BASELINE BEACH LITTER DATA FOR SIERRA LEONE 2021-2022

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- OSPAR
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OVERVIEW OF RESEARCH QUESTIONS

- What are the **current volumes and compositions** of marine litter across Sierra Leone's **beaches**?
- Is there **temporal variation** of marine litter in Sierra Leone between **wet and dry season**?
- Is **there spatial variation or similarities** between marine litter categories across survey sites?
- What are the **main sources and drivers** of marine litter in Sierra Leone?
- How can this monitoring approach be adapted to establish a **cost-effective long-term monitoring programme** that captures representative data?
- How can this initial marine litter data set guide and support longer term monitoring and **policy decision support**?

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The **current volumes and compositions** of marine litter across Sierra Leone's **beaches**?

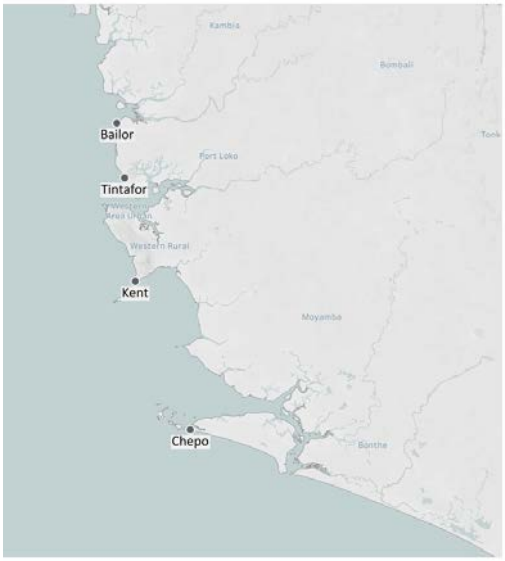


Figure: Survey sites along the coastline of Sierra Leone.

- Four sandy beach sites were chosen.
- All sites have regular use with up to 100 visitors a day, except Kent, a private beach used seasonally.
- The survey approach monitored 100m parallel to the water's edge, in alignment with the **OSPAR methodology (2010)**.

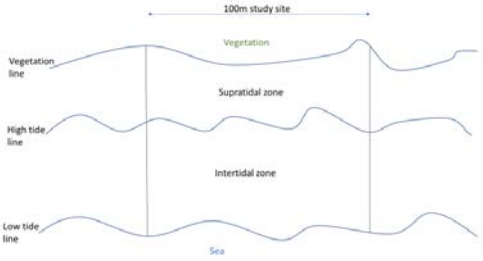


Figure: Diagram showing the combined methodologies (adjusted from Meakins et al., (2022)).

- "From the water's edge to the back of the beach"
- These categories align with the OSPAR approach – but can easily be adapted to fit local contexts and capture regionally/locally unique items.

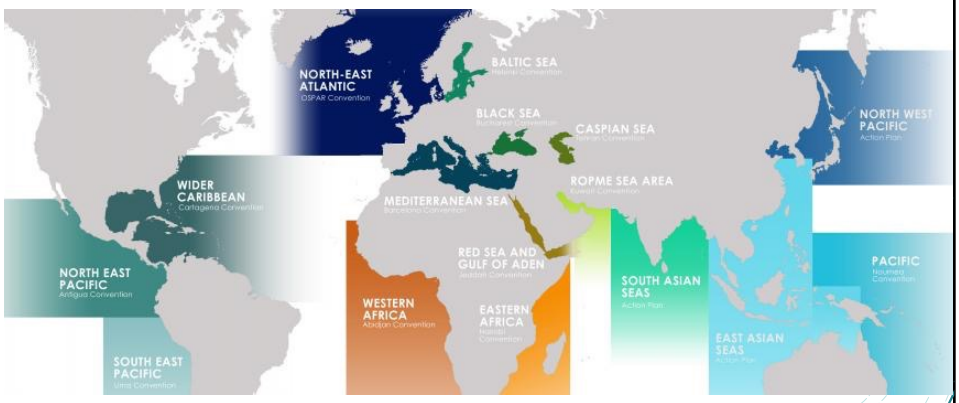
- Quantification of litter is in terms of number of items and DW 100 m^{-1}. Survey data is also converted to items and DW m^{-2} calculations – which is the required quantification for submitting data for SDG indicator 14.1.1b, which we will discuss in more detail later.

- OSPAR used to provide guidance for 1000m/1km of coastline for objects generally larger than 50cm, but they have dropped this guidance in their revised version

(date?)

METHODS & HARMONIZATION:

- OSPAR
- SDG 14.1.1b



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UNEP REGIONAL SEAS PROGRAMMES

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Academics, governments, intergovernmental organizations, and non-governmental organizations involved in marine conservation and environmental protection often use the OSPAR in developing marine litter research protocols, policies and strategies to address marine litter. It allows for a thorough and comparable assessment of beach litter data.

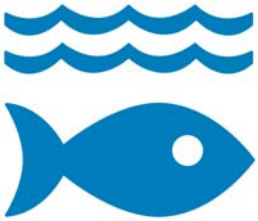
Under its North-East Atlantic Environment Strategy (NEAES) 2010-2020, OSPAR set an objective "*to substantially reduce marine litter in the OSPAR maritime area to levels where properties and quantities of marine litter do not cause harm to the coastal and marine environment*".
Abidjan….

Overall, marine litter levels are still high and further efforts are needed. There is a predominance of plastics among marine litter that is reported across all OSPAR Regions.

Single-use plastics and maritime-related litter are frequently found beach litter items at OSPAR level, with some important regional differences. Nonetheless, there are some positive signs suggesting that progress has been made on preventing plastics

from entering the marine environment in some areas.

14 LIFE BELOW WATER



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SDG 14 TARGETS:

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts

14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

14.4: By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices

14.5: By 2020, conserve at least 10 per cent of coastal and marine areas

14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing

14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources

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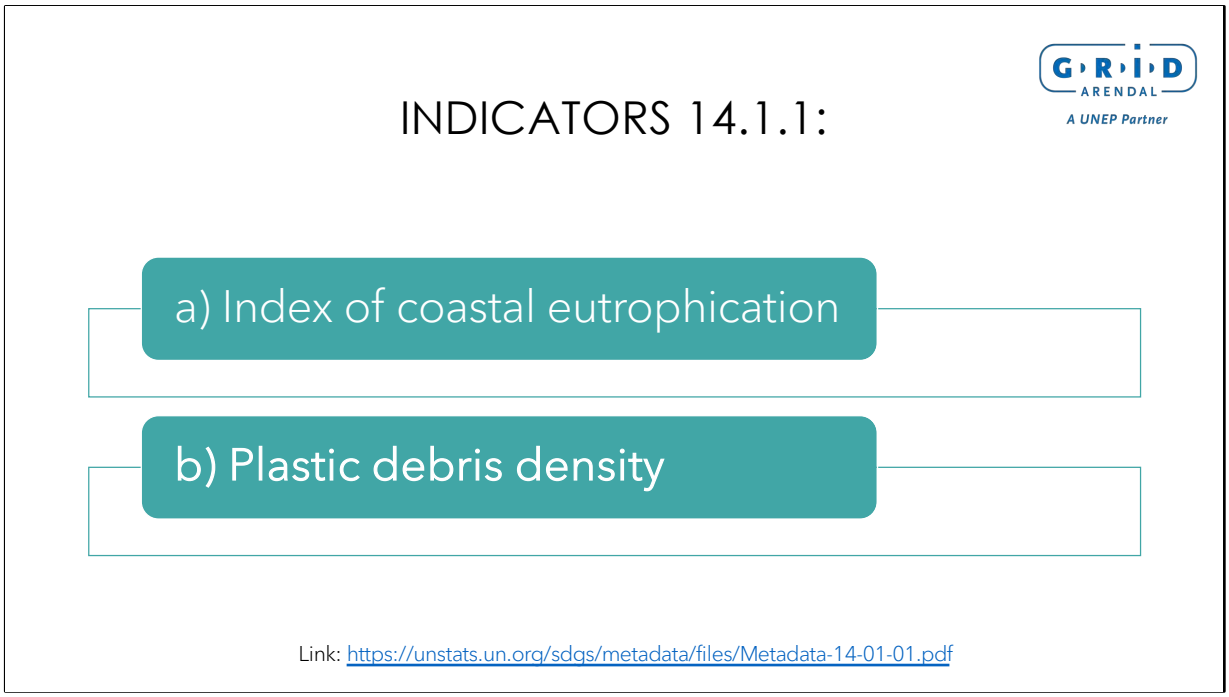

"The indicator 14.1.1a "Index of coastal eutrophication" (ICEP) is based on loads and ratios of nitrogen, phosphorous and silica delivered by rivers to coastal waters."

"The indicator 14.1.1b "Plastic debris density" Based on the existing internationally agreed Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) guidelines and existing national data collections – as it is the most available type of data, it is
recommended that the SDG reporting includes sub-indicators related to beach litter, floating plastic and plastic in the sea column, plastic on the sea floor and additional option indicator of ingestion by biota; the GESAMP guidelines provide several options for monitoring plastic debris, depending on environmental compartment, monitoring capacity and research/policy questions **[maybe add some of this to first presentation instead?]**

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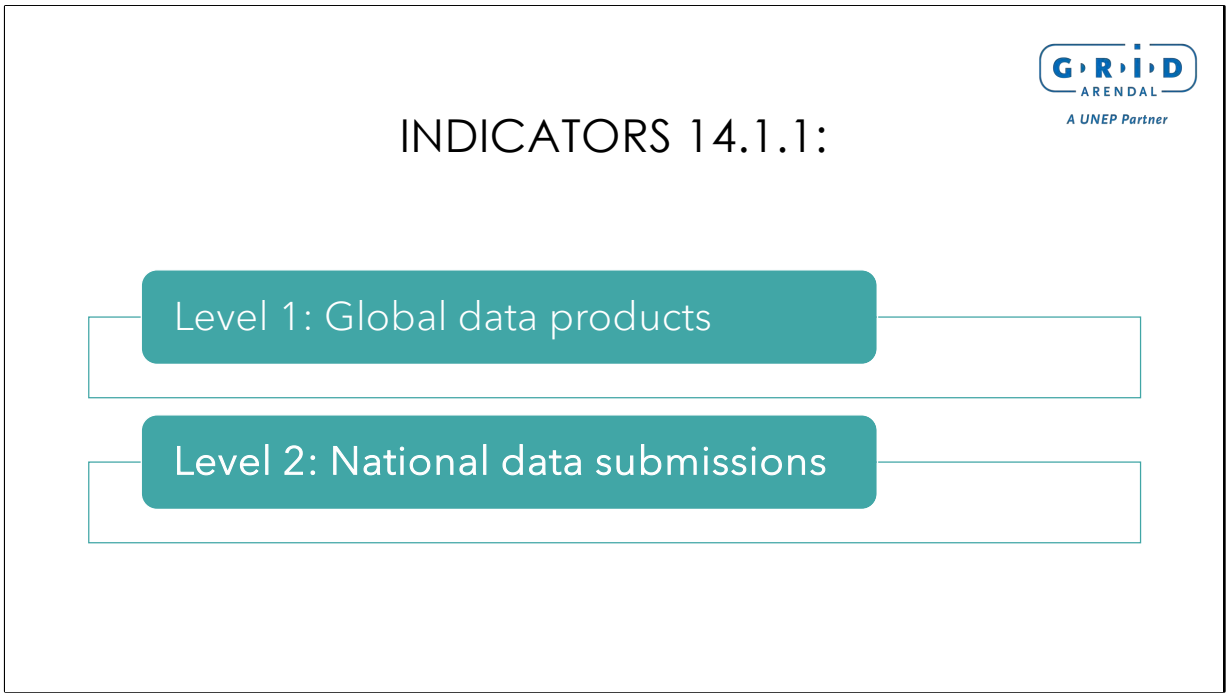
I**t is also important to note the importance of monitoring information on waste management and the sources of plastic pollution for understanding plastic pollution**."

While there isn't a specific SDG focused on waste generation or management, there

are several indicators under Goal 12 ("Ensure sustainable consumption and production patterns") that indirectly measure aspects of waste generation and management. These include:

Indicator 12.4.1: "Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement."
Indicator 12.5.1: "National recycling rate, tons of material recycled."
Indicator 12.5.2: "Amount of waste generated per capita and per economic activity."
Indicator 12.6.1: "Number of companies publishing sustainability reports."
Indicator 12.7.1: "Number of countries implementing sustainable public procurement policies and action plans.

Additionally, waste management and reduction are also indirectly addressed in other SDGs, such as Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action) among others, highlighting the scope of waste management concerning broader sustainable development objectives.



Across the 14.1.1a and 14.1.1b, two **mandatory** levels are proposed:

Level 1: Global Data Products (globally available data from satellite observations and modelling),

Level 2: National Data, which are collected from countries (through the relevant Regional Seas Programme for countries that are member of a Regional Seas Programme, or directly by UNEP).

Level 2 data for 14.1.1b as also been largely contributed from sources including: Florida State University, EPA: European Environment Agency, Marine Litter Watch (MLW); OC: Ocean Conservancy: International Coastal Clean-up (ICC).

The United Nations Environment Programme (UNEP) and the Regional Seas will be carried out extensive data validation procedures that include built-in automated procedures, manual checks and cross-references to national sources of data. Communication will be carried out with countries for clarification and validation of data. Only data that are considered accurate or those confirmed by countries during the validation process will be reported by UNEP on the Global SDG Database. The

United Nations Environment Programme (UNEP) and the Regional Seas do not makeany estimation or imputation for missing values, so the number of data points provided are actual country data.

PROPOSED PARAMETERS FOR 14.1.1.B

Monitoring parameters (and methods)	Level 1	Level 2
Plastic patches greater than 10 meters*	X	
Beach litter originating from national land-based sources	X	
Beach litter (beach surveys)		X
Floating plastics (visual observation, manta trawls)		X
Water column plastics (demersal trawls)		X
Seafloor litter (e.g. benthic or fish survey trawls)		X

The methodologies for these indicators are available in the document:
https://wedocs.unep.org/handle/20.500.11822/35086

The most well established and only indicator that **comes with any guidance** is beach litter (note not plastic specifically). Defined as "Marine litter - any persistent, manufactured or processed solid material which is lost or discarded and ends up in the marine and coastal environment." in indicator 14.1.1b guidance**, but doesn't specify e.g. size class – check 2021 doc – the first reporting cycle for level 2 data has just recently started and will become aligned with the Regional Seas data collection calendar.**

The guidance/methodologies for these indicators are available in the 2021 UNEP document "Understanding the State of the Ocean: A Global Manual on Measuring SDG14.1.1, .2.1 and .5.1.

Last updated about a year ago – quantification specifies number per km sq, but informed that this is being updated again this month, considering that most beach litter surveys are done on a smaller scale and most data that has been submitted is in m^2 or transformed from m2 to km2 – and there are many caveats that can lead to inaccurate extrapolations e.g. spatial variations/assuming coastal homogeneity
The OSPAR quantification can easily be converted to m^2 if the width of the beach is

known.

SIERRA LEONE BEACH LITTER DATA TRANSFORMATION FOR SDG 14.1.1B

Site	Avg. count ($100m^{-1}$)
Bailor	1797.55
Chepo	922.45
Kent	581.73
Tintafor	3325.64

1.Calculate the survey area in square meters:

$$\text{Area} = 100 \text{ x } Width\ of\ beach$$

2. Convert the items per 100 meters to items per square meter:

$$\text{Items per square meter} = \frac{Items\ per\ 100\ meters}{Area} \text{ x } 100$$

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data transformed by dividing each survey result (items per 100m)

SIERRA LEONE BEACH LITTER DATA TRANSFORMATION FOR SDG 14.1.1B

Site	Avg. count ($100m^{-1}$)	Avg. count (m^{-2})	Avg. weight (g^{-1} $100m^{-1}$)	Avg. weight (g^{-1} m^{-2})
Tintafor	3326	1.04	63650	19.89
Bailor	1798	0.18	32479	3.29
Chepo	923	0.28	8677	2.64
Kent	582	0.15	8473	2.21

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Table of our data transformed – weight not a proposed indicator unless reporting in tonnes of beach/ocean litter originating from national land-based sources

Note that the ranking for the avg. count (not weight) for Bailor changes because of this transformation, because Bailor is around twice the width of the other sites, highlighting some of the caveats of transforming data from length of coastline to area.

METHODS & HARMONIZATION:

Country	Author	Survey type	Sites	Size class	Observed density
Sierra Leone	**Present study**	**Standing stock**	**4**	**>2.5cm**	**1656.84 items 100m^{-1} (582-3326 items 100m^{-1}); 28 kg 100m^{-1} (9-64 kg 100m^{-1})**
Ghana	Nunoo and Quayson (2003)	Weekly accumulation	4	Not detailed	698 and 876 items 1000m^{-2} week^{-1}; 7253 and 5951g 1000m^{-2} week^{-1}
Kenya	Okuku et al. (2020)	Daily accumulation	6	>2.5cm	1.53±1.23 and 11.46±7.72 (for dry zones) and 2.69±2.13 and 8.93±7.87 items m^{-1} day^{-1} (for wet zones)]
	Okuku et al. (2021)	Standing stock	1	>2.5cm	0.091-0.736 items m^{-2}; mean of 0.383 ± 0.260 items m^{-2}
South Africa	Chitaka (2020)	Daily accumulation	5	>2cm	36-2961 items 100m^{-1} day^{-1}; 0.19-4.4 kg 100m^{-1} day^{-1}
	Chitaka (2020)	Daily accumulation	5	>2cm	305-2082 items 100 m^{-1} day^{-1}; 557-3799g 100^{-1} day^{-1}
	Ryan (2020)	Standing stock	1	>1cm	Surface: 11.8 items m^{-1}; 249 g m^{-1}; Buried: 123.2 items m^{-1}, 149 g m^{-1}
		Standing stock	1	>1cm	Surface: 14.6 items m^{-1}, 227 g m^{-1}; Buried: 92.8 items m^{-1}, 77.7 g m^{-1}
	Ryan (2021)	Standing stock	1	>1cm	Core items: 0.2 to 19.9 items·100 m^{-1} d^{-1}
	Ryan (2021)	Standing stock	32	Plastic container/bottle items	8-450 bottles km^{-1}
	Weidemann (2020)	Monthly accumulation	1	Not detailed	2.4±1.7 items m^{-1} month^{-1}; 24.9±82.6 g m^{-1} month
		Monthly accumulation	1	Not detailed	2.3± 0.3 items m^{-1} month-1; 3.6± 48.0g m^{-1} month^{-1}
Tanzania	Maione (2021)	Standing stock	4	>2.5cm	Mean weight of 74.2kg/site (46.8-89.7kg)

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Other beach data across Africa, mainly SA

Challenges in comparing different methods – only two other studies reporting in items/g per 100m and 1 in items per m2 (others per 1000km^2, or per m per day/month/avg. weight per site)

METHODS & HARMONIZATION:

Country	Author	Survey type	Sites	Size class	(Transformed to) per m^2	(Transformed to) per m
Sierra Leone	**Present study**	**Standing stock**	**4**	**>2.5cm**	**0.2-1.0 items m^{-2}**	**1-33 items m^{-1}**
Ghana	Nunoo and Quayson (2003)	Weekly accumulation	4	Not detailed	0.7 and 0.9 items m^{-2}	
Kenya	Okuku et al. (2020)	Daily accumulation	6	>2.5cm		2-12 items m^{-1} day^{-1}
	Okuku et al. (2021)	Standing stock	1	>2.5cm	0.1-0.74 items m^{-2}	
South Africa	Chitaka (2020)	Daily accumulation	5	>2cm		0.04-3 items m^{-1} day^{-1}
	Chitaka (2020)	Daily accumulation	5	>2cm		3-21 items m^{-1} day^{-1}
	Ryan (2020)	Standing stock	1	>1cm		11.8 items m^{-1}
		Standing stock	1	>1cm		14.6 items m^{-1}
	Ryan (2021)	Standing stock	1	>1cm		0.002 to 0.2 items m^{-1} d^{-1}
	Ryan (2021)	Standing stock	32	Plastic container/bottle items only		0.008-0.45 bottles m^{-1}
	Weidemann (2020)	Monthly accumulation	1	Not detailed		2.4 items m^{-1} $month^{-1}$
		Monthly accumulation	1	Not detailed		2.3 items m^{-1} $month^{-1}$
Tanzania	Maione (2021)	Standing stock	4	>2.5cm		

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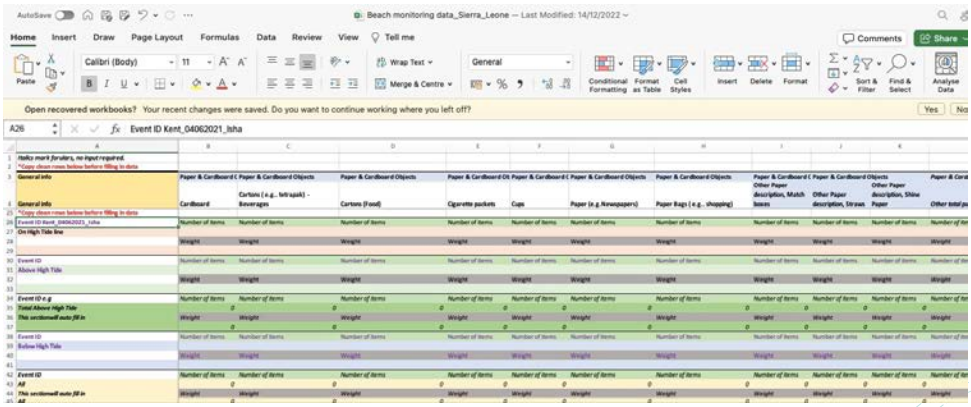
Transform to m^2 or per m – no peer-reviewed studies reporting in km^2

Tintafor one of the highest reports

DATA MANAGEMENT



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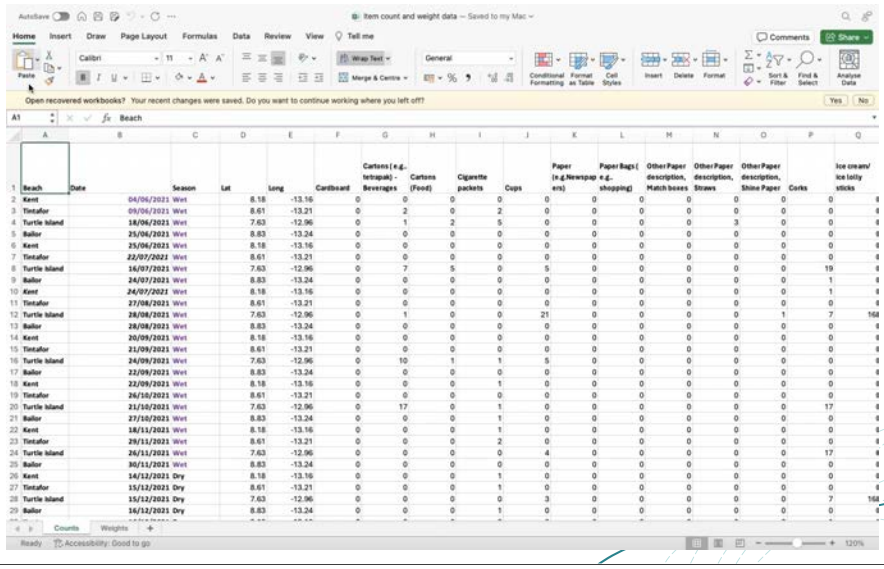
Data was input to an excel Masterfile from data sheets that were filled in by hand. Naturally in dealing with such large datasets, human error can lead to mistakes inputting data or formulas used – so it is vital to have a verification stage to ensure there are no irregularities (ideally multiple people providing random spot checks of data).

A total of 124 different categories/items of litter were found in this study. With this level of detail we can explore the volumes and types of litter, not only between beaches, but we can examine the diff

compartments of the beach to further understand potential sources and behaviours of litter items.

DATA EXPLORATION & VISUALIZATION



Beach	Date	Season	Lat	Long	Cardboard	Cartons (e.g., tetrapak) - Beverages	Cartons (Food)	Cigarette packets	Cups	Paper (e.g.Newspaper)	Paper Bags (e.g. shopping)	Other Paper description, Match boxes	Other Paper description, Straws	Other Paper description, Shine Paper	Corks	Ice cream/ ice lolly sticks
Kent	04/06/2021	Wet	8.18	-13.16	0	0	0	0	0	0	0	0	0	0	0	
Tintafor	09/06/2021	Wet	8.61	-13.21	0	2	0	2	0	0	0	0	0	0	0	
Turtle Island	18/06/2021	Wet	7.63	-12.96	0	1	2	5	0	0	0	0	3	0	0	
Ballor	25/06/2021	Wet	8.83	-13.24	0	0	0	0	0	0	0	0	0	0	0	
Kent	25/06/2021	Wet	8.18	-13.16	0	0	0	0	0	0	0	0	0	0	0	
Tintafor	22/07/2021	Wet	8.61	-13.21	0	0	0	0	0	0	0	0	0	0	0	
Turtle Island	16/07/2021	Wet	7.63	-12.96	0	7	5	0	5	0	0	0	0	0	19	
Ballor	24/07/2021	Wet	8.83	-13.24	0	0	0	0	0	0	0	0	0	0	1	
Kent	24/07/2021	Wet	8.18	-13.16	0	0	0	0	0	0	0	0	0	0	1	
Tintafor	27/08/2021	Wet	8.61	-13.21	0	0	0	0	0	0	0	0	0	0	0	
Turtle Island	28/08/2021	Wet	7.63	-12.96	0	1	0	0	21	0	0	0	0	1	7	
Ballor	28/08/2021	Wet	8.83	-13.24	0	0	0	0	0	0	0	0	0	0	0	
Kent	20/09/2021	Wet	8.18	-13.16	0	0	0	0	0	0	0	0	0	0	0	
Tintafor	21/09/2021	Wet	8.61	-13.21	0	0	0	0	0	0	0	0	0	0	0	
Turtle Island	24/09/2021	Wet	7.63	-12.96	0	10	1	1	5	0	0	0	0	0	0	
Ballor	22/09/2021	Wet	8.83	-13.24	0	0	0	0	0	0	0	0	0	0	0	
Kent	22/09/2021	Wet	8.18	-13.16	0	0	0	1	0	0	0	0	0	0	0	
Tintafor	26/10/2021	Wet	8.61	-13.21	0	0	0	0	0	0	0	0	0	0	0	
Turtle Island	21/10/2021	Wet	7.63	-12.96	0	17	0	1	0	0	0	0	0	0	17	
Ballor	27/10/2021	Wet	8.83	-13.24	0	0	0	1	0	0	0	0	0	0	0	
Kent	18/11/2021	Wet	8.18	-13.16	0	0	0	1	0	0	0	0	0	0	0	
Tintafor	28/11/2021	Wet	8.61	-13.21	0	0	0	2	0	0	0	0	0	0	0	
Turtle Island	26/11/2021	Wet	7.63	-12.96	0	0	0	0	4	0	0	0	0	0	17	
Ballor	30/11/2021	Wet	8.83	-13.24	0	0	0	0	0	0	0	0	0	0	0	
Kent	14/12/2021	Dry	8.18	-13.16	0	0	0	1	0	0	0	0	0	0	0	
Tintafor	15/12/2021	Dry	8.61	-13.21	0	0	0	1	0	0	0	0	0	0	0	
Turtle Island	15/12/2021	Dry	7.63	-12.96	0	0	0	0	3	0	0	0	0	0	7	
Ballor	16/12/2021	Dry	8.83	-13.24	0	0	0	1	0	0	0	0	0	0	0	

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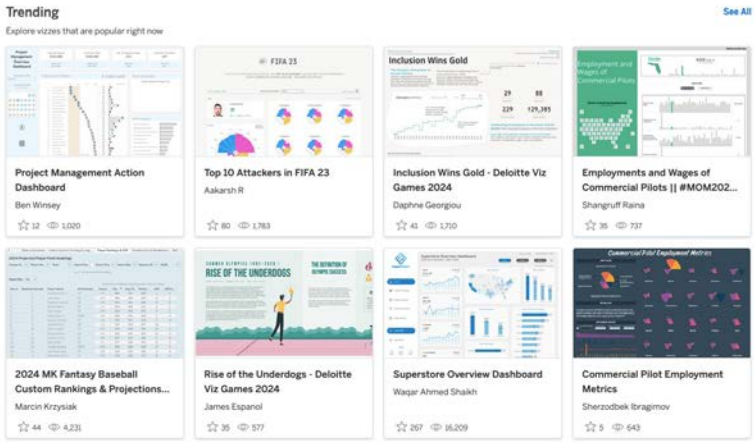
[different data sets provided]

DATA EXPLORATION & VISUALIZATION



Link: https://public.tableau.com/app/discover

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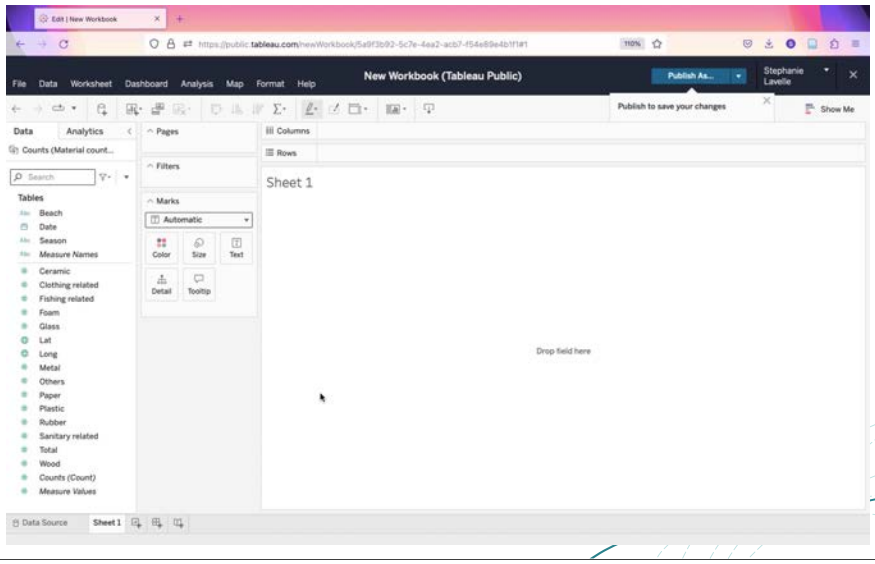
Free visualisation tool (limited descriptive statistics) – just need to sign in and have an account

Is there **temporal variation** of marine litter in Sierra Leone between **wet and dry season**?



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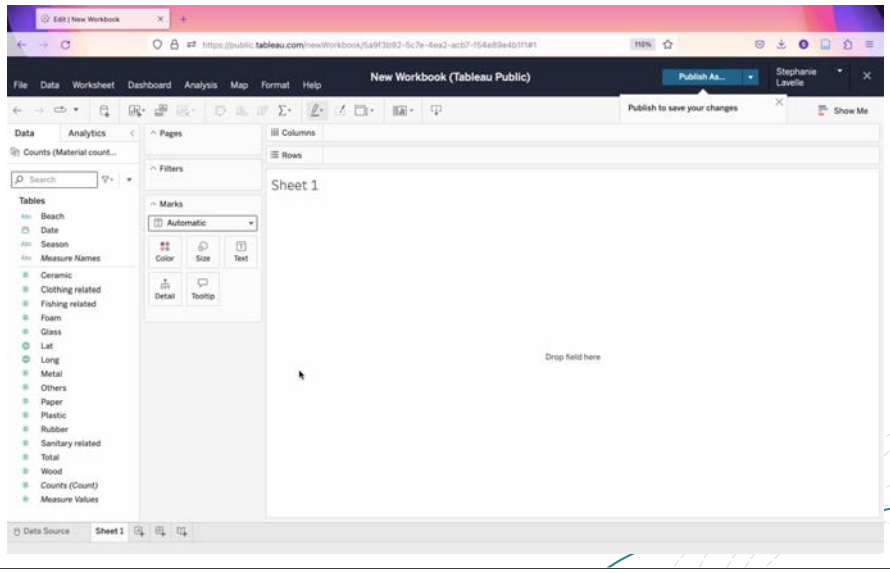
Is **there spatial variation or similarities** between marine litter categories across survey sites?



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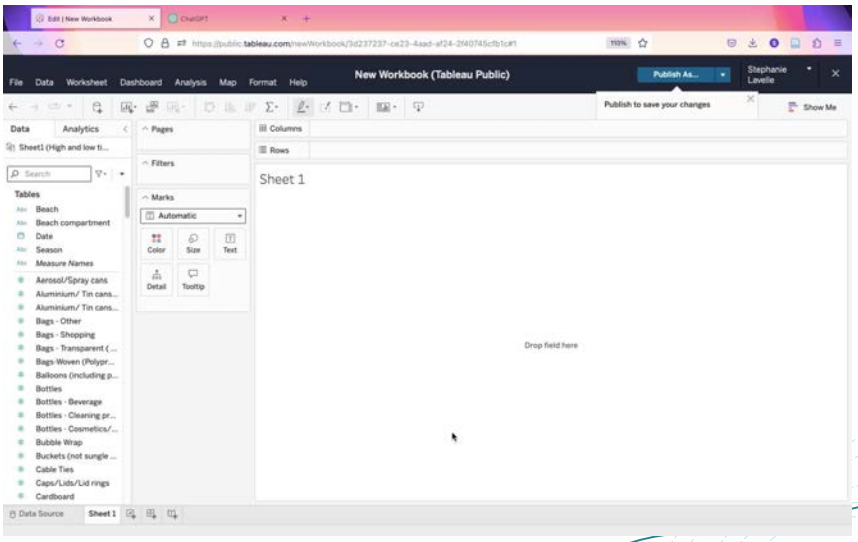
What are the **main sources** and drivers of marine litter in Sierra Leone?



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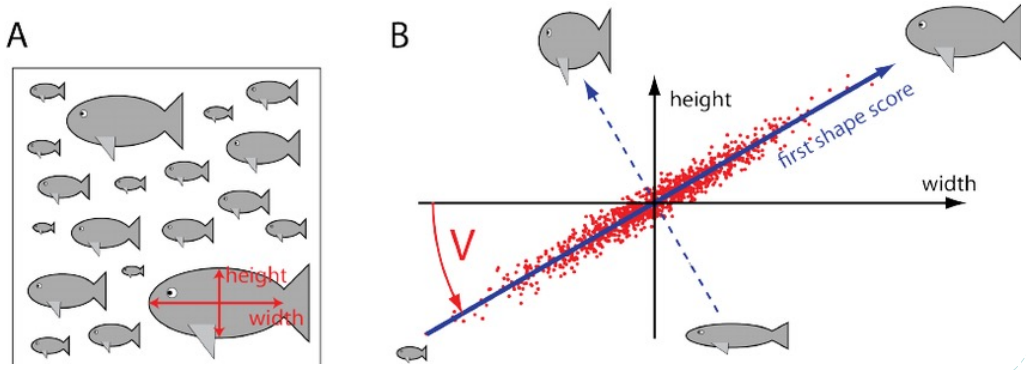
PRINCIPAL COMPONENT ANALYSIS



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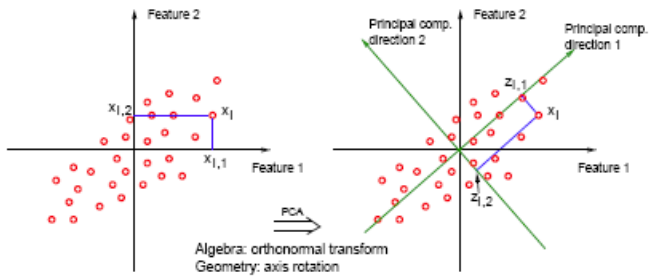
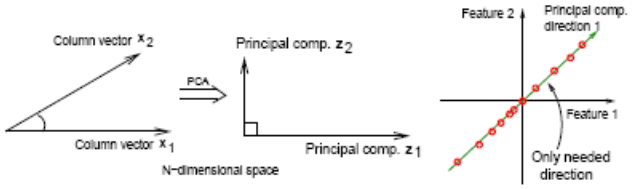
Principal Component Analysis (PCA) is a statistical technique that can help evaluate variables within groups of data.

Used to reduce the dimensionality of a dataset while preserving most of its important information. The main goal of PCA is to identify patterns and structures in data by transforming the original variables into a new set of variables, called principal components.

PRINCIPAL COMPONENT ANALYSIS





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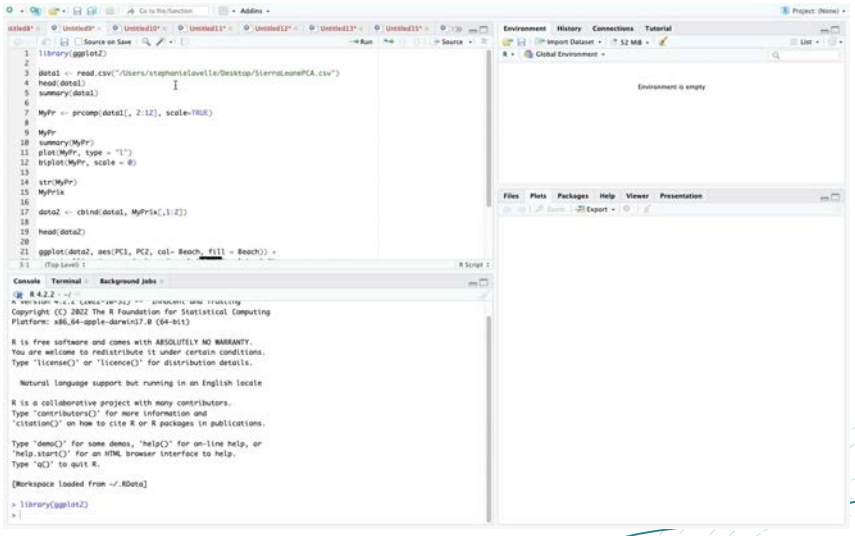
Standardization: PCA typically starts with standardizing the data to have a mean of 0 and a standard deviation of 1 across each feature.
Covariance Matrix: PCA computes the covariance matrix of the standardized data. The covariance matrix represents the relationships between different features in the dataset.
Eigenvalue Decomposition: PCA then performs eigenvalue decomposition on the covariance matrix to find its eigenvectors and eigenvalues.
Principal Components: The eigenvectors represent the directions of maximum variance in the data, and the eigenvalues indicate the amount of variance explained by each eigenvector. The eigenvectors are sorted based on their corresponding eigenvalues, and the top k eigenvectors (principal components) are selected to form a new feature space.
Dimensionality Reduction: Finally, PCA projects the original data onto the new feature space formed by the selected principal components, effectively reducing the dimensionality of the dataset.

By retaining only the principal components that capture the most variance in the data, PCA helps in simplifying complex datasets while minimizing information loss. It

is widely used in various fields such as image processing, finance, and genetics for tasks like data visualization, noise reduction, and feature extraction.

PRINCIPAL COMPONENT ANALYSIS



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Principal Component Analysis (PCA) in R (insert video)

PRINCIPAL COMPONENT ANALYSIS

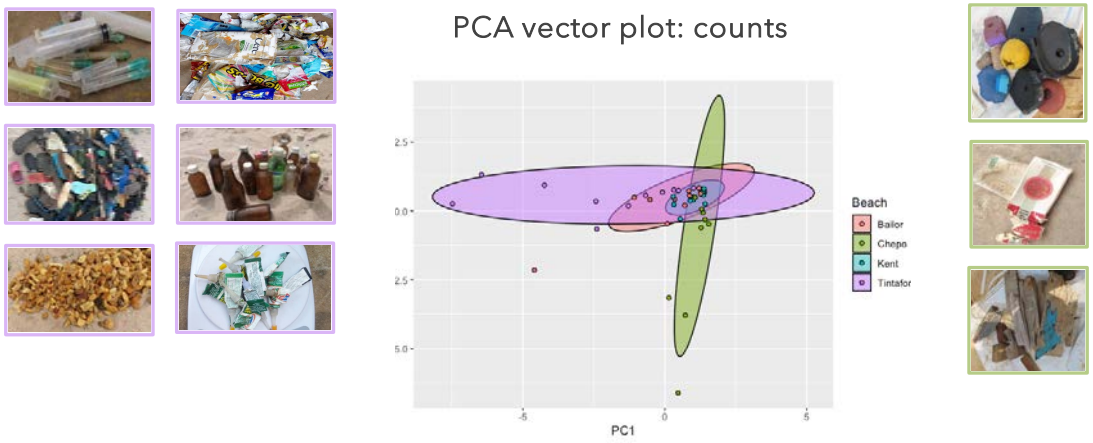

Figure: PCA vector plots for litter material categories for counts grouped by site

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The PCA vector plots illustrate how two components, PC1 and PC2, account for 64 % of the total variance for both count and weight analyses of material categories. Relationships are clear between PC1 and Tintafor, as well as PC2 and Chepo. Considering the count analysis; sanitary related, plastic, clothing-related, glass, foam and metal are strongly related to PC1, while rubber, paper and wood are strongly correlated with PC2.

PRINCIPAL COMPONENT ANALYSIS

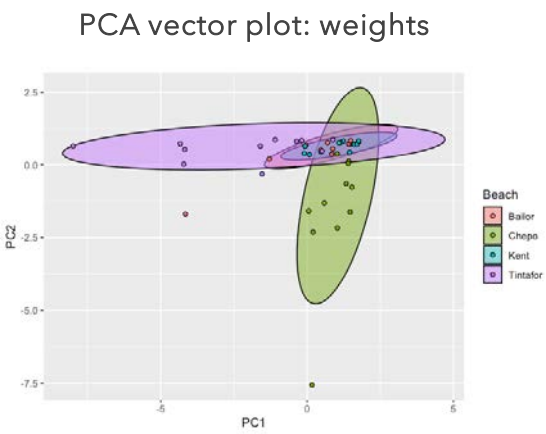


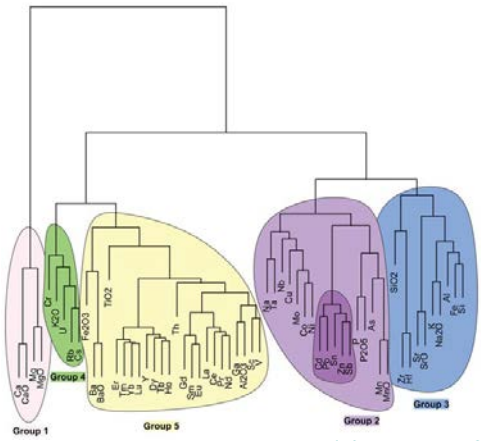
Figure: PCA vector plots for litter material categories for weights grouped by site

For weight analysis a similar trend is observed where clothing-related, sanitary- related, glass, foam, plastic and metal are strongly correlated with PC1, while rubber, paper and fishing gear are strongly correlated with PC2.

How can this monitoring approach be adapted to establish a **cost-effective long-term monitoring programme** that captures representative data?

In consideration of cost-efficiency and choosing one representative site:

Agglomerative hierarchical clustering is a method used to group similar data points together based on their characteristics.



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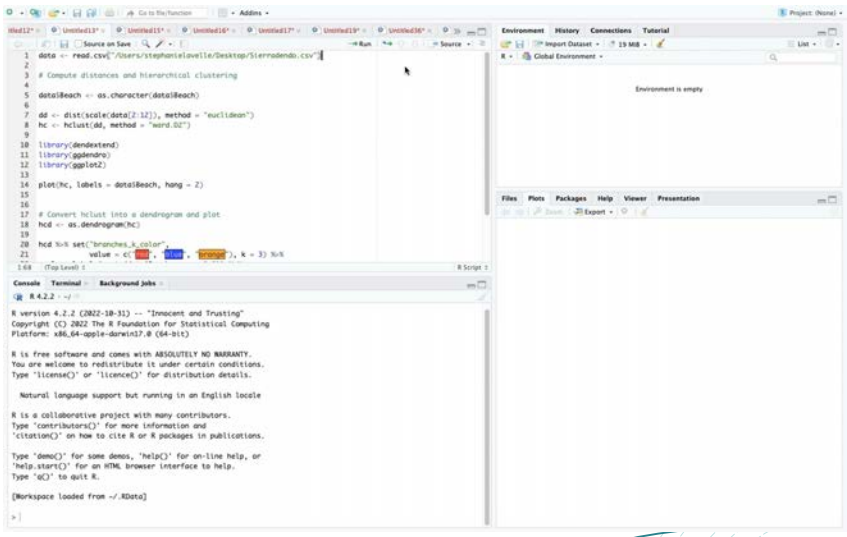
Similarity Measurement: Calculate the similarity (or dissimilarity) between each pair of clusters. This is often done using a distance metric such as Euclidean distance, Manhattan distance, or correlation distance.

Merge Closest Clusters: Merge the two closest clusters into a single cluster. The distance between clusters is determined by the chosen similarity measure.

Dendrogram: Aa dendrogram (tree diagram) is constructed to illustrate the hierarchical structure of the clusters. This dendrogram can be used to visualise how clusters are formed and decide on the number of clusters to use.

AGGLOMERATIVE HIERARCHAL CLUSTERING



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AHC in R (insert video)

THANK YOU