

SCIENTIFIC REPORT

Characterisation of floating plastic macrodebris in Benoa Bay using the Mobula 8 collecting vessel

Field campaign 06/2023 to 03/2024, Bali, Indonesia

Center for Remote Sensing and Ocean Sciences (CReSOS), Udayana University
The SeaCleaners, Scientific Hub
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STATUS OF THIS EDITION

This edition is based on the scientific survey report prepared by CReSOS and The SeaCleaners in 2024. It has been restructured, translated into French and complemented with the Mobula 8 operational data held in the project archives (collection log 06/2023 to 12/2023, protocol annexed to the cooperation agreement, calendar of survey days). All values were checked: totals were recalculated from the cell values and the discrepancies identified are reported in Appendix D. The raw characterisation data are held by CReSOS.

The study was carried out by The SeaCleaners, then operated by its French entity. Since 06/2024, The SeaCleaners Swiss, founded in 2019, has taken over all activities of the association and is responsible for the dissemination of this work.

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Abstract

From 06/2023 to 03/2024, CReSOS (Udayana University) and The SeaCleaners carried out the first characterisation of floating plastic macrodebris in Benoa Bay, southern Bali, using debris intercepted by the Mobula 8, a collecting vessel designed for sheltered waters.

Seven sites representative of the main environments of the bay (mangroves, river mouth, port areas, channel, tourist shoreline and outer waters) were monitored using repeated linear transects, two days per site and per month. Items larger than 50 millimetres were counted, classified as whole items or fragments and assigned to a harmonised list derived from the CSIRO and European Joint Research Centre references. In total, 3,840 plastic items were characterised, 85.7% of them whole.

Soft plastics clearly dominate the sample (about 83% of items), ahead of hard plastics (13%). Food wrappers, cups and lids, thin film bags and sachets make up most of the identified items; among recognisable products, snack packaging (258 items), mineral water (214) and instant drinks (181) rank first. The spatial distribution is highly contrasted: West Benoa Harbour (L7) and the harbour canal (L4) together account for more than half of all items, whereas South Harbour (L5) accounts for less than 4%. Counts peak in 06/2023 and 07/2023 and then decrease sharply, although no lasting trend can be established over a period shorter than one annual cycle.

In parallel, the Mobula 8 operational log records 5,316.9 kilograms of plastic removed from the bay between 06/2023 and 12/2023, over 105 collection days. The high share of whole items, the nature of the products and the location of the most affected sites suggest recent and largely local inputs linked to urban, port and tourism activities, modulated by tidal currents. These results provide a first baseline for the bay and support a harmonised protocol that can be reproduced at other intervention sites.

Keywords : floating macrodebris, soft plastics, Benoa Bay, Bali, collecting vessel, transects, characterisation, single use packaging

3,840
plastic items characterised, 06/2023 to 03/2024

83%
soft plastics among items counted

52%
of items recorded at two sites, L7 and L4

5,316.9
kilograms of plastic collected by the Mobula 8, 06/2023 to 12/2023

HOW TO READ THE INDICATORS

Characterised items come from transect sampling: they represent neither all the debris collected by the vessel nor the total stock in the bay. Operational tonnages and scientific counts describe complementary realities and must not be added together.

1 Introduction and objectives

Plastic pollution of tropical coastal environments is one of the major environmental challenges in Southeast Asia. According to Jambeck and colleagues (2015), Indonesia generated about 3.22 million tonnes of mismanaged plastic waste per year in 2010, of which 0.48 to 1.29 million tonnes were likely to reach the ocean, ranking it second worldwide after China. While several studies have described microplastics in Benoa Bay (Nugroho and colleagues, 2018; Suteja and colleagues, 2024), no published data, to our knowledge, addressed the distribution, abundance and nature of floating macroplastics in the bay.

In 03/2023, The SeaCleaners commissioned its first collecting vessel, the Mobula 8, in Benoa Bay as part of its first international operation. To document the debris intercepted, the association partnered with the Center for Remote Sensing and Ocean Sciences (CReSOS) of Udayana University, a research centre founded in 2002 with the Japan Aerospace Exploration Agency and the Indonesian National Institute of Aeronautics and Space, specialised in remote sensing and the observation of coastal and marine environments. A cooperation agreement signed in 05/2023 set out the joint protocol, the funding of the study by The SeaCleaners and the sharing of results.

1.1 Objectives

- Establish a baseline of the nature, abundance and spatial and temporal distribution of floating macroplastics in Benoa Bay.
- Identify the most frequent item categories and product types in order to inform prevention at source.
- Test, under real conditions, a characterisation protocol compatible with international references and transferable to other Mobula intervention sites.

These objectives are part of the three focus areas of The SeaCleaners Scientific Hub: quantifying plastic pollution in coastal environments, building a community of partners and practitioners, and sharing the state of knowledge on floating debris in coastal waters.

2 Study area

Bali generates about 4,281 tonnes of waste per day. According to the Bali Partnership (2019), nearly 48% is managed responsibly; the remainder is mismanaged or uncollected, and about 11% of the island's waste ends up in aquatic environments. River inputs to the sea are concentrated on the south coast, where the main urban and tourist areas are located (figure 1).



Figure 1. River to ocean plastic leakage in Bali, in kilograms per day. Source: Bali Partnership.

Benoa Bay, in southern Bali, falls under the regencies of Badung and Denpasar. It is a shallow, semi enclosed tidal bay fringed with mangroves, sandy beaches and coral areas. It is almost closed to the south by the narrow sandy Benoa peninsula, which leaves an entrance about 1 kilometre wide to the busy port of Benoa. North of this entrance, Serangan Island is separated from Bali by very shallow waters, 400 metres wide at the narrowest point (Ningsih and Azhar, 2013).

Six rivers flow into the bay, which combines port activities, boating, tourism and residential areas (Nugroho and colleagues, 2018). It is also exposed to eutrophication, untreated sewage discharge and the proximity of the Suwung landfill.

3 Materials and methods

3.1 The Mobula 8 collecting vessel

The Mobula 8 is a collecting catamaran, developed with EFINOR Sea Cleaner, designed for calm waters: rivers, canals, estuaries and harbours. It operates with a crew of three (one pilot and two operators) up to 5 nautical miles from the coast in calm conditions and can be transported by road on a trailer. During collection, the vessel moves at 1.5 to 2 knots; opening the bow creates a suction effect that draws floating debris located 2.5 to 4 metres upstream into the opening. Between the two hulls, a basket retains debris larger than 5 millimetres; it is lifted after each transect for initial sorting on the central table.



Figure 2. The Mobula 8 operating in Benoa Bay.

Mobula 8 specifications	
Surface cleaning capacity	15,000 square metres per hour
Collection width	4 metres, thanks to the front funnelling device
Collection depth	Floating solid and liquid debris down to 0.4 metre below the surface
Solid debris storage	5 to 8 cubic metres (2,400 kilograms) in big bags
Liquid debris storage	600 litres; hazardous debris in dedicated boxes

Table 1. Main technical specifications of the Mobula 8.

3.2 Sites and sampling design

Sites were jointly defined by the science and operations teams according to the characteristics of the bay (tides, currents, accessibility in a shallow bay, proximity to rivers, ports and mangroves). At each site, collection follows the same protocol: three linear transects, each repeated three times, carried out at exactly the same location, allowing comparison between transects, sites and months. The start and end coordinates of each transect were recorded by GPS during the first outing. Seven sites were selected (table 2, figure 3).

Code	Site	Environment	Days per month	Transects per day	Access constraints
L1	Serangan	Open water and mangroves	2	3	Tide, bridge clearance
L2	Rangda	River	2	3	Same as L1
L3	Harbour	Benoa port and fishing port	2	3	None
L4	Harbour canal	Channel linking the bay to open water	2	3	Vessel traffic
L5	South Harbour	Tip of Nusa Dua	2	3	Tide
L6	Outside Benoa	Outer waters	Opportunistic	3	Weather
L7	West Benoa Harbour	Fishing port, western sector	2	3	Vessel traffic

Table 2. Monitoring sites in Benoa Bay and sampling design.

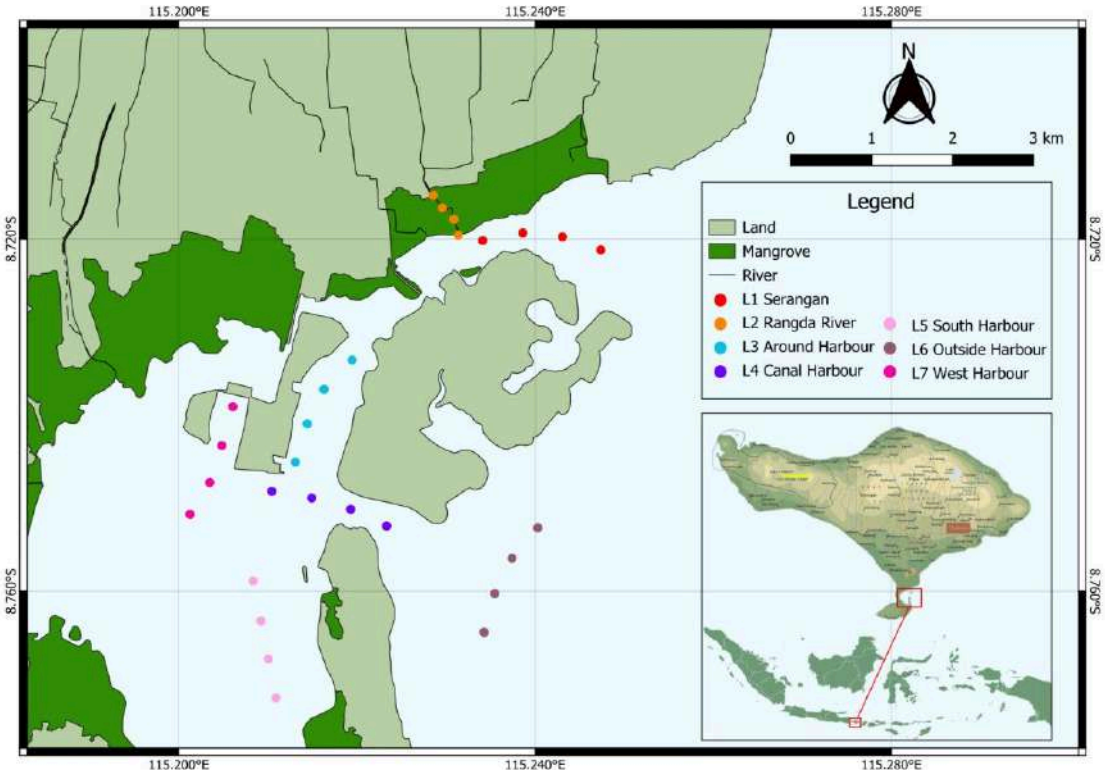


Figure 3. Location of transects in Benoa Bay (L1 Serangan, L2 Rangda River, L3 harbour, L4 harbour canal, L5 South Harbour, L6 outside the bay, L7 West Harbour). Source: CReSOS.

3.3 Schedule

The campaign ran from 06/2023 to 03/2024, that is ten months covering the dry season (June to August) and the wet season (December to February). Survey days were planned each month according to tide times, with collection windows of three to six hours per site. The schedule actually achieved, reconstructed from the data files, is given in Appendix A: some sites could not be sampled in some months because of technical stoppages of the vessel, weather or navigation constraints.

3.4 Debris characterisation

Debris from each transect was kept separately, labelled and then characterised on land by CReSOS surveyors. Items larger than 50 millimetres were counted against a predefined list adapted from the CSIRO datasheets (version 1.3) and the European Joint Research Centre joint list (Appendix B), distinguishing whole items from fragments, and grouped into eight categories: hard plastics, soft plastics, plastic straps, rubber, foam, fishing gear, miscellaneous and other. Each category was weighed and its volume estimated; identifiable brands were recorded. The “other” category, which includes items that are not necessarily plastic, is excluded from the analyses.

3.5 Associated operational data

Outside the transects, the Mobula 8 crew kept a daily collection log: area, times, presence of surveyors on board and weight of debris by material family (organic, plastic, textile, glass, metal, paper, wood, rubber, other). This log, available from 06/2023 to 12/2023, is used here to describe the collection effort. It also includes a dedicated column for the weight of plastics taken from the transects, used in section 4.6.

3.6 Data processing and quality control

Monthly counts by site and form come from the CReSOS survey report. For this edition, totals were recalculated from the cell values and cross checked against the available data entry files. Percentages by category are taken from the original report. An analysis using generalised additive models, designed to model the non linear relationship between time and debris concentration at each site, is being prepared by CReSOS for publication.

4 Results

4.1 Collection effort and operational volumes

The vessel began regular operations in 06/2023. From 06/2023 to 12/2023, the log records 105 collection days out of about 150 theoretically possible days, 42 of which had CReSOS surveyors on board. The remaining days were lost to maintenance, weather, navigation constraints or public holidays; in particular, the vessel was out of the water for most of 11/2023 for antifouling. Over this period, 5,316.9 kilograms of plastic were recorded, out of 14,754.4 kilograms of material in total, including nearly 9 tonnes of organic matter (figure 4).

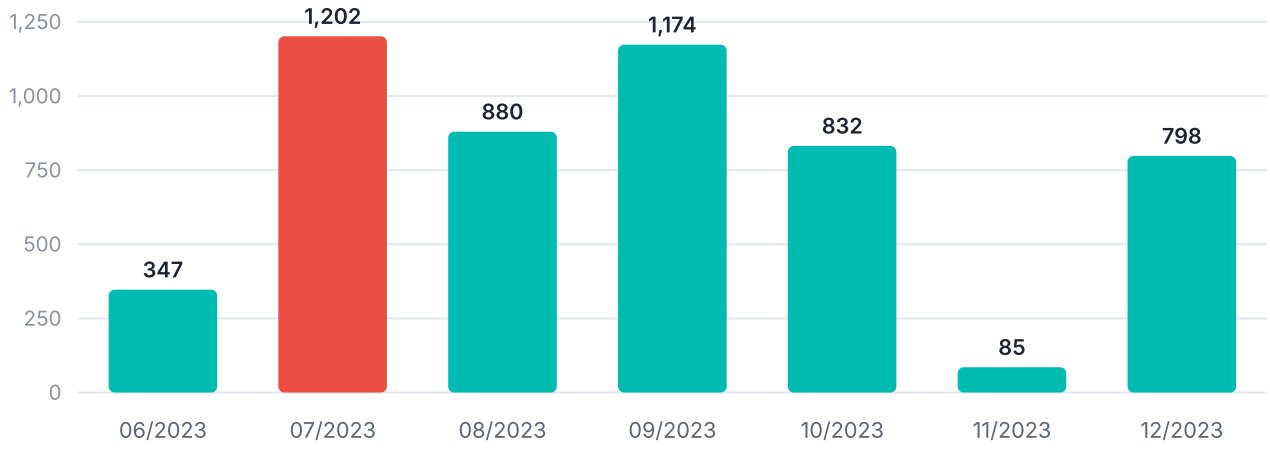


Figure 4. Plastic collected each month by the Mobula 8, in kilograms (operational log, 06/2023 to 12/2023). The low in 11/2023 reflects the vessel being out of service.

Month	06/2023	07/2023	08/2023	09/2023	10/2023	11/2023	12/2023	Total
Plastic (kilograms)	347.2	1,201.8	879.9	1,173.5	831.8	85.0	797.7	**5,316.9**
All materials (kilograms)	628.6	8,030.3	3,068.4	1,300.6	837.8	86.0	802.7	**14,754.4**
Collection days	13	18	19	16	15	5	19	**105**
Days with surveyors	1	4	9	8	6	4	10	**42**

Table 3. Monthly summary of the operational log. In 06/2023, organic matter was counted in bags rather than weighed: the total for that month is underestimated.

Plastic collection varies strongly from month to month. These variations are consistent with seasonal changes in wind and current (from 11/2023, winds push debris westward, out of reach of the vessel) and with operational stoppages; however, the data do not allow a precise effect to be attributed to each factor, nor a lasting decrease in pollution to be inferred.

4.2 Abundance and form of items

Across the whole campaign and the seven sites, 3,840 plastic items were characterised (excluding the "other" category). Whole items largely dominate: 3,289 items, that is 85.7%, against 551 fragments (14.3%).

4.3 Composition by category

Soft plastics are the dominant category, with 85% of whole items and 72% of fragments; across all items, they account for about 83% of the sample. Hard plastics come second (13% of both whole items and fragments). Foam, rubber, straps and miscellaneous items remain marginal, but are proportionally more frequent among fragments, which are more diverse than whole items (figure 5).

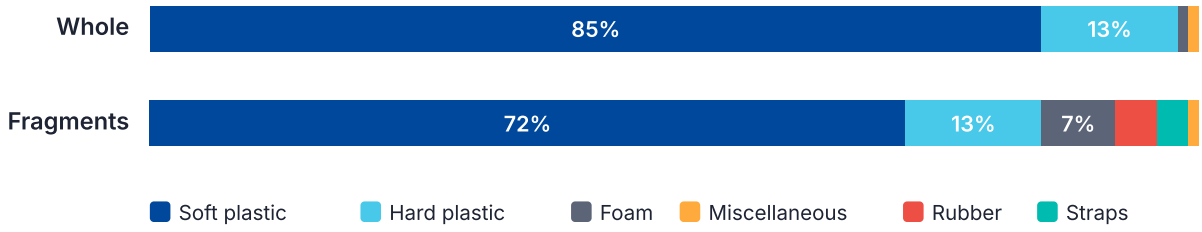


Figure 5. Composition of whole items and fragments by category, as a percentage of the number of items (06/2023 to 03/2024).

On average per site, soft plastics rose from 78 items in 06/2023 to a maximum of 125 items in 07/2023, then gradually decreased. Hard plastics fell from an average of 18 items per site in 06/2023 to a single item in 02/2024. Soft plastics are the dominant category in nine months out of ten (table 4); only in 06/2023 do hard plastics appear among the ten most frequent groups, at the harbour canal (L4), with bottle caps and lids.

Month	Items	Category	Most affected site	Main items
07/2023	877	Soft plastic	L7	Food wrappers, other soft
06/2023	543	Soft plastic	L4	Food wrappers, cups and lids
09/2023	363	Soft plastic	L4	Food wrappers, other soft
08/2023	302	Soft plastic	L4	Food wrappers, other soft
12/2023	264	Soft plastic	L2	Thin film bags, cups and lids
01/2024	218	Soft plastic	L2	Thin film bags, other soft
10/2023	202	Soft plastic	L4	Food wrappers, cups and lids
03/2024	197	Soft plastic	L7	Food wrappers, other soft
06/2023	126	Hard plastic	L4	Bottle caps and lids, other hard
11/2023	117	Soft plastic	L1	Thin film bags, other soft

Table 4. The ten most frequent month and category groups. The "items" column gives the monthly total for the category across all sites; the site shown is where the category was most abundant that month.

4.4 Spatial distribution

The distribution of items between sites is highly contrasted (figure 6). West Benoa Harbour (L7), next to the fishing port, accounts for 1,103 items (28.7%), ahead of the harbour canal (L4) with 899 items (23.4%) and the Rangda River (L2) with 613 items. Conversely, South Harbour (L5), at the tip of Nusa Dua, accounts for only 149 items, less than 4% of the sample.

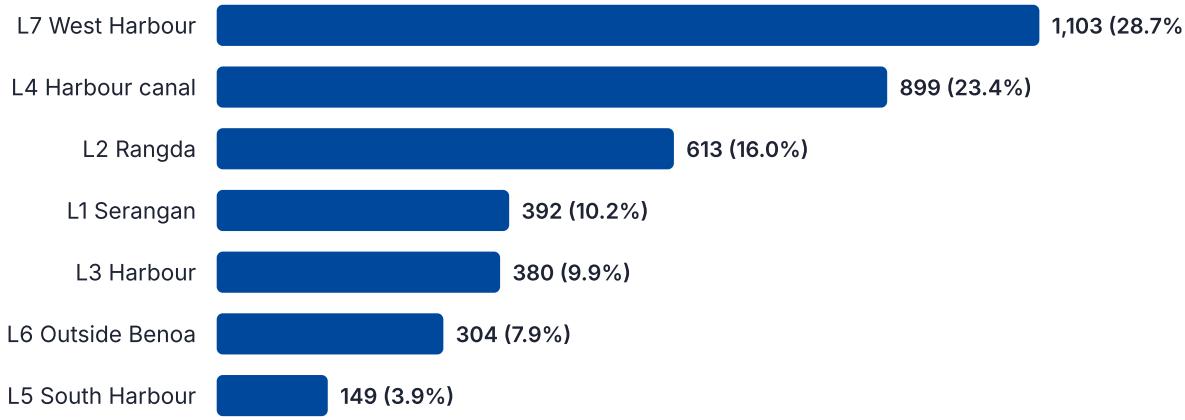


Figure 6. Total number of items characterised per site and share of the sample (06/2023 to 03/2024). Sampling effort is not strictly identical between sites (Appendix A).

4.5 Temporal variability

Counts peak at the start of the campaign (figure 7). Whole items reached their maximum in 07/2023 (861 items), mainly at L7 (294), L2 (178), L1 (134) and L4 (133); fragments peaked in 06/2023 (231 fragments), essentially at the harbour canal (L4, 156 fragments). Counts then fell sharply, with occasional increases in 09/2023 and 12/2023; the rise in fragments in 12/2023 came mostly from the Rangda River (L2). By 03/2024, counts were lower and more even across sites.

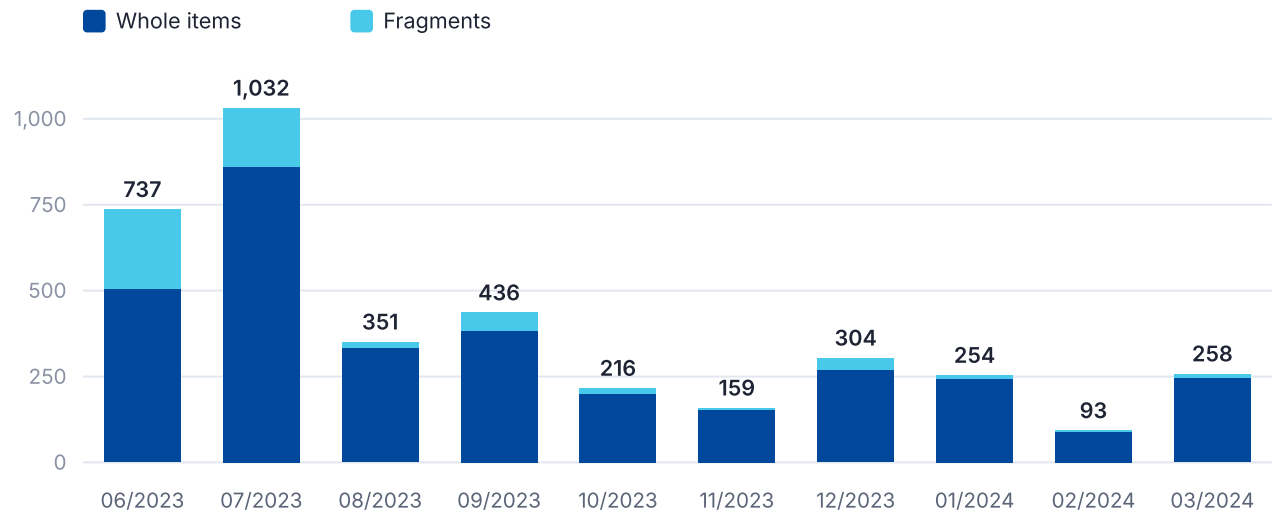


Figure 7. Number of items characterised per month, all sites combined, by form.

Month	Form	Site							Total
		L1	L2	L3	L4	L5	L6	L7	
06/2023	Fragments	0	0	3	156	0	34	38	**231**
	Whole	0	0	30	**197**	0	129	**150**	**506**
07/2023	Fragments	47	6	30	31	0	0	57	**171**
	Whole	134	**178**	120	133	0	2	**294**	**861**
08/2023	Fragments	0	0	6	10	0	0	0	**16**
	Whole	0	0	66	124	11	4	130	**335**
09/2023	Fragments	9	0	10	15	7	8	5	**54**
	Whole	57	49	22	55	50	29	120	**382**
10/2023	Fragments	0	0	3	11	2	1	0	**17**
	Whole	0	0	14	79	31	15	60	**199**
11/2023	Fragments	0	0	2	2	0	0	0	**4**
	Whole	52	44	14	45	0	0	0	**155**
12/2023	Fragments	1	23	0	2	0	2	5	**33**
	Whole	28	103	26	16	18	17	63	**271**
01/2024	Fragments	2	5	1	0	1	0	0	**9**
	Whole	22	101	11	14	9	9	79	**245**
02/2024	Fragments	0	3	0	0	0	1	1	**5**
	Whole	4	45	4	1	0	9	25	**88**
03/2024	Fragments	0	0	1	0	0	4	6	**11**
	Whole	36	56	17	8	20	40	70	**247**
Total per site		**392**	**613**	**380**	**899**	**149**	**304**	**1,103**	**3,840**

Table 5. Number of items per month, site and form in Benoa Bay (CReSOS values). In red, values of 150 items or more. Totals are recalculated from the cell values (see Appendix D).

4.6 Product types

Identifying the original product type links the debris observed to the uses that generate it and helps target prevention. Identified items mostly take a few forms: bottles, caps, cups, detached labels, packaging and sachets, the latter being the most frequent. Four product types dominate, all as whole items: snacks (258 items), mineral water (214), instant drinks (181) and instant noodles (108). They are followed, in much smaller numbers, by confectionery, seasonings, ice cream, detergents and soft drinks, then hygiene and cleaning products (shampoo, wet wipes, diapers, medicines).

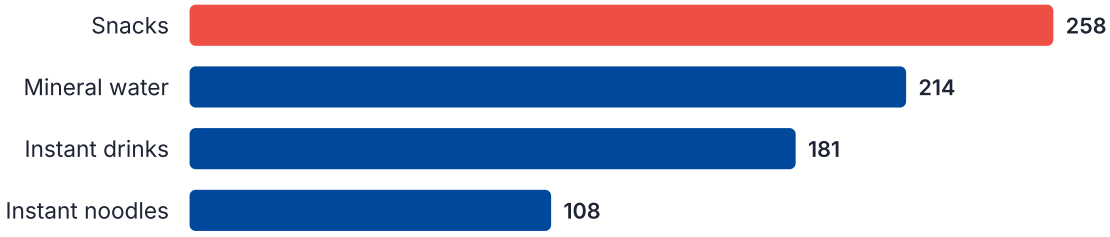


Figure 8. The four most frequent product types, in number of items.

Product	L1	L2	L3	L4	L5	L6	L7	Total
Snacks	14	45	21	**72**	18	19	69	**258**
Mineral water	16	26	17	46	8	30	**71**	**214**
Instant drinks	23	**40**	16	32	5	25	**40**	**181**
Instant noodles	10	21	7	**27**	6	11	26	**108**

Table 6. Most frequent product types per site (in red, the most affected site).

Snacks and mineral water are concentrated at L4 and L7, which show the highest accumulation of products. At Serangan (L1), instant drinks come first (23 items); at the Rangda River (L2) and around the harbour (L3), snacks dominate; outside the bay (L6) and at West Harbour (L7), mineral water is the leading product (30 and 71 items). Details per site are given in the original report; the brand audit, confidential under the cooperation agreement, is not published here (Appendix C).

4.7 Mass of sampled plastics

The operational log records the weight of plastics taken from the transects from 06/2023 to 12/2023: 28.7 kilograms in total, including 10.0 at West Harbour (L7) and 6.9 at the harbour canal (L4). Relative to the 3,235 items counted over the same period, this corresponds to an indicative mean mass of about 9 grams per item, consistent with the predominance of lightweight packaging. This value should be interpreted with caution, as weighing was not systematically matched to the counts.

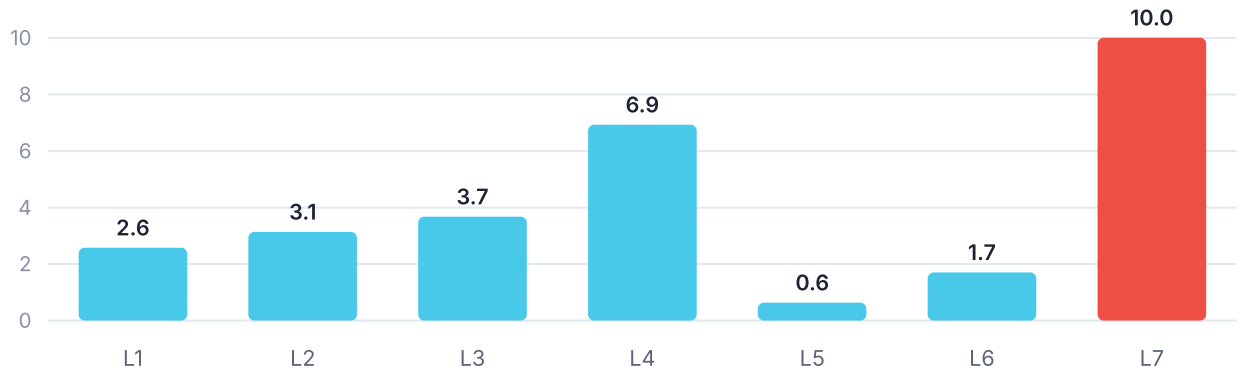


Figure 9. Mass of plastic taken from the transects per site, in kilograms (06/2023 to 12/2023).

5 Discussion

5.1 Pollution dominated by single use packaging

Soft plastics, mostly from single use packaging (sachets, food wrappers, bags, cups), are the leading category of floating macrodebris in Benoa Bay, both whole and fragmented. Debris of this type (bottles, packaging, bags, cups, plates, cutlery, straws and even flip flops) is associated with tourism, but also with household use (Maione, 2019). Food containers and thin plastics mainly originate from urban areas (Barnes and colleagues, 2009), which is consistent with the high population density around the bay. Soft and hard plastics also dominate the coastal areas of Bali according to Hendrawan and colleagues (2019), indicating that this waste remains insufficiently managed across several areas and activities of the island.

Area	Dominant debris	Source
Benoa Bay, Bali	**Soft plastic (83%)**	**This study**
Kuri coast, Maros Regency, South Sulawesi	Soft plastic (40.51%)	Sahara and colleagues (2020)
Waters of Pemuteran and Padang Bai, Bali	Soft plastic (40%) and hard plastic (15%)	Putra and colleagues (2023)
Le Grandeur beach, Balikpapan, East Kalimantan	Plastic (45%)	Ardan and colleagues (2022)
Pelagos Sanctuary, Mediterranean Sea	Mesoplastic (78.5%) and macroplastic (83.4%)	Fossi and colleagues (2017)
Sebatik Island, Sabah	Plastic (41.7%)	Estim and Sudirman (2017)

Table 7. Comparison with other marine debris studies. Protocols (environment, minimum size, unit) differ: the comparison is indicative.

5.2 Recent and largely local inputs

The form and size of debris depend on the time spent in the environment and on its condition when it entered. As debris fragments over time, the share of fragments increases with the age of the pollution (Andrady, 2011; Zarfl and colleagues, 2011). The high proportion of whole items observed here (nearly 86%) therefore suggests that floating debris in the bay entered it recently and largely comes from local sources. Larger and more buoyant items can also travel further than small ones, which tend to sink before dispersing (Fazey and Ryan, 2016); since the dominant debris consists of plastics less dense than seawater (Ryan, 2015), it spreads easily throughout the bay.

5.3 Drivers of spatial distribution

Accumulation at West Harbour (L7) can be linked to fishing port activities, tourism and insufficient waste management around the bay: intensive use of packaging, limited management infrastructure and consumption habits (Dinas Lingkungan Hidup, 2022; Waste4Change, 2022). The harbour canal (L4), at the entrance of the bay, is one of the deepest areas with the fastest currents (Suteja and colleagues, 2021); this narrow passage links the bay to open water and concentrates flows, which likely contributes to the high presence of debris.

Conversely, South Harbour (L5), close to Tanjung Benoa and its many water sports (jet skiing, parasailing, diving; Astina and Muliadiasa, 2018; Kardini and Sudiartini, 2020), shows low counts. At high tide, the current mainly flows from Tanjung Benoa into the bay (Al Tanto and colleagues, 2017), which coincides with the conditions of many outings and may explain the low accumulation at L5.

5.4 Temporal variability

The peaks in 06/2023 and 07/2023 coincide with the high tourist season and the dry season, while the decline observed from 10/2023 corresponds to the shift in monsoon winds, which push debris westward. Suryawan and colleagues (2021) described a decrease in marine debris generation in southern Bali between 2013 and 2019, possibly linked to better management practices or to fluctuations in tourist numbers. As the campaign did not cover a full annual cycle, these observations do not support a conclusion on trends: monitoring over at least twelve months would be needed to check whether April and May show a similar increase.

5.5 Implications for prevention

The ten most frequent groups all relate to everyday consumption: public awareness, packaging reduction and better management at source are therefore priority levers. The regulatory framework exists: Bali Governor Regulation number 97 of 2018 bans single use plastic bags, polystyrene and straws, and Regulation number 47 of 2019 requires source separation. Identifying the most frequent products also provides a basis for dialogue between authorities, companies and civil society organisations to reduce single use plastic and promote ecodesign.

KEY FACTS ON WASTE MANAGEMENT IN BALI

- The 16 million annual tourists (6 million international and 10 million domestic) generate 3.5 times more waste per day than residents and account for 13% of the island's waste.
- 87% of residents say they are willing to sort their waste.
- Targeting 15 of Bali's 57 subdistricts would reduce ocean plastic by 44%.
- More than 400 community, private, public, cultural and religious organisations are already active in clean ups, education, collection and recycling.

Source: Bali Partnership (2019).

6 Limitations and methodological lessons

This study was the first project of The SeaCleaners Scientific Hub combining a Mobula vessel with detailed characterisation. The partnership with Udayana University, based on mutual trust, was effective and the quality of the data produced by the CReSOS team should be emphasised. Several limitations nevertheless frame the scope of the results.

6.1 Study limitations

- **Duration** : ten months of monitoring do not cover a full annual cycle.
- **Uneven effort** : vessel downtime, weather and navigation constraints prevented some sites from being sampled in some months (Appendix A); comparisons between sites are based on totals rather than densities normalised by area.
- **Share of plastic in all debris** : the planned data entry application (ArcGIS QuickCapture), which was to record the vessel position continuously and classify each collected item according to the eight OSPAR categories, could not be used. The dataset therefore cannot establish the share of plastics among the other debris families.
- **Imaging** : the multispectral drone flights planned to validate satellite data (European Space Agency Eyes on Plastics project, with EOMAP) were only allowed at two sites because of the nearby airport and could not ultimately be carried out.
- **Mass and volume** : weights per category were not consolidated for the whole campaign; the mass data presented are indicative.
- **External factors** : dredging works made some navigation hazardous, and smoke from a fire at the landfill near the marina disrupted operations.

6.2 Lessons for future campaigns

- Hold face to face meetings between partners for each component of the project (science, education, operations) from the design stage.
- Define objectives, impact indicators and roles with all internal and external partners, and formalise a communication protocol between the crew, the operations team and the science team.
- Explicitly reserve vessel time for science and provide a sorting area suitable for characterisation.
- Hold review points at launch, mid project and project end, and keep to the analysis milestones (protocol validation after the first month, analysis by season).
- Harmonise data entry from the outset and systematically cross check survey days against the collection log for quality control.

7 Conclusion and outlook

This campaign marked several firsts for The SeaCleaners: first collection with a Mobula, first international operation, first partnership with Udayana University and first study of floating macroplastics in Benoa Bay. It provides an original dataset on the nature, distribution and dynamics of macroplastics in the bay, which forms a solid basis for future work.

Three avenues emerge:

- improve collection efficiency by combining satellite detection, ground truth data and statistical modelling (generalised additive models) to forecast accumulation areas and periods;
- change behaviour around the bay, including in the tourism sector, through targeted education developed with the psychology and communication departments of Udayana University;
- achieve a lasting reduction in debris density by combining collection, knowledge of sources, community education and work with local authorities.

This experience now informs the scientific strategy of The SeaCleaners Swiss, supported by its international scientific advisory board and Professor I Gede Hendrawan: harmonising collection and characterisation methods to achieve a common standard that is comparable from one site to another, in Malaysia as in Indonesia, and extending it to the new collection systems the organisation plans to deploy.

ADVANCING APPLIED RESEARCH

Producing open, comparable and published data on floating debris requires long term commitment. Research institutions, foundations, companies and public authorities who share this commitment to rigour and transparency are invited to join this programme, as scientific partners or as supporters.

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Appendices

A Calendar of survey days

Month	L1	L2	L3	L4	L5	L6	L7
06/2023	·	·	21, 22	19, 20	·	26, 27	21, 22
07/2023	03, 04	17, 18	05, 06	14, 25	20, 31	27, 28	12, 13
08/2023	·	·	09, 10	09, 10	15, 18	14, 21	07, 08
09/2023	14, 15	14, 15	12, 13	12, 13	18, 19	22, 25	20, 21
10/2023	·	·	11, 12	11, 12	16, 17	09, 10	18, 19
11/2023	27, 28	27, 28	29, 30	29, 30	·	·	·
12/2023	12, 13	12, 13	04, 05	04, 05	14, 15	08, 11	06, 07
01/2024	17, 18	17, 18	08, 09	08, 09	10, 11	12, 15	19, 22
02/2024	23, 26	23, 26	12	12	·	21, 22	20
03/2024	not consolidated	not consolidated	not consolidated	not consolidated	not consolidated	not consolidated	not consolidated

Days of the month on which each site was sampled, reconstructed from the CReSOS data entry file (“Data for Sat Det”). A dot indicates no survey; dates for 03/2024 are not included in this file.

B Item characterisation list

Category	Items
Hard plastics	PVC pipe; beverage bottle under 1 litre; other bottle; bottle cap and lid; food container; utensil, plate, bowl; lighter; lollipop stick or cotton bud; body care and cosmetic containers; engine oil containers; jerry cans; fibreglass; non fishing floats; toys; other hard
Soft plastics	Thin film carry bag; food wrapper and label; sheeting; cup and lid; chemical product caps; unidentified caps; straw; sanitary products; other soft
Plastic straps	String, rope, ribbon; packing strap; cable tie; other
Rubber	Flip flop; shoe; rubber band; other
Foam	Food container; cup, plate, bowl; polystyrene; other
Fishing gear	Net; fishing line; buoy and float; glow stick; fish boxes in foamed polystyrene or hard plastic; other
Miscellaneous	Boat parts; household waste bags; cigarette butts with filters; nurdles; other

List adapted from the CSIRO datasheets (version 1.3, 03/2019) and the European Joint Research Centre joint list; each item is counted as whole or fragmented. Correspondence codes are given in the protocol annexed to the cooperation agreement.

C Brand audit

Identifiable brands were recorded using a reference list of products common in Indonesia (beverages, cups, food wrappers and confectionery). In accordance with the cooperation agreement, these results remain confidential until the partners approve their release; they are held by CReSOS.

D Data control note

- The original report states 3,834 items (550 fragments and 3,284 whole). The sum of the cell values in table 5 gives 3,840 items (551 fragments and 3,289 whole); the 6 item difference (0.2%) comes from the totals for 06/2023 (503 whole stated against 506) and 08/2023 (333 against 335) and one unit on fragments. Recalculated values are used here; the category percentages from the original report are not significantly affected.
- The original table of the ten most frequent groups presented monthly totals by category as site values; it has been clarified (table 4). Several site references in the original text were corrected to match the tables (fragment peak at L4 rather than L7; product order at L6 and L7).
- The operational log totals 14,753.4 kilograms in its annual summary; the 09/2023 sheet includes 1 additional kilogram in the “other” category, hence the total of 14,754.4 kilograms used here. The count of days with surveyors is based on the on board presence flag, not on the existence of transect data.
- An intermediate data entry file (“Data for Sat Det”) totals 3,588 items without the 03/2024 data; its values match the report for most sites and months. Final consolidation of the dataset is under way with CReSOS ahead of publication.
- The bibliographic reference “NAP, 2011” in the original report, unrelated to marine debris, has been removed; incomplete references have been completed or harmonised.