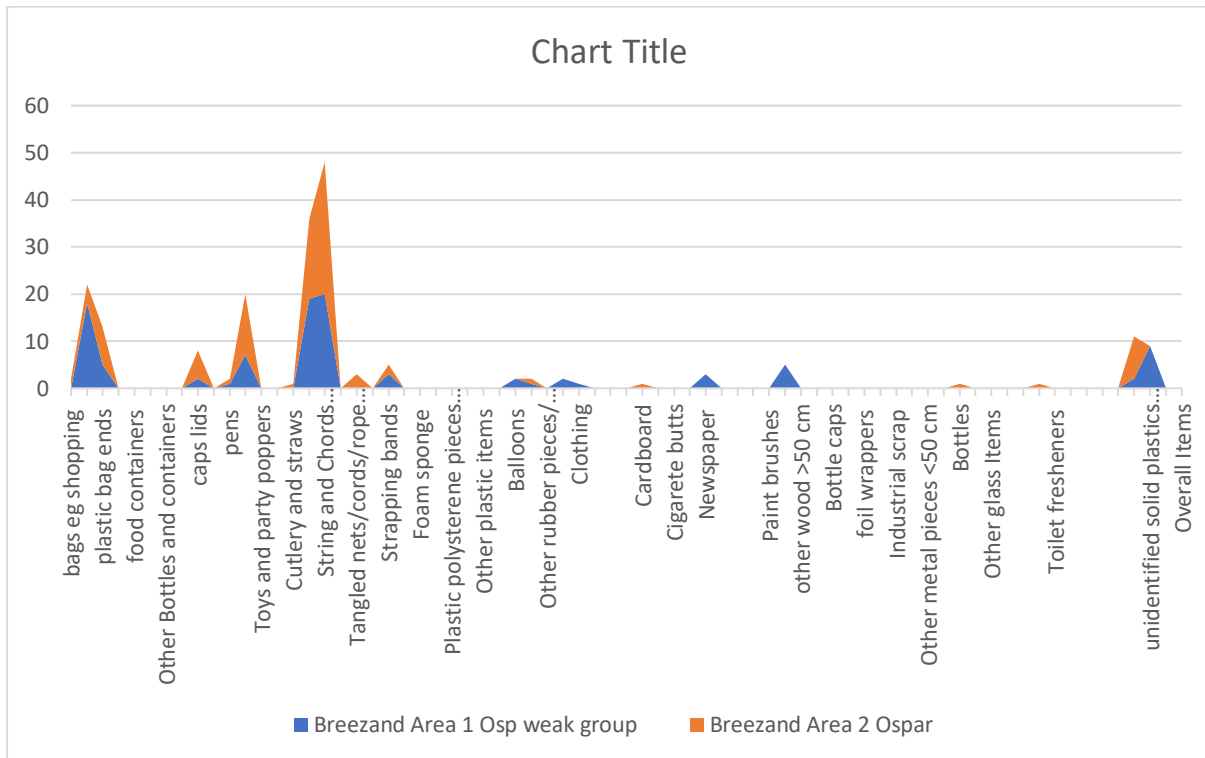


Figure 34 - Comparison area 1 and 2 Breezand beach using OSPAR method

3.5 Roompot



Figure 35 - sampling areas beach at Roompot (Google maps)

The beach in Roompot is an interesting beach for observing. It does not meet criteria from OSPAR since there are beach houses for tourists year-round on the beach (for sleeping). In addition, we met someone managing these houses during the clean-up event and she stated that the trash bins are being emptied and the surrounding area is being cleaned every few days. The OSPAR criteria that are met are:

- Be composed of sand or gravel and exposed to the open sea
- Accessible to the surveyors all year around
- Accessible for ease of marine litter removal
- Have a minimum length of 100 meters and if possible over 1 km in length



Figure 36 - monitoring the beach at Roompot with Litterati app (photo own archive)

3.5.1. Monitoring event

Date: 06-12-2019

Monitoring methods used: both OSPAR and Litterati app.

Time: 13:30-15:30 hrs. PM

Meteorological data:

- Temp: 9-10c felt like 5c
- Wind: 42km/h SSW with 65km/h gusts
- Precipitation: 1.8mm

The last beach we observed was the beach in Roompot, where we drove to using 3 cars. We were 16 participants and decided to divide the participants into 3 groups. We used the Litterati methods on the outside areas and the middle area was monitored with the OSPAR method. We monitored for about 1 hour and 20 minutes, while there was a lot of wind and some rain. Wind and slight rain during the event are the reason the surveying time was cut to this. Nevertheless, the participants actually managed to survey their area (almost) completely before losing their motivation. The two Litterati groups used the same method of taking the picture of the trash as discussed in the “Ritthem” Litterati approach before.

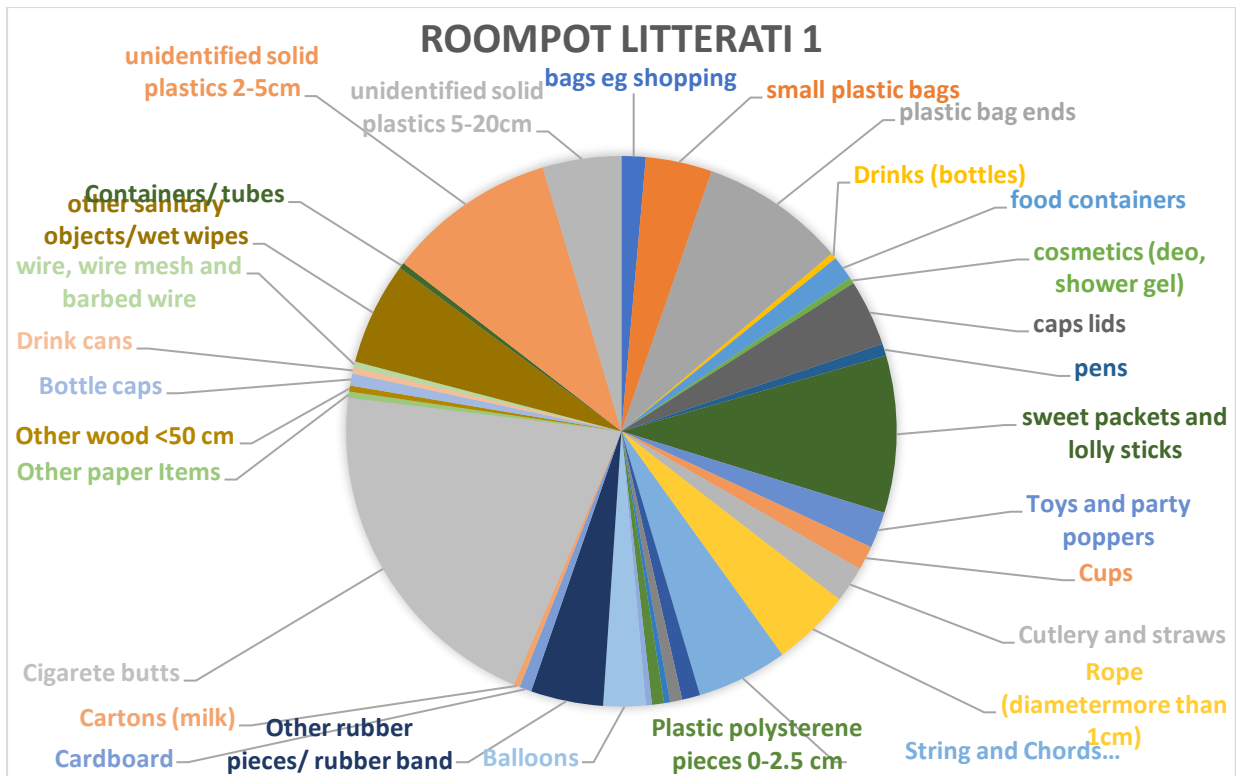


Figure 37 - Pie chart of litter found in area 1 at Roompot beach using Litterati app

The overall amount of objects found in area 1 is: 282. The top 5 items found:

1. Cigarette butts: 58 items = 21%
2. Unidentified plastics 28 items = 10%
3. Sweet packets and lolly sticks: 26 items = 9 %
4. Plastic bag ends: 24 items = 9%
5. Strings and chords: 15 items = 5%

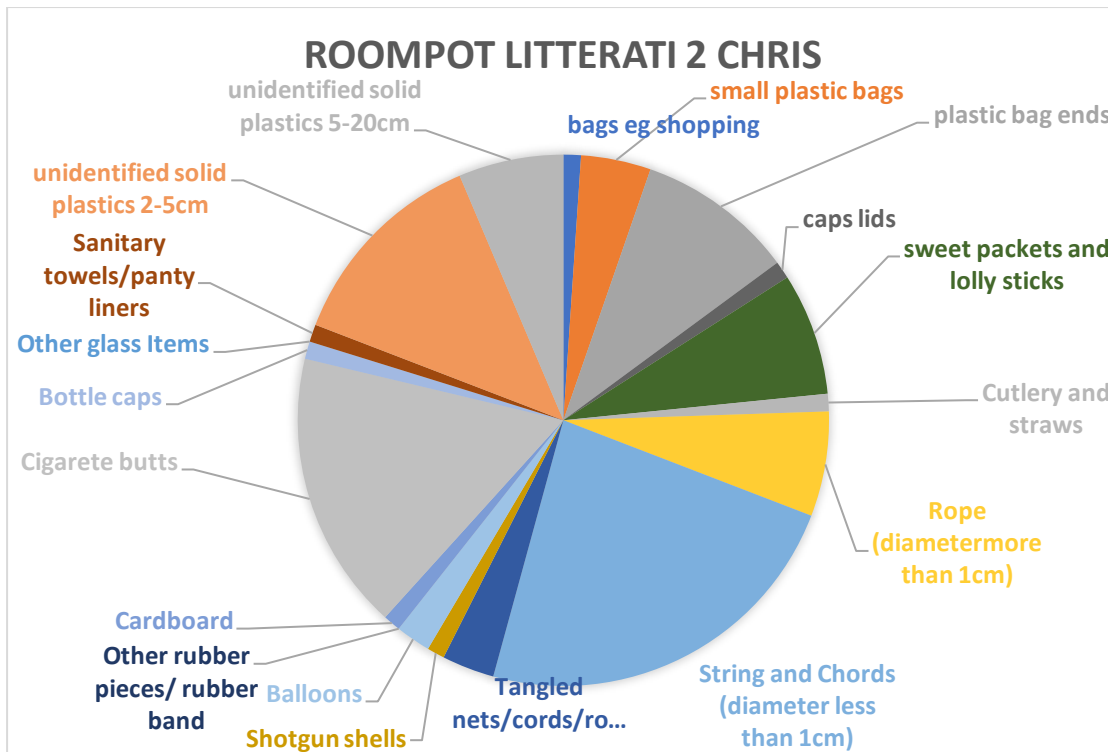


Figure 38 - Pie chart of litter found in area 3 at Roompot beach using Litterati app

The overall amount of objects found in area 3 is: 193. The top 5 items found:

1. Strings and chords: 22 items = 23%
2. Cigarette butts: 16 items = 17 %
3. Unidentified solid plastic: 12 item = 13%
4. Plastic bag ends: 9 items = 10 %
5. Sweet packets and lolly sticks: 7 items = 7%

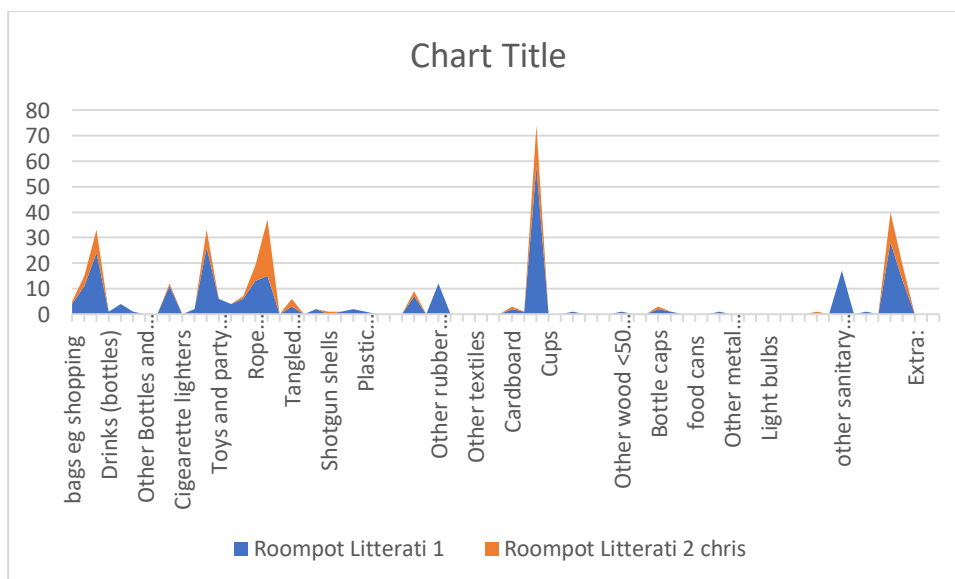


Figure 39 - Comparison area 1 and 2 Roompot beach using Litterati app

The overall amount of objects found in area 2 is: 94. The top 5 items found:

1. Cigarette butts: 59 items = 31%
2. Rope diameter more than 1 cm: 19 items = 10%
3. Strings and chords: 19 items = 10%
4. Unidentified solid plastics 2-5cm: 18 items = 9 %
5. Unidentified solid plastics 5-20 cm: 15 items = 8 %

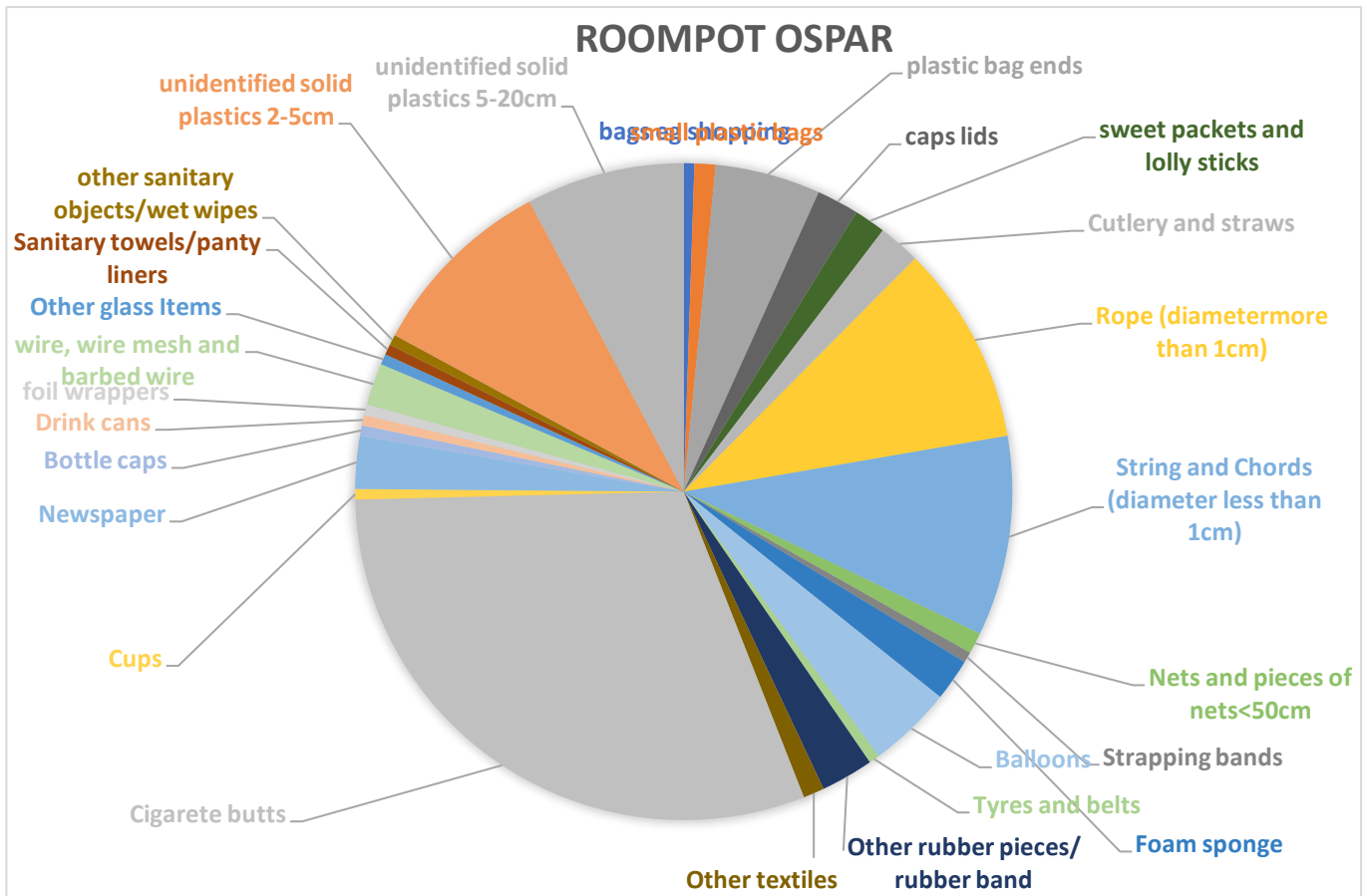


Figure 40 - Pie chart of litter found in area 3 at Roompot beach using the OSPAR method

In the appendix 2 screenshots and photos from the Litterati app are grouped per clean-up session.

3.6 Results from the survey on citizen science and user friendliness of monitoring methods

20 participants of the beach clean-up and monitoring sessions filled in the survey. The outcomes are described below. The questions of the survey can be found in appendix 1.

3.6.1 Questions on motivation

As reason for: "What are your reasons to join the participatory research and which one was the most important?" the answers were (in order of importance):

- Environmental interest (12x)
- Credit incentive (9x)
- Contribute (7x)
- Science/ research interest (3x)
- Discover (1x)
- Community (1x)
- Fun (1x)

The question if people would like to join more often in the future, all 20 respondents answered yes. As reasons why the answers were (in order of importance):

- Environmental interest (5x)
- Contribute (4x)
- Credit incentive (3x)
- Community (2x)
- Fun (1x)

A mentioned factor potentially prohibiting this was "a lack of time offers of such activities".

To the question "Did you ever participate in anything like this before?" The majority of the respondents (18) answered no, and 2 answered yes.

As answer to the question "Do you feel like you learned something for your everyday life today?" 18 respondents said they learned something valuable. The mentioned lessons learned were (in order of importance):

- What areas are polluted and where the waste comes from (5x)
- Reduce your own trash (5x)
- To care more about the environment
- Everyday impact of the trash
- Fun activity

The question "Do you feel like contributing while monitoring than just cleaning and why?" was positively answered by 15 respondents. The reasons mostly mentioned were:

- Yes I get the feeling it helps somebody get to the source of the plastic problem
- Yes because as a result we learn more about the effects
- Yes because getting a deeper understanding of the problem brings us closer to a solution

5 respondents did not feel that monitoring contributed more than just cleaning. The reasons mostly mentioned were:

- No because monitoring is slower
- No because monitoring only deals with a certain area

Not many people participate in other scientific or communal activities in their free-time. 19 respondents answered no and just one respondent is volunteering in a park close by. Mentioned reasons were:

- Not enough time
- No awareness of such projects

Having contributed once most respondents are curious to see the scientific results of the monitoring actions, because all ranked on the scale between 7 and 10.

-How interested are you into the scientific results?

1() 2() 3() 4() 5(1x) 6() 7(6x) 8(3x) 9(5x) 10(2x)

3.6.2 Questions on monitoring methods used

The first question compared the OSPAR method and the Litterati app. The question was “How difficult did you find the classification of the plastics on the beach?” (10 being most difficult). It is difficult to compare because not all respondents used both methods.

Method A (OSPAR)

1 2 (2x) 5 (4x) 6 7 (2x) 8 (2x) 9 (2x) 10

Method B (Litterati)

1 (1x) 2 (3x) 3 (1x) 4 (2x) 5 (2x) 6 (2x) 7 (3x) 8 (1x) 9 (1x) 10

The next question was “How difficult do you find the overall setup for the methods and what is the biggest challenge?”. Again it should be noted that not all respondents used both methods.

Method A (OSPAR)

1 2 3 (2x) 4 (1x) 5 (4x) 6 (1x) 7 8 (4x) 9 10

Method B (Litterati app)

1 (3x) 2 (3x) 3 (3x) 4 (2x) 5 (4x) 6 (2x) 7 (2x) 8 9 10

The mentioned challenges were:

OSPAR: “It is difficult to exactly categorize the plastic on the beach even with the catalogue.”

Litterati app: “It is easy to use but takes so much time.”

“It is hard to keep your phone out during the whole time with bad weather, like rain and wind.”

We also asked “How efficient do you think the methods are in cleaning and monitoring” and “What could change to improve this? “

Method A (OSPAR)

1 2 3 4 (1x) 5 6 7 (2x) 8 (3x) 9 10

Method B (Litterati app)

1 2 3 4 (1x) 5 (1x) 6 7 8 (4x) 9 (2x) 10 (2x)

As reasons for the improvement of the OSPAR method were mentioned:

- hard to find items on the list and some have not been on the list which makes it harder to identify (8x)
- very detailed already (8x)
- collect it and categorize later on (7x)
- some items have not been in the list and unfortunately we found a lot of those (4x)
- very old fashioned (1x)

As reasons for the improvement of the Litterati app were mentioned:

- it's much easier to take pictures (10x)
- more efficient than OSPAR method but it slows down the cleaning (8x)
- maybe if more people take the pictures it will be more efficient (8x)
- with a bigger group this could have been more efficient (8x)
- this method could be improved by leaving the stand with more people at the same time (7x)
- there was so much plastic that it was impossible to do this properly in the app (4x)
- if more people have the app maybe it is more efficient (1x)

But also 10 respondents said about the Litterati app: “The method is good nothing needs to change”. 9 respondents said “it is good because it is categorizing by itself at some point maybe”. And one respondent remarked that the Litterati app takes less time than the OSPAR method.

The last question in the survey asked if the respondents feel like making a contribution to scientific research in a meaningful manner, if so why or why not? For the OSPAR method 5 respondents answered with yes and for the Litterati app 8 respondents answered with yes. Two respondents answered no and stated: “I would feel this way if I knew exactly how my work contributes and how the data is used”.

4 Conclusions and recommendations

4.1 Conclusions on litter per beach

When looking at the amount of beach litter as well as the type we see differences per beach. In general the beaches along the Eastern Scheldt had less litter than along the Western Scheldt. Also the amount of (mostly) blue strings from the fishing nets is lower on the Roompot beach (16,5%) compared to the Breezand (24,5 %), which could be explained by the influence of the storm surge barrier. On the Roompot beach maybe due to the year-round habited holiday homes the amount of cigarette butts was the highest of all objects found, namely 23,3% on average for the 3 stretches of 100 m wide monitored. On the other 4 monitored beaches cigarette butts were not even in the top 5. Also the Roompot beach was although being cleaned more regularly twice as polluted than the Breezand beach.

The table below gives an overview of the average per 100 meters of the total amount of litter found at all our monitored beaches. We could conclude that:

1. per stretch of 100 meter of beach an average of 278 pieces of waste are found;
2. 99% of the amount of waste on the monitored beaches is plastic waste;
3. 60,6% of the plastic waste originates from fisheries and shipping and is composed of the blue chords;

and the top 5 of most found litter objects is:

	Plastic waste item	Average/100 m (from all monitored 100 m stretches of the 5 beaches)
1	Blue chords from fishing nets	406
2	Plastic bag ends	28
3	Unidentified plastic objects > 2,5 cm	23
4	Food and candy wrappers	10
5	Cigarette butts	9,5

When comparing the results of the monitoring from October to December 2019 on the 5 beaches in Zeeland to the most important findings from the plastic waste monitoring on beaches in Veere, Noordwijk, Bergen aan Zee and Terschelling from 2010-2015 (Hougee & Boonstra, 2016), where the most important findings were:

1. per stretch of 100 meter of beach an average of 380 pieces of waste are found;
2. 90% of the amount of waste on the beaches is plastic waste;
3. more than half of the plastic waste originates from fisheries and shipping;

and the top 5 of most found litter objects were:

	Plastic waste item	Average/100 m (from all monitored 100 m stretches of the 5 beaches)
1	Fishing nets and ropes	147
2	Little pieces of polystyrene < 50 cm	64
3	Caps	19
4	Food and candy wrappers	13
5	Balloons and ribbons	12

We can conclude that the average amount per 100 meters beach from all monitoring sessions was 278/100 m. So 100 objects per 100 meter lower than the long term monitoring by Hougee and Boonstra (2016). This could be the influence of the low season, but also that waste behavior of users has improved over the years. But the amount of blue chords is more than three times more. During our monitoring balloons and strings were hardly found, and bottle caps and lids were number 6.

4.2 Conclusions on the monitoring methods

For all combined monitoring and beach clean-up sessions we used the OSPAR method and/or the Litterati app. We asked questions about the user friendliness of these 2 methods in our survey (see appendix 1), but also directly during the sessions and we observed how participants executed their tasks. Almost 50% of the respondents grade the classification of the types of litter as rather to very difficult in both methods. In comparing the overall set-up of the both methods 75% of the respondents value the OSPAR as rather difficult and 42% the Litterati app.

Below the overall positive and negative feedback on the use of both methods.

OSPAR positive user points	OSPAR negative user points
Very complete	Time consuming
Easy to classify (due to example picture)	Difficult to execute with rainy/windy weather
When you have access to a room where you do the counting afterwards it is more easy	No public data sharing
	No photo proof afterwards
	Difficult to find all the categories the first time
	Not all found objects could be matched with the list
	Old fashioned (mentioned 1x)

Litterati app positive user points	Litterati app negative user points
Public sharing of data	Set-up a protocol how to make a picture, e.g.: on the floor from same distance
Easy to take pictures-don't need Wi-Fi on the beach, pictures can be uploaded later	One cannot see the photographed objects from others, only the total amount photographed
Using a bigger group makes it more efficient	Slows down the cleaning
System of tagging is self-learning	Tagging of objects is not unambiguous
	With sandy-wet hands difficult to use the phone
	Difficult to access data from others

During our combined monitoring and beach clean-up sessions we found out how to monitor most effective and efficiently. Of course this was influenced by the amount of participants. The weather when being stormy and/or rainy does influence the efficiency of OSPAR a bit more than Litterati app (when covering the phone with a cover bag).

Another striking thing was that when we asked to collect the blue chords and strings from the fishing nets separately and we counted these afterwards the amount collected largely went up.

4.3. Feedback from citizen scientists on the rationale behind joining monitoring

We handed out a survey to all participants of the combined beach clean-up and monitoring sessions. 20 participants filled in this survey (see appendix 1). Part of the questions concerned the reason why participants joined the combined clean-up and monitoring sessions. The most mentioned reason (60%) was for environmental interest, the second (45%) to earn study credits and the third (35%) to contribute to a cleaner environment. More or less the same reasons were mentioned to join combined clean-up and monitoring sessions in the future as well.

What was valued by participants is the fact that via the monitoring they know more about the type and amount of the beach litter and where it piles up. On top of that they think more about solutions how to reduce the amount of beach litter.

75% of the participants think they contribute more with combined monitoring and clean-up sessions, because more information about the source of the plastic beach litter is gathered and that the data could contribute to better solutions for the plastic litter on beaches. However 25% found the monitoring too time consuming and slowing down the clean-up process. Next to that they don't think that results can be upscaled. All participants are interested in the results from the monitoring.

Because we used students as citizen scientists the weekly schedule at the university has a bigger influence on having time for monitoring than the weather, because we sometimes also had a big group with bad weather. The fact that study credits can be earned does have a positive impact on the amount of volunteers as well.

4.4 Recommendations

Some recommendations based on the monitoring of the 5 beaches in Zeeland from October-December 2019 are:

- Using students as citizen scientists is a good manner to have a basic group and to train this group on the monitoring skills. It would be good to try to organize a 'fixed' group which would monitor 4x per year at 3x 100 m wide stretches at 3 beaches along the Western Scheldt and 2 beaches along the Eastern Scheldt over a period of 5 years.
- The OSPAR is more precise in tagging the litter objects, while with Litterati you can make a challenge and influence policies more easily due to the worldwide visibility. Also you have photos of all objects. A combination of both would be optimum.
- To save time with the manual tagging it would be interesting to see if orally tagging could be a way to speed up the process during monitoring. When the app hears one say plastic bottle cap while photographing it the tag would be added.
- Regularly flying the beaches with a drone to see where litter is piling up as well as influence of tides, seasons etc.
- Check if plastic can be monitored by analyzing drone photos.

Appendix 1-Survey questions citizen science & plastic waste monitoring

1. Demographics

1. What is your age?

.....

2.What is your gender?

m/v/n

3.What is your nationality?

.....

4.What's your occupation?

.....

2. Motivation

1. What were your reasons to join this participatory research and which one was the most

2. Are you planning to participate in research events like this in the future and why or why not?

3. Did you ever before participate in a research like this before?

4. Do you feel like you learned something valuable for your everyday life, if so what?

5. Do you feel like contributing more while monitoring than just cleaning and why?

6. Do you participate in other scientific or communal activities during your free time and if so why or why not?

7. How much interest do you have in the data gathered and the outcomes? (10= high interest)

1 2 3 4 5 6 7 8 9 10

3. Methods

This section aims to compare the two methods. The Ospar method that was carried out with pen and paper will be referred to as “Method A” while the Litterati App is “Method B”. Please circle the appropriate answer for you.

1. How difficult did you find classifying the plastics found on the beach? ()

Method A) 1 2 3 4 5 6 7 8 9 10

Method B) 1 2 3 4 5 6 7 8 9 10

2. How difficult did you find the overall setup of the method? What was the biggest challenge? (10= most difficult)

Method A) 1 2 3 4 5 6 7 8 9 10

Method B) 1 2 3 4 5 6 7 8 9 10

3. How efficient do you think the methods are in cleaning and monitoring? What do you think needs to change to make the research activity more efficient? (10= superefficient)

Method A) 1 2 3 4 5 6 7 8 9 10

.

Method B) 1 2 3 4 5 6 7 8 9 10

4. Do you think you could do this method in a small group self-organised? Why or why not?

Method A)

Method B)

5. Do you feel like you are contributing to scientific research in a meaningful manner? If so why or why not?

Method B)

Appendix 2 Photos from Litterati app

Session 2 Nollestrand

(to be added)

Session 2 Ritthem beach







Session 2 Zoutelande (to be added)

Session Roompot (to be added)

