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Anthropogenic debris accumulation in the Argentine deep sea: evidence of an irreversible sink

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The seafloor is recognized as a major sink for marine debris, while deep-sea litter remains poorly investigated due to the logistical and economic constraints associated with seabed exploration. This study reports for the first time the occurrence of marine debris found on the Argentine deep seafloor using the SOI's Remotely Operated Vehicle (ROV), providing the first documented evidence for this region. A total of 29 litter items were recorded across 55.6 km of surveyed seafloor. The highest debris abundance was recorded in submarine canyon areas (1.4 items/km), whereas the Malvinas Basin showed the lowest levels (0.1 items/km), likely associated with hydrodynamic conditions. In addition, plastic items, fishing ropes, and nets were the most frequently recorded types of debris. These findings establish a baseline of the current status of deep-sea marine debris and propose future directions for the region.

KEYWORDS

marine litter, ROV surveys, seafloor, Southwest Atlantic, submarine canyons

1 Introduction

Anthropogenic marine debris was defined by the United Nations Environment Program (United Nations Environment Programme, 2009) as any persistent manufactured or processed solid material discarded, abandoned, or disposed of in the marine environment. Approximately 80% of marine litter entering the ocean originates from land-based sources, while the remaining 20% comes from marine sources, such as shipping, fishing, aquaculture, ocean infrastructure, and tourism (Ramirez-Llodra et al., 2011). Plastics dominate marine debris, accounting for around 80% of the recorded marine debris (Vorsatz et al., 2025). In response to the global scale of this issue, the United Nations launched negotiations in 2022 toward a legally binding international instrument on plastic pollution (UNEA, 2022). Marine plastic debris has been documented in a wide range of environments, from coastal zones and shallow coastal waters to offshore and deep-sea ecosystems (Bergmann et al., 2017; Galgani, 2015; Lee et al., 2006; Lee et al., 2013; Barnes et al., 2009; Chiba et al., 2018; Taylor et al., 2016; Abel et al., 2023). In particular, marine sediments have been identified as a major sink for plastic debris, with estimates suggesting that between 25 and 900 Tg of non-fibrous plastic accumulated globally between 1950 and 2010, far exceeding the mass of floating plastics (Martin et al., 2022). Despite this, deep benthic environments remain poorly studied, even though evidence of seafloor litter dates back several decades (Holmström, 1975).

In the deep-sea, debris can reach depths exceeding 10,000 m, where it accumulates due to hydrodynamic transport, sinking driven by biofouling, and the absence of significant removal mechanisms (Chiba et al., 2018; Peng et al., 2018; Kooi et al., 2017). Anthropogenic litter has been shown to damage large animals through accidental ingestion and entanglement, and toxic chemicals released during plastic fragmentation (Schlining et al., 2013; Hermabessiere et al., 2017; Jeong et al., 2024). Furthermore, marine debris provides a substrate for deep-sea organisms, potentially altering colonization patterns and influencing species distribution; however, the impact of this material is still not completely understood (Gregory, 2009; Seeley et al., 2020; Burkett, 2025). The records of marine debris, especially plastics, in the deep sea highlight the ubiquity of these materials, even in places that are inaccessible to humans (Canals et al., 2021). In deep-sea benthic environments, where oxygen concentrations are reduced and light-driven photooxidation is absent, degradation timescales are likely to be considerably longer than at the surface (Hernandez et al., 2022).

The distribution of marine debris in the deep sea is strongly influenced by seafloor geomorphology, with accumulation frequently occurring in trenches, basins, and canyons (Galgani et al., 2000; Miyake et al., 2011; Mordecai et al., 2011). Submarine canyons in particular serve as pathways for transporting debris into the deep ocean, where it tends to accumulate due to more stable hydrodynamic conditions and weaker currents. The increasing use of Remotely Operated Vehicles (ROVs) has provided new insights into marine litter in deeper environments (Galgani et al., 2000). However, most studies are based on the North Pacific, the South Pacific, and the Indian Ocean; only a few have been conducted in the South Atlantic (Chiba et al., 2018), with no studies to date in the Argentine Sea. Despite the growing research

efforts on these crucial topics, our knowledge of the distribution and occurrence of deep-sea litter remains limited.

This knowledge gap is particularly relevant for Argentina, whose maritime territory covers more than 6.5 million km², with 70% corresponding to deep-sea environments (Bravo et al., 2025), covering approximately 4,600,000 km². These deep-sea zones range in depth from 200 to 6000 meters (COPLA, 2017). Thus, the study of this vast deep sea is defined as a new strategic frontier for sustainable development, not only due to its size but also its ecological value and economic potential (Bravo et al., 2025). Deep-sea ecosystems provide critical services, including carbon sequestration, nutrient cycling, and the maintenance of benthic food webs (Bravo et al., 2023; Thurber et al., 2014), and the Argentine continental margin is particularly relevant in this regard, hosting unique and highly diverse habitats such as cold-water coral reefs, submarine canyons, and chemosynthetic cold seep ecosystems (Bravo et al., 2024; Bridges et al., 2023). These ecosystems are particularly sensitive to disturbance given the slow recovery rates and long-lived nature of many deep-sea organisms (Clark et al., 2016), underscoring the urgency of assessing anthropogenic pressures such as debris accumulation in this region.

The Argentine continental slope is subject to intense and largely unregulated maritime activity that may contribute to deep-sea debris accumulation. While global assessments consistently attribute approximately 80% of marine debris to land-based sources (Ramirez-Llodra et al., 2011), this proportion reflects global averages and may not apply to offshore continental margins, where deep-water areas lie hundreds of kilometers from the coast. Indeed, recent evidence from other ocean regions suggests that plastics originating from fishing activities are more likely to reach offshore accumulation zones than plastics emitted from coastal or riverine sources, as land-derived debris tends to strand rapidly on nearby coastlines (Lebreton et al., 2022). The Argentine continental margin, characterized by an extensive canyon system that facilitates the rapid transport of surface debris to the deep seafloor, may thus receive a relatively greater contribution from ocean-based sources than the global average would suggest.

This context is particularly relevant given the scale of human activity in the region. Between 2018 and 2021, over 800 foreign fishing vessels accumulated nearly 900,000 hours of apparent fishing effort within 20 nautical miles of Argentina's Exclusive Economic Zone, with more than half of these vessels showing gaps in tracking systems, limiting effective coastal monitoring (Valentine, 2021). This intense fishing pressure along the slope, combined with the growing expansion of offshore hydrocarbon exploration, with 13 multinational companies awarded permits over 225,000 km² of the Argentine continental margin in 2019 (Bravo et al., 2024), represents a combination of ocean-based pollution sources that may play a particularly relevant role in deep-sea debris accumulation in this region. Together, these pressures highlight the need for baseline documentation of deep-sea debris in this region, contributing to the global assessment of ocean pollution and informing national waste management policies.

This study reports the first visual survey of plastic pollution and marine debris on the deep seafloor along the Argentine continental margin. Based on imagery collected using a remotely operated vehicle (ROV), we describe the occurrence, composition,

abundance, and spatial distribution of debris across different surveyed areas. Furthermore, we explore how these findings vary across latitudinal and depth gradients and discuss the potential influence of geomorphological features and oceanographic conditions on debris accumulation in the region. This study establishes the first regional baseline of deep-sea litter in the Southwestern Atlantic, contributing to the growing body of knowledge on anthropogenic impacts in deep benthic ecosystems and supporting future monitoring and management efforts.

2 Material and methods

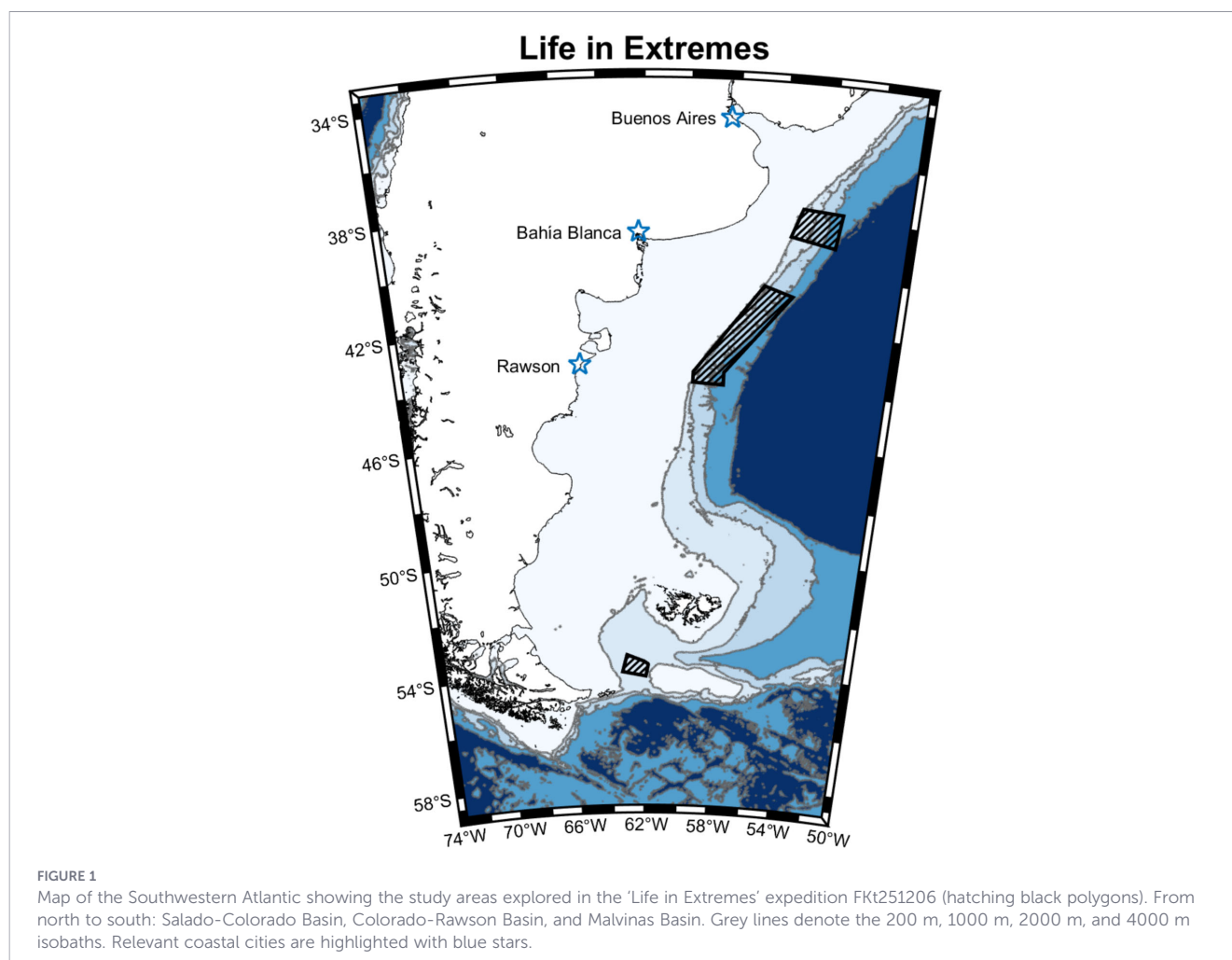
2.1 Study area and sampling

Seafloor surveys and debris documentation were conducted between December 14, 2025, and January 10, 2026. The work was part of the expedition “Life in Extremes” (FKt251206) onboard the research vessel Falkor (too) of the Schmidt Ocean Institute (SOI). The campaign included three study areas: the Salado-Colorado area, the Colorado-Rawson basin, and finally, the Malvinas basin (Figure 1). While these regions were initially defined by the exploratory objectives of the “Life in Extremes” expedition, they

provided a representative latitudinal and oceanographic transect for studying marine debris. This segmentation allows for the comparison of debris accumulation in contrasting environments.

The Salado-Colorado area (Sal-Col) comprises the continental slope and the abyssal plain, extending from approximately 200 to 4500 m depth. The region is characterized by complex seafloor morphology, including pockmarks, which are crater-like depressions on the seafloor of ~450 m wide and ~12 m depth (Bravo et al., 2024). Besides, this study area is located within a highly dynamic frontal system associated with the Brazil-Malvinas Confluence, where water masses of northern and southern origin converge (Gordon and Greengrove, 1986; Valla et al., 2018). Upper circulation is dominated by the Brazil and Malvinas Currents, while deeper and abyssal layers are influenced by the Deep Western Boundary Current and cold, dense waters formed in the Weddell Sea that enter the Argentine Basin. Sedimentary dynamics are shaped by inputs from the Salado and Colorado basins, as well as indirect contributions from the Río de la Plata system, promoting southward transport and redistribution of fine sediments and organic matter. As a result, the seafloor exhibits marked sedimentological heterogeneity and a mosaic of accumulation and erosion areas, which are relevant for benthic dynamics and for the retention, burial, or exposure of plastic debris (Violante et al., 2014; Violante et al., 2017).

The Colorado-Rawson area (Col-Raw) is characterized by the presence of several submarine canyons incising the continental



slope, spanning depths between approximately 700 and 3,000 m. This area includes the Bahía Blanca and Ameghino canyon systems. Within this system, two canyons were investigated: one located about 518 km southeast of the city of Bahía Blanca (Argentina) and another situated approximately 461 km offshore from the city of Rawson (Argentina). The area is directly influenced by the main equatorward-flowing branch of the Malvinas currents and, at abyssal depths, by the northward flow of Antarctic Bottom Water. From a sedimentological and geomorphological perspective, the region exhibits pronounced bathymetric and sedimentary variability, with the fine-grained sediments prevailing in the deeper sectors of the canyons and slightly coarser materials occurring in shallower zones (Violante et al., 2014; Principi et al., 2024).

The Malvinas area extends from 250 to 1,000 m depth and is characterized by a depression zone in the central area with orientation NW-SE, reaching a maximum depth of 975 m. It is considered a contour fossa, bounded to the east by a horseshoe-shaped mound approximately 5 m high relative to the surrounding seabed and located to the northeast of the study area (Ormazabal et al., 2024). The site is situated within an exclusively subantarctic and relatively shallow environment (depths < 1,000 m), influenced by the inshore branch of the Antarctic Circumpolar Current (Frey et al., 2021; Carbajal et al., 2026), as well as by the recirculation associated with the detrainment of water masses northwest of the Burdwood Bank (Matano et al., 2019).

2.2 Data collection

The primary tool was SOI's Remotely Operated Vehicle (ROV) SUBastian, which performed visual surveys. During dives, the ROV's Science Camera recorded continuously in 4K Ultra HD (2160p30, H.264 codec), generating a detailed, permanent video record at approximately 45 gigabytes per hour for subsequent analysis. The primary dataset and the findings presented in this article are based on the systematic visual census captured by the ROV's imaging systems, and representative debris samples were collected for material verification and general surface characterization. A supplementary table (Supplementary Table 1) is provided describing the visual classification criteria applied to each recorded debris item, including typology, structural properties, benthic interaction, and visible signs of degradation. Given the exploratory nature of the dives, the ROV operated at variable altitudes above the seafloor depending on bottom topography and navigation conditions. This variability in flying height directly affected the camera's field of view and the effective width of the surveyed strip, precluding the accurate estimation of a consistent swept area. Litter occurrence was therefore expressed as items per kilometer of transect (items km⁻¹), which provides a more reliable and reproducible metric under these survey conditions, and allows direct comparison with comparable ROV and submersible-based studies in deep-sea environments.

3 Results

A total of 17 dives were conducted during the cruise, covering 55.6 km of seafloor, of which marine debris was encountered in 9

dives. Overall, 29 litter items were recorded (Table 1; Figure 2). The distribution of these items by depth and material type across the surveyed areas is presented in Figure 3. The highest number of items (n=6) was recorded during dive S0886 in the Col-Raw area, whereas only 1 item was observed during dive S0880 (Sal-Col).

In the Salado-Colorado area, a range of heterogeneous deep-sea environments was surveyed, including sockmarks (crater-like depressions on the seafloor), coral mounds, and scarps, at depths ranging from 480 to nearly 4,000 m. A total distance of 26.65 km was covered across eight waypoints. Marine litter was recorded at four of these waypoints, totaling eight items: plastic bags, burlap bags, and fishing lines. Overall, the occurrence of marine litter in this area corresponded to approximately 0.3 items per kilometer, equivalent to one item every ~3.3 km surveyed (Figure 4A). The highest concentration of these items was encountered at specific depths around ~500 m, ~2,800 m, and ~4,000 m (Figure 3). Besides, some of the recorded items exhibited clear signs of degradation, including perforations and fraying, particularly in larger, high-surface-area debris such as the burlap bag, the plastic bag with aluminum, and the fishing line. Fishing line was observed to be not only degraded but also entangled among rocks. In addition, a large plastic bag showed extensive colonization by benthic organisms like anemones, small bivalves, polychaetes, sponges, sea urchins, and snails, as well as microbial mats and calcified tube worms.

In the Colorado-Rawson Basin, canyon and wall-canyon environments were explored at depths ranging from 1,264 to 3,000 m. A total distance of 13.14 km was surveyed across four waypoints. Marine litter was recorded at all surveyed waypoints, with a total of nineteen items observed. Overall, the occurrence of marine litter in this basin corresponded to approximately 1.4 items per kilometer, equivalent to one item every ~0.7 km surveyed (Figure 4B). As shown in Figure 3, the highest abundance and diversity of these items were found concentrated at depth intervals between 1,000 and 3,000 m. The recorded items were predominantly composed of plastic materials, including plastic bags, packaging, and fishing-related debris. Less frequent items included textiles and metallic debris. A detailed description of litter types is provided in Table 1.

In the Malvinas basin, geomorphologies associated with fluid seepage and chemosynthetic ecosystems were surveyed at depths around 600 m. A total distance of 18.88 km was surveyed, with 2 items of debris found; the occurrence of marine debris was 0.1 items per kilometer, or 1 item every ~9.4 km (Figure 4C). The recorded items consisted of a tarpaulin and a fishing net with weights (Table 1). Both items appeared to be relatively large and exhibited partial burial in sediment, as well as the presence of associated organisms on exposed surfaces, such as ascidians, anemones, corals, sea urchins, and small crustaceans.

4 Discussion

Despite growing awareness that the deep seafloor is a major sink for marine litter (Galgani, 2015; Canals et al., 2021), relevant regions of the deep ocean, such as the Southwestern Atlantic, remain underexplored (LITTERBASE, Tekman et al., 2025). In this context, the present study represents the first assessments in a large sector of the SW Atlantic Ocean, the Argentine deep sea, providing baseline

TABLE 1 Geographic coordinates, depth, temperature, and study area of the locations where anthropogenic debris items were recorded.

Anthropogenic debris	Latitude	Longitude	Depth (m)	Temp (°C)	Area	Dive
1.Degraded burlap bag	-38.307542	-55.148609	505.61	4.50	SAL - COL	S0879
2.Possible plastic rope	-38.306926	-55.147745	503.07	4.49	SAL - COL	S0879
3.Plastic bag with fauna associated	-38.37499	-55.20168	451.66	4.66	SAL - COL	S0880
4.Plastic bag (burlap)	-38.90200	-53.99326	2867.46	1.72	SAL - COL	S0882
5.Plastic bag	-38.899735	-53.997769	2787.36	1.8	SAL - COL	S0882
6.Plastic bag with aluminum	-38.96123	-53.56406	3968.42	0.37	SAL - COL	S0883
7.Fisher lines	-38.96035	-53.56363	3960.90	0.35	SAL - COL	S0883
8.Plastic bag (burlap)	-38.96059	-53.55901	3960.64	0.35	SAL - COL	S0883
9.Plastic box	-41.43760	-56.17338	2875.62	1.96	COL-RAW	S0884
10.Mayonnaise package	-41.43897	-56.17461	2945.92	1.82	COL-RAW	S0884
11.Plastic bag	-41.43429	-56.17076	2595.59	2.05	COL-RAW	S0884
12.Fisher lines	-41.43876	-56.17471	2947.37	1.82	COL-RAW	S0884
13.Plastic package	-41.43895	-56.17459	2945.54	1.82	COL-RAW	S0884
14.Fisher line	-41.43220	-56.16692	2487.44	2.07	COL-RAW	S0884
15.Clothes	-41.43200	-56.16656	2487.24	2.06	COL-RAW	S0884
16.VHS	-41.43519	-56.17123	2643.46	2.05	COL-RAW	S0884
17.Plastic bag	-41.29351	-56.98103	1273.43	2.60	COL-RAW	S0885
18.Fisher line	-41.29386	-56.98091	1280.84	2.61	COL-RAW	S0885
19.Possible clothes	-41.29044	-56.97416	1075.83	2.82	COL-RAW	S0885
20.Band	-43.44906	-59.25375	1257.98	2.85	COL-RAW	S0886
21.Plastic bag	-43.44899	-59.25452	1251.33	2.84	COL-RAW	S0886
22.Plastic bag	-43.44856	-59.25498	1245.90	2.85	COL-RAW	S0886
23.Plastic bag	-43.44848	-59.25490	1240.76	2.85	COL-RAW	S0886
24.Plastic cup	-43.44845	-59.25465	1227.18	2.85	COL-RAW	S0886
25.Plastic bag (burlap)	-43.44799	-59.25459	1208.92	2.85	COL-RAW	S0886
26.Plastic bag	-43.64543	-58.54230	2364.35	2.03	COL-RAW	S0887
27.Metallic trash	-43.63835	-58.53631	2196.53	2.04	COL-RAW	S0887
28.Tarpaulin	-53.662348	-62.028738	620.62	4.35	MALVINAS	S0889
29.Fishing net with weights	-53.66225	-62.02894	617.08	4.35	MALVINAS	S0889

Environmental parameters were acquired using the ROV SuBastian, operated by the Schmidt Ocean Institute during cruise FK1251206.

observations that contribute to filling a critical knowledge gap. Plastic debris represented the dominant category of litter, including plastic bags and fishing gear. This finding aligns with other studies worldwide where deep-sea litter is largely dominated by plastic items (Galgani et al., 2000; Hanke et al., 2025a). For example, plastic dominates the benthic debris in deep Arctic seafloors (Bergmann and Klages, 2012), in European seas (Pham et al., 2014), in the Red Sea (Saudi Arabia) (Castellan et al., 2025), in the deepest site of the Mediterranean Sea (Hanke et al., 2025a) and in submarine canyons west of Portugal (Mordecai et al., 2011). The predominance of plastic in these environments raises concerns about long-term biological effects due to the potential to fragment into microplastics. In the case of fishing gear, it can persist for decades to centuries in the deep-sea ecosystems, providing a long-term source of marine chemical pollution and causing irreversible physical damage (e.g., massive habitat destruction, ghost fishing; Baco et al., 2010; Baco et al., 2023; Yasuhara et al., 2026). The materials used in fishing gear

and other marine applications, such as nylon, polyamide, and ultra-resistant polymers like Dyneema, are suspected to degrade very slowly in environments where oxygen is scarce and light is absent (Ward and Reddy, 2020). Additionally, some studies have attributed the seafloor debris to marine vessel sources (Moore and Allen, 2000) and different sea and land-based sources, including long-range sea transport and direct dumping (Hanke et al., 2025b).

In this study, we found the largest amount of debris in the Colorado-Rawson area, particularly within submarine canyons and at depths between 1,000 and 3,000 m. This region exhibits pronounced bathymetric variability, with abrupt depth changes over relatively short distances associated with the shelf-slope transition and the presence of geomorphological features such as steep slopes, terraces, and submarine canyons (Violante et al., 2014; Principi et al., 2024). The combination of complex topography and active bottom circulation could potentially promote the localized accumulation of sediments and allochthonous materials. Consequently, deep, low-energy

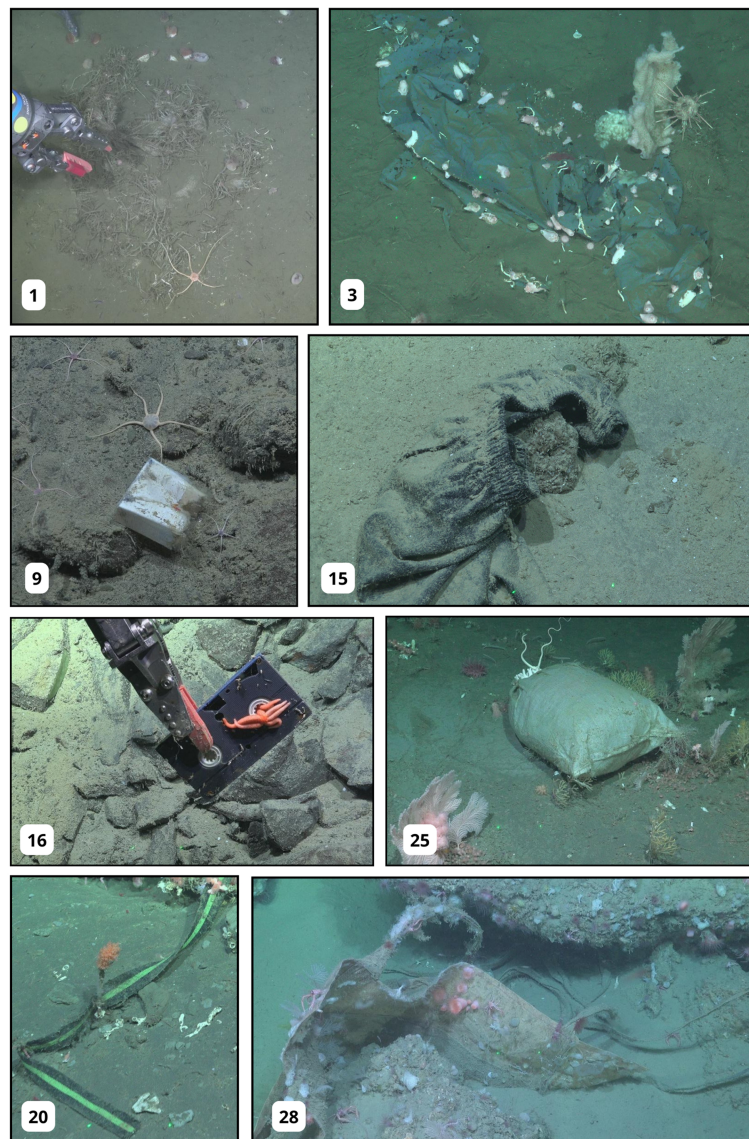


FIGURE 2

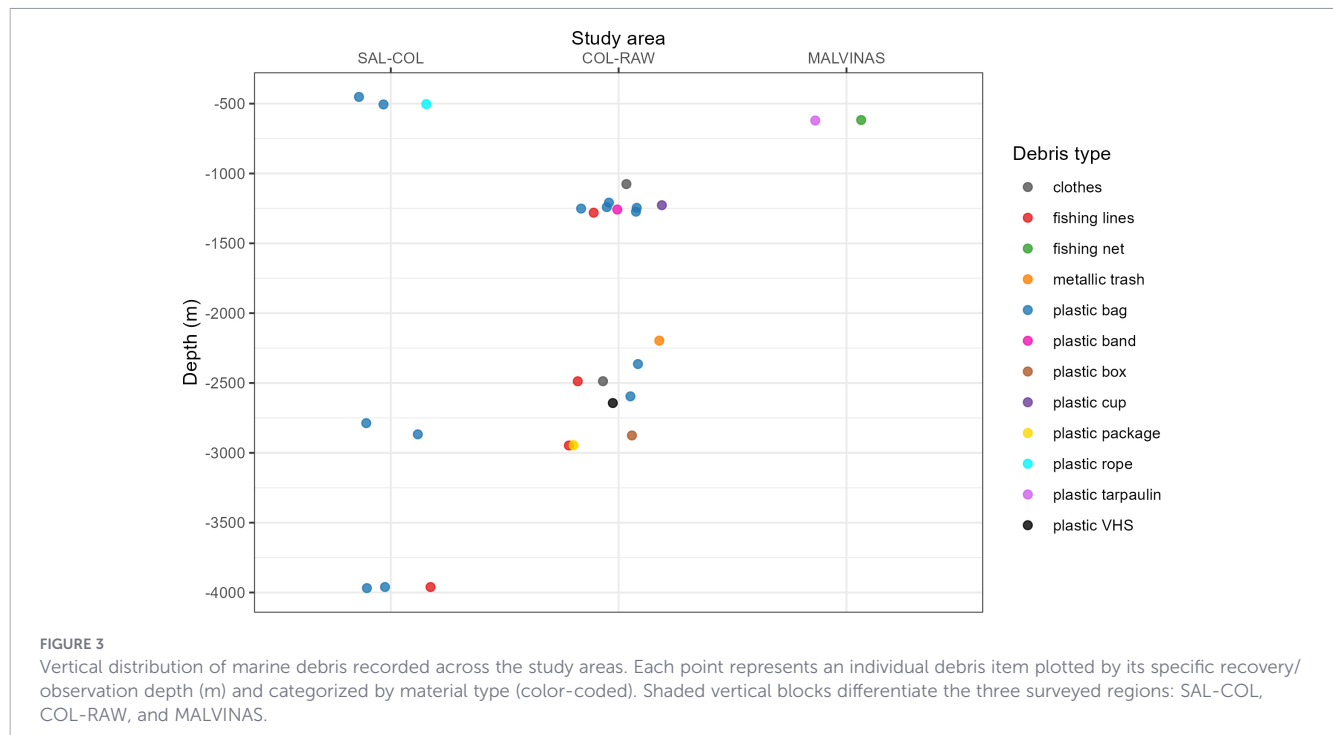
Photographs of debris items recorded during the dives. Numbers in each image correspond to the item identification numbers listed in Table 1. Images and environmental parameters were acquired using the ROV SuBastian, operated by the Schmidt Ocean Institute during cruise FKt251206.

sectors within these canyons might act as retention zones for plastic debris, suggesting that the Colorado-Rawson area could represent a critical site for further investigating litter distribution patterns.

According to the literature, submarine canyons act as natural conduits, facilitating the downslope flow of dense water masses from the continental shelf to the deep sea (Canals et al., 2006). Additionally, they serve as vectors for the accumulation of buoyant marine debris, which then accumulates in the deepest canyon reaches (Canals et al., 2006; Pusceddu et al., 2013; Schlining et al., 2013; Tubau et al., 2015; Galgani et al., 2000). Submarine canyons are areas where organic matter accumulates, dominated by deposit- and suspension-feeding invertebrates. Research has shown that some deposit feeders (e.g., holothurians) select plastic over sediment grains under laboratory conditions (Graham and Thompson, 2009). Besides, many canyons also act as traps for sediment flows. This promotes the burial of trash and reduces the probability of it being carried away by underwater currents. The combination of

complex topography and active bottom circulation is hypothesized to favor the localized accumulation of sediments and allochthonous materials, including debris. These characteristics may partially explain the comparatively higher occurrence of debris observed in the Colorado-Rawson area (Violante et al., 2017; Principi et al., 2024).

The Colorado-Rawson basin, where the highest litter occurrence rate was recorded in this study (1.4 items per kilometer), shows similar or even lower values than those reported for other marine environments worldwide. For instance, similar values were found in the Red Sea, with maximum densities of $1.01 \text{ items km}^{-1}$ documented at depths of $\sim 600 \text{ m}$, although the overall average for the area was considerably lower ($0.19 \text{ items km}^{-1}$) (Castellan et al., 2025). In contrast, higher values have been reported in other regions: Watters et al. (2010) recorded 3.5 items per 100 m (35 items per km) along the deep-sea habitats of the California coast at depths ranging from 20 to 365 m, while Debrot et al. (2014) found



9.53 items km^{-1} across the ABC islands (Aruba, Bonaire and Curaçao) in the southeastern Caribbean Sea, spanning depths between 80 and 900 m. Markedly higher values were documented in the semi-enclosed Saronic Gulf (Greece), where Ioakeimidis et al. (2015) reported an average of 22.7 items km^{-1} at depths of 94–115 m, likely reflecting the influence of densely populated Athens metropolitan area and the Port of Piraeus on litter accumulation. These comparisons highlight the strong influence of geomorphological, oceanographic, and anthropogenic settings on litter accumulation. In this context, although the Colorado-Rawson basin represents the area of the highest occurrence rate within the study, its values remain among the lower end of those reported for comparable deep-sea environments globally.

In contrast, lower debris abundances were recorded in the Salado-Colorado area and the Malvinas basin. The Salado-Colorado area is located within the highly dynamic Brazil-Malvinas Confluence, where the interaction of multiple water masses and strong circulation at upper, deep, and abyssal levels, together with heterogeneous seabed conditions and active depositional and resuspension processes, may limit the long-term retention of debris on the seafloor (Gordon and Greengrove, 1986). Similarly, the Malvinas area is characterized by a relatively shallow subantarctic setting influenced by the Antarctic Circumpolar Current and regional recirculation processes, as well as by marked sedimentological heterogeneity (Frey et al., 2021; Carbajal et al., 2026). The low amount of litter observed at the Malvinas Basin site may reflect lower accumulation and retention capacity compared to areas such as the Colorado-Rawson region, where fishing activities and operations at the shelf break are intense (Arrizabalaga et al., 2011). In such areas, litter and marine debris may sink and be episodically advected by bottom current along the main canyon axes, promoting their accumulation. Although the relatively low coastal population density could reduce land-based

inputs at the Malvinas basin, the study area lies on the Patagonia slope in the Southwest Atlantic. In this region, fishing activity is widespread, particularly along the continental shelf and slope, where fisheries operate over broad spatial scales that encompass the study area (Waluda et al., 2008). In this context, the fishing-related debris in Malvinas suggests that maritime sources may be more relevant than terrestrial inputs in shaping benthic litter composition in the study area. Additionally, the predominantly wind-driven circulation in the Malvinas Basin is suggested to further facilitate the northward advection of floating debris, reducing local retention and deposition. These hydrodynamic and geomorphological conditions may contribute to the comparatively lower debris occurrence observed in the Malvinas Basin relative to the Colorado-Rawson area.

On the other hand, although lower amounts of anthropogenic litter were recorded at the Malvinas Basin site, the presence of substantial kelp debris indicates that vertical export and gravitational deposition may occur in this area. The transport of macroalgal material to deep-sea environments has been attributed to multiple mechanisms, including the collapse of gas vesicles under water pressure, ballasting by attached organisms, and advective transport through submarine canyon systems (Krause-Jensen and Duarte, 2016). However, the relatively low retention of anthropogenic litter at this site may reflect contrasting fate dynamics between natural organic matter and synthetic materials. While kelp detritus is subject to rapid degradation and remineralization once deposited, plastic and other anthropogenic items persist but may be redistributed by the strong bottom currents reported for the Malvinas region. Together, these patterns suggest episodic inputs of both natural and anthropogenic material, but differential long-term retention governed by material-specific degradation rates and regional hydrodynamic forcing.

In summary, these hydrodynamics and geomorphological conditions appear to be less favorable for persistent debris

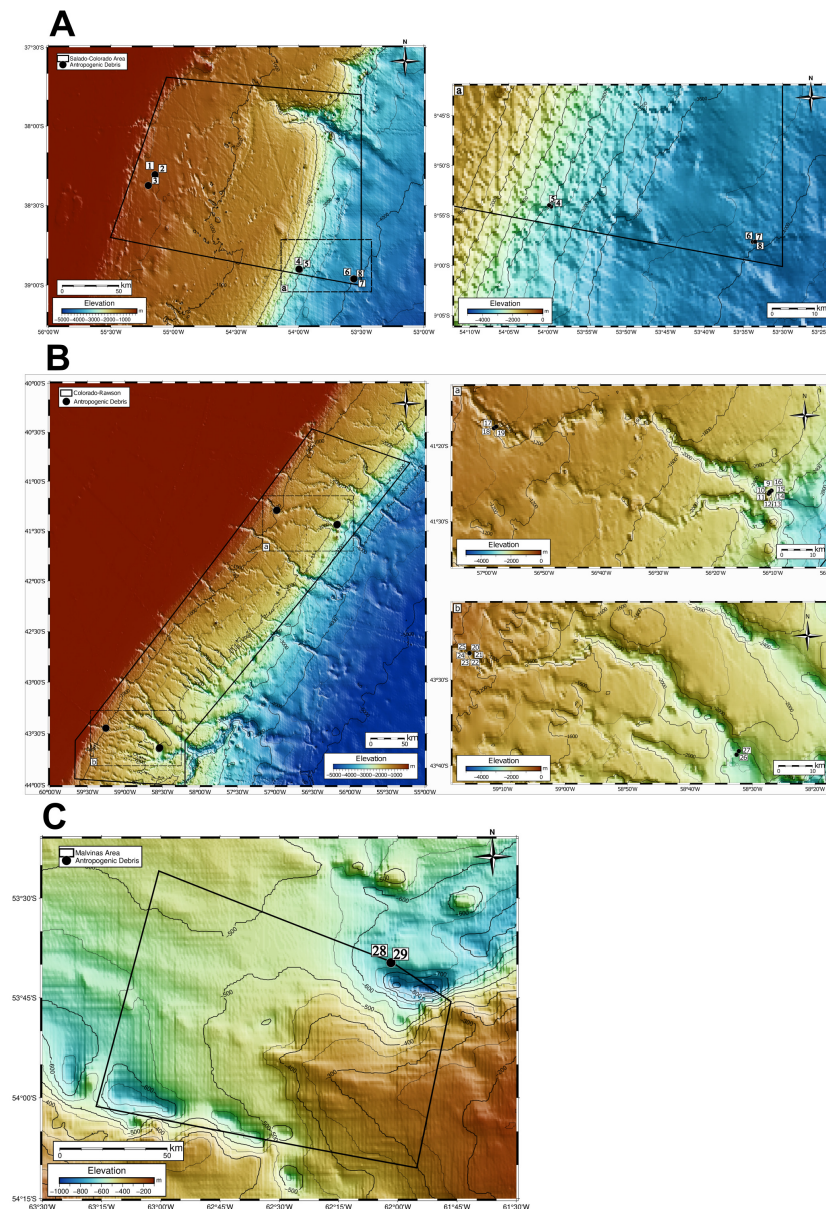


FIGURE 4

Study areas showing the locations of recorded anthropogenic debris. Numbered points indicate the sites where items were found. Numbers refer to the debris identification numbers reported in Table 1. Study areas: (A) Salado-Colorado area; (B) Colorado-Rawson area; (C) Malvinas Basin area.

accumulation compared to deep low-energy environments associated with submarine canyons in the Colorado-Raw area, where litter could potentially be more effectively retained and concentrated over time. However, given the exploratory nature of this study and the limited number of observations, these interpretations should be regarded as preliminary hypotheses that require further investigation to be validated.

5 Conclusion

This exploratory study provides the first baseline report about marine litter on the Argentinian deep seafloor, based on systematic

visual observations. By documenting the presence, general composition, and spatial distribution of debris across previously unexplored deep-sea environments, this work contributes novel studies for the Southwestern Atlantic, a region where research on deep-sea marine litter remains extremely limited. These results expand the current global understanding of deep-sea debris accumulation patterns and highlight the role of geomorphological and hydrodynamic processes in controlling litter transport, deposition, and retention at depth.

Although the overall abundance of debris was low compared to values reported for other marine environments worldwide, anthropogenic litter was recorded in all surveyed regions, confirming that even remote and deep-sea environments of the South Atlantic are not exempt from human pollution. Plastic items dominated the observed

debris, reinforcing global patterns that plastics are the most persistent and widespread form of marine litter in benthic systems.

Submarine canyons in the Colorado-Rawson exhibited the highest concentration of debris, highlighting the potential role of this zone for the accumulation of anthropogenic debris. The complex topography and active bottom circulation likely promote the accumulation of this debris in deep, low-energy sectors, making them key locations for debris accumulation.

Although this study was limited by the opportunistic nature of visual studies and the relatively small number of elements observed, it establishes a critical, exploratory regional baseline for the Argentinian deep sea. Within these limitations, in the context of Argentina's vast deep-water territory, documenting marine litter is essential to understanding the extent of anthropogenic impact, informing conservation strategies, and supporting future management and policy decisions aimed at the sustainable use of deep-water ecosystems.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#). Further inquiries can be directed to the corresponding author.

Author contributions

MA: Methodology, Conceptualization, Supervision, Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing, Formal analysis, Visualization. FR: Methodology, Data curation, Conceptualization, Validation, Writing – original draft, Investigation, Formal analysis, Writing – review & editing. MF: Visualization, Writing – original draft, Project administration, Funding acquisition, Resources, Conceptualization, Investigation, Writing – review & editing, Supervision. EB: Formal analysis, Methodology, Writing – original draft, Software, Data curation. LA: Methodology, Data curation, Software, Writing – original draft. AA: Methodology, Software, Data curation, Writing – original draft. JC: Software, Writing – original draft, Data curation, Methodology. DA: Writing – original draft, Methodology, Data curation. XB: Writing – original draft, Methodology, Data curation. LC: Data curation, Software, Methodology, Writing – original draft. MD: Supervision, Writing – original draft. BD: Methodology, Data curation, Writing – original draft. JG: Writing – original draft, Methodology, Data curation. JI: Data curation, Methodology, Writing – original draft, Software. DL: Methodology, Data curation, Writing – original draft. LL: Writing – original draft, Conceptualization, Methodology. LM: Writing – original draft, Data curation, Methodology. SM: Writing – original draft, Methodology, Data curation. LP: Methodology, Data curation, Writing – original draft. FS: Conceptualization, Writing – original draft, Methodology. LS: Conceptualization, Writing – original draft,

Methodology. MS: Methodology, Writing – original draft, Formal analysis. CS: Methodology, Writing – original draft, Conceptualization. MW: Writing – original draft, Formal analysis, Methodology. GZ: Writing – original draft, Software, Formal analysis. MB: Conceptualization, Writing – review & editing, Supervision, Validation, Funding acquisition, Project administration, Formal analysis, Writing – original draft, Resources, Visualization, Investigation.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2026.1876155/full#supplementary-material>

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