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Public awareness and perceptions of ocean plastic pollution and support for solutions in the United States

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We conducted a nationally-representative survey of United States (U.S.) adults (n=1,960) in 2021 to gather insights on the knowledge, perceptions, and concerns about threats to the ocean, with a specific focus on plastics and microplastic pollution. Responses from the U.S. adult survey group were compared to a group of highly-engaged, Ocean Conservancy members who are very attuned to ocean issues (n=882). Ocean Conservancy is a U.S.-based nonprofit environmental advocacy group working to protect the ocean from today's greatest challenges. Plastic pollution was the primary ocean concern identified by both U.S. adults and Ocean Conservancy members, surpassing eight other threat categories including oil spills, chemical and nutrient pollution, and climate change. Broad concern was reported for both study groups about the impacts of ocean plastics on marine wildlife, with human health and coastal community impact concerns being less prominent. About half of U.S. adults and 90% of Ocean Conservancy members had heard of microplastics. Both study groups indicated widespread support for microplastic pollution prevention measures in the U.S. and believed industry to be most responsible for taking action to address it. Ocean Conservancy members were generally better informed and more concerned about plastic pollution impacts and microplastics than U.S. adults and reported significantly greater levels of personal action to reduce their plastic footprint when compared to U.S. adults. In general, U.S. adults reported a willingness to refuse single-use plastics, but less frequently brought personal food containers to restaurants for takeout, or contacted local representatives or businesses about reducing plastic waste and pollution. Overall, our survey results provide new insights about public understanding of ocean threats and plastic pollution, willingness to participate in individual plastic-reduction actions, and support for needed solutions.

KEYWORDS

ocean threats, plastic pollution, microplastics, risk perception, public support

1 Introduction

The increasing production of plastics since the mid-20th century, in combination with unsustainable waste management, has led to a plastic pollution crisis (Kaza et al., 2018). As plastic is made from fossil fuels, plastic production is intrinsically linked to climate change and its continued production and pollution has only exacerbated the impacts of our warming planet (Ford et al., 2022). In recent decades, plastic pollution has gained substantial attention due to its visibility as a physical pollutant (Bucci et al., 2020; Mehinto et al., 2022) and global ubiquity as a contaminant (Borrelle et al., 2020); however, trends in both plastic production and plastic pollution are only increasing. Plastic pollution in the ocean has increased since the turn of the century (Eriksen et al., 2023) and it is now documented in every ecosystem. Plastics are found in remote pockets of the ocean, lakes and rivers, sea ice, snow, soil, the atmosphere and wildlife (e.g., Lusher et al., 2015; Barboza et al., 2018; Villarrubia-Gómez et al., 2018; Corradini et al., 2019; Zhang et al., 2020). In the environment, plastics pose a grave threat to ecosystem health. For example, wildlife ingest, are smothered by, and become entangled in plastics, which can simultaneously leach toxic chemicals and transport hitchhiking invasive species and pathogens (Li et al., 2021). Plastic pollution is no longer a future concern for humans, it now pervades our daily lives. For example, plastics, in the form of micro- (<5mm) and nanoplastics (<100 nm), contaminate human bodies via the foods we eat, beverages we drink and the air we breathe (Mohamed Nor et al., 2021). Studies have demonstrated consumption of plastics can cause inflammation, oxidative stress, and DNA damage in human tissues (Zuri et al., 2023). Plastic pollution is now regarded as a global threat for which many have called for urgent and coordinated action to mitigate further harm (Borrelle et al., 2020; MacLeod et al., 2021; Lavers et al., 2022; Persson et al., 2022).

Although public perceptions of ocean and microplastic pollution in the United States (U.S) remain understudied, research has shown that a significant proportion of the American public do not fully understand the extent of human-caused environmental damage from other global crises such as climate change (Leiserowitz, 2005; Ratter et al., 2012). Many also treat this environmental issue as psychologically 'distant' - something that will impact others in remote locations, and not for some years to come (Whitmarsh and Capstick, 2018). Although there is broad public awareness of such environmental issues, a lack of deeper understanding of the impacts, and a willingness to change individual behaviors has typically been attributed to lack of knowledge, with some differences attributed to gender and age (Semenza et al., 2008). As with climate change, plastic pollution is often treated as a 'distant' issue, with different perceptions and support for management actions expected between different demographic groups (Henderson and Green, 2020; Garcia-Vazquez and Garcia-Ael, 2021).

Each year, the body of scientific research on the prevalence and impacts of macro- and microplastics in the environment grows (Iroegbu et al., 2021; Kasavan et al., 2021; Ali et al., 2022), but social science research on these topics lags in comparison (Pahl et al., 2017; Henderson and Green, 2020). Social science allows us to

better understand public perceptions of plastic waste, pollution and solutions, which can inform interventions and increase success of pollution mitigation measures (Hartley et al., 2015; Pahl and Wyles, 2017). By documenting public knowledge about ocean plastic and microplastic pollution, decision makers can tailor policies to align with community support for certain changes, and also identify areas where increased public knowledge is needed (Laroche et al., 2001; Steel et al., 2005; McKinley and Fletcher, 2012).

The U.S. is the world's largest producer of plastic waste per capita (Law et al., 2020), yet to date no peer-reviewed social science study has focused on U.S. public perceptions of both macro and microplastic pollution. Previous research has investigated public perceptions and understanding of macro and microplastic pollution at several scales, including specific communities, states, single countries or multiple countries. The aim of such surveys has included understanding public knowledge and risk perception (Deng et al., 2020; Forleo and Romagnoli, 2021; Kramm et al., 2022; Walker et al., 2023), and informing research or policy agendas (Davison et al., 2021; Walker et al., 2021; Molloy et al., 2022).

Due to its high visibility and the known impacts of plastics on planetary health, some members of the U.S. public are extremely interested in, and driven by, the issue of plastic pollution. Those individuals may gravitate toward conservation-focused Non-Governmental Organizations (NGOs), which they support either through financial donations, in-kind donations, as followers on social media, attendance at events or other means. Ocean Conservancy is a U.S.-based ocean conservation NGO that works to protect the ocean from today's greatest global challenges in pursuit of a healthy ocean and the wildlife and communities that depend on it (Ocean Conservancy). As of September 2023, Ocean Conservancy has over 160,000 members in the U.S.; members receive regular communications about plastic pollution (among other topics), providing them with information in the form of newsletters, links to blog posts about specific topics such as research on microplastics and human health, campaigns to join and provide support, and suggestions for other ways to take action. We hypothesize that this regular communication helps retain these topics at the forefront of people's minds and through the provision of information this increases their knowledge and accurate perceptions of risk. By becoming actively involved in solutions on an individual level, this further provides motivation to support larger plastic pollution mitigation measures such as national scale legislation and policy.

In this study, we used a social survey distributed via an online panel to U.S. adults (18+ years in age) and among a selection of 'highly engaged' Ocean Conservancy members. For each of our study groups, our aims were to better understand: 1) Perceptions of ocean health and threats; 2) Perceptions of ocean plastic pollution and impacts; 3) Understanding and perceptions of microplastic pollution and impacts; 4) Opinions about who bears responsibility for actions to tackle plastic and microplastic pollution; and 5) Willingness to take individual actions to tackle plastic pollution.

Our goal is to provide data for the general adult American public from which future studies can measure evolving attitudes and behaviors. We also compare and contrast those findings with responses from members of Ocean Conservancy, an ocean

conservation NGO who have strong existing relationships or ties to the ocean. Ocean Conservancy members served as a comparison group to the U.S. adult population, as we hypothesized they would have higher-than-average literacy and resulting concern regarding ocean issues, including for ocean plastic pollution and microplastics, and higher-than-average levels of support for plastic reduction measures. Our findings can be used to support proposed policy actions aimed to reduce plastic pollution, aid in communication about various facets of the issue and inform future plastic pollution management and mitigation actions.

2 Materials and methods

Ocean Conservancy, with support from Edge Research, conducted a nationwide survey of US adults between October 23 – November 23, 2021, following the American Association for Public Opinion Research best practices in data collection (University of Toronto IRB Protocol #29347; [Supplementary Figure 1](#)). Data were collected using the Qualtrics survey platform. All survey recruits underwent an opt-in process to participate and were required to verify that they were 18 years of age or older. Participation in the survey was voluntary and respondents could opt out at any time. No personal identification information was collected from survey respondents and all individual survey responses were confidential and anonymous. Only surveys that were completed were analyzed.

2.1 Survey questions

Survey questions included categorical demographic questions, Likert-Scaled questions (positive or negative responses to a statement), interval questions on awareness, attitudes, concerns and support for various public policies and personal actions regarding microplastics, and open-ended questions to capture respondents' thoughts and questions about microplastics ([Supplementary Figure 1](#)). Respondents were required to answer all questions except open-ended questions, but 'not sure', 'don't know', and refusal options were offered for most questions. Numeric response questions regarding frequency, type and amount of protein consumption (seafood, meat, and plant-based) in the diet were posed only to the U.S. adult study group, with the intention for these data to be used in a future study estimating U.S. adult exposure to microplastics through consumption of commonly-consumed foods ([Milne et al., 2023](#)).

2.2 Survey participants

U.S. adult respondents were recruited using an online, non-probability sample obtained via a national opt-in consumer research panel. Respondents were not directly compensated for taking individual surveys; however, they accrued points as they participated in surveys which they were able to convert to compensation. Respondent demographic information was

recorded, and quotas were set to ensure the sample would be demographically and geographically distributed in accordance with 2020 U.S. Census Bureau population estimates (American Community Survey dataset ACSST5Y2020). Once the desired quota of each age, gender identity, state of residence, race and ethnicity category was reached, no additional respondents were accepted for that group. Only U.S. adult respondents were asked questions about protein consumption. A subset of 1,431 seafood consumers analyzed in this paper were defined as those who self-reported eating seafood at least once a month. The 560 non-seafood consumers are those who reported eating seafood a few times a year or less. Ocean Conservancy-connected respondents originated from a pool of roughly 23,000 highly-engaged members (defined as those who had engaged via email with Ocean Conservancy at least twice in calendar year 2021). Those individuals were sent a basic introductory email ([Supplementary Figure 2](#)) with a unique link to complete the survey. Only responses from individuals who resided in the U.S. were reported. Demographic information was collected from Ocean Conservancy members, but demographic quotas were not set for the Ocean Conservancy member survey group as they were for U.S. adults.

2.3 Data analysis

Data tabulation was completed in SPSS Dimensions V.7.0.1. No weighting was applied to the data. Statistical tests were performed using the SPSS Columns Proportion Test formula, done separately for each relevant pair of columns within each relevant row. This test analyzes whether the proportion of respondents in one column is significantly different from the proportion in the other column. The test may not be valid for samples of fewer than 30 cases and was not applied in those instances. It is a two-tailed test, which reports all significant differences between the proportions in all of the columns regardless of which columns contain the greater proportions. Data were tested at the 95% confidence level; only values of $p \leq 0.05$ are reported as statistically significant differences.

3 Results

In total, 1,960 U.S. adults from the general public and an additional 882 Ocean Conservancy members provided complete survey responses which were included in these analyses. For the U.S. adult survey, a total of 5,902 respondents entered the survey and of those, 20 did not qualify to take the survey (below the age of 18), 3,821 were turned away because of quota-filling, and 101 responses were removed for poor data quality. For the Ocean Conservancy member survey, emails were sent to 23,000 highly-engaged members.

Different demographic characteristics were observed between U.S. adults and Ocean Conservancy members. U.S. adult respondents included approximately equal proportions of male and female respondents. Most respondents (66%) had an education lower than a college degree, and a majority identified as white by race (62%). Most respondents were from Southern

states (38%) and lived over 50 km from the coast (55%). Compared to the general U.S. adult population, Ocean Conservancy members were older, proportionally more female, reported a higher level of education, were more concentrated in the West and Northeastern regions of the U.S., were a higher proportion Caucasian, and lived closer to the coast than the general U.S. public (Supplementary Figure 3).

3.1 Impressions of ocean health

To evaluate U.S. consumers' awareness of issues related to ocean plastic, respondents were asked about their impressions of ocean health including water quality, as well as the health and abundance of marine life and habitats. Of U.S. adults, the largest percentage had a positive perception of current ocean health (41% total; 14% very good health; 27% somewhat good health). Just over a quarter (28%) perceived the ocean to have fair health, while 27% perceived the ocean to be in poor health (17% somewhat poor health; 10% very poor health). In contrast, 65% of Ocean Conservancy members perceived the health of the ocean to be poor (29% somewhat poor; 37% very poor).

Of all recorded demographics, age and proximity to the ocean most impacted U.S. adult opinions of ocean health. Older respondents (>50 years) had a significantly more negative perception of current ocean health compared to younger respondents ($p < .01$), as did those living greater than 50 miles from the ocean compared to those living within 50 miles from it ($p < .01$; Figure 1).

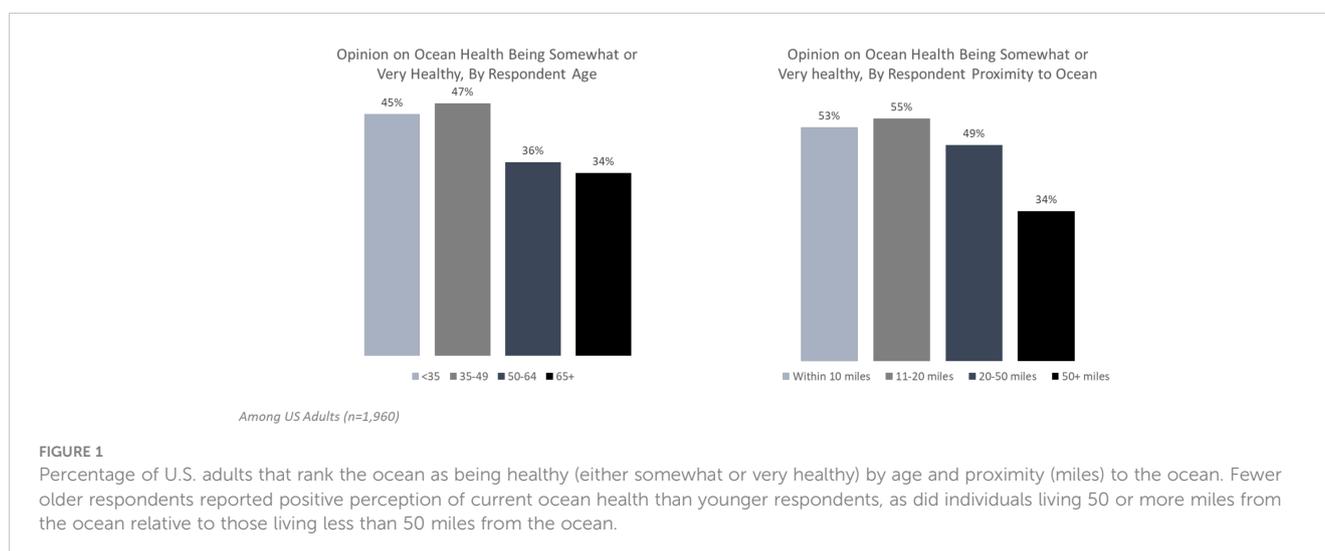
Following questions about ocean health, respondents were asked to assess which of nine issues related to ocean health were a pressing problem for today, a problem for tomorrow, or not much of a problem. Respondents considered all proposed problems to be pressing for the near or immediate future, with only 5%–13% rating any given item as “not much of a problem” (Figure 2). Plastic pollution was viewed as the most pressing problem for today by 78% of respondents. This was significantly higher than the 72% that rated oil spills as the most pressing problem today ($t = 2.168$; $p < .05$).

Other pollution-related issues, including chemical pollution (69%) and nutrient pollution (68%) were perceived to be the next most pressing concerns. Notably, climate change lagged as an ocean related concern, ranking sixth (59%) among the nine listed problems, significantly lower than pollution concerns from chemicals or nutrients (69% and 68%, respectively; $p < .01$) and on par with concerns about declining sea life populations (60%) and lack of marine protected areas (58%).

Among Ocean Conservancy members, concern for all nine ocean threats was universally high, with 80% of respondents ranking every threat as a pressing problem for today. Concern was significantly higher than general U.S. adults for every issue tested, ranging from 21% more respondents rating plastic pollution as a pressing problem for today (99%; $p < .01$), to 36% more respondents rating lack of protected areas as a pressing problem for today (94; $p < .01$; Figure 3).

3.2 Perceptions of ocean plastic pollution and its impacts

Respondents that rated plastic pollution as the most or second most pressing problem compared to other issues were then asked from a list of specific issues which were most concerning about marine plastic pollution. Of the issues presented, impacts to marine animals were the primary concern about marine plastic pollution for both U.S. adults and Ocean Conservancy members (Figure 4). Specifically, 30% of U.S. adults rated the risk of entanglement and injury to marine animals as one of their top two concerns, 29% ranked marine animals eating plastic in their top concerns, and 28% assigned chemicals leaching into the environment or organisms in their top concerns. One other concern was the sheer volume of plastic in the ocean, with 25% of U.S. adults selecting this as one of their top two most concerning issues (Figure 4). Concern regarding the volume of plastic in the ocean was particularly strong within the youngest age cohort (18–24 years old; 32%). These top four concerns were all significantly higher ($p < .01$) than the next highest concern about human health impacts (selected by 18%).



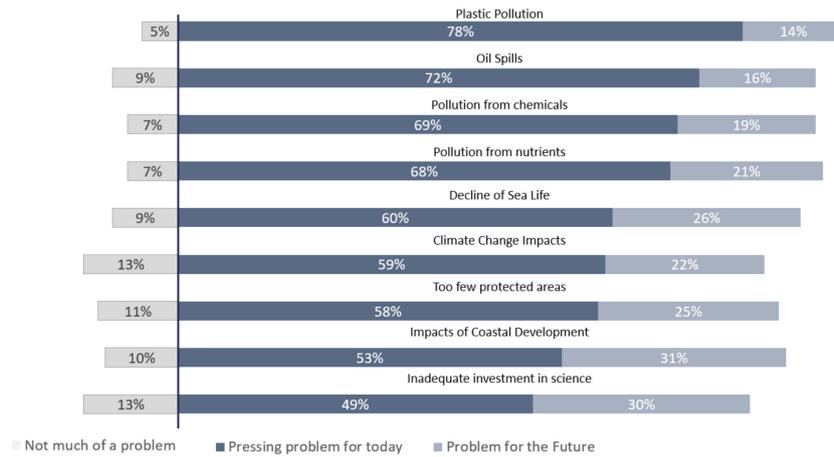


FIGURE 2 U.S. adult rankings of nine prominent ocean threats as either a 'pressing problem for today', a 'problem for the future', or 'not much of a problem'. Plastic pollution is seen by the highest percentage of U.S. adults as a pressing problem for today, but other pollutants (oil, chemicals) are also top concerns. The vast majority of the U.S. public recognize all nine of these issues affect the ocean in the immediate term or future, with only a small proportion (<13%) rating some issues as being not much of a problem.

U.S. adults and Ocean Conservancy members agreed on their top ocean plastic concerns and were the least concerned about aesthetic impacts of plastic trash ruining beautiful places (U.S. adults 10%; Ocean Conservancy members 3%) or a disproportionate impact on coastal communities (U.S. Adults 9%; Ocean Conservancy members 3%; Figure 4). This was true even among those living within 20 miles of the coast with only 13% of U.S. adults rating coastal community impacts as a top two concern about plastic pollution; for Ocean Conservancy members living within 20 miles of the coast, only 3% cited coastal community impacts as a top concern.

3.3 Microplastics: awareness and concerns

Approximately half of the U.S. adult population (49%) had heard of the term 'microplastics', but of those, only 18% reported being 'very familiar' with the topic. Most (58%) were somewhat familiar, and 24% were not very familiar with the term microplastics. Regarding specific concerns about microplastics, almost half (48%) of U.S. adults indicated they were very concerned about microplastics in the environment, compared to 41% who were very concerned about human exposure to microplastics. Respondents who reported eating seafood weekly

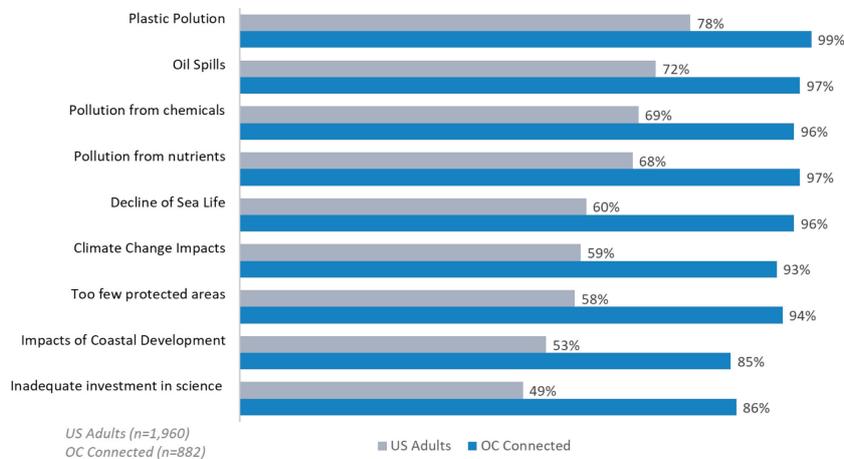


FIGURE 3 Comparative difference (in percentage) of U.S. adult and Ocean Conservancy (OC)-connected individuals' rankings of nine prominent ocean threats classified as a 'pressing problem for today'. Plastic pollution is seen by both study groups as the highest-ranking problem facing our ocean today. OC-Connected supporters ranked every ocean threat more pressing than did the general U.S. adult population; statistically significant differences between U.S. adult and Ocean Conservancy member responses were present for all 9 items ($p < .01$).

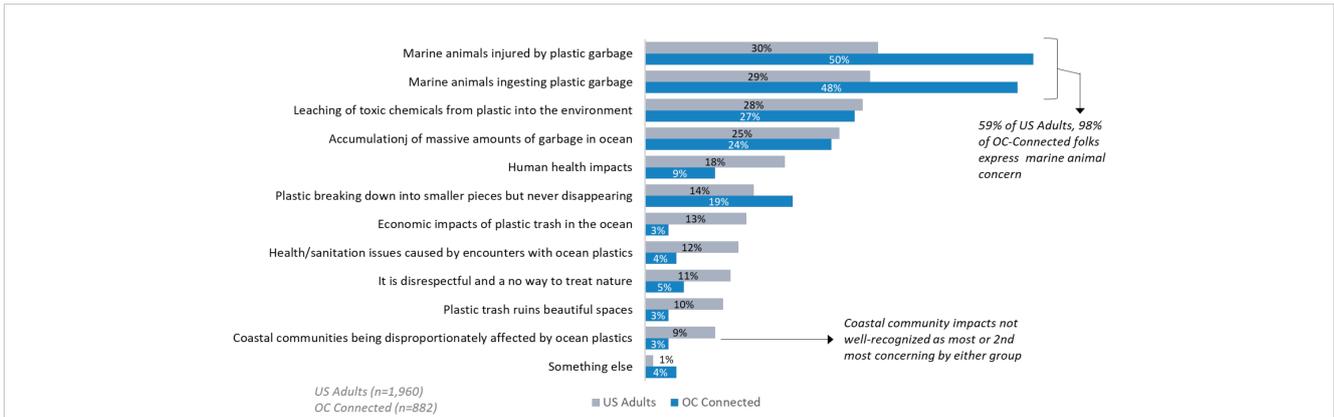


FIGURE 4

Responses to individual rankings of [combined] first and second place concerns about ocean plastic pollution among U.S. adults who believe plastic pollution is a pressing problem of today or problem for the future (n= 1,786) and Ocean Conservancy (OC)-connected respondents (n=882) who believe plastic is a pressing problem of today or problem for the future (100%).

or more had significantly higher levels of concern over these issues compared to the general U.S. adult population, with 56% and 49% marking 'very concerned' about microplastics in the environment and human exposure, respectively (p<.05).

In contrast, almost twice the proportion of Ocean Conservancy members (91%) had heard about microplastics compared to U.S. adults. Of U.S. adults, 19% reported being very familiar and 69% were somewhat familiar with the term microplastics. Along those lines, a significantly higher proportion of Ocean Conservancy members (91%) expressed being very concerned about microplastics when compared to U.S. adults (55% very concerned; p<.05). Ocean Conservancy member rankings of being very concerned was consistent with rankings by U.S. adults; concerns about impacts of microplastics on the environment were significantly higher (86%) than concerns arising from human exposure to microplastics (65%; p<.01).

Those aware of microplastics prior to the survey were asked to rate the extent to which they believe microplastics are a threat in various environments (i.e., ocean ecosystems, ocean animals, freshwater ecosystems, freshwater animals, terrestrial ecosystems, terrestrial animals, and human health) using a 5-point scale. Among U.S. adults, the most important threats were perceived to be related to ocean animals and ecosystems, followed by freshwater animals and environments, human health, and then terrestrial animals and environments (Figure 5). This result mirrors earlier responses regarding concerns over plastic pollution in general, with a pronounced focus on ocean fauna. The perceived 'somewhat/very significant' threat to ocean animals and ocean ecosystems (87% and 86%, respectively) were significantly greater than perceived 'somewhat/very significant' threats to terrestrial animals and terrestrial ecosystems (77% and 79%, respectively; p<.05).

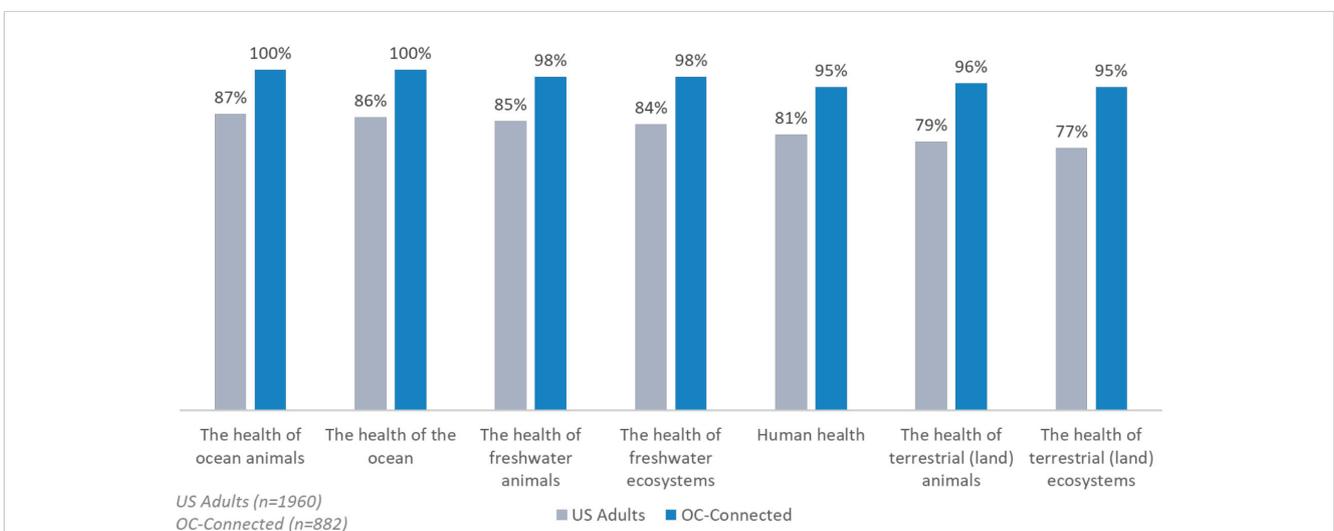


FIGURE 5

Percentage of respondents that answered 'somewhat' or 'very significant' to the question "How significant a threat do you think microplastics are to the following..." by U.S. adults (n= 1,960) and Ocean Conservancy (OC)-connected individuals (n= 882). Those connected to OC had more intense concerns on all potential ecosystem impacts compared to U.S. adults as a whole.

Concern for microplastic threats among the Ocean Conservancy members was significantly higher ($p < .01$) than U.S. adult respondents for every example tested, with the same pattern of greatest concerns for ocean-related impacts (ocean animals 100% somewhat/very significant threat; ocean ecosystems 100% somewhat/very significant threat); followed by freshwater impacts (98% respectively for freshwater animals and ecosystems) and terrestrial impacts (terrestrial animals 96%, terrestrial ecosystems 95%; Figure 5).

3.4 Impact on perceptions after providing microplastics information

After gathering initial impressions, respondents were presented the following information regarding microplastics:

Microplastics are plastic pieces that are less than five millimeters in length (or about the size of a sesame seed). These tiny plastics with different sizes, shapes, colors and formulations enter the environment where they break up into smaller and smaller pieces, persisting from decades to thousands of years. Microplastics come from a variety of sources, including from larger plastic debris, tires wearing down during use, and clothing and textiles made from synthetic materials. Manufactured microplastics may intentionally be added to cleaning products, coatings, or cosmetics, and are so small, they become airborne and also easily pass-through water filtration systems, winding up in soils, lakes, rivers, and the ocean.'

After reading this, survey respondents were asked to re-rank their level of concern about microplastics, to gauge any possible change in perspective after being introduced to new information. After the passage was read, U.S. adults expressed higher levels of concern about microplastics than they had before reading the passage, with the percentage of people being very concerned increasing from 55% to 66%. Degree of concern was also correlated with frequency of seafood consumption, with greatest concern among those that consume seafood weekly (or more

frequently than weekly; 64%), followed by monthly consumers (53%) and those who eat seafood a few times a year or less (47%).

Survey respondents were then shown a series of concerns about plastics and microplastics in the environment and asked to rate how much each issue concerned them on a five-point scale. Responses showed that every issue was similarly concerning, with responses ranging from 58% that were very concerned about the emission of chemical pollution into the air from the process of plastic production from fossil fuels, to 67% who highlighted that they were very concerned that microplastics are nearly impossible to effectively clean up once they have been released into the environment (Figure 6). When these issues were presented to Ocean Conservancy members, between 98-100% ranked every one of the issues presented as being 'very concerning', highlighting widespread unease for each of the outlined concerns about plastics and microplastics in the environment.

3.5 Taking action on microplastics and plastic pollution

When asked to select the entity most responsible for reducing the use of plastics and preventing microplastic pollution from increasing, the U.S. public acknowledged that all stakeholders play a role. The greatest responsibility was directed to the plastic industry (manufacturers and producers; 41%). Government was ranked as the second most responsible, though significantly less so than industry ($p < .05$; Figure 7). Although most of the current government action to reduce the prevalence of single-use plastics has come from the local level, 19% of U.S. adults found the Federal government significantly more responsible for plastic reduction than state (6%) or local (4%) governments ($p < .01$). Some responsibility was also placed on consumers (18%). Ocean Conservancy members largely agreed with the general public, with few significant differences in responses between U.S. adults and Ocean Conservancy members, though Ocean Conservancy

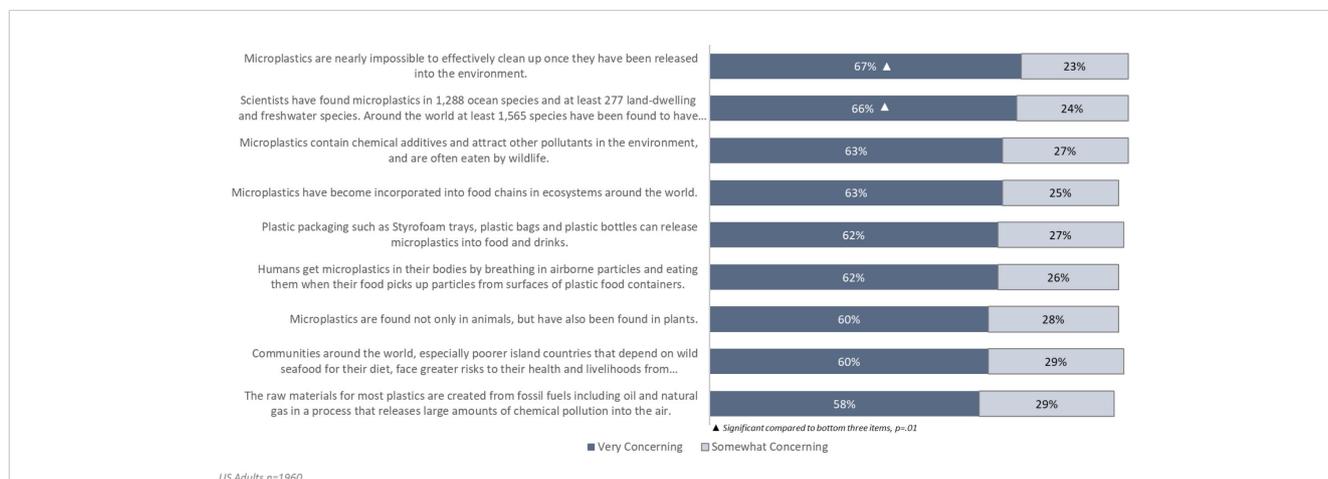


FIGURE 6 U.S. adult reports of being 'very' or 'somewhat' concerned about various impacts of microplastic pollution after reading an informational passage on microplastics. While microplastic persistence, pervasiveness and entry into the food chain are top concerns, the information generated high concern overall with few major differences detected among topics.

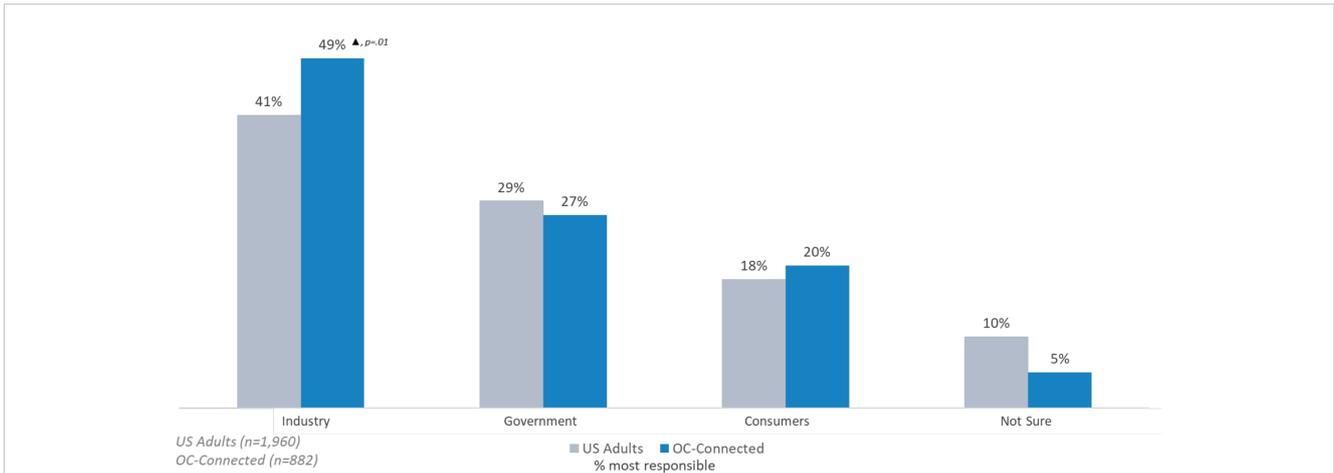


FIGURE 7
 Responses to the question "Who do you think has the most and second most responsibility to reduce the use of plastics and prevent microplastic pollution from increasing?". Both the U.S. public and Ocean Conservancy (OC)-connected respondents placed responsibility for action first on the plastics industry, then on government (federal, state and local), and finally on consumers, with a small percentage reporting being 'not sure'.

members did place significantly greater responsibility on the plastic industry (manufacturers and producers) to reduce the use of plastics and prevent microplastic pollution from increasing than did U.S. adults (p=0.01; Figure 7).

Our survey also measured support for a series of policy actions to combat the amount of microplastics entering the environment, water supply, and ocean; Environmental Protection Agency (EPA) regulation of the discharge of plastic into waterways, phasing out single use plastics through federal regulation, local/citywide plastic bag bans, contributing time or money to campaigns against single use plastic, mandating filtration of microplastics in all washing machines, and a government-funded assessment of the risk to human health from exposure to microplastics all received support. Respondents showed broad support for regulatory action to prevent microplastic pollution. For example, of U.S. adults, 85%

either somewhat or strongly supported requiring federal agencies to regulate nurdle (pre-production plastic pellet) discharge. Despite considering local governments to be among the least responsible for plastic reduction, 82% of the U.S. public either somewhat or strongly supported the passage of municipal plastic reduction measures such as bag bans and requirement for paper-based restaurant carryout/delivery containers (with 54% strongly supporting; Figure 8).

Consistent with the greater concern about microplastics among Ocean Conservancy members, this group expressed near-unanimous support for all provided regulatory actions aimed at preventing microplastic pollution, ranging from 93% support for contributing time or money to state or local campaigns that limit or ban single-use plastics, to 99% support for EPA regulation of plastic pre-production pellet discharge, passage of plastic-reduction

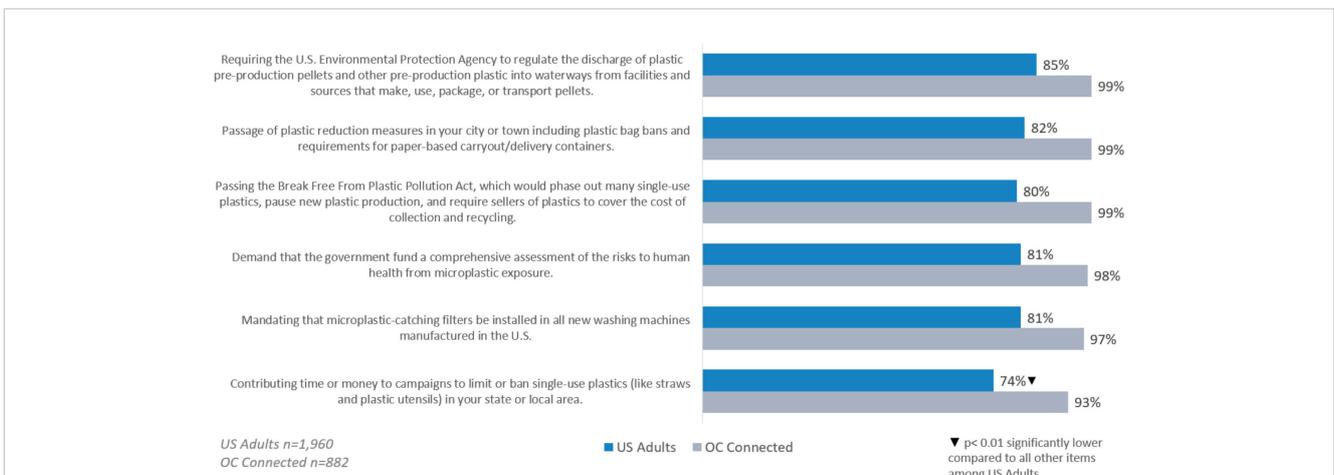


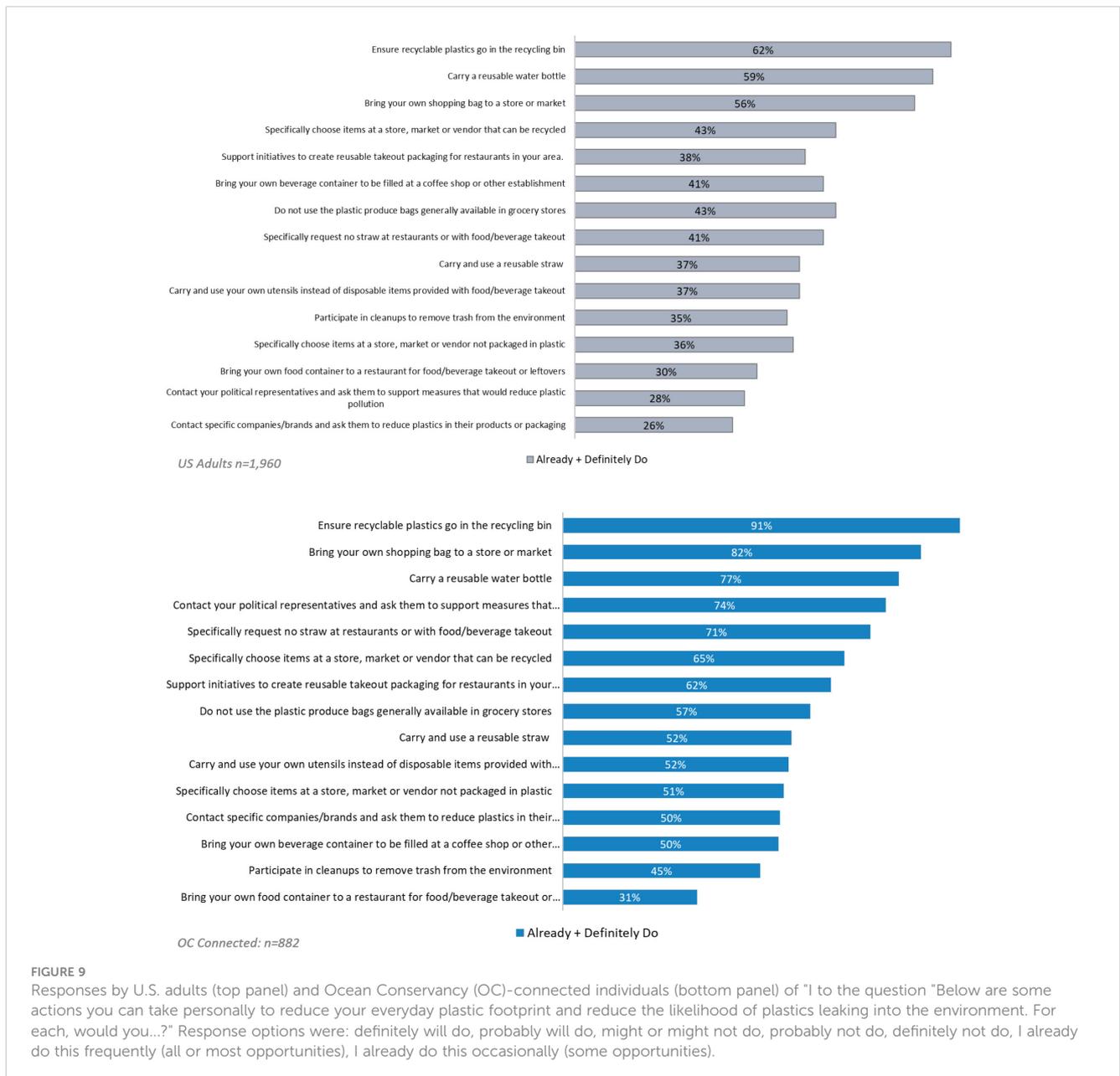
FIGURE 8
 Those who responded 'somewhat' or 'strongly support' for each listed action when asked the question: "Below are some actions that could be taken to stop the amount of microplastics entering the environment, water supply and ocean. For each, do you...?" by U.S. adults and Ocean Conservancy (OC)-connected individuals. Response options included: Strongly support, somewhat support, undecided, somewhat oppose, and strongly oppose. Among U.S. adults, there was broad support for most regulatory actions, but less interest in a government study or involvement in a local campaign. OC-connected respondents expressed nearly 100% support for all regulatory actions aimed at preventing microplastic pollution.

measures like bag bans, and passage of the proposed federal Break Free From Plastic Pollution Act (Figure 8).

At the end of the survey, respondents were asked about actions they already take or would be willing to take to reduce their personal plastic footprint and the likelihood of microplastics leaching into the environment. Actions the public were currently doing (either occasionally or frequently) or were definitely willing to do include ensuring proper recycling (62%), carrying a reusable water bottle (59%), and bringing their own shopping bag to stores (59%; Figure 9). U.S. adults were significantly more willing to do these three 'top tier' actions compared to the 12 other actions surveyed ($p < .05$). A second tier of actions that respondents were already doing or were definitely willing to do include choosing recyclable items at the store (43%), refusing plastic produce bags (43%), carrying reusable beverage containers (41%), requesting no straw (41%),

supporting reusable restaurant takeout initiatives (38%), carrying a reusable straw (37%), carrying one's own utensils (37%), participating in beach clean-ups (35%), or carrying one's own food/beverage containers (30%). A final group of three actions formed a "bottom" tier that U.S. adults are significantly less likely to be already doing or willing to do ($p < .01$). These included bringing personal food containers to restaurants for takeout (30%), contacting public officials to urge support for measures to reduce plastic (28%) and contacting companies to ask them to reduce use of plastic (26%; Figure 9).

Ocean Conservancy-Connected respondents reported significantly greater levels of personal action to reduce their plastic footprint compared to U.S. adults, with 91% already doing or definitely willing to ensure proper recycling ($p < .01$), 82% already or definitely willing to bring their own shopping bag to stores



($p < .01$), and 77% already or definitely willing to carry a reusable water bottle ($p < .01$; [Figure 9](#)). This pattern of higher self-reported action by Ocean Conservancy members vs U.S. adults holds for all actions tested with the exception of bringing one's own takeout containers to restaurants, which is only 1% greater than U.S. adults (31%; [Figure 9](#)).

4 Discussion

This study detected broad concern for ocean health among U.S. adults and Ocean Conservancy members, with pronounced concerns specifically related to plastic pollution. We found both universally greater concern and understanding of the plastic pollution issue among Ocean Conservancy members, as compared to U.S. adults. There was broad and universal support across all U.S. adults and Ocean Conservancy members for policymakers to advance legislative solutions that hold the plastic industry responsible for solving the problem of ocean plastic pollution.

When comparing overall responses from our two survey populations- U.S. adults and Ocean Conservancy members-, we found Ocean Conservancy members were generally better informed and more concerned about plastic pollution impacts than U.S. adults. For example, Ocean Conservancy members found all nine ocean threats- which ranged from climate change to impacts of coastal development and plastic pollution- more pressing than U.S. adults did ([Figure 2](#)). Additionally, a significantly higher percentage of Ocean Conservancy members had heard of the term 'microplastics' relative to U.S. adults (90% vs 50%), though neither population reported being very familiar with the concept of microplastics. Furthermore, when presented with a series of concerns about plastics and microplastics in the environment, Ocean Conservancy members reported widespread unease, as evidenced by between 98-100% ranking all of the issues as 'very concerning'; this is in stark contrast to U.S. adult responses, whereby 67% was the maximum ranking of any item being 'very concerning' but was as low as 58% ([Figure 6](#)). While similar concerns were prioritized for both groups as being 'very concerning', Ocean Conservancy members reported universal intensity of concern across all items, highlighting that they interpreted all of the options as very worrying. Last, Ocean Conservancy members also reported significantly greater levels of personal action to reduce their plastic footprint compared to U.S. adults; this pattern of higher self-reported action by Ocean Conservancy members vs U.S. adults held for all actions tested with the exception of bringing one's own takeout containers to restaurants ([Figure 9](#)).

While there were substantial differences in some responses between survey populations, there were also a fair number of similarities detected, signaling universal concern. For example, concerns about the impacts of ocean plastics centered on impacts to marine wildlife for both groups, with human health concerns lagging behind ([Figure 4](#)). In a similar vein, concerns reported about the impacts specific to microplastics by both U.S. adults and Ocean Conservancy members centered on threats to the ocean and marine

wildlife, and support for action to abate these threats was strong. For both respondent groups, human health and terrestrial ecosystems were less recognized as being threatened than ocean and freshwater ecosystems and animals. Ocean Conservancy members, however, had overall more intense concerns on all potential ecosystem impacts of microplastics relative to U.S. adults ([Figure 5](#)). Additionally, while our two respondent groups were very different in terms of some demographics, they were similar in that over 50% of both groups reported living greater than 50 miles from the coast. This was a rather interesting finding for the Ocean Conservancy member group, given the extent to which they are still very plugged in to ocean issues, especially those related to plastic pollution impacts.

U.S. adults and Ocean Conservancy members reported being least concerned about aesthetic impacts of plastic trash or disproportionate impacts on coastal human communities, even for those living by the coast. This was a somewhat unexpected result, as visible plastic pollution has been shown to negatively impact tourism revenue in some parts of the world ([Jang et al., 2014](#); [Qiang et al., 2020](#)), and many communities expend effort and money to prioritize regular beach cleanups for this reason, to preserve tourism and the health of their environments (e.g., [Rodríguez et al., 2020](#); [Sandhubaya et al., 2021](#)). Both survey groups thereby appeared to prioritize physical impacts over aesthetic impacts in this survey.

Microplastic pollution has become a frequent topic in the media, however little is known about public perceptions of microplastics, and increased public awareness is needed to face the growing threat of microplastics in the environment ([Garcia-Vazquez and Garcia-Ael, 2021](#)). Generally, U.S. adults reported being aware of microplastics, but few people reported knowing a lot about the topic. Ocean Conservancy members reported greater knowledge about microplastic pollution and also greater levels of concern regarding the threats it poses than U.S. adults.

In line with high levels of concern for the impacts of plastics on marine life, both U.S. adults and Ocean Conservancy members perceived the greatest threats from microplastic pollution to be on the health of ocean animals and the ocean itself, followed by freshwater ecosystems, with human health and terrestrial ecosystems lagging slightly as less prominent concerns. Due to the evolution of plastic pollution research first focusing on the ocean, then on ocean life, then expanding to other environments and most recently humans, it may be that more information about the effects of microplastics on oceans and wildlife compared to other ecosystems and humans has been received by the public.

Although in-depth knowledge of microplastics was low for U.S. adults (18% 'very familiar' with the term microplastics), our results demonstrated that after both U.S. adults and Ocean Conservancy members were provided with more information about microplastics in the form of a written explanatory passage, the overall level of concern increased. This highlights how provision of information and increased understanding of microplastics contributes to changes in topics of concern and could ultimately compel individuals to take more individual action or pressure governing agencies and industry to push for necessary plastic reduction measures. Our findings support a need for dissemination of

additional information on not just the ocean implications of microplastic pollution, but also what is currently known about impacts to freshwater environments, terrestrial environments and human health.

In our survey, levels of concern regarding human health impacts of microplastics were greater for seafood consumers than non-consumers, and this level of concern was greater among individuals consuming seafood frequently than those who only consume seafood a few times a year. Previous studies have shown that connection to the environment and ocean can influence behaviors and perceptions about environmental issues (Schultz et al., 2004). While questions regarding connectedness were not explicitly asked in this survey, we did ask respondents about seafood consumption to test if eating seafood at least once a month was tied to higher ocean literacy or concern about plastic pollution. Frequent seafood consumers exhibited significantly greater concern about the potential impacts of microplastics on the environment and humans than did non-consumers, potentially pointing to higher awareness about the issue, or greater connection to ocean animals and the perils they face.

To reduce plastics use and prevent microplastic pollution, U.S. adults placed most responsibility on the plastics industry (manufacturers and producers) compared to government or individual consumers. This finding demonstrates a general understanding among the public that decreased production is an important part of the solution to plastic pollution, with room for both government regulation and personal action to address the issue in an even more comprehensive manner. To enable meaningful microplastic pollution prevention, U.S. adults supported extended producer responsibility and various pollution prevention measures. For example, support for bans and phasing out of single-use plastics was high, as was support for prevention of microplastic emissions, such as reducing pre-production plastic pellet discharge and installing filters on washing machines. Taken as a whole, these results signal the public wants to see specific sources of both macro and microplastic pollution curbed, despite limited knowledge on the topic of microplastics.

When it came to taking individual action to reduce plastic waste, there was high uptake by U.S. adults to participate in certain actions like ensuring recyclable items go in recycling bins at home and carrying reusable items (bags, bottles) in favor of single-use plastics. The general public may be drawn to these actions in particular, due to familiarity with the concept of recycling which has long been promoted through media and labeling (Klaiman et al., 2017), though the recycling system is quite complicated in the U.S. and what is placed in the recycling bin may differ from what materials and products are able to be effectively recycled (US EPA, 2019). These findings may also reflect growing cultural norms surrounding bringing reusable water bottles and bags (Adeyanju et al., 2021), or the effectiveness of concerted initiatives and programs (e.g., Beyond the Bag initiative) targeted at rethinking our usage of individual single-use plastic products.

Of all individual-level plastic-reduction actions presented, the U.S. public was least likely to formally voice their opinions, in the form of communicating with public officials or companies. This is not unexpected, as the policy landscape related to plastics can be confusing (Wang et al., 2022), and individuals may not know exactly

how to best share feedback with decision makers. Providing ideas, prompts, or specific recipes for action may promote more involvement of U.S. adults in this space. For example, a higher percentage of Ocean Conservancy members were willing to formally voice their opinions to businesses and politicians, which may be because Ocean Conservancy provides regular opportunities to do this through e-mailed action alerts. Ocean Conservancy's model may be evidence that providing these roadmaps to engagement may work to encourage this type of action.

Although general perceptions of ocean health among U.S. adults were mixed but generally positive, the greatest positive perception reported was for U.S. adults living close to the ocean. This was unexpected, as generally individuals living closer to a marine coastline would be expected to have a more negative perception of ocean health, potentially driven by a better understanding of ocean threats through their economic and cultural ties to ocean services (e.g., fishing and tourism), and regular contact with the marine environment. The reason for this result is unclear, but the relationship between proximity to the coast and threat perception or concern for ocean health differs around the world among different communities and places (Potts et al., 2016; Davison et al., 2021; Manson et al., 2021) and appears to be largely affected by specific characteristics of the local society and environment (Hamilton and Safford, 2015).

Even with a positive-leaning perception of ocean health, U.S. adults are aware of ocean plastic pollution, enough so to value this issue above many other established threats. In fact, plastic pollution was ranked as the most pressing ocean problem of today. This result has also been reported in previous studies in the U.S., Europe, and Australia where pollution has repeatedly been ranked the greatest ocean threat (Gelcich et al., 2014; Lotze et al., 2018; Davison et al., 2021; Ansell, 2022). U.S. adults reported being most concerned about impacts of plastic pollution on marine life, from entanglement and injury, ingestion, and chemical leaching. To date, the scientific community has identified roughly 1,300 marine species impacted by plastics (Santos et al., 2021), highlighting the breadth of evidence supporting these concerns. Impacted organisms range from zooplankton to blue whales, and include species frequently consumed by humans (Desforges et al., 2014; Kahane-Rapport et al., 2022). These and other recent scientific findings have been amplified in traditional and social media particularly in the past decade, garnering substantial exposure for the pervasiveness of plastic pollution in the ocean and the animals that depend on it. It is therefore no surprise that the public is distraught by the notion of plastics harming marine life. The scientific community has, in at least one peer-reviewed article, also identified ingestion and entanglement of marine life as top concerns with respect to ocean plastic pollution (Wilcox et al., 2016), which aligns with public concerns and perceptions. The public consensus that plastic pollution is a pressing problem for today indicates that messaging and information surrounding plastic pollution has successfully raised the profile of the issue.

U.S. adults generally rated climate change as a less pressing ocean issue compared to plastic pollution. It has been previously argued that the focus on plastic pollution may decrease urgency to address other important issues such as climate change (Stafford and Jones, 2019). However, plastic production is intrinsically linked to climate change

and continued plastic production exacerbates the warming of our planet (Ford et al., 2022). It is evident that continued action on all fronts is required to address the increasing threats from these environmental crises (Avery-Gomm et al., 2019). Surveys of other nations have also reported climate change rated as a lower concern for the ocean (Gelcich et al., 2014). However, climate change is not a forgotten issue, as recently, 60% of U.S. adults reported viewing climate change as a major threat to the well-being of the United States (Tyson and Kennedy, 2020). In the context of ocean issues, what may be lacking is public understanding of the intimate link between climate change and plastic pollution from the extraction of fossil fuels to plastic production and eventual disposal (Lavers et al., 2022) and the connection between climate change and hazards to the health and survival of marine animals, for which public concern is high.

One potential limitation for the interpretation of our study results is that the survey was conducted during the COVID-19 pandemic. Survey timing may therefore have influenced responses about plastic pollution perceptions, actions and/or levels of support for various plastic-reduction measures, especially with respect to single-use plastics. During the pandemic, some single-use plastic items including gloves and face masks became critical and widely-used public health tools (Prata et al., 2020), which may have impacted public perception of utility and necessity of single-use plastics more broadly. As some researchers have noted, the sudden uptick in use of personal protective equipment and other single-use plastic items during the pandemic led to environmental leakage of such items and a pronounced need to better manage their disposal (Patrício Silva et al., 2020; Chowdhury et al., 2021). Ocean Conservancy intends to conduct this survey periodically over the next decade to monitor changes in responses over time, and post-pandemic.

Our survey explored knowledge and perceptions of a representative group of U.S. adults and compared responses to a group of U.S.-based Ocean Conservancy members who are highly attuned to ocean issues. Our findings illustrate that there is widespread support for microplastic pollution prevention measures in the U.S., and that industry must take action to address it. This broad support is predicated on concerns about the impacts of ocean plastics and microplastics. Further dissemination of targeted information regarding specific facets of these issues can help inform and shape public opinion, ultimately helping to protect our shared future from the growing issue of plastic pollution.

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.

Ethics statement

The studies involving humans were approved by University of Toronto Office of Research Ethics. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

BB: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing - original draft, Writing - review & editing. HD: Resources, Validation, Visualization, Writing - original draft, Writing - review & editing. LD: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing - original draft, Writing - review & editing. GL: Conceptualization, Supervision, Visualization, Writing - review & editing. LP: Data curation, Formal analysis, Visualization, Writing - review & editing, Validation. NM: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing - review & editing.

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Conflict of interest

The authors declare that the research 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.2023.1323477/full#supplementary-material>

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