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Public perceptions, knowledge, responsibilities, and behavior intentions on marine litter: Identifying profiles of small oceanic islands inhabitants

Sara Bettencourt [a,b,c,d,*], Diogo Nuno Freitas [e,f,g], Sónia Costa [c,d], Sandra Caeiro [a,b]

[a] Center for Global Studies, Department of Science and Technology, Portuguese Distance Learning University, Lisbon, Portugal
[b] CENSE - Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University of Lisbon, Lisbon, Portugal
[c] MARE - Marine and Environmental Sciences Centre/ARNET - Aquatic Research Network, ARDITI - Regional Agency for the Development of Research, Technology and Innovation, Madeira, Portugal
[d] OOM - Oceanic Observatory of Madeira, ARDITI, Madeira, Portugal
[e] ITI/LARSyS/M-ITI - Madeira Interactive Technologies Institute, Madeira, Portugal
[f] NOVA LINCS - NOVA Laboratory for Computer Science and Informatics, Lisbon, Portugal
[g] Faculty of Exact Sciences and Engineering, University of Madeira, Madeira, Portugal

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ABSTRACT

Marine litter is a global threat, particularly on oceanic islands where the problem is exacerbated. Perceptions, knowledge, awareness, and attitudes towards the theme are crucial in its mitigation and prevention. This study assessed these points through a questionnaire to the inhabitants of a Portuguese archipelago. Data revealed that people associate marine litter with plastic and its impacts and are well informed about its sources and pathways. Yet, the degradation rates of marine items were frequently underestimated and the problem of marine litter was attributed, among others, to littering, single-use products, and excessive packaging. Some individuals did not consider themselves responsible for reducing marine litter, attributing responsibilities to third parties. The youngest group, men, and students were the ones who reported less litter-reducing intentions and behaviors. Distinct profiles were traced using the questionnaire's answers, highlighting who needs marine litter literacy. Individuals who do not consider marine litter a current threat and live in a community that does not care about marine litter (profiles 1 and 2) were the groups that needed deeper intervention, due to their low perception and understanding of the problem. Marine litter literacy, management, and governance measures are necessary so that the public recognizes marine litter as a current threat, is worried about its impacts, avoids plastic use, and choses re-useable products (profile 4). In the studied oceanic islands, results indicated marine litter is not fully perceived by the public. A global and transformative shift in the way people are educated and behave towards waste and pollution is required, thereby highlighting the importance of increasing public perceptions assessment and marine litter literacy in the society.

1. Introduction

Marine litter is a worldwide concern that poses severe threats to the environment, society, and economy. Urgent actions to avoid and reduce marine litter are needed. At the G20 Summit in 2017 (Hamburg, Germany), a 'G20 Action Plan on Marine Litter' was adopted to 'Promote public information campaigns for citizens and businesses to reduce waste generation, to re-use and to facilitate their participation in waste collection systems and to avoid littering' (Barnett et al., 2018, p. 9).

Marine litter, also known as marine debris, can be defined as the persistent, manufactured, or processed solid materials discarded, disposed of, or abandoned in the marine and coastal environment (UNEP - United Nations Environment Programme, 2009). These materials can be deliberately dumped into the sea, coasts, rivers, and beaches or brought indirectly to the ocean by rivers, sewage, stormwater, currents, tides, or wind. The accidental loss also contributes to the accumulation of litter in the sea (Veiga et al., 2016). The sources of marine litter can be classified as land- or ocean-based, depending on how debris enter the sea. The land-based sources include the recreational use of the coast, unprotected landfills, dumping of garbage (households and industries),

* Corresponding author. OOM - Oceanic Observatory of Madeira, Edifício Madeira Tecnopolo, Piso 0, Caminho da Penteada, 9020-105, Funchal, Madeira, Portugal.
E-mail address: bettencourtsmp@gmail.com (S. Bettencourt).

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public littering, and sewage overflows (Galgani et al., 2015). It is estimated that these sources contribute to about 80% of the total litter in the ocean (Allsopp et al., 2006). Nevertheless, this assumption is poorly documented and should be validated (Werner and O'Brien, 2018). The ocean-based sources are associated with human activities and actions at sea: fishing, merchant shipping, research, and military vessels, recreational boats, cruise ships, and offshore petroleum installations (Sheavly and Register, 2007).

Worldwide, plastic is the most common material found in the marine environment, followed by cigarette butts, metal, glass/ceramics, wood, paper/cardboard, and textiles/fabrics (Hahladakis, 2020). The continuous input of marine litter items causes severe impacts. Entanglement, smothering, ingestion, ecosystem deterioration, and dispersal of non-native species are some of the widely known environmental consequences of marine debris (Fossi et al., 2018; Gall and Thompson, 2015; Kühn et al., 2015). Social (Potts and Hastings, 2011; Sheavly and Register, 2007) and economic (Mouat et al., 2010; Newman et al., 2015) threats can equally be directly or indirectly attributed to marine litter. These environmental, social, and economic impacts are typically interconnected, being difficult to tackle separately.

Addressing the problem requires understanding and engagement of citizens with the topic (Dilkes-Hoffman et al., 2019; Rayon-Viña et al., 2019). Public perceptions can be measured as a combination of awareness, knowledge, and concern (Oosterhout et al., 2022). Furthermore, identifying public perceptions is crucial for developing management measures and policies (Gkargkavouzi et al., 2020; Olsen et al., 2020). Prevention, mitigation, removal, and behavior change are the four actions proposed to reduce marine litter inputs and impacts. Prevention is one of the most favorable approaches, given that it prevents the generation of debris and their entry into the sea, as well as behavior change measures, which have a long-term impact. Education can be used to support behavior change (Bettencourt et al., 2021; Hartley et al., 2018; Wichmann et al., 2022), as it influences and promotes the adoption of sustainable behaviors (Chen, 2015; Rangel-Buitrago et al., 2020), particularly important when tackling marine litter and waste management problems.

There has been a growing number of studies assessing people's perceptions of the marine litter problem, its impacts, and solutions (Dilkes-Hoffman et al., 2019; Ferreira et al., 2021; Filho et al., 2021; Hartley et al., 2018; Slavin et al., 2012). Nevertheless, few authors linked what people know about marine litter, what people's efforts to prevent it are, and which demographic factors influence it. With such data, it is possible to quickly establish profiles that determine who needs marine litter literacy interventions. If this is not understood, interventions to increase marine litter literacy cannot be properly designed.

Considering marine pollution is a prevalent problem on oceanic islands (Kiessling et al., 2017), with some ecosystems acting as crucial marine litter accumulation zones (Portz et al., 2022), we examined the perceptions, knowledge, responsibilities, and behavioral intentions of people from two oceanic islands about litter. We combined that data to trace different profiles and investigate whether people living in these locations better perceive the marine litter issue and act accordingly to prevent it. If the hypothesis that marine litter is not fully perceived by the public becomes validated, measures to manage the problem and guide future research can be adapted.

2. Methods

2.1. Study site, participants, and sampling

Marine litter is a significant problem frequently exacerbated on oceanic islands. The present work was carried out on two small oceanic Portuguese islands – Madeira and Porto Santo – which are the inhabited islands of the Autonomous Region of Madeira. Madeira is an important touristic destination awarded eighth times as the 'Europe's Leading Island Destination' by World Travel Awards, and Porto Santo the 'Best Beach in Europe 2022' by European Best Destinations. Atmospheric circulation and the southward Portugal currents are important pathways of marine litter intercepting Madeira Island (Cardoso and Caldeira, 2021).

The 2021 census revealed that Madeira and Porto Santo have a population of 251,060 individuals. To determine the sample size of the population, the adjusted Yamane's formula was applied. The equation was adjusted to allow the determination of optimum sample sizes for continuous and categorical variables at all levels of confidence: $n = N/(1 + N\varepsilon^2)$, where n is the minimum returned sample size, N the population size, and ε the degree of accuracy expressed as a proportion (Adam, 2020). A sample of 271 valid questionnaires was determined to be needed, considering a margin of error of ±5% and a confidence level of 90%.

The geographical dispersion - Madeira (741 km^2) and Porto Santo (43 km^2) - required an extra effort to survey residents of all municipalities, particularly those who live in more rural areas (e.g., by sending the questionnaire to the different municipalities and parish councils). Questionnaires were randomly distributed in printed (for the less digitally literate) and electronic forms (social media, email, and QR codes) from April to July 2021 following a convenience sampling technique, where data is collected until the required sample size is reached (Saunders et al., 2009). To reach a wider and diversified sample, the questionnaire was spread through social media advertising to Internet Protocol (IP) addresses in Madeira and Porto Santo islands.

Lime Survey, which is an online survey software, was used (version 2.06) to collect the answers. Individuals were informed about the research and the confidentiality of responses and provided consent to participate in the study. A total of 350 valid questionnaires were obtained. For the questionnaire answers to be valid, the respondents had to be older than 18 years old and reside on the island of Madeira or Porto Santo and the survey had to have all the questions answered.

2.2. Questionnaire

Considering the research question 'What do people know and how do they perceive marine litter?', a questionnaire was prepared following the recommendations to be based on existing studies and use standardized questions (Lotze et al., 2018). Questions were adapted from the MARLISCO survey 'Perceptions about marine litter' (Hartley, 2013), and new ones were added according to the survey's population and geographical context. The questionnaire was pre-tested with a small group as suggested by Bolarinwa (2015). The test group included 25 people of different ages, gender, profession, and place of residence. With feedback from respondents, minor adjustments were made in the questions and answer options. The final version of the questionnaire comprised 20 questions (1 short answer and 19 closed answers) and space for optional comments/observations. All questions and response options were written in Portuguese and the estimated time of completing the survey was 10 min.

The short-answer question was the first query of the questionnaire. It requested the participants to write two words immediately associated with marine litter, which were subsequently clustered into eight categories. That was the first question in the questionnaire to avoid biased answers, as the subsequent words used in the questionnaire could influence the answers. The following questions were closed-answers of multiple choice or single choice Likert scale and covered distinct topics (Appendix Table I in the Supplementary Material).

As some municipalities had small sample sizes, the following grouping was performed, as proposed by Hermida and Costa (2020): Funchal, Câmara de Lobos, South-West Coast (including the municipalities of Ribeira Brava, Ponta do Sol, and Calheta), North Coast (including Porto Moniz, São Vicente, and Santana), South-East Coast (Machico and Santa Cruz), and Porto Santo Island. The professional activity was codified according to the groups established in the

'International Standard Classification of Occupations' (ILO - International Labour Organization, 2012) and used by the Portuguese National Institute of Statistics (INE - Instituto Nacional de Estatística, 2011). Three additional groups were introduced to facilitate the self-filling of the questionnaire: student, don't know how to answer, and other. Some of the answers provided in the 'don't know how to answer' and 'other' fields were manually introduced in the respective professional groups by the authors when the data were analyzed.

2.3. Statistical analysis

The data from the questionnaires were statistically analyzed using Python programming language (version 3.8), with auxiliary external libraries, such as the SciPy library. Each statistical test was conducted considering the significance level of .05 (alpha) (Coolican, 2014). Due to a low number of respondents, the conducted statistical analyses did not include respondents with households of zero members or respondents that answered "NA" in the gender. Likewise, the only occupations considered were technicians and associate professionals, clerical support workers, and students, as it would not be possible to draw meaningful and general conclusions about other respondents.

All Likert scale questions were considered on an ordinal scale, with responses encoded as a value from 1 through 5. For this reason, instead of reporting the mean and standard deviation, the median and interquartile range (IQR) are used in the descriptive statistics, as they provide a more accurate measure of central tendency (Coolican, 2014). The IQR can be interpreted as a measure of the spread of the data of the central group. In this view, if IQR = 0, then a significant number of respondents provided the same answer.

Moreover, Likert scale questions were analyzed with non-parametric tests to test if the difference between the examined groups was significant (Boone and Boone, 2012; Joshi et al., 2015). More particularly, the Kruskal–Wallis one-way analysis of variance (which is an extension of the Mann–Whitney U test for more than two groups) was used to test whether the difference in distributions of three or more groups concerning one factor is significant. Since the Kruskal–Wallis test does not specify which groups are statistically significantly different, the Dunn's test, suitable for testing the difference between two conditions, was used for the pair-wise post-hoc tests, thus detecting the groups that differ. A two-sided alternative hypothesis was tested for the latter statistical test and the p-values were adjusted according to the Bonferroni adjustment for multiple comparisons (Coolican, 2014).

The Chi-Squared (χ^2) test of independence was used for the multiple-choice questions to test whether the association between categorical variables was statistically significant. It is important to note that the Chi-Squared test of independence assumes that the observations are independent of each other and requires the expected frequencies to be at least 5 in no less than 80% of the cells in the contingency table. This last prerequisite was not satisfied for some statistical tests. In these cases, the statistical results were marketed as N/A (not available). Finally, the Chi-Squared test of independence was also used for the pair-wise post hoc tests; Yates' correction for continuity was applied, and the p-values were adjusted according to the Bonferroni adjustment for multiple comparisons (Wuensch, 2011).

In the Kruskal–Wallis, the effect size was calculated using the eta squared formula and the Cramér's Φ was reported for the significant Chi-Squared tests of independence (Coolican, 2014).

It is also of interest, based on the data from the questionnaires, to identify the respondents' profiles. The method for selecting respondents' profiles consists of two steps: cluster analysis and Decision Trees (DTs) splitting. The k-means clustering method (Lloyd, 1982) was used to group respondents into five clusters based on the average data in each cluster. However, this method does not identify the rules used to split the groups. In this manner, DTs were used. The input samples for DTs were the data from the questionnaires, and the target values were the groups identified by the cluster analysis. The algorithm starts by selecting the root node corresponding to the question that best separates the respondents. After that, the DT continues this process for the next important feature, splits the participants, and creates and adds new branches to the DT (Fürnkranz, 2010). This process is repeated until the maximum depth of the tree (in the case of this work, 5) is attained. It is noteworthy that the Gini Impurity function was used to identify the DT's root node and subsequent question splits.

3. Results

3.1. Survey sample – demographic data

A total of 350 valid questionnaires were obtained, achieving more than the minimum of the required sample. Table 1 clusters the respondents' sociodemographic variables. Most of the respondents were between 36 and 50 years old, were female, and lived in the municipality of Funchal. Households with three members were the most common. Concerning the respondents' occupations, the majority were professionals (e.g., science and engineering; health; teaching; business and administration professionals), followed by technicians and associate professionals (e.g., science and engineering; health; business and administration associate professionals), and students (secondary and higher education).

3.2. Marine litter knowledge and perceptions

3.2.1. Definition

The respondents' concept of marine litter was evaluated through an open question, where people wrote the words they associate with marine litter (Fig. 1). 'Plastic', 'microplastic', and 'bioplastic' were referred to 189 times (27.0%). Terms linked to marine litter impacts and 'pollution' were also frequently mentioned. Solutions to reduce marine

Table 1
Sociodemographic characteristics of the respondents.

Item	Variable	No.	%
Gender	Female	195	55.7
	Male	153	43.7
	Not answered (NA)	2	0.6
Age groups	19–25	53	15.1
	26–35	81	23.1
	36–50	129	36.9
	≥51	87	24.9
Residence area	Funchal	215	61.4
	Câmara de Lobos	26	7.4
	South-West Coast	26	7.4
	North Coast	6	1.7
	South-East Coast	70	20.0
	Porto Santo	7	2.0
No. of household members	0	11	3.1
	1	38	10.9
	2	74	21.1
	3	115	32.9
	4	82	23.4
	≥5	30	8.6
Occupations	Managers	10	2.9
	Professionals	168	48.0
	Technicians and Associate Professionals	47	13.4
	Clerical Support Workers	33	9.4
	Services and Sales Workers	14	4.0
	Skilled Agricultural, Forestry, and Fishery Workers	3	0.9
	Craft and Related Trades Workers	1	0.3
	Plant and Machine Operators and Assemblers	1	0.3
	Elementary Occupations	9	2.6
	Armed Forces Occupations	4	1.1
	Student	42	12.0
	Don't know how to answer	5	1.4
	Other	13	3.7

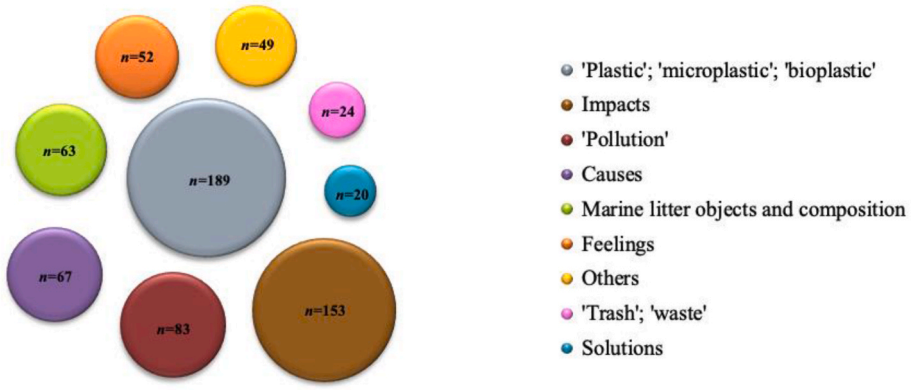

Fig. 1. Representation of the first words participants linked with the concept of marine litter. Colors refer to different groups of words, and the circle diameter indicates the word frequency.

litter were the less written ideas (2.9%).

3.2.2. Composition, degradation time, and microplastics

Plastic, cigarette butts, and sanitary waste were the three most common marine litter composition materials ranked by the participants. 98.0% of citizens admitted that plastic belongs to the top 3 marine litter material composition. Cigarette butts were indicated by 73.1% of the surveyed participants and sanitary waste by 28.6%.

Knowledge regarding the estimated degradation rates for frequent marine litter items was evaluated having as reference values the rates from National Oceanic and Atmospheric Administration and Woods Hole Sea Grant (Table 2). More than half of the respondents believed that cigarette butts take less than 20 years to decompose, with 24.3% correctly estimating the degradation time (1–5 years). This was the item with the largest percentage of correct answers. Men, older participants (≥51 years old), and clerical support workers (e.g., general and keyboard; customer service; numerical and material recording clerks) were the groups of participants who most correctly estimated the time. The degradation times of plastic bags and aluminum cans were correctly estimated by 12.3% and 14.6% of the respondents, respectively. Plastic bottles were recognized by almost 40% as having a degradation time between 400 and 500 years. Disposable diapers were the marine litter object with the highest discrepancy of values: it is estimated that disposable diapers take 450 years to degrade, but most people believe that it takes 10–20 years to disappear, approximately 30 times less time than in reality. A χ^2 analysis of the frequencies difference between gender, age group, and occupation across the number of correct answers was not significant ($p > .240$ for all cases). In other words, the statistical analysis did not show evidence that gender, age group, and occupation (positively or negatively) influence the knowledge regarding the estimated degradation rates.

For the question 'What is the name given to the plastic particles with less than 5 mm in size often found in the ocean?', microplastics were pointed as the correct answer by 95.1% of the surveyed people, followed by mesoplastics (3.4%) and macroplastics (1.4%).

3.2.3. Perceived sources/pathways, factors, and impacts

When asked about the sources and pathways that contribute to litter reaching the coast and sea, the median of answers attributed the maximum score to three paths: (i) direct release of litter into the ocean, (ii) litter resulting from the discharge of sewage to the coast, and (iii) litter transported through streams, irrigation channels, and rivers. Direct release of litter on the coast was the source less mentioned (Table 3). Statistical results (Appendix Tables II and III in the Supplementary Material) indicated that participants similarly perceived the direct release of litter on the ocean and coast, and sewage discharge to the coast, regardless of their age and occupation. This indicates that respondents recognize both land- and ocean-based activities as marine litter sources.

Statistically significant differences were detected in the perception of

Table 2
The estimation of the degradation time of different marine litter objects. The color gradient indicates the percentage of responses (darker: more responses; lighter: fewer responses). The predicted correct degradation time for each item is marked by a green box (cigarette butt: 1–5 years, plastic bag: 10–20 years, aluminum can: 200 years, plastic bottle: 450 years, and disposable diaper: 450 years).

	Cigarette butt		Plastic bag		Aluminum can		Plastic bottle		Disposable diaper	
Time	No.	%	No.	%	No.	%	No.	%	No.	%
1-5 years	85	24.3	7	2.0	5	1.4	0	0.0	21	6.00
10-20 years	107	30.6	43	12.3	23	6.6	22	6.3	77	22.0
50 years	58	16.6	45	12.9	54	15.4	41	11.7	63	18.0
100 years	46	13.1	79	22.6	63	18.0	68	19.4	60	17.1
200 years	17	4.9	53	15.1	51	14.6	58	16.6	36	10.3
300 years	10	2.9	20	5.7	40	11.4	23	6.6	26	7.4
400 years	8	2.3	33	9.4	34	9.7	46	13.1	28	8.0
500 years	19	5.4	70	20.0	80	22.9	92	26.3	39	11.1

Table 3
Perceived sources, pathways, contributing factors, and impacts of marine litter. Mdn = Median; IQR = Interquartile range.

Item	Mdn	IQR
Sources and pathways (1 – none to 5 – a lot)		
Direct release on the ocean	5.0	1.0
Sewage discharge to the coast	5.0	1.0
Litter transported through streams, irrigation channels, and/or rivers	5.0	1.0
Direct release on the coast	4.0	1.0
Contributing factors (1 – not at all important to 5 – very important)		
Single-nature use of several products and packaging	5.0	1.0
Fishers and boats that release garbage into the sea	5.0	1.0
Littering in the streets, irrigation channels, and streams	5.0	1.0
Over-packaged products that are difficult to recycle	5.0	1.0
Extensive use of plastic in everyday products and packaging	5.0	1.0
Businesses along the beaches and coast	4.0	1.0
Littering on the beach	4.0	2.0
Lack of bins in public areas	4.0	2.0
Impacts (1 – none to 5 – high)		
Quality of the marine environment	5.0	0.0
Human health	5.0	0.0
Appearance/aesthetic of the beaches and coast	5.0	1.0
Shipping and fishing	4.0	1.0
Tourism	4.0	1.0

the litter transported through streams, irrigation channels, and rivers. The age group 19–25 assigned a lower contribution of these pathways when compared to the age groups of 36–50 and ≥51 years old. In the same direction, students showed a lower perception of the contribution of streams, irrigation channels, and rivers as pathways for litter accumulation, especially when compared to professionals.

Various factors were rated by the participants as contributing to litter reaching the marine environment. The excess of single-use products and packaging; fishers and boats that dump garbage into the sea; people littering in the streets, irrigation channels, and streams; over-packaged products that are difficult to recycle; and extensive use of plastic in everyday products and packaging were perceived as the most important causes of marine litter accumulation (Table 3). Stores along the beaches and coasts, people littering the beaches, and lack of bins in public areas were perceived by the population as less relevant causes of marine debris accumulation. Statistical tests (Appendix Tables II and III in the Supplementary Material) indicated there is no evidence that age or occupation significantly alters each contributing factor's ratings. However, this excludes the lack of bins in public areas, which the age group 26–35 considers a more important factor than the 36–50 years old group.

The degree of marine litter impacts on the quality of the marine environment, tourism, human health, shipping and fishing industry, and the appearance/aesthetic of the beaches and coast were equally evaluated. Participants reported marine litter to pose different levels of threat, with the quality of the marine environment and human health being the most identified consequences (Table 3). The interquartile range for these impacts was zero and the median five, indicating that respondents were mostly convinced that these are the topmost impacts. It was possible to identify a trend in the students and clerical support workers regarding the perception of the impacts of marine litter on human health, shipping and fishing, and tourism. These two groups were the ones that most often had opposite opinions, with students always attributing a lower impact of marine litter on those items (Appendix Table III in the Supplementary Material). The appearance/aesthetic of beaches and coasts also had a median of five, but the interquartile range was one, indicating that some respondents considered it a medium-level impact. The shipping and fishing industries and tourism had a 'medium' impact median. It is interesting, however, that the younger-age group attributes a lower impact of tourism in the marine debris (Appendix Table II), especially when compared to older groups (i.e., 36–50 and ≥51).

3.3. Risk perception and social norms

The assessment of risk perception revealed that most of the participants perceived lasting damages caused by marine litter and recognized it as a topic that deserves more attention at the national level (Table 4). Similarly, most respondents agreed that the amount of debris is increasing and reported being worried about the consequent impacts. Interestingly, only the item related to the concern about the impacts of marine litter showed to be statistically different depending on age and occupation. Results showed that people aged 36–50 and more than 51 years old were more worried than the inhabitants between 19 and 25 years old, and students were less concerned than professionals (Appendix Tables IV and V in the Supplementary Material). When asked about marine litter being a problem in the region where they live and not just in other countries, the inhabitants agreed that marine pollution is a real concern in the place where they live. The statement 'marine litter is a future environmental threat rather than a current threat' gave rise to a greater dispersion of opinions, with some agreeing and others disagreeing, mainly the youngsters (19–25 years old), who considered marine litter a more distant threat. Nevertheless, the Kruskal–Wallis tests revealed that the risk perception did not vary significantly with age, only with occupation, with professionals recognizing more clearly marine litter as a present threat than clerical support workers (Appendix Tables IV and V in the Supplementary Material).

The perceptions of the respondents' about others (i.e., family, friends, and local community) were equally assessed. The median showed that most of the participants partially agree that their family and friends think it is important to reduce marine litter and support them in taking actions to reduce marine litter (Table 4). Inhabitants were unsure of whether their families and friends knew what marine litter was and talked about it. Concerning the local community's care about marine litter, respondents were undecided whether people care or not, with more than 20% partially or totally disagreeing that their local community cares about marine litter questions.

The recognition that most respondents' family and friends know what marine litter is, talk about it, and think it is important to reduce it were the social norms that varied statistically significantly with age. The older ones (51 or more years old) reported that their relatives and friends know and talk more about marine litter than the contacts of the 19–25 and 26–35 years old. Similarly, family and friends of older respondents (51 or more years old) think it is more important to reduce marine litter, especially when compared with the younger ages' groups (i.e., 19–25 and 26–35 years old groups). The social norms perception about marine litter by professional occupation was equally analyzed and

Table 4
Risk perception and social norms about marine litter. Mdn = Median; IQR = Interquartile range.

Item	Mdn	IQR
Risk perception (1 – totally disagree to 5 – totally agree)		
Marine litter is an important topic that deserves more attention at national level	5.0	0.0
The amount of litter on the coast and in the sea is increasing	5.0	1.0
The marine litter impacts are a cause of concern for me	5.0	1.0
The ocean is so large that it is unlikely that marine litter cause lasting damage	1.0	0.0
Marine litter is a problem in other regions, but not on Madeira Island	1.0	1.0
Marine litter is a future environmental threat rather than a current threat	1.0	3.0
Social (1 – totally disagree to 5 – totally agree)		
Most of my family and friends think it is important to reduce marine litter	4.0	1.0
Most of those close to me support me in taking actions to reduce marine litter	4.0	1.0
Most of my family and friends know what marine litter is and talk about it	4.0	2.0
Most people in my local community care about marine litter	3.0	1.0

did not show statistically significant differences. The statistical tests that support these conclusions are depicted in Appendix Tables VI and VII in the Supplementary Material.

3.4. Responsibility

As important as verifying if respondents recognize the necessity of reducing marine litter, is identifying whom they hold responsible for it. A set of individual and collective entities were listed. Results indicate that all groups are responsible. Nevertheless, it is interesting that respondents first consider the general public responsible for reducing marine litter and only then recognize their own role (Fig. 2). Governments and town councils were also regarded as key actors in tackling marine litter. In contrast, companies that collect and recycle garbage, scientists, and researchers were perceived as the least responsible. Results were also compared by age and occupation to explore the influence of these variables on perceived responsibility. The χ^2 analysis revealed that almost all age groups equally perceive responsibility. The exception were the participants aged 51 and over, who were generally more likely to attribute more responsibility to teaching professionals, bathers, and commercial users of the coast and sea when compared to younger groups (Appendix Table VIII in the Supplementary Material).

Regarding the relationship between perceived responsibility and occupation, the results that stand out are the ones that refer to managers, clerical support workers, and services and sales workers. The last two groups are highlighted because the role of these individuals in reducing marine litter in their archipelago just appears in the fourth place, translating their low individual perception of responsibility. The managers' group (e.g., chief executives, senior officials, and legislators; administrative and commercial managers) did not mention themselves in the top five of those who must reduce marine litter, attributing the responsibility to town halls, regional government, general population, fishers, and beachgoers. It is noteworthy that the χ^2 pair-wise tests (Appendix Table IX in the Supplementary Material) showed that the professionals, compared to the students, attribute more responsibility for marine litter reduction to the occupations of education and research. Moreover, professionals also perceive a higher responsibility to bathers and fishers than the clerical support workers.

3.5. Self-perceived responsibility and solutions

Different results for self-perceived responsibility and competence were obtained: all people believe that they can contribute to reduce marine litter, however, not everybody considers themselves responsible for that (Table 5). The Kruskal–Wallis test results showed that age significantly affects how respondents consider themselves contributors and responsible for marine litter reduction: the youngest group (19–25 years old) is the one that seems to be more indecisive about their self-perceived responsibility, being, statistically significantly different from the older groups. Concerning the self-perceived competence, the only two age groups that showed statistically significant differences were the age groups of 26–35 and 36–50, being the group 26–35 the one with a higher self-perceived competence (Appendix Table X in the Supplementary Material). Considering the occupations, professionals consider themselves more responsible than students (Appendix Table XI in the Supplementary Material). No other pair-wise comparison revealed

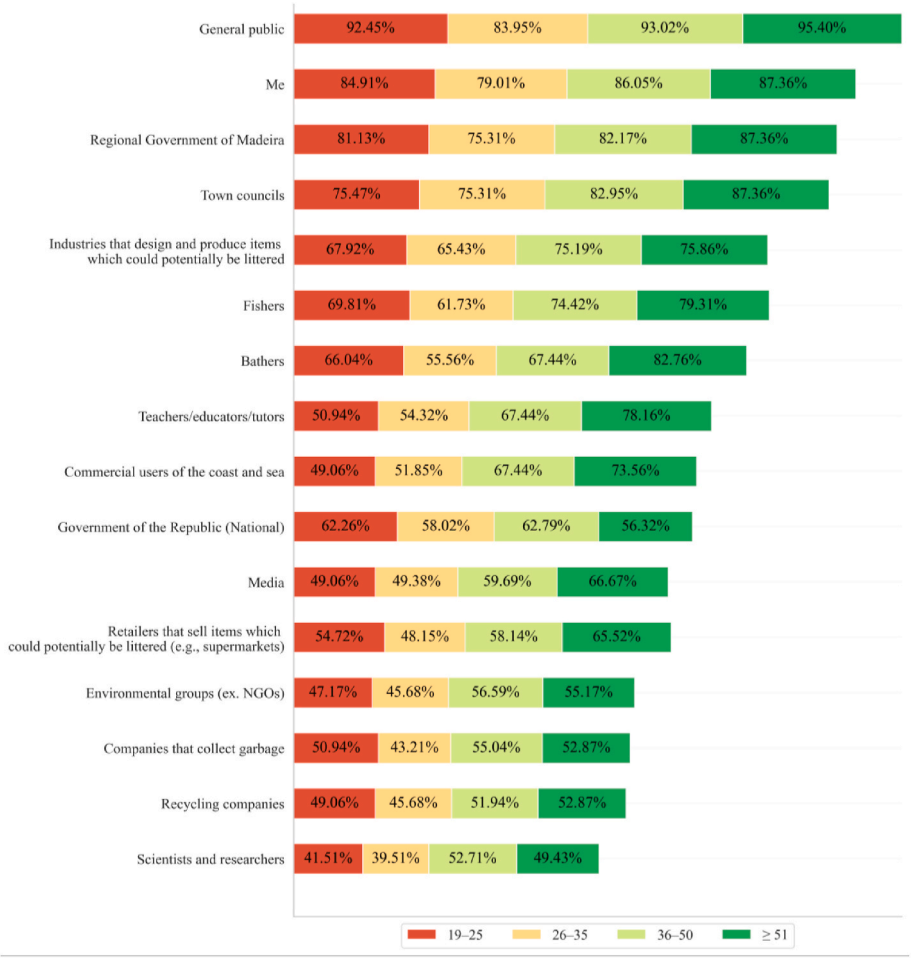

Fig. 2. Perceptions of the responsibility for reducing marine litter, according to respondents' age.

Table 5
Self-perceived role, solutions, and litter-reducing intentions to diminish marine litter. Mdn = Median; IQR = Interquartile range.

Item	Mdn	IQR
Self-perceived role (1 – totally disagree to 5 – totally agree)		
I can contribute to reducing marine litter	5.0	0.0
I am responsible for reducing marine litter	5.0	1.0
Solutions (1 – totally disagree to 5 – totally agree)		
People changing their behavior is part of the solution to the marine litter problem	5.0	0.0
If there are no radical changes in people's behavior, the marine litter problem will not be solved	5.0	0.0
Recycling is part of the solution to the marine litter problem	5.0	1.0
Litter-reducing intentions (1 – extremely unlikely to 5 – extremely likely)		
Use own bags when shopping	5.0	0.0
Don't litter the irrigation channels and streams	5.0	0.0
Don't litter	5.0	0.0
Don't leave trash on the beach	5.0	0.0
Don't leave trash in the mountains	5.0	0.0
Sort the garbage and recycle	5.0	0.0
Advise my family and friends to adopt sustainable practices	5.0	1.0
Avoid the use of plastic bags	4.5	1.0
Buy products with environmentally friendly packaging	4.0	1.0
Use re-useable products, rather than single-use and disposable ones	4.0	1.0
Avoid plastic use	4.0	2.0
Ask people to pick up their litter if littering in the street	4.0	2.0

statistically significant differences among the groups.

When inquired about what is necessary to tackle marine litter, people changing their behaviors, and doing so in a radical way, was pointed out by all the respondents as the most necessary aspects, without significant statistical differences among the different age groups and occupations. Recycling was a solution that did not gather unanimity among the participants. Respondents between 26 and 35 years old were the ones that considered this measure less necessary when compared to the remaining age groups (Appendix Table X in the Supplementary Material). Comparisons between the different occupations were not significant (Appendix Table X in the Supplementary Material).

Participants were then asked to rate the likelihood of performing certain actions to diminish marine litter. Using their own bags when shopping; not disposing of litter on irrigation channels, streams, floors, beaches, and mountains; and sorting and recycling the garbage were the intentions with a median of five and an interquartile range of zero. This indicates it is extremely probable that respondents practice the referred actions. Avoiding plastic use and asking people to pick up litter that is left on the floor were the intentions that participants reported being less willing to accomplish. When the results are analyzed by age, some differences can be observed mainly between the groups 19–25 and 36–50 years old (Appendix Table XII in the Supplementary Material) in the following intentions: avoid plastic bags; avoid plastic use; buy products with environmentally friendly packaging. Mainly, the oldest (36–50 years old) indicate that they are more likely to take these actions than younger people (19–35 years old). When the intention of sorting the garbage and recycling was ascertained, the 36 or more years-old respondents said to be more enthusiastic about doing that in comparison to younger inhabitants (35 years old or less). Two trends were identified regarding occupations (Appendix Table XIII in the Supplementary Material). On one side, students are less keen to use plastic bags and general plastic items when compared to the other occupations. On the other side, technicians and associate professionals have a higher predisposition for leaving trash on the beach, floor, and littering the irrigation channels and streams compared to other occupations. As gender affects behavior, results were also compared between females and males. Women reported being more willing to use their own bags when shopping, avoid the use of plastic items and bags, advise family and friends to adopt sustainable practices, sort the garbage and recycle, and not to litter (Appendix Table XIV in the Supplementary Material).

When the municipality area was crossed with the inhabitants' intentions, some differences were observed. Sorting the trash and recycling was an intention reported by most of the respondents in Funchal, South-East Coast, Porto Santo, and North Coast. Porto Santo was the area that collected the highest number of behavioral intentions with the maximum punctuation (extremely probable of practicing the action). As per the statistical tests (Appendix Table XV in the Supplementary Material), Funchal and South-East coast inhabitants exhibited the same intention of sorting the garbage and recycling. This intention was higher than the one shown by the inhabitants of Câmara de Lobos and the South-West coast.

Together with the intentions, the behaviors were registered through multiple choice selection. As depicted in Fig. 3, almost 30% of the respondents reported not littering the floor/irrigation channels/streams and using their own bags when going the supermarket. Drawing attention to someone's incorrect waste disposal behavior was the least-practiced action by the inhabitants in the week prior to the collection of data.

Age, gender, and household were factors that significantly influenced actions (Appendix Tables XVI, XVII, Table XVIII in the Supplementary Material). Older participants (≥51 years old), women, and, as outlined in Fig. 1 in the Supplementary Material, people living in smaller families reported having practiced more sustainable actions in the week before the application of the questionnaire.

3.6. Respondents' profiles

Four main profiles (Fig. 4) were identified at the end of the analysis of the questionnaire, following the cluster analysis using *k*-means clustering and DT splitting (Fig. 2 in the Supplementary Material). For this work, the DT splitting obtained a mean accuracy of 89.3%.

Each profile revealed important characteristics that respondents tend to have, directing distinct educative and raise-awareness interventions to such targets. Although the DT depicted in Fig. 2 in the Supplementary Material used all the questions from the questionnaire, some questions were considered unimportant according to the maximum defined depth (i.e., 5) and information gain metrics (i.e., the Gini Impurity function). As a result, those questions were not used by the DT splitting to draw the four profiles.

Profile 1 ($n = 22$) relates to people who do not consider marine litter a current threat and live in a community that does not care about marine litter. Therefore, these people do not avoid the use of plastic nor advise family and friends to adopt sustainable practices. The positive point this group has is not littering in the mountains. Profile 2 ($n = 46$) shares commonalities with people in profile 1: neither do they consider marine litter a current threat, nor do they have a caring local community. However, individuals with this profile avoid using plastic and ask people to pick up their litter when littering. Individuals fitting profile 3 ($n = 66$) do not litter, have support in taking actions to reduce marine litter, and live in a good environment, with a caring community, and with family and friends knowing and talking about marine litter. Nevertheless, these individuals do not consider marine litter a current threat. On the contrary, people who consider marine litter a current threat (profile 4, $n = 77$) are worried about its impacts, so they adopt sustainable practices: avoid using plastic bags, recycle, and use re-useable products.

4. Discussion

This study examined the perceptions about marine litter that inhabitants of oceanic islands have. A questionnaire was used to survey the public and to establish distinct profiles, which can be used to propose measures to tackle the problem.

4.1. Survey sample – demographic data

A diverse audience responded to the questionnaire. The characteristics of the respondents are in line with those registered in the

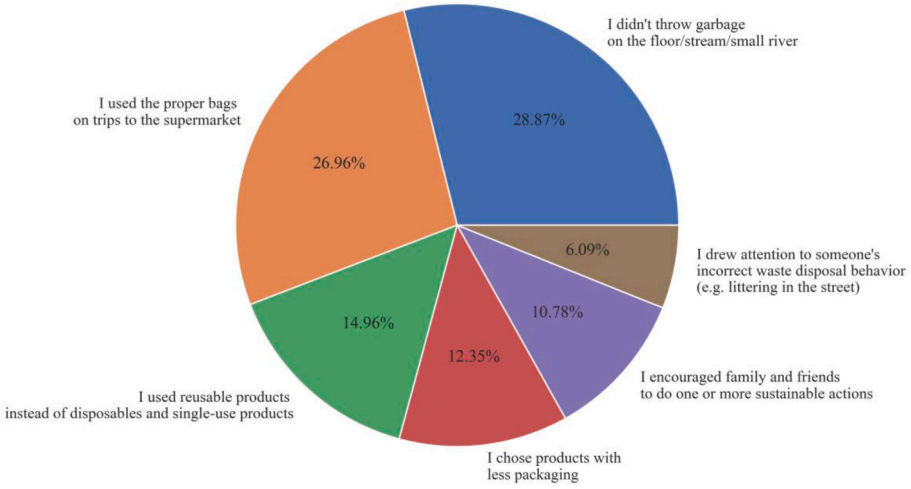

Fig. 3. Sustainable actions taken by the participants.

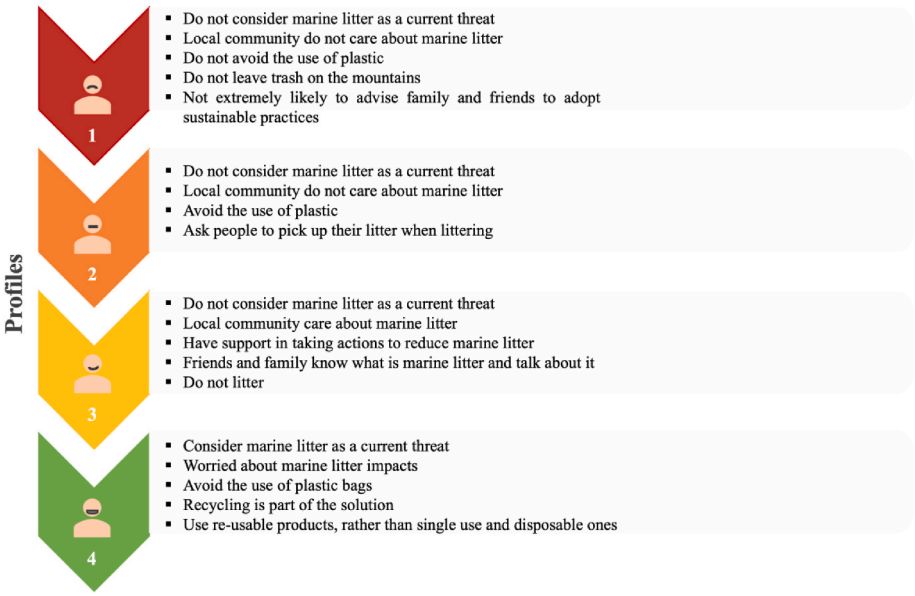

Fig. 4. Four main respondents' profiles.

Autonomous Region of Madeira, which has 53.1% women and 46.9% men according to the last census (DREM - Direção Regional de Estatística da Madeira, 2021). These censuses were made in 2021, so the available results are preliminary. The previous censuses were collected ten years ago, and the statistics are no longer up to date for comparison. Hence, data on population by age groups, households, and occupation was not available and no comparisons were carried out between the studied sample and the inhabitants of the Autonomous Region of Madeira inhabitants. Regarding the residence, compared to the 2021 census, the proportion of respondents per area approximately corresponds to the percentage of the population living in the municipalities.

4.2. Marine litter knowledge and perceptions

Different questions were used to evaluate what people know about marine litter, namely the definition, material composition, and degradation time. Overall, a moderate baseline knowledge was revealed by inhabitants.

Cigarette butts and plastic items belong to the list of common debris items on land (Hardesty et al., 2021). According to the Awi-Litterbase database, plastic-affiliated debris makes up approximately 75% of the total marine litter (Tekman et al., 2021). Littered cigarette butts are heterogeneously distributed (Green et al., 2014), being the dominant items in several beach litter studies (Araújo and Costa, 2019; Novotny et al., 2009). These data are very much in accordance with the perception of the surveyed participants, as 98.0% classified plastic items and 73.1% the cigarette butts as the most common marine litter items. The presence of sanitary waste on some of Madeira's beaches (unpublished data) may lead to respondents to extrapolate the reality of their region to the global reality, pointing to sanitary waste as the third most common marine litter category.

Regarding the degradation time, people estimated approximately the reported degradation rates, with a tendency to undervalue the times of degradation. Underestimates of decomposition time are in line with other studies (Deng et al., 2020), showing that despite people recognizing that marine litter takes several years to degrade, the order of magnitude is sometimes unknown. A reinforcement of people's knowledge about marine litter's long decomposition rates (through images on the products or even on the label, for example), could encourage correct waste disposal practices curbing the entry of tons of items into the sea

every year. Visualization, where images are linked with emotions, can indeed lead to changes in consumption and disposable behaviors (Pahl et al., 2017). The high number of anti-littering cigarette butts campaigns undertaken in the last years could have positively influenced the percentage of correct answers compared to other items, thus justifying the registered differences.

A similar explanation can be attributed to the high number of correct responses to the question 'What is the name given to the plastic particles with less than 5 mm in size often found in the ocean?'. Microplastics were pointed to as the correct answer by 95.1% of the surveyed inhabitants. The growing number of studies on microplastics in the marine environment (Barboza and Gimenez, 2015) probably lead to the widespread knowledge of the term among the population, and even though people are not sure about the theoretical definition, microplastic is a word they associate with marine litter. Also, the public frequently hears in the media sensational headlines when studies related to microplastic discoveries (Gestoso et al., 2019; Iñiguez et al., 2017; Ragusa et al., 2021) come out.

The inhabitants were surveyed about the sources and pathways that contribute to litter reaching the coast and sea, to verify if people perceive that marine litter is not just 'produced' on the marine environment, as one might be misled by the term. The authors also wanted to verify the degree of perception of residents regarding the streams as transport routes for marine litter, as 47.4% pointed out in the questionnaire that Funchal's streams are very dirty. Results showed that most of the inhabitants identify streams and irrigation channels as garbage routes, an output extremely important considering the region's characteristics (Madeira Island does not have rivers, instead, it has small streams). Like rivers (Rech et al., 2014), streams act as a source of marine litter because they have a typical radial drainage pattern, characteristic of oceanic islands, that transport high amounts of solid materials to the sea in the rainy season (Prada et al., 2005; Ritter et al., 2020). Studies in other islands equally showed the influence of waterways (Carson et al., 2013).

Together with the identification of marine litter sources and pathways, the participants perceived different factors contributing to litter reaching the marine environment. The nature of the products (single-use and over-packaged) and human behaviors (fishers that release garbage into the sea and people littering) were pointed out as significative causes of litter accumulation. Such results are in accordance with previous surveys, where extensive use of plastic and it single use nature, together with human behaviors were highlighted as very important factor contributing to marine litter (Hartley, 2013).

Regarding the negative impacts of marine debris, inhabitants recognized that litter poses several consequences. The quality of the marine environment was perceived as the biggest consequence, a result observed in other studies (Hartley, 2013). This result was expected, as people associate charismatic animals (e.g., whales and turtles) with ingestion or entanglement on litter (Frias and Nash, 2020). Furthermore, several anti-littering campaigns that were developed in Madeira Island use marine species to demonstrate the impact of marine debris, reinforcing the perception that the main consequences of litter are on the fauna. Human health was also recognized as an important challenge created by marine litter. Campbell et al. (2016) survey showed that people recognize beach litter injuries as a major concern, mainly wounds. Additionally, sewage-related debris linked to water quality concerns has been gaining relevance as a public health hazard (Potts and Hastings, 2011; Williams et al., 2005). The appearance/aesthetic of the beaches and coast was ranked as the third most relevant impact of marine litter. As the study was conducted in an archipelago (and so the respondents have more opportunities to visit beaches), it was predictable that respondents perceived this impact as being higher. In fact, most respondents only visit Funchal's beaches in the summer months/bathing season (40.3%) and consider them a little dirty (41.4%). Similar expectations were observed for the shipping and fishing industries and tourism, which had a 'medium' impact median. Being a touristic destination awarded as a 'Europe's Leading Island Destination', it was expected that respondents from Madeira Island attributed a higher impact of marine litter on tourism. According to Mouat et al. (2010), reduced recreational opportunities, loss of visual amenities, negative publicity and reputation, and ultimately a decline in the number of tourists and lower revenues, are some of the potential consequences of marine litter on coastal tourism. Estimates indicate that dirty beaches can reduce tourism revenue by up to 52% (Ballance et al., 2000), considering that litter and sewage discharge evidences are factors considered in coastal scenic evaluations (Mestanza-Ramón et al., 2020; Rangel-Buitrago et al., 2018). A survey conducted in the Netherlands confirms that: tourists prioritize clean destinations when choosing a coastal holiday destination (Werner et al., 2016). Therefore, reinforcement in the awareness of the population about the impacts of marine litter on tourism is necessary, especially in regions and oceanic islands whose economic activity is heavily dependent on tourism. Similarly, increasing people's literacy on the impacts marine litter has on shipping and fishing is necessary, as marine litter costs each Portuguese vessel an average of €2930 per year, usually due to fouled propellers (Mouat et al., 2010).

4.3. Risk perception and social norms

Six items surveyed the risk perception of oceanic islands' inhabitants. Globally, respondents considered marine litter an important topic and were concerned about it, stating it is a local and actual problem that requires more attention. Inhabitants agreed that marine pollution is a real issue in the place where they live, an expected result considering that people living closer to the coast or shoreline tend to show a higher sense of marine citizenship and to be aware of the impacts (Heck et al., 2018; McKinley and Fletcher, 2010). Furthermore, it was recognized by almost all respondents that marine litter deserves more attention at the national level, a result that reinforces that marine litter management and governance measures are necessary (section 4.7).

What family, friends, and the local community know and think about marine litter and how they behave regarding it were also assessed. Part of the respondents' family and friends recognized it is important to reduce marine litter and supported them in doing so. Nevertheless, few family members and friends know and talk about it. A reinforcement of campaigns raising awareness about the theme (section 4.7) appears to be necessary. Respondents were undecided about how their local community cares or not about marine litter, a result equally observed by Hartley (2013). These authors predicted the respondents do not know the community well enough to answer the question (Hartley, 2013).

4.4. Responsibility

Surveyed inhabitants believed all groups indicated in the questionnaire were somewhat responsible for reducing marine litter. Other people, the respondents themselves, governments, town councils, and industries that design and produce items that can potentially be littered were regarded as key actors in tackling marine litter. Companies that collect and recycle garbage, scientists, and researchers were perceived as the least responsible. Similar results were obtained in McKinley and Fletcher's interviews, with the responsibility of marine environment management being mainly attributed to the government (McKinley and Fletcher, 2010). In Dilkes-Hoffman et al. (2019) survey, companies and industries were perceived as the ones holding the highest level of responsibility for altering the way plastic is used, whereas Campbell et al. (2016) results shown that beach users are the main responsible for beach litter avoidance. Oppositely, Gkargkavouzi et al. (2020) survey showed that respondents consider scientists as being far more competent in managing the marine environment in comparison to the central government and local authorities. These differences indicate respondents' perceptions about who is responsible for reducing marine litter varies among the regions.

4.5. Self-perceived responsibility and solutions

Responsibility and competence were surveyed: although people believe they can contribute to reduce marine litter, they do not consider it as their responsibility. Most inhabitants believed people must change their behavior and do it radically to tackle the problem.

Using their own bags, not littering, and sorting and recycling the garbage were the litter-reducing behavioral intentions respondents admitted being more prone to perform. Reducing the use of plastic and asking people to pick up litter they threw away were the intentions that registered a lower propensity to be practiced by the respondents. Circumscribe the use of plastic is something that is not entirely on the side of the respondents, as there are still not many alternatives to packaged products provided by brands and industries. Additionally, there are very few bulk stores on the studied islands and insularity forces many of the daily consumption products to come packaged to guarantee their quality and hygiene. About not asking people to pick their litter, Hartley (2013) observed the same low intention and believed it may be due to the little ease of the task.

Together with intentions, behaviors were recorded. Not littering and using their own bags when shopping were the actions that the participants admitted the most to practice. Results are in line with those of Martinho et al. (2017), which showed a reduction in the use of plastic bags by about 74% in Portugal a few months after the implementation of a plastic bag tax. Nevertheless, people report that they cannot completely give up on buying plastic bags due to convenience, namely their price and availability (Deng et al., 2020; Sun et al., 2017). Drawing attention to someone's improper waste disposal behavior was the action respondents practiced the least. This result was expected, as people often feel constrained to reprimand others and fear counter-punishment or retaliations (Balafoutas et al., 2016).

4.6. Respondents' variables

4.6.1. Respondents' demographic characteristics

Older participants, women, and people living in smaller families reported having practiced more sustainable actions. Such results are in accordance with Deng et al. (2020) observations that reported senior people buying plastic bags less frequently than youngsters and females being more willing to reduce pollution than men. The gender hypothesis that females are more environmentally responsible than males, more likely to consider environmental concerns in their purchases, and more prone to recycle has been presented by Mainieri et al. (1997) and confirmed by Zambrano-Monserrate and Ruano (2020). The latter observed that houses in which women are heads of the household are more prone to choose non-plastic bags for shopping. Hartley group (2018) also verified that women and older participants report more behavioral intentions to reduce marine litter. Our results are consistent with the literature and reinforce that marine litter education interventions must target the youngest, as several authors have proven education efficiency among the younger ones (Hartley et al., 2015; Locritani et al., 2019; Torres et al., 2019). About occupations, the same trend was verified and reinforces the above: students are the ones who less perceive the problem, thus interventions must rely on this youngest group.

When the municipality area was crossed with inhabitants' intentions, some differences were observed, mainly at litter deposition intentions. A possible explanation for this might be due to the differential waste management collecting system existent between the areas.

4.6.2. Respondents' profiles

We used a decision tree to establish respondents' profiles. Defining groups of individuals who share common variables facilitate the establishment of approaches to reduce marine pollution and manage the waste. Several educative actions and raise awareness initiatives already developed (Kusumawati et al., 2020; Tabuenca et al., 2019; Torres et al., 2019) can be adapted according to the target audience.

People who fall in profile 1 are the ones that need more educational interventions, as well as their community. The intervention should be broad and encompass different topics on marine litter. Individuals fitting profile 2 do not consider marine litter a current threat nor live in a caring community but avoid plastic use and ask people to pick up their litter when littering. Educational and awareness-raising actions are also needed for this group but focusing above all on raising awareness of the community about the actuality and dimension of the theme. Profile 3 people do not litter, have support in taking actions to reduce marine litter, family and friends know and talk about marine litter, and the community cares about marine litter. Yet, these individuals do not consider marine debris a current threat. Interventions for this group must focus on raising awareness, explaining marine litter is an up-to-date and worrying threat. On the contrary, people in profile 4 consider marine litter a current threat and are worried about its impacts, adopting sustainable practices. These people are the group who better perceive and know marine litter. For instance, initiatives and educative interventions that focus on marine litter, its impacts, pro-environmental practices, attitudes, and social norms must be created for all who do not fall into profile 4. Additionally, literate communities was found to be important, with family members and friends claimed as important sources of information (Mokos et al., 2020).

It is important to note here that in the case of the Madeira archipelago, only 27.6% of the respondents fall into profile 4, which shows that marine litter perception is not something to take for granted for all. Some of the inhabitants do not recognize marine litter as a current threat, a recognition that is essential to engage people with the issue and that appears as an essential step in adopting good practices and behaviors. Yet, more than half of the surveyed public is concerned with the issue and has positive behavioral intentions. Since this study was conducted on small oceanic islands, and in these regions marine litter and waste management problems are exacerbated, it was expected a higher percentage of inhabitants in profile 4. Yet, our findings are in line with the perceptions of the public from other oceanic islands. In Cape Verde, participants of public participatory sessions showed concern about the causes and consequences of marine litter (Ferreira et al., 2021) and in Azores participants identified marine litter as the most severe threat to the marine environment and recognized the value the marine environment has for the island's economy (Abecasis et al., 2013). On Rapa Nui Island few litter was found on beaches and the inhabitants were environmentally conscious, adopting coastal protection actions (e.g., picking up litter) and waste-reduction measures (e.g., recycling, volunteering for beach clean-ups) (Kiessling et al., 2017).

Together with evaluating the perceptions Madeira Autonomous Region inhabitants have, the questionnaire here used serves as a quick and cheap tool to assess and identify in other geographical contexts which targets need to be intervened and to what degree, allowing the development of different educational and awareness-raising strategies according to the profiles.

4.7. Marine litter management and governance

Evaluation of the perceptions, knowledge, awareness, and attitudes of the population towards marine pollution is essential for the definition of prevention and behavior change actions. Questionnaire results showed that increasing literacy and raising awareness activities among individuals are necessary, particularly for the youngest group, men, and students. These actions must be, however, complemented with management and governance measures, both from global to local levels, as an integrated approach is necessary to tackle the issue (Chen, 2015). The same conclusions were obtained by Wichmann et al. (2022), who found that just participating in environmental citizen science projects is not enough, auxiliary educational activities are required. The authors believe inhabitants need to realize the importance of managing and preserving the ocean and coast so that the marine litter problem can be

better perceived. Yet, this ocean-oriented cultural identity must be supported by other actions.

Regional governments and town councils were identified by respondents of all ages as very responsible entities for reducing marine litter. That is important, as their identification can drive action: 'the ban (…) was facilitated by a broad concern among the general public, which led to a bottom-up movement culminating in the national government taking stakes in the issue' (Cristi et al., 2020, p. 105079). Respondents referred in the comments/observations section of the questionnaire that effective management practices and governance approaches were needed: 'it is the superior entities that have to take the necessary measures', 'there should be measures on the part of the municipalities, stricter for those who produce the most garbage, who do not make the proper separation (…) penalties, for example in the bill for water, electricity', 'the town council seems to have some faults, with regard to pumping stations', 'it is necessary that the responsible entities, namely the Regional Government, carry out awareness campaigns', 'a measure to be implemented in the region could be the use of bioplastics', 'there is a lack of containers for waste separation in many locations', 'lobbies/economic interests are delaying the implementation of measures that should have been underway for a long time', and 'it is a matter of the will of people and governments' [direct citations of respondents' comments]. These statements are in line with Williams and Rangel-Buitrago's (2019) observations that demonstrated that weak coastal governance, insufficient financial support, poor political practice, lack of commitment, and nature of public participation can hinder the formation of integrated coastal zone management regulations.

It becomes necessary to diversify the policy tools and move from a passive to an active governance to manage seas and marine pollution effectively. The central governments, local governments, enterprises, and the public are the main stakeholders of marine environmental governance, with their participation being necessary to ensure a successful governance (Yu and Bi, 2019). In this view, over the years there has been a shift into policies that control waste discharge from multiple sources, that strengthen the monitoring and treatment of existing wastes, and that stimulate recycling (Yu and Cui, 2021).

However, irrespective of the region, a principle that cannot be neglected when implementing an approach to litter management is the necessity of always thinking of adaptive management (Williams and Rangel-Buitrago, 2019). Additionally, due to the transboundary nature of the marine litter issue, a global response that turns to holistic solutions is necessary: 'No single solution exists to cope with the litter issue. However, legally binding global governance that will effectively limit and control the magnitude of litter pollution is greatly needed' (Rangel-Buitrago et al., 2022, p. 113546).

Some recommendations to better manage litter and promote the conservation of ocean and coasts can be found in the literature (Gjyli et al., 2020; Prata et al., 2019; Sheridan et al., 2020). In the Madeira archipelago, questionnaire data suggest that measures that stimulate the choice of reusable products (e.g., through benefits or taxes), regulation on production and consumption of over-packaged products, themes related to ocean conservation on political agendas, and raise awareness of the 10R's-principles (refuse, rethink, reduce, re-use, repair, refurbish, remanufacture, repurpose, recycle, and recover) are necessary (Potting et al., 2017). Although these measures were derived from the questionnaire presented to inhabitants of a Madeira archipelago, they are generic and can be applied to any region.

4.8. Study limitations

The present study focused on self-reported concerns, perceptions, intentions, and behaviors, which can be affected by social desirability bias. This means that participants can answer in a way they consider socially accepted by others to gain their approval (King and Bruner, 2000). To avoid this effect, the questionnaires were completed without the presence of the researchers, thus circumscribing the putative inflated answers (Okamoto et al., 2002).

A random sampling of individuals was undertaken during this study. Nevertheless, as some questionnaires were obtained through uncontrolled methods, it is possible that they have increased the participation of individuals who have a closer link to the sea theme. Additionally, some of the municipalities registered a low number of answers, a limitation difficult to surpass considering the high prevalence of older people in those zones. The distribution of paper questionnaires aimed to surpass this constraint, as electronic distribution directs responses to younger audiences and with internet access. Still, the number of answers obtained in this questionnaire is in line with similar studies: 127 responses in a study with 16 European countries (Filho et al., 2021), 374 answers in a questionnaire spread over 11 months in Greece (Charitou et al., 2021), and 107 participants in focus groups about marine biodiversity (Tonin and Lucaroni, 2017). Furthermore, to avoid people withdrawing from the questionnaire, questions about the income or educational level were not included, even though the questionnaires guaranteed the anonymity of respondents. Other authors have reported this limitation (Deng et al., 2020), and questions exclusion is in line with guidance for writing effective questionnaires (Price et al., 2015).

5. Conclusion

The public survey focused on perceptions, awareness, knowledge, responsibilities, and behavioral intentions regarding marine litter, a problem of growing global concern. Results show that people are aware of the problem, linking the theme mainly to plastics and their impacts. Yet, the population is not completely aware of the order of magnitude of the degradation rates of some items. Less than 20% of the respondents accurately estimated the decomposition time of plastic bags, an everyday item. We believe raising awareness about the extensive degradation times of several items is hence a fundamental point to avoid their presence in the marine environment. Most of the respondents identified the sources and pathways of marine litter and perceived it as a actual problem. Excess of single-use products and packaging, fishers and boats releasing garbage into the sea, and people littering were pointed out as some important causes of marine pollution. Nevertheless, when intentions and behaviors were analyzed, not all participants reported, among others, avoiding plastic use or choosing environmentally friendly packaging. It was pointed out by respondents that one of the waste management measures may involve greater inspection and government action, through the application of fines and the existence of more sustainable alternatives (e.g., bioplastics). This reinforces that end users sometimes have to choose poor environmentally friendly products because the producers and industries impose them to consumers, not assuming their role in marine litter reduction. Similarly, individuals perceived others to be responsible for curbing increases in marine debris. If marine litter is not seen as a universal problem that requires everyone's action, including the producers, it is unlikely to be resolved. Additionally, the youngest, men, and students were the ones who reported less litter-reducing intentions and behaviors. Overall, the questionnaire results allowed us to identify distinct key profiles (from profile 1 - the less aware of the theme, to profile 4 - the more aware and informed on the subject of marine litter), validating the hypothesis that marine litter is not fully perceived by the public of the studied oceanic islands. Besides, knowing the profile of the respondents is important when planning educational initiatives, highlighting to whom marine litter literacy is needed. These insights can be used to motivate and empower individuals who reported being less conscious about the severity and dimension of the marine litter problem, thus becoming exemplar models for the marine litter fight. At the same time, results show that it is necessary to ensure effective marine litter, ocean, and coastal management within different frameworks so that this major environmental problem is tackled in a coordinated manner across councils and government departments. Results equally show that in the Madeira archipelago, marine litter perception is not currently something

to take for granted.

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Declaration of competing interest

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Data availability

No data was used for the research described in the article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2022.106406.

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