FACETS

OPEN ACCESS | Research Article

Including local voices in marine debris conversations to advance environmental justice for island and coastal communities: perspectives from St. Paul Island, Alaska

Veronica M. Padula[a,b], **Anne H. Beaudreau**[c], **Douglas Causey**[d], **Lauren M. Divine**[b], **and Marissa Merculieff**[b]

[a]Seattle Aquarium, Conservation Programs and Partnerships, Clean Seas Program, 1483 Alaskan Way, Seattle, WA, USA; [b]Aleut Community of St. Paul Island Tribal Government, 2050 Venia Minor Road, St. Paul Island, AK, USA; [c]University of Washington, School of Marine and Environmental Affairs, 3707 Brooklyn Avenue NE, Seattle, WA, USA; [d]University of Alaska Anchorage, Department of Biological Science, 3103 Science Circle, Anchorage, AK, USA

Corresponding author: **Veronica Padula** (email: v.padula@seattleaquarium.org)

Abstract

Marine debris is ubiquitous across the global ocean and is an increasing threat to human health, economies, habitats, and wildlife. While local to national action plans are important in addressing this issue, they do not necessarily reflect the needs of coastal communities most heavily impacted. Remote island and coastal communities, particularly in Alaska, do not generate the majority of marine debris impacting their ecosystems; however, they are often left with the task of removal and disposal. Thus, the detrimental effects of marine debris are not only an ecological problem but an issue of environmental justice. This project aimed to catalyze the inclusion of place-based knowledge in marine debris solutions for St. Paul Island, a predominantly (>85%) Alaska Native community in the Bering Sea. We interviewed 36 community members during 2017–2020, documenting their observations of marine debris types, amount, distribution, and impacts over recent decades. Participants reported increasing plastic debris since the 1980s, particularly plastic bottles and fishing gear. Nearly 80% expressed concern about impacts to subsistence resources, including entanglement and ingestion. St. Paul Island community members' experiences highlight that solving marine debris issues requires broader policies and mitigation strategies addressing sources of debris and advancing environmental justice by impact reduction. Furthermore, this case study can serve as an example of how locally relevant action plans can be developed in other coastal communities around the world by including knowledge and concerns of community members, as they are the most heavily and personally impacted by the marine debris on their shorelines.

Key words: plastic pollution, Bering Sea, local and traditional knowledge, marine litter, subsistence, environmental justice

Introduction

Marine debris, especially plastic, is ubiquitous and persistent in the ocean and an increasing threat to human health, economies, aquatic habitats, and wildlife (Worm 2015; Kandziora et al. 2019; United Nations Environment Programme 2021). The plastics industry uses approximately 8% of global oil production, leaving an immense ecological footprint on the planet (Redclift 1996; Thompson et al. 2009; Clapp 2012). Approximately 10% (about 7.25 million metric tons annually) of plastics produced worldwide become waste and reach the ocean (Jambeck et al. 2015). In 2010, coastal populations in the United States created more plastic waste than any other country, followed by EU-28 countries and China (Law et al. 2020). Oceanic plastic pollution is a transboundary challenge because it is problematic to assign responsibility to one entity (e.g., a particular country) for its removal when it is found in Areas Beyond National Jurisdiction (Vince and Hardesty 2018). Additionally, it is difficult to identify origins of plastic and other marine debris, especially as it erodes and degrades over time.

Island and coastal communities have witnessed the degradation of their environment as marine debris accumulates on shorelines and endangers marine organisms. For example, seabirds breeding in the Easter Island Ecoregion incorporate plastic debris into their nests and ingest plastics (Luna-Jorquera et al. 2019). Marine fauna that provide a valuable food resource to communities are susceptible to lethal or sublethal impacts such as entanglement in debris, ingestion of plastic, and chemical contamination from plastics (Wilcox et al. 2016; Lavers and Bond 2017; Barnes et al. 2018). Filter-feeding marine organisms concentrate microplastics in their tissues, which can then be ingested by humans (Ivar do Sul and Costa 2014). Island and coastal communities often bear an undue burden of negative impacts of marine debris, from production to disposal (Bullard 1994). Thus, the movement to view marine debris as an environmental justice issue has gained traction in recent years. National and international policies aimed at reducing and mitigating its impacts, such as the Save Our Seas Act 2.0 (Public Law 116-224 2020), are an important part of the solution. However, they may be most effective when paired with local, community-centered approaches that better include knowledge bearers and stakeholders, build capacity and good practice protocols, and celebrate achievements to stimulate further actions that protect ocean health (Kandziora et al. 2019).

In Alaska, USA, which has a coastline longer than all other states combined, marine debris accumulates on shorelines of remote Arctic and subarctic coastal communities far from large population centers. Marine debris is not a new problem in Alaska and has been observed since at least the 1930s (Fowler 1987). Federal government programs have assisted communities and organizations in making substantial strides in debris removal. For example, the National Oceanic and Atmospheric Administration Marine Debris Program has provided funding to some Alaskan communities for marine debris removal and prevention efforts, resulting in over 900 metric tons of debris removed since 2006 (https://marinedebris.noaa.gov/alaska). Another federal government initiative in 5 national parks in Alaska removed over 10 metric tons of debris from 80 km of coastline (Polasek et al. 2017). Despite the benefits of these projects, funding is limited and not every community is provided the resources necessary for marine debris removal on a regular basis.

An important step toward addressing the disproportionate impacts of marine debris on Alaskan coastal communities is to include local voices in defining the scope of the problem and potential solutions. This study meets this challenge by reporting community members' historical and current observations of marine debris on and around St. Paul Island, Alaska, and their perceptions of marine debris impacts on the environment and subsistence resources. St. Paul Island (100 km^2) is one of five remote, volcanic islands in the Pribilof Islands region in the central Bering Sea, located approximately 483 km from the Alaska mainland (https://www.aleut.com/about/; Fig. 1). The primary residential area is located on a peninsula on the southern tip of St. Paul Island, and there were 481 residents as of 2019 (U.S. Census Bureau 2019). Unangan (or Aleut) people have continuously occupied the Aleutian Islands chain and the Pribilof Islands region of Alaska for centuries. St. Paul Island is home to the largest Unangan community in the world and is known as *Tanax̂ Amix̂*, or "The Island-Uncle" (Jochelson 2003), a name that is still used today. The community harvests *laaqudax* or northern fur seals (*Callorhinus ursinus*), qawan or Steller sea lions (*Eumetopias jubatus*), chagix̂ or Pacific halibut (*Hippoglossus stenolepis*), aguĝnax̂ or green sea urchins (*Strongylocentrotus droebachiensis*), and various san, or seabird, and duck species for customary and traditional use ("subsistence"). Laaqudax, in particular, are a cultural foundation of the St. Paul Island tribal community and an important subsistence resource (Veltre and Veltre 1987; Divine et al. 2020). Commercial fisheries in the region also depend on marine resources, including Pacific halibut, walleye pollock (*Gadus chalcogrammus*), atxidax̂ or Pacific cod (*Gadus macrocephalus*), and qimgiitan (crab), and both red king crab (*Paralithodes camtschaticus*) and snow crab (*Chionoecetes opilio*).

Marine debris research has been ongoing in the Bering Sea region for many decades. The first observations of northern fur seal entanglement on the Pribilof Islands date back to the 1930s during the commercial seal harvests that occurred on St. Paul and St. George Islands, highlighting the critical role these communities have played in calling attention to the marine debris issue very early on (Fowler 1987). It was not until the 1960s that marine debris research, monitoring, and cleanup activities in the Bering Sea began in response to increasing northern fur seal entanglements (Fowler 1987), which coincided with the growth of trawl fisheries for walleye pollock (National Research Council 1996). Research on the impacts of marine debris on northern fur seals continued for decades (e.g., DeLong et al. 1990; Yoshida et al. 1990*a*, 1990*b*; Spraker and Lander 2010). Simultaneously, plastic ingestion by planktivorous seabirds in the subarctic waters of Alaska, including the Aleutian Islands, was first detected in 1969 (Day 1980). Furthermore, marine debris surveys by scientists were initiated both on land (Merrell 1980, 1984) and at sea (Day et al. 1990*a*, 1990*b*).

This study provides a unique and otherwise undocumented perspective on the long-term impacts of marine debris on a remote island community in the Bering Sea, a region where ocean resources are foundational to cultures, livelihoods, and economies. The first objective was to examine trends in type, relative abundance, and distribution of marine debris over several decades based on observations from St. Paul Island residents. It was expected that community members would report increases in marine debris, and changes in types of marine debris, over their lifetimes. The second objective was to understand individual community members' perceptions of the origins of types of marine debris, its impacts on the local environment, and strategies for reducing impacts. These findings can contribute to the development of locally relevant action plans to manage marine debris by including knowledge of community members and serve to educate a broader audience on the environmental justice challenges remote coastal communities face.

Methods

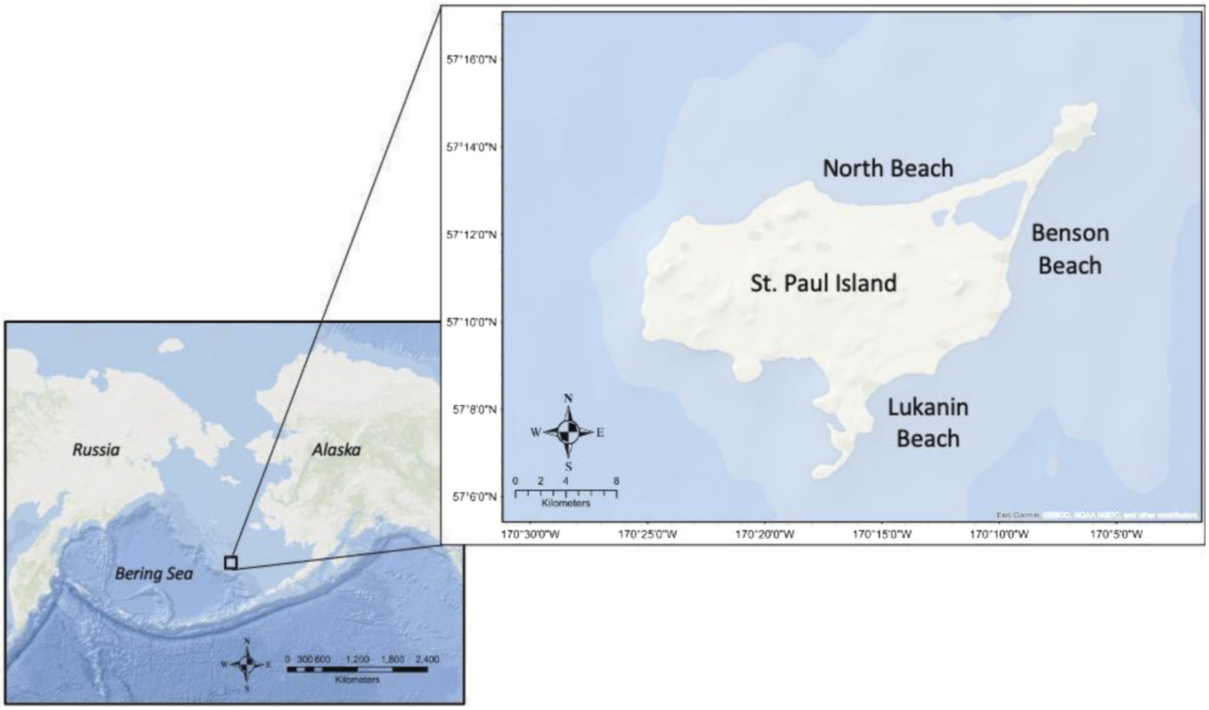
Positionality statement

While our findings hold relevance to island and coastal communities around the world that are impacted by marine pollution, the context of this study is deeply place-based, in the homelands of Unangan (the Aleut) people. This study was motivated by St. Paul Island community concern for pollution impacting the land and sea. Our conversations with community leaders and members over many years, along with some of the co-authors' own experiences witnessing plastic marine debris polluting the island's shorelines and participating in numerous marine debris cleanups, led to a desire to better understand the impacts and solutions from the perspective of St. Paul Island residents.

Three members of the author team (VP, LD, and MM) have been employed by the Aleut Community of St. Paul Island Tribal Government (ACSPI), the federally recognized sovereign government of the community of St. Paul Island,

FACETS 00: 1–13 (2023) | dx.doi.org/10.1139/facets-2023-0047

Fig. 1. Map of St. Paul Island, Alaska, with areas frequented by interview participants labeled in the inset. Many participants spend time at Lukanin and Benson beaches on the eastern shores of the island. North Beach is regularly visited by fewer participants, but it is a known "catcher beach" for marine debris. This map was created using the Ocean Basemap in ArcGIS Online (Esri, Redlands, California).



for more than a decade (VP worked for ACSPI during the writing of this manuscript and has since changed employment; LD and MM continue to work for ACSPI and are members of the Executive Team). One member of the author team (MM) is a citizen of the Aleut Community of St. Paul Island and has been a leader within ACSPI for over two decades. In their roles with the ACSPI, VP and LD spent many years fostering relationships with community members through various research and education activities, including community-engaged research centering Indigenous Knowledge of the St. Paul Island ecosystem and building capacity for local, Indigenous youth to lead and participate in research. The two other members of the author team are researchers at universities in Alaska and Washington, with long-term experience in transdisciplinary, community-engaged participatory research (AB and DC).

While members of the author team have different degrees of connection to St. Paul, we are all experienced in community-engaged collaboration with Alaska communities. At the time the research occurred, we were all Alaska residents, although two members of our team have moved outside of the state since then (AB and VP). Four authors are white and non-Indigenous, with a primary residence outside of St. Paul Island (AB, LD, DC, and VP), and one is Indigenous and resides on St. Paul (MM). Four of us come from a natural resource management and research background (AB, LD, DC, and VP), and one of us is a tribal lawyer, with extensive experience in environmental and social justice (MM). We strove to conduct community-engaged research that was in service to the community of St. Paul Island through ongoing relationship building, seeking guidance from community partners through all stages of the research, requesting approval to conduct the research from ACSPI, and following a process of informed consent. This approach is informed by principles for ethical engagement with Indigenous communities and driven by a core value that multiple ways of knowing broaden our collective understanding of the world and the environmental changes experienced by coastal peoples.

Interview methodology

Semi-structured interviews were conducted from December 2017 through January 2020 with St. Paul Island community members over 18 years of age with long-term seasonal or year-round residency (>10 years) and knowledge of the area, who interact with the environment through commercial fishing, subsistence harvesting, walking along the coast, and/or participating in beach cleanups. Prior to interviews, an interview guide (Appendix A), consent form, one-page introduction to the project, and recruitment materials were reviewed and approved by the Alaska Area Institutional Review Board (2017-06-024), University of Alaska Fairbanks Institutional Review Board (1072734-1), and informally by the ACSPI. Participants were recruited using flyers posted in public spaces on St. Paul Island (grocery store, clinic, tribal government office, and municipality office) and through personal contacts of the lead author, who has conducted field work on

St. Paul Island since 2015 and has been employed by ACSPI since 2017. Snowball sampling (chain referral) was also used to identify potential participants recommended by interviewees, a technique effective for recruiting participants with specific experience or expertise in small communities, where it is possible to build an exhaustive network of interview candidates (Bernard 2011). Interviews were conducted with individuals (28) and two groups of participants (one group of 3, one group of 4) who were more comfortable conversing in a group setting. A mix of individual and group interviews is common for interview-based research in small communities with tightly interconnected social networks, where allowing for group conversation can increase the comfort level for participants (Bernard 2011; Green et al. 2022). For group interviews, responses to questions given by individual participants were analyzed separately; otherwise, group responses reflecting a consensus among participants were analyzed as a whole. At the start of each interview, participants reviewed the project goals and consent form. Interviews were audio-recorded if participants gave prior informed consent. All interviews were conducted by the lead author and ranged from 30 to 60 min (average 40 min). Interviews were voluntary and participants were free to skip questions or elaborate on topics of particular importance to them.

During the first part of the interview, participants were asked about their residency on St. Paul Island and fishing and hunting experience, including harvested species, gear types used, and typical harvesting seasons. Participants were also asked about areas of the island where they most commonly fished, hunted, or recreated. The next part of the interview was designed to elicit participants' observations of marine debris and its impacts on the St. Paul Island environment. Participants were asked to define marine debris in their own words, provide examples of marine debris, indicate where they have seen it (e.g., shoreline, floating in the ocean, and on or inside animals' bodies), and discuss possible debris origins and its persistence in the environment. A subset of interview questions was designed to track trends in marine debris over time. Specifically, participants scored the abundance level of 10 different debris types (Appendix A) on a 7-point scale, from very low to very high, for each decade in which they had made observations. Finally, participants were asked what concerns they had regarding marine debris and their perceptions about the efficacy of local marine debris cleanups.

Analysis

Quantitative data from closed-ended questions (i.e., relative abundance of debris types) were analyzed using R Studio (R Core Team 2019). Categorical responses were converted (very low to very high) to numerical indices (1–7). Because individuals may have different historical baselines from which to compare changes in abundance (e.g., Beaudreau and Levin 2014), normalized relative abundance indices were calculated as follows. For each interviewee, a mean and standard deviation of reported abundance indices were calculated. Abundance index values were then normalized by subtracting the mean and dividing by the standard deviation. The distribution of normalized relative abundance indices across interview participants was visualized as a series of box plots, where the box shows the interquartile range of indices reported by participants and the line within the box indicates the median value for a given material type and time period. Together, the box plots show how relative abundance of each material type has changed over time since 1960, according to participants' observations.

Qualitative data from open-ended interview questions were interpreted using thematic analysis, a flexible approach for identifying and summarizing patterns or conceptual themes in qualitative data (Braun and Clarke 2006) that allows for interpretation of those themes within multiple theoretical frameworks (Boyatzis 1998). Phases of thematic analysis outlined by Braun and Clarke (2006) were followed; first, familiarity with the data was gained through repeated and active reading of interview transcripts, which generated an initial, inclusive set of codes describing basic ideas in the data, codes were then aggregated under broader themes and subthemes, and iteratively reviewed and refined to reach a final set of nested themes. Nested themes were visualized by creating thematic network diagrams organized into three hierarchical levels: (1) basic themes, the lowest-order themes derived from data; (2) organizing themes, the middle-order themes that arise when basic themes are organized into clusters reflecting the same main idea and are more abstract yet more revealing than basic themes; and (3) global themes, the highest-order themes that reflect principal concepts in the data overall and arise when organizing themes are clustered to present an assertion about a given reality or issue (Attride-Stirling 2001).

Results

Overall, 30 interviews were conducted, comprising 35 participants (Table B.1); 37% of participants self-identified as female, 52% as male, and 11% did not report their gender. Most participants (approximately 69%) self-identified as Alaska Native or American Indian, 14% identified as white, 6% identified as another race or ethnicity, and 11% did not report their race. Ages ranged from young adults in their twenties to elders in their late sixties. Most were year-round residents who had lived on St. Paul their entire lives, while a portion lived on the island seasonally (e.g., to fish commercially in summer) but had spent at least part of the year on St. Paul Island for decades. All participants earned at least their high school degree, with many having attended some college or attained a bachelor's degree and a few having attained a graduate degree. Qualitative and quantitative data from interviews describing marine debris types, trends, and impacts are summarized in four global themes, outlined below (Table 1).

Global theme 1: marine debris is diverse and prevalent on St. Paul Island

Interview participants defined marine debris in their own terms and described the materials that comprise marine debris. All participants gave examples of what they have

Table 1. Summary of four global themes reflecting observations and concerns about marine debris on St. Paul Island, Alaska, with associated organizing and basic themes, drawn from thematic analysis of interviews ($n = 35$ participants).

Global theme	Organizing theme	Basic theme
Marine debris is diverse and prevalent on St. Paul Island	Definitions of marine debris	Object
		Material type
	Descriptions of marine debris	Unnatural
		Abundant in the environment
Marine debris quantity has been stable or increased since the 1960s, with variation among specific types of debris	Changes in marine debris over time	Uncertainty about changes
		Little change in quantity
		Increases in quantity
		Changes in specific materials or types of debris
	Present-day conditions	More awareness today
		Seasonal changes in debris
		Differences in prevalence of specific materials
Most marine debris does not originate on St. Paul Island	Transport by natural processes	Weather events
		Natural disasters
		Ocean currents
	Transport by human activities	Waste from other countries
		Shipping (barges and fishing vessels)
St. Paul Island community members are concerned about the impacts of marine debris	Concerns about impacts of marine debris	Impacts on animals (e.g., starvation or death, entanglements, ingestion of chemicals, etc.)
		Source of pollution
		Interference with traditional practices (e.g., subsistence harvesting)
	Solutions to the marine debris issue	Efficacy of marine debris cleanups
		Addressing marine debris at its source

Note: Interview questions are detailed in Appendix A.

seen while recreating, hunting, conducting marine debris cleanups, or participating in other activities along the shore. Some also gave examples of what they have seen while fishing. Together, these observations captured the wide range of debris types that are most commonly observed on and around St. Paul Island. Within this global theme, organizing themes were delineated into "definitions of marine debris" and "descriptions of marine debris".

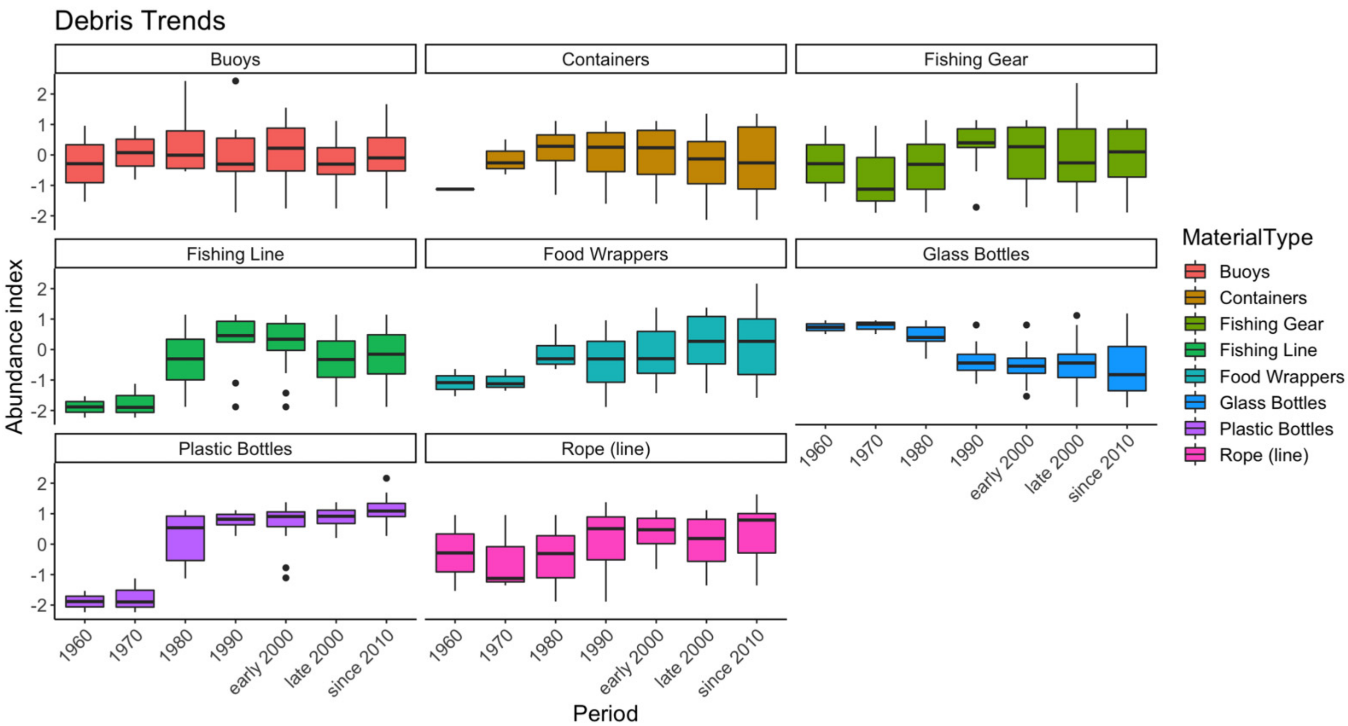
Participants defined marine debris in terms of both the material with which it is made and examples of objects found in the environment that are made from those materials. Fishing gear was a prominent response, with most participants (79%) specifically mentioning the words "fishing gear" or giving an example such as nets, rope/line, or buoys. Other examples included bottles, packaging, boxes, containers, packing bands, wrappers, bonfire trash, and assorted individual items that stood out as oddities to participants such as radio sondes, toothbrushes, and various clothing items. Almost all participants (89%) mentioned plastic when asked to define marine debris. Other material types included metal, glass, rubber, foam, chemicals, oil, nylon, wood, and fiberglass. The detail with which participants described marine debris illustrated both their familiarity with it and the ubiquity of diverse debris types in the local environment.

Participants also expressed varying sentiments about marine debris or observations of its prevalence. More than half of the participants (57%) mentioned that marine debris is "manmade" or "unnatural", suggesting that it does not belong in the environment in the first place. They also described marine debris as "abundant" and expressed concerns that marine debris occurs on shorelines in such large amounts that it is difficult to remove. We asked interviewees about the island localities and habitats in which they have seen marine debris (or litter in general), as well as their perceptions of the origins of marine debris on St. Paul Island. All participants said they saw marine debris along the shorelines and floating in the ocean. Many also saw debris on (87%) or inside (37%) animals' bodies, such as entanglements of *laaqudax* in fishing nets or plastic packing bands. Other places where people reported seeing debris were inland and along roads, at the boatyard, and on the grassy tundra.

Global theme 2: marine debris quantity has been stable or increased since the 1960s, with variation among specific types of debris

Participants were asked whether they have seen changes in the amounts and types of marine debris on and in the waters surrounding St. Paul Island. Participants' responses generally clustered into two organizing themes, "changes in marine debris over time" and "present day conditions". In discussing changes in marine debris over time, participants' ob-

Fig. 2. Box plots depicting the distribution of normalized relative abundance indices of various debris types seen around St. Paul Island across interview participants. The box shows the interquartile range of indices reported by participants, and the line within the box indicates the median value for a given material type and time period. Together, the box plots show how relative abundance of each material type has changed over time since 1960, according to participants' observations.



servations reflected variation in perceptions and patchiness of debris in time and space. Basic themes in the qualitative data reflected uncertainty in how debris has changed over time, observations of little change or increases in quantity of debris over time, and changes in some materials or types of debris but not others (Table 1).

The quantitative data on relative abundance of debris types helped explain some of this variation in qualitative descriptions of long-term changes in marine debris prevalence and distribution. Plastic bottles stand out as the item that has increased most over time (Fig. 2). The median relative abundance index for plastic bottles increased sharply from the 1970s to the 1980s and then continued to increase gradually thereafter (Fig. 2). The relatively narrow spread around median indices indicates strong agreement among participants. This increasing trend was described by one person who grew up on St. Paul Island:

> Plastic containers, plastic bottles, plastic oil barrels, buckets—I see a lot of that out there…and we hardly ever seen any plastic other than like an occasional hard hat or maybe a boot or something like that, but that was in the '70s going into the early '80s, and from the '80s on there were fishing debris on the beach back then in the '70s and early '80s—like line and nets and things like that—and those were the kind of plastics that I think we probably seen the most of back then. And then the trend started going towards plastic in the '80s for sure, '90s, and all the way up. It's just—it's amazing how fast the plastic has exploded on the beaches…we were walking over at Southwest Point where the hair seals haul out and I was like, there's plastic all over the place, it was everywhere…

Participants reported an overall decrease in glass bottles over the same period (Fig. 2). Median abundance scores increased slightly for other items over time, such as food wrappers and rope (line); however, the interquartile ranges around the median abundance scores are wider, indicating greater variation in people's observations of relative abundance levels for these items. Median abundance scores for containers and buoys were relatively flat over time, with large interquartile ranges, while fishing line and fishing gear varied without trend (Fig. 2).

Participants tended to describe their observations of debris in more detail for more recent time periods, compared to earlier periods. This may indicate that while community members noticed marine debris on the island's beaches and around town in the past, they may not have been gauging quantities or are more uncertain in their recollections from decades past. Additionally, local awareness of marine debris may have grown in recent years, as global concern about marine debris has increased in the past two decades. While it was difficult in some instances for participants to recollect historical changes in marine debris, many described the types and quantities of debris they see most often now. According to participants ($n = 23$) who provided a relative ranking of the types of debris they see most often, plastic bottles and lines were most often observed, followed by plastic bags, beverage cans, plastic, nets, and floats. Many participants also observed seasonal changes in the amount of marine debris, citing severe weather conditions as a possible reason for increases in marine debris during winter.

Global theme 3: most marine debris does not originate on St. Paul Island

A prevailing theme was that most of the marine debris does not originate on St. Paul Island but arises from natural processes and human activities that carry marine debris to the island from elsewhere (Table 1). Most participants (93%) said that natural processes, such as currents and tides, wind/weather, and tsunamis, and other natural disasters, bring marine debris to St. Paul Island. One individual who had participated in environmental education events also mentioned that work with scientists helped to build a better understanding of how currents move debris around St. Paul Island itself:

> [A scientist] put out these wood blocks to see the currents around the island…we were connecting the currents around the island and "debris catch-alls" as we were calling them then, that you're going to have debris that is going to wash up over here behind black bluffs, you're going to have debris that is on either end of north beach or et cetera…

This understanding of ocean processes therefore helped deepen an understanding of how and why debris settles in certain areas of the island.

Participants identified shipping and waste from other countries as the primary human activities that served as a source of debris to the island (Table 1). They made a clear distinction between the local fishing fleet (i.e., Pacific halibut vessels homeported at St. Paul Island) and larger ships that utilize the Bering Sea region for fishing and commerce. Not many participants believed the local fleet was responsible for the debris they see, based on observations of derelict trawl nets removed during marine debris cleanups (the local fleet uses longline gear). Few participants specifically said that marine debris originates because of fishing industry practices, but the frequent mentioning of fishing vessels suggests a connection between commercial fishing and marine debris. One interviewee who participated in beach cleanups since the early 2000s described multiple sources of debris, distinguishing between debris from off-island sources and trash or litter that is local in origin, saying,

> It's pretty obvious, fishing vessels, vessels in general, that would be the number one. The second one would be natural disasters… that's a possibility… I don't see a lot of trash that is blown from the community [to the shore]. Twenty to thirty years ago it was bad, especially with the plastic bags that used to be allowed at the store. Today, it's maintained quite a bit, maintained a lot better, and so when I see marine debris on the beaches today or trash or items on the beach, I almost look at all of it as marine debris not so much as island trash.

Just under half of participants (45%) mentioned specific geographic origins of marine debris. "Asia" and "Russia" were both mentioned, suggesting that some participants believe that debris enters the western boundaries of the Bering Sea and Pacific Ocean and is transported to their shorelines. As noted by some participants, marine debris cleanup crews on St. Paul Island have found plastic bottles with labels printed in Russian and East Asian languages. More rarely, participants mentioned other sources of debris, including wildlife (e.g., entangled seals bringing debris onshore and cormorants utilizing waste fishing line in their nests), oil and gas industry, floating "garbage islands" in the ocean, and the local landfill.

Global theme 4: St. Paul Island community members are concerned about the impacts of marine debris

Longstanding traditions of Indigenous stewardship guide harvest practices and caretaking of the land and sea, including removal of debris from shorelines. Community members have been clearing natural (e.g., driftwood) and anthropogenic (e.g., plastics) materials from the beaches of the *laaqudax* rookeries for generations in preparation for the seals' arrival for breeding season each year. One participant who grew up on St. Paul Island described it this way:

> Being aware of the island and our people watching the shorelines for feeding purposes and hearing things like our chiefs at the time would say "ok no more hunting on this particular rookery, seals are starting to come ashore" and they would clean it and my dad would tell me people would remove any little things that were there at the time in the '30s and '40s, and then it became too much by the '60s, '70s, and '80s. Too much marine debris, too much garbage, but the fact that we come from a people that were preparing for the animals to return home was always a connection to my past and what my people did.

The community began conducting federally funded large-scale marine debris cleanups in the 1990s, during which groups of 10–15 people would remove tens of thousands of kilograms of marine debris from shorelines over the course of 10 days. These major marine debris cleanups have been occurring at least biennially since that time. When the cleanups began, the community faced issues with where to place the collected debris. One interview participant who had participated in cleanups on St. Paul Island since their inception explained,

> At some point we were collecting debris galore, galore enough that the city did not want us to be taking it to the landfill because it was messing with their equipment and getting caught, so we were trying to figure out how to keep collecting debris.

Marine debris collected today is stored in bulk containers at the landfill until a barge can remove them from St. Paul Island and transport them to appropriate facilities in Seattle, Washington. Marine debris cleanups remain logistically complex and difficult operations that continue to be successfully executed by the community.

Participants discussed the impacts of marine debris on the St. Paul Island environment and community and identified mitigation measures, with special attention to plastics. Participants discussed concerns about marine debris, particularly its negative impacts on animals and traditional land-based practices. They unanimously agreed that plastic has long-term effects on the environment. Many participants expressed a general concern for animals, providing examples such as ingestion of plastic, entanglement, starvation or death, absorption of chemicals, and declining populations. Such concern about the well-being of animals, without specific reference to those animals being subsistence resources, reflects a general empathy for wildlife and reciprocal relationship with the natural world.

A majority (79%) of participants believed that plastic marine debris impacts subsistence resources on St. Paul Island, while fewer were unsure about the effects. A number of participants provided examples of types of subsistence resources they believe are impacted by plastic marine debris, including seals, birds, fishes, and whales. Participants expressed concern that plastic marine debris interferes with the food they eat, affects resource availability, and impacts the food web. As one person with many years of fishing and hunting experience explained,

> …the stuff does constantly shed the microplastics, no matter what, even through ingestion. I think I probably worry more about absorption into the tissue of the animals that we're actually subsisting off of, that can't be good, it's a petroleum product.

Marine debris was also seen as interfering with intergenerational, land-based practices of subsistence harvesting. As one St. Paul Island resident who has participated in marine debris cleanup activities for over 20 years explained,

> [Marine debris cleanup] was met with a lot of frustration also where you would have visitors come and they were aware of all the cool things we were doing with young people with cleaning up beaches and disentangling fur seals from marine debris and I was like, what is cool about that? We shouldn't even be having to do this. No, it's not cool that I'm going out with a group of kids and we're picking up garbage, we should be out here gathering good things and eating good things and enjoying life. Don't tell me we're doing wonderful things.

Participants had varying views about how to address the issue. A little over one-third of participants had engaged in a large-scale marine debris cleanup as described above at some point in their lives, while many had not. Almost half of participants (48%) expressed the sentiment that marine debris cleanups do not fix the problem regardless of whether they had participated in a cleanup, noting that it is a temporary solution to a recurring problem. Some that had participated in cleanups expressed frustration at returning to a beach they had cleaned to find it filled with trash again, as if their hard work had been erased. As one participant with at least 40 years of fishing experience commented,

> It's like a cat chasing its tail—they go out, they make a beach pristine, and we go out there a year or two later and *bam*, tons and tons of garbage again. I think to be impactful we would even have to get to the source of the problem.

In contrast, 38% of participants expressed the general sentiment that marine debris cleanups are an important part of the solution because they bring awareness to the issue, prevent debris from getting washed back out to the ocean, and help prevent wildlife entanglements. Some participants went further to express concern over the difficulty in recycling plastic on St. Paul Island and the chemicals that may be emitted into the atmosphere when plastic is burned, as is done at the community landfill. Some participants expressed the need to go to the source of the waste creation and fix that issue before it reaches the ocean and becomes marine debris. This suggestion highlights the idea that much of the marine debris collected on St. Paul Island is not generated there. Finally, 83% of participants do not think plastic can biodegrade, while the remaining respondents did think plastic could biodegrade or were unsure. However, it seems that St. Paul Island community members generally understand that plastic lasts a very long time in the environment.

Discussion

Overview of key findings

St. Paul Island, by nature of its location in the Bering Sea, is exposed to large amounts of marine debris accumulating on its shorelines, which puts the community's subsistence, economic, and cultural resources at risk. St. Paul Island residents have observed increases in certain types of marine debris over time, particularly plastics and fishing gear and are concerned about the impacts of marine debris on the ecosystem, particularly the health and well-being of wildlife populations. These observations of increasing marine debris over time might reflect the overall global increase in the use of plastic items, especially single-use plastics, but it might also indicate the difficulties in properly managing plastic waste and plastic recycling (Eriksen et al. 2023). Likewise, observations of declines in glass bottles may be related to the increase in plastic bottles, due to its lighter weight and lower cost to ship. The community's observations of increasing plastic debris are reflective of observations from other parts of the world, such as increases in plastic bottles in the South Atlantic Ocean and along South Africa's beaches (Ryan and Swanepoel 1996; Ryan et al. 2019).

Fishing industry contribution to marine debris

Identifying the specific origins of plastic pollution on St. Paul Island is challenging, which is a common issue in regions with high concentrations of marine debris from multiple sources (Sheavly and Register 2007). However, participants often cited commercial fishing as a source of marine debris on St. Paul Island's shorelines. Marine debris cleanup data also support this observation, as fishing gear often makes up the largest proportion (by weight) of what is collected during major marine debris cleanups (Divine and Padula 2020), especially on oceanic islands (e.g., Luna-Jorquera et al. 2019). For example, in 2019, the St. Paul Island marine debris cleanup crew removed a combined weight of 7092 kg of rope and line, nets, soft/inflatable buoys, and hard plastic buoys from the northern shores of the island, accounting for more than 78% of the total debris removed during that cleanup effort (9030 kg; Divine and Padula 2020).

FACETS **00:** 1–13 (2023) | dx.doi.org/10.1139/facets-2023-0047

A 2009 report to the United Nations Environment Program estimated that 640 000 tons of fishing gear is lost to the marine environment annually (Macfadyen et al. 2009). Understanding the specific circumstances in which gear is lost near St. Paul Island will be important for identifying strategies to reduce derelict gear. For example, research in Australia's Gulf of Carpentaria identified three types of events that could cause gear loss: events leading to stowed gear washing overboard, events leading to gear loss or abandonment during operations, and events leading to degraded gear or scraps discarded overboard (Richardson et al. 2018). Economic pressures also seemed to drive decision-making that could lead to gear loss (Richardson et al. 2018). This knowledge of debris sources led to several strategies to reduce pollution originating from the northern prawn fishery (Australian Government Publishing Service 1989; Pownall 1994; White 2003; AFMA 2014), including spatial and temporal fishery closures, restrictions on certain gear types, vessel monitoring systems, waste management education for vessel crews, and a significant reduction in the overall size of the fleet (Richardson et al. 2018). Research conducted by the Northwest Straits Marine Conservation Initiative, which has removed derelict fishing gear from sites throughout Puget Sound, Washington, USA, has shown that gear removal could help in ecosystem recovery and function (June and Antonelis 2009).

The Bering Sea region supports some of the largest commercial fisheries in the world, as well as small-boat commercial fisheries that support livelihoods and cultures in a region with limited economic development opportunities (Aydin et al. 2019). Therefore, specific measures to reduce fishing gear loss will be fleet-specific and must be done in collaboration with local communities and the fishing industry. As study participants noted, the local Pacific halibut fishing fleet on St. Paul Island has shown leadership in addressing this issue. The Central Bering Sea Fishermen's Association (CBSFA) recently teamed up with Blue Ocean Gear (https://blueoceangear.com/) to pilot "Smart Buoys" on Pacific halibut longlines. Smart Buoys have tracking devices to aid fishermen in finding their sets should they drift from the original location, reducing the potential for gear loss. CBSFA also provides a funding match for the federal funds used to execute major marine debris cleanups on St. Paul Island. This stewardship by the fishing industry is a key part of the solutions to addressing marine debris locally and regionally, as seen in other regions of the world such as Rapa Nui (Kiessling et al. 2017).

Marine debris impacts on subsistence and community-based mitigation measures

Coastal communities are closely tied to the marine ecosystem through subsistence and cultural traditions (Garcia Rodrigues et al. 2017), and marine debris is a threat to traditional and contemporary practices. Negative effects of marine debris on species that are important for subsistence harvest, such as plastic ingestion by seabirds (Hyrenbach et al. 2009) and entanglement of marine mammals (Fossi et al. 2012), have been documented in Alaska (Day 1980; Fowler 1987). For example, *laaqudax* (Laist 1987) experience some of the highest entanglement rates of any pinniped species (Antonelis et al. 2006). Young seals and pups are particularly susceptible to entanglement in packing bands because they are more curious and tend to interact with bands in the environment (Goldstein et al. 1999; Hanni and Pyle 2000). In response, the Ecosystem Conservation Office, a branch of the ACSPI, developed a long-term *laaqudax* disentanglement program in the early 2000s that continues today.

St. Paul Island had a long tradition of removing debris, such as natural items like driftwood, from *laaqudax* rookeries prior to their arrival for the breeding season. As more anthropogenic debris littered the beaches, it became too cumbersome to remove and therefore the tradition faded away. It was then revived in the form of major marine debris cleanups in the 1990s, which continue today. However, leaving communities like St. Paul Island "holding the bag" for marine debris means they often must find funding sources to conduct cleanups. As more debris washes up on shorelines and communities compete for limited funding, more labor is required to apply for funding, do the actual work of removing debris from the environment, ship the debris to landfills or recycling facilities, and report the statistics to funding agencies. These pressures were evident in the responses of some participants, who noted that fewer cleanups due to limited funding may have contributed to more marine debris on the shorelines.

Some participants expressed doubt over the value and need for marine debris cleanups, having witnessed the tedious and time-consuming work of removing tons of marine debris from the island's shorelines, only to see more debris wash up in the following months and years. Similar observations have been made in other parts of the world, such as on the beaches of South Africa, where cleanup efforts started as early as 1945 and continued to increase over the decades that followed (Ryan and Swanepoel 1996). However, as other participants noted, marine debris cleanups are important for reducing harm to wildlife and environmental contamination. Removal of large plastic debris is also critical to prevent further breakdown of debris into microplastics (Weinstein et al. 2016), whose removal from the environment is vastly more complex and unlikely (Rochman 2016). Other island communities in Alaska, such as Kodiak Island in the northern Gulf of Alaska, also face the never-ending task of marine debris removal. Organizations like Island Trails Network (https://www.islandtrails.org/) and Ocean Plastics Recovery Project (https://oceanplasticsrecovery.com/) have been tackling this issue in the Kodiak region for almost 15 years and have removed tons of debris from the shorelines. The Center for Alaskan Coastal Studies (https://www.akcoastalstudies.org/) has led marine debris cleanup efforts in the Kachemak Bay region since 2010. A database of marine debris cleanups conducted in Alaska (https://sitkascience.org/research-projects/marine-debris/) documented that 16 Bering Sea communities collectively removed more than 544 300 kg of marine debris from their shorelines between 2008 and 2018. Interview participants expressed that marine debris cleanups must be done in parallel with efforts to manage waste at its sources.

Driven by a deep commitment to environmental stewardship, the St. Paul Island community is working to improve local waste management to the extent possible. Currently, waste from individual homes is collected by the municipality of St. Paul weekly and transported to the landfill outside of town. Waste is sorted and a proportion of it is buried at the landfill and waste that can be safely burned is burned in a burn box. While the community is limited in its ability to change these core waste management practices or to increase recycling due to its remoteness, St. Paul residents have made other actions to reduce waste production locally. For example, plastic bags were banned at the local grocery store over two decades ago. Similar local efforts have been implemented in communities around the world with varying levels of success. For example, a plastic bag ban in the Australian Capital Territory resulted in a reduction of single-use polyethylene bags, but an increase in other types of plastic bags (Macintosh et al. 2020), likewise plastic bag bans have had varying levels of success in Rwanda, Kenya, and Uganda (Behuria 2021). While local efforts are critical in stemming the tide of marine debris, they are no match for the global contribution to debris that accumulates on and around St. Paul Island. This view was expressed by many participants in the study, who commented that stopping waste at its source, or preventing waste creation altogether, is a critical step in reducing its impact (Eriksen et al. 2023).

Marine debris challenges and solutions for island communities

Remote coastal communities are often disproportionately impacted by marine debris and may lack adequate capacity to mitigate the harm it causes (Stoett and Vince 2019). St. Paul Island is not alone in this struggle. One study found that marine debris incidents and cleanups cost communities of the Azores archipelago, located in the Northeast Atlantic, an average of €710 698 ($839 000 USD) per year or 0.02% of the Azores Gross Domestic Product (Rodríguez et al. 2020). Azorean study participants cited derelict fishing gear as a primary cause for incidents, followed by soft plastics such as plastic bags and raffia sacks used for animal feed (Rodríguez et al. 2020). Similarly, in remote coastal communities of Indonesia, litter on shorelines is a growing problem driven by both ocean plastic pollution and local plastic use and waste disposal (Phelan et al. 2020). This necessitates a more global approach to investigating the sources of marine debris, especially terrestrial sources, since studies have shown that at least three-quarters of debris in the ocean originates from land-based sources (Derraik 2002; Hardesty et al. 2014; Jambeck et al. 2015).

Action plans to address the marine debris crisis are being developed at international, regional, national, and local levels (e.g., Law of the Sea Convention 1994; Basel Convention Secretariat 2002). However, efforts to tackle marine debris and its related issues have historically excluded the perspectives of communities that are often most heavily impacted by plastic pollution (United Nations Environment Programme 2021). Environmental justice is attained by providing opportunities for input from all stakeholders, involving affected communities in decision and policy making, and acting according to their guidance to correct environmental injustices (Anand 2017). For example, researchers in Canada are working with communities in the Eastern Arctic (Inuit Nunangat) to characterize plastic pollution in surface waters such that the information can be incorporated into broader governance measures and environmental protection (Liboiron et al. 2021).

Conclusion

Marine debris pollution is a complex global crisis that is intricately linked to other environmental problems associated with climate change, biodiversity loss, and human health issues (Vince and Stoett 2018). St. Paul Island is one of thousands of coastal communities that are disproportionately affected by marine debris. Much of the waste that pollutes the island's shorelines is not of local origin, yet the community assumes a central role in cleaning it up. As this research has shown, the community is particularly concerned with the negative effects of marine debris on wildlife. Reducing the impacts of marine debris on St. Paul Island and other island communities requires a multi-pronged approach that includes local to global policies and actions. Ultimately, environmental justice is only achieved through a global effort to hold industries more accountable for their actions, create financial incentives for industries to curb their pollution and improve waste management strategies, and reduce waste entering the ocean.

Acknowledgments

This work was done with the gracious support and generosity of the St. Paul Island community, especially the Aleut Community of St. Paul Island Tribal Government, Central Bering Sea Fishermen's Association, and Trident Seafoods. We conducted our interviews on the lands of the Unangan people and are deeply indebted to their willingness to participate in this study and grateful for their ongoing environmental stewardship of the St. Paul Island ecosystem. Thanks to the Tribal Government's Ecosystem Conservation Office team members Paul Melovidov and Aaron Lestenkof who have worked tirelessly to conduct major marine debris cleanups on St. Paul Island. We are also grateful to Brenda Konar, Andrew McDonnell, and Tuula Hollmen, who provided valuable reviews of the manuscript. The Aleut Community of St. Paul Island Tribal Government provided tuition funding for V. Padula (an employee benefit); salary support to A. Beaudreau and D. Causey was provided by the University of Alaska. The University of Alaska Fairbanks also provided funding for thank you gifts to interview participants.

Article information

Editor

Nicole Redvers

History dates

Received: 28 March 2023
Accepted: 4 July 2023
Version of record online: 21 September 2023

Data availability

Data generated or analyzed during this study are not available due to the nature of this research. The raw data for this manuscript consist of interview transcripts and contain identifiable content about harvest locations and individuals. Providing raw data publicly would compromise the confidentiality of the respondents and lead to non-compliance with the institutional review boards that approved this work.

Author information

Author ORCIDs

Veronica M. Padula https://orcid.org/0000-0001-5108-0862

Author contributions

Conceptualization: VMP, AHB
Data curation: VMP
Formal analysis: VMP
Investigation: VMP, AHB
Methodology: VMP, AHB
Project administration: VMP, AHB, DC
Resources: AHB, DC, LMD
Supervision: VMP
Validation: LMD, MM
Visualization: VMP, AHB
Writing – original draft: VMP, AHB
Writing – review & editing: VMP, AHB, DC, LMD, MM

Competing interests

The authors declare there are no competing interests.

Supplementary material

Supplementary data are available with the article at https://doi.org/10.1139/facets-2023-0047.

References

Anand, R. 2017. International environmental justice: a North–South dimension. e-book ed. Routledge, London.

Antonelis, G.A., Baker, J.D., Johanos, T.C., Braun, R.C., and Harting, A.L. 2006. Hawaiian monk seal: status and conservation issues. Atoll Research Bulletin.

Attride-Stirling, J. 2001. Thematic networks: an analytic tool for qualitative research. Qualitative Research, **1**: 385–405. doi:10.1177/146879410100100307.

Australian Fisheries Management Authority (AFMA). 2014. Northern Prawn Fishery operational information booklet. Canberra, Australia.

Australian Government Publishing Service. 1989. New direction for commonwealth fisheries management in the 1990s: a government policy statement 1989. DPIE Publications, Canberra, Australia.

Aydin, K., Dalton, M., Daly, B., Eich, A.M., Evans, D., Harris, B., et al.. 2019. Bering Sea Fishery Ecosystem Plan. North Pacific Fisheries Management Council, Anchorage, AK. Available from https://www.npfmc.org/fishery-management-plan-team/bsfep/[accessed 15 December 2021].

Barnes, D.K.A., Morley, S.A., Bell, J., Brewin, P., Brigden, K., Collins, M., et al. 2018. Marine plastics threaten giant Atlantic Marine Protected Areas. Current Biology, **28**(19): R1137–R1138. doi:10.1016/j.cub.2018.08.064. PMID: 30300595.

Basel Convention Secretariat. 2002. Technical guidelines for the identification and environmentally sound management of plastic wastes and for their disposal. Available from www.basel.int/Implementation/Plasticwaste/Technicalguidelines[accessed 15 December 2021].

Beaudreau, A.H., and Levin, P.S. 2014. Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. Ecological Applications, **24**(2):244–256. doi:10.1890/13-0817.1.

Behuria, P. 2021. Ban the (plastic) bag? Explaining variation in the implementation of plastic bag bans in Rwanda, Kenya and Uganda. Environment and Planning C: Politics and Space, **39**(8): 1791–1808.

Bernard, H.R. 2011. Research methods in anthropology: qualitative and quantitative approaches. AltaMira Press, Lanham, MD.

Boyatzis, R.E. 1998. Transforming qualitative information: thematic analysis and code development. SAGE Publications, Thousand Oaks, CA.

Braun, V., and Clarke, V. 2006. Using thematic analysis in psychology. Qualitative Research in Psychology, **3**: 77–101. doi:10.1191/1478088706qp063oa.

Bullard, R.D. 1994. Dumping in Dixie: race, class, and environmental quality. Westview Press, Boulder, CO.

Clapp, J. 2012. The global reach of plastic waste. *In* Histories of the dustheap. *Edited by* S. Foote. MIT Press, Cambridge, MA. pp. 199–225.

Day, R. 1980. The occurrence and characteristics of plastic pollution in Alaska's marine birds. Doctoral dissertation, University of Alaska Fairbanks.

Day, R.H., Shaw, D.C., and Ingell, S.E. 1990a. The quantitative distribution and characteristics of marine debris in the North Pacific Ocean, 1984–88, *In* Proceedings of the Second International Conference on Marine Debris, 2–7 April 1989. NOAA Technical Memo, NMFS. NOAA-TH-NMFS-SWFSC-154. *Edited by* R. Shomura and M. Godfrey. Honolulu, HI.

Day, R.H., Shaw, D.C., and Ingell, S.E. 1990b. The quantitative distribution and characteristics of neuston plastic in the Northern Pacific Ocean, 1985–88, *In* Proceedings of the Second International Conference on Marine Debris, 2–7 April 1989. NOAA Technical Memo, NMFS. NOAA-TH-NMFS-SWFSC-154. *Edited by* R.S. Shomura and M.L. Godfrey. Honolulu, HI.

DeLong, R.L., Gearin, P.J., Bengtson, J.L., Dawson, P., and Feldkamp, S.D. 1990. Studies of the effects of entanglement on individual northern fur seals. *In* Proceedings of the Second International Conference on Marine Debris, 2–7 April 1989. NOAA Technical Memorandum, NMFS. NOAA-TM-NMFS-SWFSC-154. *Edited by* R.S. Shomura and M.L. Godfrey. Honolulu, HI. pp. 492–493.

Derraik, J.G.B. 2002. The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin, **44**: 842–852. doi:10.1016/S0025-326X(02)00220-5.

Divine, L., and Padula, V. 2020. Continuing a legacy of stewardship along our shorelines. *In* NOAA Marine Debris Program. Available from https://blog.marinedebris.noaa.gov/continuing-legacy-stewardship-along-our-shorelines[accessed 15 December 2021]

Divine, L.M., Melovidov, P.I., Lestenkof, A.P., Lestenkof, P.M., and Kochergin, M. 2020. Subsistence harvest of juvenile laaqudan (northern fur seals, *Callorhinus ursinus*) on St. Paul Island, Alaska in 2020. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 13pp.

Eriksen, M., Cowger, W., Erdle, L.M., Coffin, S., Villarrubia-Gómez, P., Moore, C.J., et al. 2023. A growing plastic smog, now estimated to be over 170 trillion plastic particles afloat in the world's oceans—urgent solutions required. PLoS ONE, **18**(3): e0281596. doi:10.1371/journal.pone.0281596. PMID: 36888681.

Fossi, M.C., Panti, C., Guerranti, C., Coppola, D., Giannetti, M., Marsili, L. et al. 2012. Are baleen whales exposed to the threat of microplastics? A case study of the Mediterranean fin whale (Balaenoptera physalus). Marine Pollution Bulletin, **64**: 2374–2379. doi:10.1016/j.marpolbul.2012.08.013.

Fowler, C.W. 1987. Marine debris and northern fur seals: a case study. Marine Pollution Bulletin, **18**: 326–335. doi:10.1016/S0025-326X(87)80020-6.

Garcia Rodrigues, J., Conides, A.J., Rivero Rodriguez, S., Raicevich, S., Pita, P., Kleisner, K.M., et al. 2017. Marine and coastal cultural ecosystem services: knowledge gaps and research priorities. One Ecosystem, **2**: e12290. doi:10.3897/oneeco.2.e12290.

Goldstein, T., Johnson, S.P., Phillips, A.V., Hanni, K.D., Fauquier, D.A., and Gulland, F.M.D. 1999. Human-related injuries observed in live stranded pinnipeds along the central California coast 1986–1998. Aquatic Mammals, **25**: 43–51.

Green, K.M., Beaudreau, A.H., Lukin, M.K., and Ardoin, N.M. 2022. Pathways to subsistence management in Alaska national parks: perspectives of harvesters and agency staff. People and Nature, **4**: 41664. doi:10.1002/pan3.10414.

Hanni, K.D., and Pyle, P. 2000. Entanglement of pinnipeds in synthetic materials at South-east Farallon Island, California, 1976–1998. Marine Pollution Bulletin, **40**: 1076–1081. doi:10.1016/S0025-326X(00)00050-3.

Hardesty, B., Wilcox, C., Lawson, T., Lansdell, M., and van der Velde, T. 2014. Understanding the effects of marine debris on wildlife. A final report to Earthwatch Australia. Canberra, Australia.

Hyrenbach, D., Nevins, H., Hester, M., Keiper, C., Webb, S., and Harvey, J. 2009. Seabirds indicate plastic pollution in the marine environment: Quantifying Spatial Patterns and Trends in Alaska. *In* Proceedings of the Marine Debris in Alaska Workshop In Edited byWILLIAMS and AMMANN University of Alaska Fairbanks Anchorage, USA: Alaska Sea-Grant.

Ivar do Sul, J.A., and Costa, M.F. 2014. The present and future of microplastic pollution in the marine environment. Environmental Pollution, **185**: 352–364. doi:10.1016/j.envpol.2013.10.036.

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., et al. 2015. Plastic waste inputs from land into the ocean. Science, **347**(6223): 768–771. doi:10.1126/science.1260352. PMID: 25678662.

Jochelson, W. 2003. History, ethnology and anthropology of the Aleut [1931]. University of Utah Press, Salt Lake City, UT.

June, J., and Antonelis, K. 2009. Marine habitat recovery of five derelict fishing gear removal sites in Puget Sound, WA. Report prepared by Natural Resources Consultants, Inc. for the Northwest Straits Initiative. Northwest Straits Foundation, Bellingham, WA. pp. 19.

Kandziora, J.H., van Toulon, N., Sobral, P., Taylor, H.L., Ribbink, A.J., Jambeck, J.R., and Werner, S. 2019. The important role of marine debris networks to prevent and reduce ocean plastic pollution. Marine Pollution Bulletin, **141**: 657–662. doi:10.1016/j.marpolbul.2019.01.034.

Kiessling, T., Salas, S., Mutafoglu, K., and Thiel, M. 2017. Who cares about dirty beaches? Evaluating environmental awareness and action on coastal litter in Chile. Ocean & Coastal Management, **137**: 82–95. doi:10.1016/j.ocecoaman.2016.11.029.

Laist, D.W. 1987. Overview of the biological effects of lost and discarded plastic debris in the marine environment. Marine Pollution Bulletin, **18**: 319–326. doi:10.1016/S0025-326X(87)80019-X.

Lavers, J.L., and Bond, A.L. 2017. Exceptional and rapid accumulation of anthropogenic debris on one of the world's most remote and pristine islands. Proceedings of the National Academy of Sciences of the United States of America, **114**(23): 6052–6055. doi:10.1073/pnas.1619818114.

Law of the Sea Convention. 1994. 1982 United Nations Convention on the Law of the Sea opened for signature 10 December 1982.

Law, K.L., Starr, N., Siegler, T.R., Jambeck, J.R., Mallos, N.J., and Leonard, G.H. 2020. The United States' contribution of plastic waste to land and ocean. Science Advances, **6**: eabd0288. doi:10.1126/sciadv.abd0288. PMID: 33127684.

Liboiron, M., Zahara, A., Hawkins, K., Crespo, C., de Moura Neves, B., Wareham-Hayes, V., et al. 2021. Abundance and types of plastic pollution in surface waters in the Eastern Arctic (Inuit Nunangat) and the case for reconciliation science. Science of the Total Environment, **782**: 146809. doi:10.1016/j.scitotenv.2021.146809.

Luna-Jorquera, G., Thiel, M., Portflitt-Toro, M., and Dewitte, B. 2019. Marine protected areas invaded by floating anthropogenic litter: an example from the South Pacific. Aquatic Conservation: Marine and Freshwater Ecosystems, **29**: 245–259. doi:10.1002/aqc.3095.

Macfadyen, G., Huntington, T., and Cappell, R. 2009. Abandoned, lost or otherwise discarded fishing gear. UNEP/FAO, Rome.

Macintosh, A., Simpson, A., Neeman, T., and Dickson, K. 2020. Plastic bag bans: lessons from the Australian Capital Territory. Resources, Conservation and Recycling, **154**: 104638. doi:10.1016/j.resconrec.2019.104638.

Merrell, T.R. 1980. Accumulation of plastic litter on beaches of Amchitka Island, Alaska. Marine Environmental Research, **3**: 171–184. doi:10.1016/0141-1136(80)90025-2.

Merrell, T.R. 1984. A decade of change in nets and plastic litter from fisheries off Alaska. Marine Pollution Bulletin, **15**: 378–384. doi:10.1016/0025-326X(84)90172-3.

National Research Council, Division on Earth and Life Studies, Polar Research Board, Commission on Geosciences and Committee on the Bering Sea Ecosystem. 1996. The Bering Sea ecosystem. National Academies Press, Washington, DC.

Phelan, A., Ross, H., Setianto, N.A., Fielding, K., and Pradipta, L. 2020. Ocean plastic crisis—mental models of plastic pollution from remote Indonesian coastal communities. PLoS ONE, **15**: e0236149. doi:10.1371/journal.pone.0236149. PMID: 32722705.

Polasek, L., Bering, J., Kim, H., Neitlich, P., Pister, B., Terwilliger, M., et al. 2017. Marine debris in five national parks in Alaska. Marine Pollution Bulletin, **117**: 371–379. doi:10.1016/j.marpolbul.2017.01.085.

Pownall, P.C. 1994. Australia's northern prawn fishery the first 25 years NPF25. Cleveland, Australia.

Public Law 116-224. 2020. Save our Seas 2.0 Act. Washington, DC, USA.

R Core Team. 2019. R: a language and environment for statistical computing. Vienna, Austria.

Redclift, M. 1996. Wasted: counting the costs of global consumption. Earthscan, London.

Richardson, K., Gunn, R., Wilcox, C., and Hardesty, B.D. 2018. Understanding causes of gear loss provides a sound basis for fisheries management. Marine Policy, **96**: 278–284. doi:10.1016/j.marpol.2018.02.021.

Rochman, C.M. 2016. Strategies for reducing ocean plastic debris should be diverse and guided by science. Environmental Research Letters, **11**: 041001. doi:10.1088/1748-9326/11/4/041001.

Rodríguez, Y., Ressurreição, A., and Pham, C.K. 2020. Socio-economic impacts of marine litter for remote oceanic islands: the case of the Azores. Marine Pollution Bulletin, **160**: 111631. doi:10.1016/j.marpolbul.2020.111631.

Ryan, P.G., and Swanepoel, D. 1996. Cleaning beaches: sweeping the rubbish under the carpet. South African Journal of Science, **92**: 275–276.

Ryan, P.G., Dilley, B.J., Ronconi, R.A., and Connan, M. 2019. Rapid increase in Asian bottles in the South Atlantic Ocean indicates major debris inputs from ships. Proceedings of the National Academy of Sciences of the United States of America, **116**(42): 20892–20897. doi:10.1073/pnas.1909816116.

Sheavly, S.B., and Register, K.M. 2007. Marine debris and plastics: environmental concerns, sources, impacts and solutions. Journal of Polymers and the Environment, **15**: 301–305. doi:10.1007/s10924-007-0074-3.

Spraker, T.R., and Lander, M.E. 2010. Causes of mortality in northern fur seals (*Callorhinus ursinus*), St. Paul Island, Pribilof Islands, Alaska, 1986–2006. Journal of Wildlife Diseases, **46**: 450–473. doi:10.7589/0090-3558-46.2.450.

Stoett, P., and Vince, J. 2019. The plastic-climate nexus: linking science, policy, and justice. *In* Climate change and ocean governance: politics and policy for threatened seas. *Edited by* P.G. Harris Cambridge University Press, Cambridge, UK. pp. 345–361.

Thompson, R.C., Swan, S.H., Moore, C.J., and Vom Saal, F.S. 2009. Our plastic age. Philosophical Transactions of the Royal Society B, **364**: 1973. doi:10.1098/rstb.2009.0054.

U.S. Census Bureau. 2019. Vintage 2019 population estimates[online]. Available from https://www.census.gov/search-results.html?searchType=web&cssp=SERP&q=St. St. Paul, AK.

United Nations Environment Programme. 2021. Neglected: environmental justice impacts of marine litter and plastic pollution. Nairobi, Kenya.

Veltre, D.W., and Veltre, M.J. 1987. The northern fur seal: a subsistence and commercial resource for Aleuts of the Aleutian and Pribilof Islands, Alaska. Études Inuit Studies, **11**: 51–72.

Vince, J., and Hardesty, B.D. 2018. Governance solutions to the tragedy of the commons that marine plastics have become. Frontiers in Marine Science, **5**: 214. doi:10.3389/fmars.2018.00214.

Vince, J., and Stoett, P. 2018. From problem to crisis to interdisciplinary solutions: plastic marine debris. Marine Policy, **96**: 200–203. doi:10.1016/j.marpol.2018.05.006.

Weinstein, J.E., Crocker, B.K., and Gray, A.D. 2016. From macroplastic to microplastic: degradation of high-density polyethylene, polypropylene, and polystyrene in a salt marsh habitat. Environmental Toxicology and Chemistry, **35**: 1632–1640. doi:10.1002/etc.3432.

White, D. 2003. Marine debris in Northern Territory waters, 2002. WWF Australia, Sydney, Australia.

Wilcox, C., Mallos, N.J., Leonard, G.H., Rodriguez, A., and Denise, B. 2016. Using expert elicitation to estimate the impacts of plastic pollution on marine wildlife. Marine Policy, **65**: 107–114. doi:10.1016/j.marpol.2015.10.014.

Worm, B. 2015. Silent spring in the ocean. Proceedings of the National Academy of Sciences of the United States of America, **112**: 11752–11753. doi:10.1073%2Fpnas.1513514112.

Yoshida, K., Baba, N., Kiyota, M., Nakajima, M., and Fujimaki, Y. 1990a. Studies of the effects of net fragment entanglement on northern fur seals. Part 2: swimming behavior of entangled and nonentangled fur seals. *In* Proceedings of the Second International Conference on Marine Debris, 2–7 April 1989. NOAA Technical Memorandum, NMFS. NOAA-TM-NMFS-SWFSC-154. *Edited by* R.S. Shomura and M.L. Godfrey. Honolulu, HI. pp. 503–512.

Yoshida, K., Baba, N., Kiyota, M., Nakajima, M., Fujimaki, Y., and Furuta, A. 1990b. Studies of the effects of net fragment entanglement on northern fur seals. Part 1: daily activity patterns of entangled and nonentangled seals. *In* Proceedings of the Second International Conference on Marine Debris, 2–7 April 1989. NOAA Technical Memorandum, NMFS. NOAA-TM-NMFS-SWFSC-154. *Edited by* R.S. Shomura and M.L. Godfrey. Honolulu, HI. pp. 494–502.