# Waste Free Waves:

## Assessing Marine Debris in the Proposed Chumash Heritage National Marine Sanctuary

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*Photo: Eleri Griffiths*

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NOAA

NATIONAL MARINE SANCTUARIES

PEMA Professional Environmental Management Association

A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management for the Bren School of Environmental Science & Management

## Signature Page

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

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As the First Peoples and original stewards of this land, efforts to preserve and protect this region's cultural heritage and ecological resources should always defer to, include, and prioritize Indigenous perspectives, people, and community needs. We encourage NOAA, along with all other agencies, local organizations and research institutions that conduct marine debris research and mitigation efforts in this region, to partner with and prioritize the needs of Indigenous communities, many of whom are located in underserved areas throughout this region and experience disproportionate effects of pollution.

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## Acronyms

**AB:** Assembly Bill

**ARIMA:** Autoregressive Integrated Moving Average

**BACI:** Before-After Control-Impact

**CHNMS:** Chumash Heritage National Marine Sanctuary

**CINMS:** Channel Islands National Marine Sanctuary

**GIS:** Geographic Information Systems

**IRB:** Institutional Review Board

**MBNMS:** Monterey Bay National Marine Sanctuary

**MDMAP:** Marine Debris Monitoring and Assessment Project

**MDP:** Marine Debris Program

**MDT:** Marine Debris Tracker

**NGO:** Non-Governmental Organization

**NMS:** National Marine Sanctuary

**NOAA:** National Oceanic and Atmospheric Administration

**ONMS:** Office of National Marine Sanctuaries

**SAC:** Sanctuary Advisory Council

**SB:** Santa Barbara

**SLO:** San Luis Obispo

**TIDES:** Trash Information and Data for Educations and Solutions

**TNC:** The Nature Conservancy

**WCRO:** West Coast Regional Office

## Abstract

California is both a major source of anthropogenic marine debris and an area particularly vulnerable to its damaging impacts. However, little is known about the quantities and impacts of marine debris in the proposed Chumash Heritage National Marine Sanctuary (CHNMS) along the central coast of California. This project, conducted by graduate students through the Bren School of Environmental Science & Management at the University of California, Santa Barbara, creates a baseline assessment of marine debris in the proposed CHNMS. It aims to inform the National Oceanic and Atmospheric Administration (NOAA) Sanctuaries West Coast Regional Office, along with sanctuary management partners and local communities, about local marine debris and potential management measures. Existing community science beach cleanup data and primary collected data were analyzed to understand spatial patterns in quantities and types of marine debris. We found that plastic debris is the most common material type; areas with the greatest debris densities are likely the Morro Bay, Avila Beach, Five Cities, and Gaviota Coast areas. Smoking, eating, and drinking are major activities that contribute to coastal debris in this region. Alongside this quantitative analysis, analyses of policies and interviews with agencies, local organizations, research institutes, and Indigenous communities revealed that current policies may not be effective at reducing marine debris, despite strong concern for marine debris and its impacts on the coastal environment in this region. Based on these findings, we recommend streamlining debris collection protocols with standardized debris categories and effort metrics, implementing innovative policies to reduce marine debris sources, ensuring co-stewardship of the CHNMS to include and prioritize Indigenous perspectives, and conducting additional research on marine and land-based sources of debris. These recommendations will enhance monitoring and mitigation of marine debris in the CHNMS.

## Key Words

Marine Debris, National Marine Sanctuary, Chumash Heritage National Marine Sanctuary, Tribal Collaborative Management, Co-Stewardship, Beach Cleanups, Community Science, Citizen Science, Data Harmonization, Policy Analysis

# 1. Background

## 1.1. Marine Debris

### *1.1.1. A Global Issue*

Marine debris is a global phenomenon that is pervasive in coastal and marine environments around the world. It is defined as "any persistent, solid material that is manufactured or processed and directly or indirectly" added to a coastal or marine environment (NOAA MDP, 2023a; UNEP, 2009). Marine debris can include plastics, metal, rubber, and textiles, in addition to derelict fishing gear and abandoned vessels. It has been documented worldwide, from remote mountain catchments to the polar regions (Allen et al., 2019; Obbard, 2018).

Marine debris comes from multiple sources. These sources are typically divided into land-based and ocean-based activities. Land-based sources include littering, illegal dumping, and leakage from mishandled waste bins, and are typically influenced by local human population size, the level of public beach access, and proximity to watersheds and upstream sources of debris (EPA, 2023). Ocean-based marine debris typically comes from fishing vessels dumping or losing fishing gear, trash dumped from cruise ships, lost shipping containers, and debris from offshore oil and gas work or aquaculture (NOAA, 2024). Both types of debris can be affected by ocean processes and currents, leading debris to sometimes wash up on the coast far from its original source (van Sebille et al., 2012; Shigeru, 2023).

Globally, the damaging impacts of marine debris on ecosystem health, public health, and the economy have been extensively researched and reported since the 1960s (Barnes et al., 2009; Kenyon and Kridler, 1969; Thompson et al., 2004). These adverse effects include but are not limited to: plastic ingestion by and entanglement of marine birds, mammals, and fish; the leaching of toxins into marine environments; hazards to ships; declines in commercial fishery productivity due to increasingly contaminated catches and equipment damage; loss of tourism income; and increased costs of cleanup operations (GESMAP, 2015; Pettipas et al., 2016; Thompson, 2017; Webb et al., 2013; Wootton et al., 2022; World Wildlife Fund, 2015; Zhang, 2017). Some of the most common and harmful types of marine debris are plastics, as well as derelict fishing gear, such as fishing lines and ghost nets (NOAA MDP, 2023a; 2023c).

### *1.1.2. Plastic Debris*

Plastic debris is by far the most common and one of the most harmful types of marine debris (NOAA MDP, 2023a). It is estimated that between 4.8 and 12.7 million metric tons of plastic enter the oceans each year (Agamuthu et al., 2019; Jambeck et al., 2015; Ocean Conservancy, 2021), causing up to 33,000 US dollars in annual economic impacts per ton of marine plastic (Beaumont et al., 2019).

There are two main types of plastic debris in the marine environment: macro- and microplastics. Macroplastic is commonly defined as any plastic debris greater than 5 mm across the object's longest axis, such as cigarette butts, plastic bags, and food wrappers (Langridan et al., 2020). Microplastic is typically defined as plastic debris smaller than 5 mm and is estimated to make up 92 percent of the plastic particles on the ocean's surface (Coyle et al., 2020). Microplastics may be discharged into the ocean from personal care products, synthetic textiles, or breakdown from macroplastics through physical, chemical, and biological processes (Coyle et al., 2020).

As macroplastics break down into microplastics, they can be more easily taken up by organisms, accumulated through the food chain, and consumed by humans (Landrigan et al., 2020). This accumulation has public health implications, as plastics can contain harmful manufactured chemicals. These chemicals include phthalates, bisphenol-A (BPA), flame retardants, and perfluorinated chemicals, which can cause health conditions such as cancer or disruption of the nervous, endocrine, and reproductive systems (Landrigan et al., 2020). Further, once in the ocean, microplastics can also bind to, absorb, and spread toxic chemicals and pollutants from other sources, such as PAHs, PCBs, DDT, toxic metals, hazardous bacteria, and other disease-causing pathogens (Hou et al., 2023; Landrigan et al., 2020). These pollutants also have negative public health impacts; exposure to microplastic-contaminated water through both direct and indirect activities puts communities at risk of contracting illnesses (Landrigan et al., 2020). Furthermore, disadvantaged and low-income communities are disproportionately impacted by the effects of plastic pollution (Plastic Pollution Prevention and Packaging Producer Responsibility Act, 2022). As a result of these disproportionate impacts and the extensive environmental and public health implications, agencies, organizations, and communities are prioritizing the monitoring and mitigation of plastic debris (NOAA MDP, 2024).

### 1.2. Monitoring Marine Debris

Coastal marine debris can often be collected and counted through beach cleanup activities. These efforts include citizen science or community science data collection programs, which allow community members and scientists to collaborate to conduct scientific research (Association of Science and Technology Centers, 2021). Community science marine debris programs that cover Central California include Marine Debris Tracker (MDT), the Surfrider Foundation's program, and the Ocean Conservancy's

Clean Swell app, which sends data to the Trash Information and Data for Education and Solutions (TIDES) database. These systems allow users to document the debris they collect along the coastline (Marine Debris Tracker, n.d.; Ocean Conservancy, 2023; Surfrider, 2023). However, community science programs use a variety of different collection and categorization methodologies, which makes macro-debris comparisons between studies, regions, and databases difficult. As a result, the impacts of debris collection programs could be greatly enhanced by more strategic sampling designs (Krone et al., 2023).

The lack of methodology standardization also presents a challenge for comparing research from microplastics studies. Methods of sampling and analyzing sediment samples for microplastics vary widely due to expense, accessibility, efficiency, and complexity. Sampling techniques include a variety of different extraction strategies, although a large number of microplastic sediment studies have focused on the high tide and/or strand lines (Hidalgo-Ruz et al., 2012; Van Cauwenberghe et al., 2015). Analysis techniques for projects with higher budgets, and those with access to certain facilities, often use more expensive and time-consuming methods, such as mass spectrometry or Fourier transform infrared spectroscopy. By contrast, studies with less funding use methods more prone to human error, such as identification of microplastics using a microscope, which can inhibit accurate results (Coppock et al., 2017). These differences prevent inter-study comparisons and accurate analysis of long-term data trends (Storrier et al., 2007). In addition, lack of standardization of methods makes it difficult to compare the scope of the microplastic debris problem across different geographic locations. Further, it presents a challenge for developing metrics on which to evaluate the success or failure of various mitigation approaches.

However, studies across the globe have shown that microplastics are ubiquitous in coastal and marine environments, and abundances of microplastics are correlated with areas of high human activity and population centers, which are also major sources of macro-debris (Masiá et al., 2021). Additionally, collection and remediation of existing macroplastic debris can prevent future breakdown into microplastics (Steele and Miller, 2022). Consequently, focusing on monitoring and mitigation of macroplastics can have cascading benefits, reducing the amount of microplastics entering the environment.

### 1.3. Mitigating Marine Debris

Despite the well-known environmental and human health impacts of marine debris, mitigation efforts vary widely from regional to international scales. Beach cleanups, both a monitoring and mitigation strategy, can be implemented on regional to national-scale efforts to remove coastal marine debris. These events are organized by community groups, non-governmental organizations (NGOs), and government initiatives, such as the California Coastal Commission's annual Coastal Cleanup Day in September. However, many of these mitigation efforts are critiqued as short-term solutions that address some, but not enough, aspects of the marine debris problem (Agamuthu et al., 2019). Beach cleanups, for example, do not address local and regional issues of the continuous inflow of pollutants, nor the global scale of the debris problem. Further, these approaches largely focus only on shorelines easily accessible from land (Krone et al., 2023), and do not account for private or inaccessible areas, therefore not providing clear insights on debris below the tide line or along private or remote coastlines. Potential avenues for future mitigation at all scales include legal action and policy, education, outreach and raising awareness, source identification, increased monitoring, and further research (Pettipas et al., 2016). Improving trash management and developing and increasing stewardship strategies, including end-of-life solutions (Krone et al., 2023), for plastic products, which make up the majority of marine debris globally, are also needed (NOAA MDP, 2023a).

As mitigation efforts continue to develop, national and state policies to reduce marine debris have increased in recent years. At the national level, the Marine Debris Research, Prevention, and Reduction Act (2006) was amended in 2012, 2018, and 2020 (Marine Debris Act Amendments, 2012; Save Our Seas Act of 2018, 2018; Save Our Seas 2.0 Act, 2020). These amendments aim to support marine debris programs as well as mitigation and monitoring efforts (NOAA MDP, 2023b). Additionally, the NOAA Marine Debris Program (MDP) recently released the United States Marine Debris Emergency Response Guide, which aims to improve preparedness for response and recovery operations from natural disasters that generate large amounts of marine debris (NOAA MDP, 2023c). On the local and state levels, waste reduction policies have largely been aimed at reducing single-use plastics, such as Grover Beach's ban on expanded polystyrene takeout containers (Ordinance No. 18-01, 2018). At the state level in California, Senate Bill 54 was passed in 2022, and stipulates statewide reductions in plastic production, consumption, and waste by 2032 (SB No. 54, 2022). However, despite calls from environmental groups, there is no current legislation in California on entirely banning single-use plastics across the state (Rust, 2022).

### 1.4. Marine Debris in Central California

With 3,400 miles of coastline including major metropolitan and remote areas, California is the most populous state in the United States and also contains the most plastic processors (OECD, 2023). It also supports large fishing and coastal tourism industries. These factors make California both a major source of marine debris and an area vulnerable to its damaging impacts.

A large body of research exists on the sources, distribution patterns, and impacts of marine debris in California, with a strong focus on Southern California coastal and marine environments, including from Point Conception through San Diego (Moore and Allen, 2000), as well as the Channel Islands (Steele and Miller, 2022), and the California Current System (Gilfillan et al., 2009; Good et al., 2020). Central to Northern California has also been a focus of research, including the Monterey Bay region (Krone et al., 2023; Rosevelt et al., 2013; Weber et al., 2019) through San Francisco (Moore et al., 2009). Many of these studies have focused on the spatial and temporal patterns of marine debris (Krone et al., 2023; Moore and Allen, 2000; Rosevelt et al., 2013), the impacts of marine debris on marine mammals and birds (Good et al., 2020; Moore et al., 2009), and sources and types of debris (Weber et al., 2019). These studies focus on a variety of coastal and marine environments, including shorelines, open ocean currents, and the seafloor. However, few studies cover the Central Coast of California, although in the proposed Chumash Heritage National Marine Sanctuary (CHNMS) marine debris has been identified as a key threat to the area's natural, cultural, and historical resources (NOAA, 2023).

### 1.5. National Marine Sanctuaries in California

California is home to four existing national marine sanctuaries (NMSs), which are managed by the NOAA Office of NMSs (ONMS) West Coast Regional Office (WCRO), that protect both coastal and offshore marine ecosystems, including estuaries, kelp forests, benthic communities, and seamounts. These sanctuaries provide important habitats for a diverse array of marine species. They are located in the areas surrounding the Channel Islands, Cordell Bank, Greater Farallones, and Monterey Bay.

The CHNMS would be the fifth NMS in California. This proposed NMS includes the ancestral land of the Chumash and Salinan Tribes and is the first to be nominated by a community coalition led by an Indigenous group (CHNMS, 2022; Federal Register, 2021). If designated, the CHNMS would recognize and bring important protections to the coastal waters off of Indigenous lands and cultural heritage sites. It would also bring increased protections to an internationally-significant ecological transition zone, where northern temperate waters meet subtropical waters to create a major biogeographic boundary that provides critical habitat for a variety of marine mammals, invertebrates, sea birds, and fish (NOAA ONMS, 2023).

All four existing NMSs in California mention or address, to some degree, the problem of marine debris in their management plans (NOAA ONMS, 2021; 2014; 2009; 2008), and the WCRO works closely with the NOAA MDP to monitor and mitigate marine debris in all of the west coast sanctuaries. In Monterey Bay NMS (MBNMS) and Channel Islands

NMS (CINMS) specifically, both have established ongoing marine debris monitoring programs with support from the NOAA MDP. MBNMS also has an active, acclaimed water quality protection program that works with diverse communities to prevent or reduce the influx of harmful pollutants and debris flowing into the sanctuary from its coastal watersheds. Additionally, MBNMS recently published a comprehensive Marine Debris Report which uses community science beach cleanup databases to quantify marine debris within the sanctuary (Krone et al., 2023). This work provides a roadmap for data standardization that will lead to better comparisons of marine debris across sanctuaries and regions.

### 1.6. Tribal Collaborative Management and Marine Debris

Tribal co-stewardship, co-management, and collaborative management are all terms used to refer to working relationships between the US government and Tribes (Bureau of Land Management, 2022). Currently, the US government prefers the term co-stewardship, as it refers to a broad range of management relationships (Bureau of Land Management, 2022). Co-management specifically refers to an official relationship between the US federal government and federally-recognized Tribes that grants the Tribes co-management authority (Department of the Interior, 2022). Collaborative management, on the other hand, refers to a less formal arrangement and is more inclusive of non-federally recognized Tribes (Donoghue et al., 2010; Sams III, 2022). Collaborative management often includes contracts, memoranda of understanding, and partnership agreements between Tribes and Indigenous groups and federal agencies.

NOAA is prioritizing Tribes' and Indigenous groups' involvement in the CHNMS via collaborative management to highlight and recognize the cultural and social ties they have had to the Central California coast for tens of thousands of years (CHNMS, 2022; NOAA ONMS, 2023; Pellowe and Leslie, 2021). According to the sanctuary's draft management plan, this involvement would include collaboration with federally and non-federally recognized Tribes and Indigenous groups to make management decisions, protect important cultural sites, incorporate traditional ecological knowledge to reach shared conservation goals, and more. The draft management plan also describes the initial collaborative management framework that would guide this work. Within the Sanctuary Advisory Council (SAC), which is tasked with providing advice and recommendations for sanctuary management, there would be at least one voting seat for federally recognized Tribes and one to three additional voting seats to "represent the knowledge, history, and culture of the Indigenous community" (NOAA ONMS, 2023, p.9). Another proposed element is the development of an Intergovernmental Policy Council, which would engage in collaborative management with federally recognized Tribes and focus on Tribal priorities and opportunities. The sanctuary also envisions creating an Indigenous Cultures Advisory Panel, which would bring federally and non-federally recognized Tribes and those with Indigenous cultural knowledge together to advise the SAC on Indigenous cultural issues, opportunities, and priorities. NOAA emphasizes that this framework is still in development, and will likely evolve over time (NOAA ONMS, 2023). However, the Indigenous knowledge and stewardship of this region is invaluable for creating an equitable and sustainable management plan for this sanctuary, and more broadly for incorporating Indigenous perspectives in the international effort to conserve 30 percent of the world's land and waters by 2030 (CHNMS, 2022).

While collaborative management is used throughout the CHNMS's draft management plan, there are also marine debris-specific efforts that are community- and Tribally-led. The Tribal Marine Stewards Network is an alliance of west coast Tribes dedicated to implementing Indigenous Tribal Knowledge and Tribal science in coastal management practices and conserving coastal resources (Tribal Marine Stewards Network, 2022). A part of this work includes surveying and monitoring various beaches (Tribal Marine Stewards Network, 2022). NOAA has also partnered with Indigenous groups to manage marine debris through the MDP (NOAA MDP, 2022). This partnership involves working with Indigenous groups in the Pacific Northwest to remove and prevent marine debris in areas such as the Olympic Coast NMS (NOAA MDP, 2022).

## 2. Significance

The ubiquitous and harmful nature of marine debris has motivated a sustained increase in marine debris monitoring and mitigation research and funding, especially for plastics, over the past several decades. For example, in the United States, all existing west coast NMSs have marine debris priorities within their management plans, and MBNMS recently conducted extensive research on marine debris (Krone et al., 2023). Building on lessons from these prior efforts, the proposed CHNMS is working to develop robust *a priori* marine debris monitoring and mitigation efforts within its Water Quality Action Plan (NOAA ONMS, 2023). In this plan, the CHNMS has a specific strategy focusing on the assessment and reduction of marine debris, with special attention to plastic debris due to its especially harmful nature.

Meeting these objectives is challenging, however, because the Central Coast of California is lacking in marine debris research and assessments compared to other areas of coastal California. Consequently, there are large knowledge gaps in our understanding of marine debris quantities, types, and spatial distributions, as well as in our understanding of the effectiveness of current efforts to reduce future marine debris within the proposed CHNMS's boundaries. Having a baseline understanding of these challenges and their potential solutions is essential for finalizing CHNMS's management plan and enhancing the wellbeing of local communities, ecosystems, and economies through marine debris research, monitoring, and mitigation.

This study aims to assess marine debris and policies in the proposed CHNMS to address the knowledge gaps in this geographic area regarding marine debris quantities, types, and spatial distributions relative to Tribal, agency, and local community concerns. This holistic assessment will inform the NOAA Sanctuaries WCRO and its CHNMS management partners in their effort to establish a robust marine debris monitoring and mitigation program that could be a global model for effective coastal management.

## 3. Objectives

The primary aim of this project was to aid the NOAA ONMS WCRO in analyzing marine debris accumulation and spatial patterns within the largest possible boundaries for the CHNMS. These boundaries incorporate the Initial Boundary Alternative as well as the Gaviota Coast Extension from the Agency-Preferred Alternative, stretching from the southern edge of MBNMS to Naples, California (Figure 1). This research allows the WCRO to track marine debris levels in CHNMS pre- and post-designation, and compare these levels to other west coast sanctuaries, including the CINMS and MBNMS, which are adjacent to the proposed CHNMS to the south and north, respectively.

Specific objectives of this study included:

1. Conducting a baseline assessment of marine debris, including identifying hotspots and types, in the proposed CHNMS
2. Analyzing the impacts of existing local coastal management practices and policies through research and interviews to understand current efforts and community needs and priorities to reduce marine debris
3. Recommending monitoring and mitigation strategies for the proposed CHNMS that center around Indigenous and local community engagement

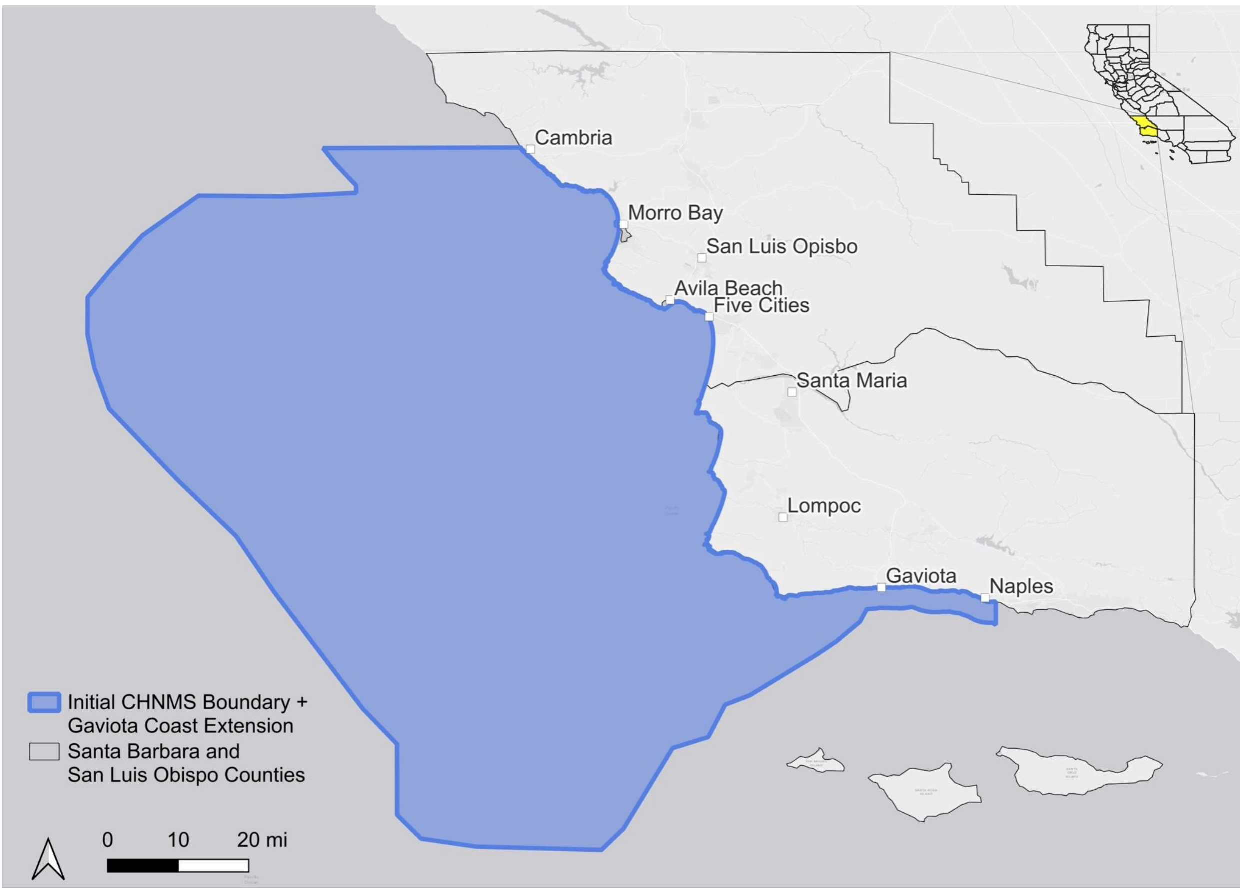



***Figure 1.*** *The study area of this project, which includes the coastline of the Initial Boundary Alternative as well as the Gaviota Coast Extension for the proposed CHNMS.*

# 4. Methods

## 4.1. Primary Data Collection

### *4.1.1. Identifying Data Gaps*

To address data gaps within the existing publicly-available beach cleanup data in the study area, we collected primary data in areas with few or no existing recorded cleanups. These areas primarily included private lands including Vandenberg Space Force Base, The Nature Conservancy (TNC)'s Jack and Laura Dangermond Preserve, and Hollister Ranch (Figure 2).

### *4.1.2. Methodology Selection*

To collect these data, we assessed several different publicly-accessible cleanup protocols to determine the most appropriate methodology for this study and future monitoring efforts within the region. The Marine Debris Monitoring and Assessment Project (MDMAP) was recommended by NOAA staff (Kehoe, pers. comm., July 2023; Burgess et al., 2021), and ultimately used because it was the most scientifically-rigorous method that still remained accessible and user-friendly. Using MDMAP also contributes to the MDP's effort to create a national-scale database for marine debris.

### *4.1.3. Site Selection*

After narrowing down potential study areas to stretches of coastline that had minimal pre-existing marine debris data, we selected specific sites based on beach accessibility and fitness for utilizing the MDMAP protocol. Google Earth was used to examine the coastline along the proposed CHNMS to find sites that were easily accessible from public roads and at least 100 meters wide. Many of these areas were on private lands, which required permission to access, and many of these areas also had limited access during our collection period (August to October 2023) due to snowy plover nesting season. These factors led to the selection of particular sites located within the private lands of TNC's Jack and Laura Dangermond Preserve, Vandenberg Space Force Base, and Hollister Ranch. Each of these areas had their own unique set of permitting requirements.

### *4.1.4. Field Collection*

The MDMAP protocol consists of several standardized steps (Burgess et al., 2021). First, sites were selected which had clear, direct access throughout, within a continuous 100-meter section of shoreline, and marked by some kind of permanent landmark to help others identify and return to that survey site over time. Materials used for surveying included: two plastic buckets (one for carrying equipment and one for collecting debris), measuring instruments (one 100-meter measuring tape and one measuring wheel), a clipboard, pen or pencil, survey sheets (four per site, one sheet per transect), gloves, and four-by-five inch surveying flags.

Using NOAA's shoreline survey guide, we recorded information about the 100-meter site's slope, primary substrate, back barrier, and beach width, along with the coordinates for the four corners of the site (Burgess et al., 2021). After measuring out the 100-meter site and marking off the edges with red flags, four five-meter-wide transects were marked off using surveying flags. These transects were chosen from a list of randomized transect numbers supplied to us by NOAA's Marine Debris team. Once the transects had been selected and marked off, they were scanned one-by-one for debris. To scan the transect, surveyors would start at the water's edge and position themselves on the outside edges of the transect, looking in towards the center of the transect as they searched for debris and walked to the back barrier. Any debris larger than 2.5 cm found was recorded before being collected. It was also noted if each piece of debris was found on the main beach or in the back barrier. If debris was smaller than 2.5 cm it was collected and recorded in the "custom" category.

#### *4.1.5. Data Digitization and Cleaning*

Once collected, we manually entered the data into a spreadsheet with a separate row for each cleanup and columns for each MDMAP debris type category. The spreadsheet was modeled on the standard MDMAP spreadsheet used in NOAA's database. All primary collected data were also uploaded to the MDMAP database online.

### 4.2. Data Harmonization and Analysis

#### *4.2.1. Obtaining Existing Data*

We used existing data from self-reported beach cleanup community science databases (Figure 2). The three organizations that had collected and provided these data for our study area were:

1. *Surfrider Foundation*
   The Surfrider Foundation is a nonprofit organization that, among other activities, supports a volunteer network in conducting beach cleanups across the United States (Surfrider Foundation, 2023). Their beach cleanup data are a result of these volunteer efforts, each led by a local chapter or student club. Often, volunteers are trained in Surfrider's data collection methodology prior to

conducting a cleanup in an effort to increase the quality of collected data. The Surfrider Foundation maintains a queryable online database of results, although results are not downloadable. Data come from submitted report forms. Data were available for Santa Barbara (SB) and San Luis Obispo (SLO) Counties for January 2018 through October 2023.

2. *Marine Debris Tracker (MDT)*
   MDT is powered by Morgan Stanley in partnership with National Geographic and the University of Georgia, but is an "open data citizen scientist" platform for debris cleanup internationally, both inland and along the coasts (MDT, n.d.). Data were available for January 2015 through November 2023 along the Central Coast of California.

3. *Trash Information for Data and Education Solutions (TIDES)*
   TIDES is run by the Ocean Conservancy and contains global marine debris data. The database comes from community science data submitted by individuals and cleanup groups (Ocean Conservancy, 2023). Data can be submitted via paper cards manually entered on the website, the Ocean Conservancy's mobile data collection app (Clean Swell), or emailed to the Ocean Conservancy. Data were available for January 2016 through November 2023 for SB and SLO Counties.

#### *4.2.2. Cleaning Data*

We used RStudio to prepare the community science data for analysis (R Core Team, 2023; RStudio Team, 2020). We cleaned data from Surfrider, MDT, and TIDES by first creating one dataset per source and formatting each dataset to ensure each row represented a single beach cleanup. We then filtered data to include only the cleanups located along the coastline within the proposed CHNMS, including data from the greatest potential sanctuary boundary extents, extending from Cambria to Naples. We used QGIS, an open-source Geographic Information System (GIS) software for spatial analyses (QGIS, 2023). A buffer of one mile (created in QGIS) was used to remove debris records that fell within the ocean or further than one mile inland from the coast. We selected the one-mile buffer to ensure all relevant coastal cleanups were included, while eliminating cleanups that more likely happened inland. This buffer distance accounted for variation in beach depth. It also helped ensure cleanups along irregular stretches of coastline were included, as well as areas where poor cellular signal inhibited recording cleanup data while directly on the beach.

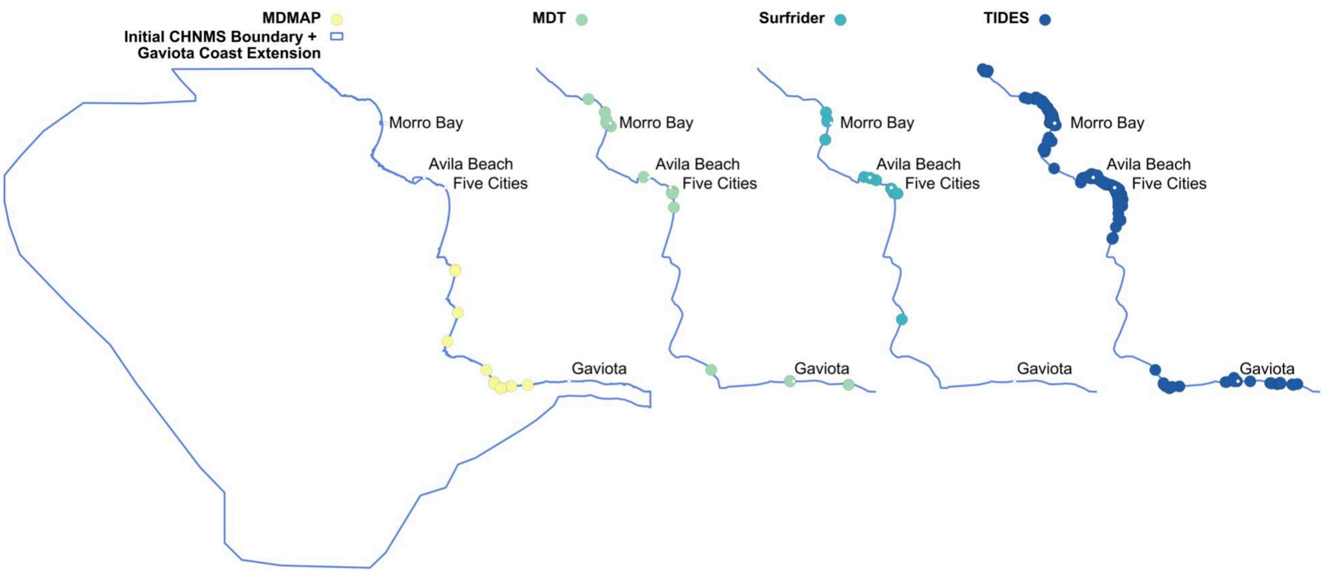



***Figure 2.*** *The spatial distribution and quantity of both our primary collected data using the MDMAP protocol (left) as well as existing data in this region collected using MDT (second from left), Surfrider (second from right), and TIDES (right).*

We removed identical entries, likely identical entries, and incongruent entries within each dataset. Two people separately reviewed all entries, and reached an agreement as to whether or not an entry should be deleted. Within each dataset, all entries were manually reviewed, starting with the date column. If the date matched on two or more entries, we reviewed additional columns, including number of people, location, total number of pieces of trash, total weight of trash, and number of cigarettes. If these columns were identical, we removed the first entry in the dataset. If they were clearly different cleanups, we preserved both/all the original entries. If the additional columns were very similar and it was still unclear if the entries were potentially duplicates, we reviewed additional item type columns, and a decision was made based on two peoples' best interpretations.

After addressing duplicates within datasets, we conducted a spatial review in QGIS to eliminate any duplicates between datasets. If there were two cleanups that took place on the same date in the same location from different data sources, the aforementioned process of reviewing additional columns was followed to delete identical entries.

We also combined some observations within the TIDES dataset into single cleanups. This combination occurred when a cleanup was conducted by the same group or person on the same date in a similar location, but the item counts were completely different. In these cases, we used the first location, and we summed the items between the observations to create one compiled cleanup entry. This was done as it was assumed user error led to the creation of multiple cleanups.

#### *4.2.3. Data Harmonization*

Given the large differences in data collection protocols across methodologies, it is important to assess the merits of different debris assessment methodologies. Each dataset was structured differently and had different categories for debris types. Surfrider had 86 item categories, MDT had 54, TIDES had 61, and MDMAP had 50. Prior to analyzing the data, harmonization of debris categories between datasets was necessary to combine the four datasets into one.

We used MBNMS's marine debris report as a starting point for the harmonization process to ensure comparability between the CHNMS and the MBNMS (Krone et al., 2023). The 41 categories from their report were used as the initial categories for our analysis, and we then added additional categories based on special interest and context from the Central Coast; regulations in SLO and SB Counties; and Indigenous, community, and NOAA priorities. We added a category if it was of special interest and was present in at least two of the three existing datasets (MDT, TIDES, and Surfrider). Additionally, we removed some categories. We removed a category if it was not present in at least two of the three datasets. After these adaptations, we had 40 final item categories that we reclassified the debris from each dataset into. The changes that we made to adapt MBNMS categories to our 40 categories included:

1. Removed "toys" as an item category, as only TIDES has the category. Toys were added to the "miscellaneous" category.
2. Removed "dog waste bags" as an item category, as only Surfrider has the category. Dog waste bags were added to the "miscellaneous" category.
3. Removed "appliances" as an item category, as only TIDES has the category. Instead, appliances were added to the "miscellaneous" category.
4. Renamed the category "packaging smoking" to "Packaging and other smoking" to better encompass the items in the category, as items in the category include lighters, cigar tips, and wrap, when they were not separated into individual categories.
5. Renamed the category "shotgun wads" to "shotgun wads and shells" to include shotgun shells.

6. Renamed the category “buoys, pots, and traps” to “buoys, pots, traps, and floats” to include floats.
7. Renamed the category “fishing net” to “fishing net and rope” to include rope items.
8. Separated the “bag” category into “plastic bags” and “paper bags” based on policy interest, and the fact that all datasets differentiated between paper and plastic.
9. Separated the “takeout food container” category into “plastic takeout food containers” and “paper takeout food containers” based on policy interest, and the fact that two of the datasets had paper takeout food categories.
10. Classified glass jars as foodware instead of bottles for both MDMAP and MDT data.

We sorted all of the data into six material type categories. We did this reclassification because each dataset had different classifications or did not classify a material type for each item. To understand what material types were the most prevalent, we used the six categories from MBNMS’s report for classification for comparability between sanctuaries, although we listed foam within the plastic category as opposed to its own category. These categories consequently were:

1. Plastic: plastic items as well as items made of foam and rubber. Based on guidance from MBNMS, rubber was included here because of the prevalence of petroleum-based synthetic rubber. Examples of plastic items include plastic fragments, plastic bags, tires, and foam fragments.
2. Cloth: examples include cloth masks, clothing, fabric rags, and towels.
3. Glass: examples include glass jars, glass fragments, and glass beverage bottles.
4. Metal: examples include metal bottle caps, aluminum cans, and aerosol cans.
5. Mixed: items that were made up of more than one material, or items that did not have a clear material type. Examples include shoes and clothes, juice boxes, and fishing pots and traps.
6. Paper/wood: examples include paper bags, lumber, and paper plates and cups.

The assignment of data into these six categories was based on the material type each dataset classified each item as. If a dataset did not specify the material type for a particular item, we assigned the material type that MBNMS used for that item. If the datasets had conflicting classifications, we used MBNMS’s category, or adjusted based on our best judgment for consistency.

We also sorted the data into seven activity type categories to assess the debris associated with different activities that lead to its presence on the beach. Connecting marine debris to its potential sources can help connect the beach cleanup data to associated policies, management strategies, and qualitative observations that could reduce impacts in the future. We used the seven categories from MBNMS's report for consistency across sanctuaries. These categories were:

1. Eating and drinking: items associated with food or beverage consumption. Examples include glass jars, plastic bottles, utensils, and takeout containers.
2. Smoking: items associated with smoking. Examples include cigarette butts, vape cartridges, and wrappers or packaging from smoking products.
3. Dumping: items that may have been dumped or washed down to the beach. Examples include appliances, construction items, tires, and treated wood.
4. Fishing: items that are primarily used when fishing offshore or from land. Examples include buoys, hooks, lures, lines, and nets.
5. Personal hygiene: items associated with personal protective equipment or sanitation. Examples include masks, gloves, condoms, and diapers.
6. Recreation: items associated with recreation activities besides eating and drinking, smoking, and fishing. Examples include balloons, toys, and dog poop bags.
7. Various: items associated with more than one, or none, of the other categories. Examples include fragments of various material types (plastic, glass, etc.) that could not be identified or associated with a particular item or activity.

If the activity type for a particular item was not evident from the description, we assigned the activity type that MBNMS used for that item. If the datasets had conflicting classifications, we used MBNMS's category, or adjusted based on our best judgment for consistency.

#### *4.2.4. Summary Statistics*

After harmonizing the data, we ran summary statistics to see what types of debris were the most and least prevalent. We examined data by cleanup, material type, activity type, and item type. For cleanups, we tracked the total number of cleanups, years, volunteers, and items. We summed the number of items counted in each material type category across the entire dataset and divided by the total number of items collected to produce the percentage of items of each material type. We repeated the same steps for activity type categories. We summed the total count of items found for each item type to understand how common different types of debris are. We then did a dataset-specific analysis to extract the top five most frequently-found item types within each original dataset. We also extracted the top five most frequently-found item categories within the eating and drinking activity category from each original dataset to get a better understanding of what items are the most common eating- and drinking-related debris.

### *4.2.5. Hotspot Analysis*

We also conducted a hotspot analysis to understand the spatial distribution of marine debris accumulations. Most traditional methods of hotspot analysis use factors such as the amount of area cleaned or distance cleaned to account for effort and to standardize analyses (Serra-Goncalves et al., 2019). Using the number of people involved in a cleanup and days since the last cleanup in the area are also common practices for standardizing data. Further, data are ideally distributed relatively evenly across the study area (Hardesty et al., 2017).

These conditions posed several significant data challenges for this project. Not all cleanups had associated distance values, and MDT does not record the number of people that participated in a cleanup. Furthermore, since we did not have distance or area for some cleanups, and only MDMAP cleanups had starting and stopping locations, we could not estimate when a particular area was last cleaned. Lastly, data were not distributed evenly across the study site. These limitations prevented us from running a typical hotspot analysis. Consequently, we instead utilized MBNMS's hotspot analysis methodology to ensure comparability between the two sanctuaries' results (Krone et al., 2023). We started by dividing the coastline into 15 equal segments of about 9.1 miles each, and classifying each beach cleanup into one of the segments. The segments were determined based on geographic features. Cities were kept within single segments, and private areas, including Vandenberg Space Force Base and TNC's Jack and Laura Dangermond Preserve, were in their own segments as well to ensure accuracy of analysis. Further, the 9.1 mile segment length was similar to the length of MBNMS's segments.

We calculated trash density, the total number of pieces of trash divided by the segment length, for each segment. Then, we ran three hotspot methodologies, each using a different metric to account for effort. We utilized three different methodologies so comparisons in debris density could be made, as different effort metrics can lead to dramatically different estimates of debris density. The first approach used events as a metric for effort. The average number of items per cleanup was calculated for each segment. The second methodology used the number of people as a metric for effort. The average number of items per person was calculated for each segment, excluding the MDT data that did not record the number of people. The third methodology was more similar to a typical hotspot analysis. It used distance as a metric for effort. The average number of items per mile was calculated for each segment, using only data from TIDES and MDMAP, as those were the datasets that included a distance metric.

Then, we visualized all four calculations for comparison and analysis. For the segments with the greatest debris density across the three hotspot methodologies, we ran summary statistics to determine what material types and source activities were the most common in each hotspot. We used contingency tables to determine if there were differences in material and activity type frequency between hotspots.

### 4.3. Policy Research and Analysis

We conducted a review of policies at the city and county level throughout the sanctuary area, as well as a review of California statewide policies, to understand how enacted regulations may affect the composition and quantity of marine debris along the coast of the proposed CHNMS. Specifically, we looked for policies that affect solid waste that were promulgated during our study period of 2015-2023. Policies enacted between 2019 and 2021 were prioritized in order to ensure enough data were present before and after the regulation's implementation for further analysis.

We searched county, city, and state agency websites to identify relevant policies. Search terms used initially included "waste," "plastic," and "ban." Once we discovered patterns in the types of materials being banned we used additional search terms, including "bag," "styrofoam," "EPS," "straw," and "utensil." Additional searches included looking for news articles related to "plastic bans" and "foam bans" to identify enacted, potentially relevant policies. Further research on these policies to determine relevance included reading regulatory documents to determine policy scope and implementation date. Finally, we cross-referenced our research with an interactive data map of plastic policies in the United States developed by Surfrider and the Plastic Pollution Coalition (Surfrider & Plastic Pollution Coalition, 2023).

After compiling relevant policies, we conducted before-after analyses on three of them. These analyses included visualizing debris density in time series graphs and attempting to run time series autoregressive integrated moving average (ARIMA) models to discern changes in debris density before and after the policies were implemented. We did this analysis for policies at varied spatial scales (i.e., city, county and state-wide policies), that mapped to one of our item categories and occurred toward the middle of our study period. These policies included:

1. Ordinance No. 18-01, which was promulgated by the City of Grover Beach on July 22, 2018, and regulates Expanded Polystyrene Products in Grover Beach,

banning takeout containers made of Expanded Polystyrene from being sold and used by businesses within the municipality (Ordinance No. 18-01, 2018);
2. Ordinance No. 2019-1, which was promulgated by the SLO County Integrated Waste Management Authority on October 9, 2019, and regulates the use and sale of polystyrene products, including foam takeout containers as well as other foam products, across SLO County (Ordinance No. 2019-1, 2019); and
3. Assembly Bill (AB)-1884, which was promulgated by the California State Assembly on January 1, 2019, and bans full-service restaurants from providing single-use plastic straws unless requested by the customer across the state of California (AB No. 1884, 2018).

For the Grover Beach policy, we used data from the segment from our hotspot analysis that covered the Five Cities area, which includes the cities and urban areas from Pismo Beach to Oceano Dunes in SLO County. For the SLO County policy, we used data from cleanups that occurred in SLO County. For the statewide ban, we used data from all of the cleanups within our study area.

Using the relevant data, for each of the policies, we then filtered out all cleanups that either did not have a distance recorded or had a distance of zero. We then calculated density for the corresponding item category. The relevant item category was “plastic takeout food containers” for the Grover Beach and SLO County policies, and “straws and stirrers” for the statewide policy. For these categories, we calculated the density per cleanup, giving us the number of plastic takeout food containers or straws and stirrers per mile for each cleanup. For each policy, the data were then summed, grouped by month, and visualized in a time series graph. However, for all three graphs, there were not enough data or there was too much noise for an ARIMA model to be pursued.

We also visualized accompanying effort for each policy to determine if effort was correlated to item density. To visualize effort, we summed the distance cleaned in miles for each policy-related area by month and visualized each in a separate, accompanying time series graph.

### 4.4. Interviews

To further develop marine debris management recommendations with an emphasis on local values and perspectives, we conducted interviews with agencies, local organizations, research institutions, and Indigenous communities. A key component of the CHNMS draft management plan is collaborative management with Indigenous communities (NOAA, 2023a). Therefore, it is important to engage with and understand community concerns at the local level to develop effective management recommendations (González, 2020). Interviews allow for strong connections to be made between the interviewer and interviewee. These strong connections generate conversations that result in more detailed information than can be gleaned from an individual filling out a survey. Establishing these connections is especially critical when engaging with Tribes, members of which are often used for data for research but gain no further value from these experiences (González, 2020). Creating a relationship and building trust between the interviewer and interviewees allows for the exploration of detailed answers, the inclusion of follow-up questions, and the potential for collaboration.

#### *4.4.1. Question Development*

We developed interview questions through coursework in ESM 269: Survey Design and Environmental Public Opinion at the Bren School. Questions were focused on monitoring and mitigation perceptions of marine debris, management strategies, and levels of concern within the CHNMS region. Demographic questions focused on the interviewee’s personal and professional background. We developed a consent form to inform subjects on the purpose, procedures, risks/benefits, confidentiality, costs, and personal/financial interests associated with the interview. The consent forms were provided to each interviewee to be signed prior to the interview. After the creation of interview materials, all information and documents were submitted to the UCSB Human Subjects Committee, which serves as the Institutional Review Board (IRB) for reviewing and approving research applications involving human subjects. For interviews with Tribal members, each Tribe provided written approval from their Tribal Council or government prior to the interview. Written consent was then submitted to the IRB for review and approval on a rolling basis. For the complete list of interview questions and IRB records, see Appendices III and IV, respectively.

#### *4.4.2. Outreach*

We conducted research on potential participants to identify interview candidates. We aimed to interview participants that were involved in either coastal conservation work or Tribal and/or local community engagement in the Central Coast region. We found interview participant contact information through publicly-available sources such as organization websites and contacted each participant via email. We conducted interviews with individuals who were interested, available, and willing to participate.

### *4.4.3. Conducting Interviews*

Each interview lasted up to 30 minutes and was conducted over the phone or via video conference (using Zoom), depending on the participant's preference, with one to two team members participating in each interview for note-taking and recording purposes. Interviewees were also offered the option to answer questions via a written document as opposed to scheduling an interview, as some interviewees had limited capacity for a scheduled call. Written consent forms were provided via email to the participants and returned as signed prior to the interviews, and verbal consent was reviewed briefly at the beginning of each interview. Each participant was asked if they were comfortable with the interview being recorded and all said yes. Interviewers introduced themselves, gave a brief overview of this project, and asked several demographic questions before introducing questions on marine debris. Marine debris questions focused specifically on the levels of concern participants' organizations or communities felt about marine debris, and what types of debris were of particular concern. We also asked about gaps and potential opportunities in solving local marine debris issues, as well as what interviewees viewed as priorities for the CHNMS to address in management and mitigation. See Appendix III for the full interview script and questions.

### *4.4.4. Transcription*

Interviews were recorded using voice recording applications. Some interviews were recorded using a Google-developed application called Recorder, which was also used to automate interview transcription. These transcriptions were then manually reviewed and edited for clarity. Transcribed text was edited to remove spelling errors, identifying information, and filler words such as "um" and "like." Markers were added to differentiate between speech from the interviewer(s) and interviewee.

### *4.4.5. Analysis*

Interviewees' responses were manually summarized by question in an anonymized spreadsheet. Key themes, as well as similarities and differences between responses from each question, were manually identified. Responses for four questions—examples of concern, debris types of concern, current solution gaps, and areas of opportunity—were also manually summarized in an anonymized spreadsheet by the four main groups of interviewees—agencies, local organizations, research institutions, and Indigenous communities—to compare responses between groups. The goals of this analysis were to highlight any new key ideas that are not present in the CHNMS draft management plan's Water Quality Action Plan (Strategy WQ-5; NOAA ONMS, 2023), as well as to complement our quantitative data analysis in informing recommendations for marine debris monitoring and mitigation.

## 5. Results

### 5.1. Harmonization Analysis and Summary Statistics

After our data cleaning process, we had 907 beach cleanups from January 2015 to October 2023 from our four data sources. Because these data were generated from community science efforts, the number of reports and amount of data collected varied over the years (Figure 3). Each of the years from 2018 through 2022 had over 130 cleanups per year. The most cleanups occurred in 2021 (203 cleanups). In 2015, there was only one cleanup. The years 2016, 2017, and 2023 all had fewer than 100 beach cleanups.

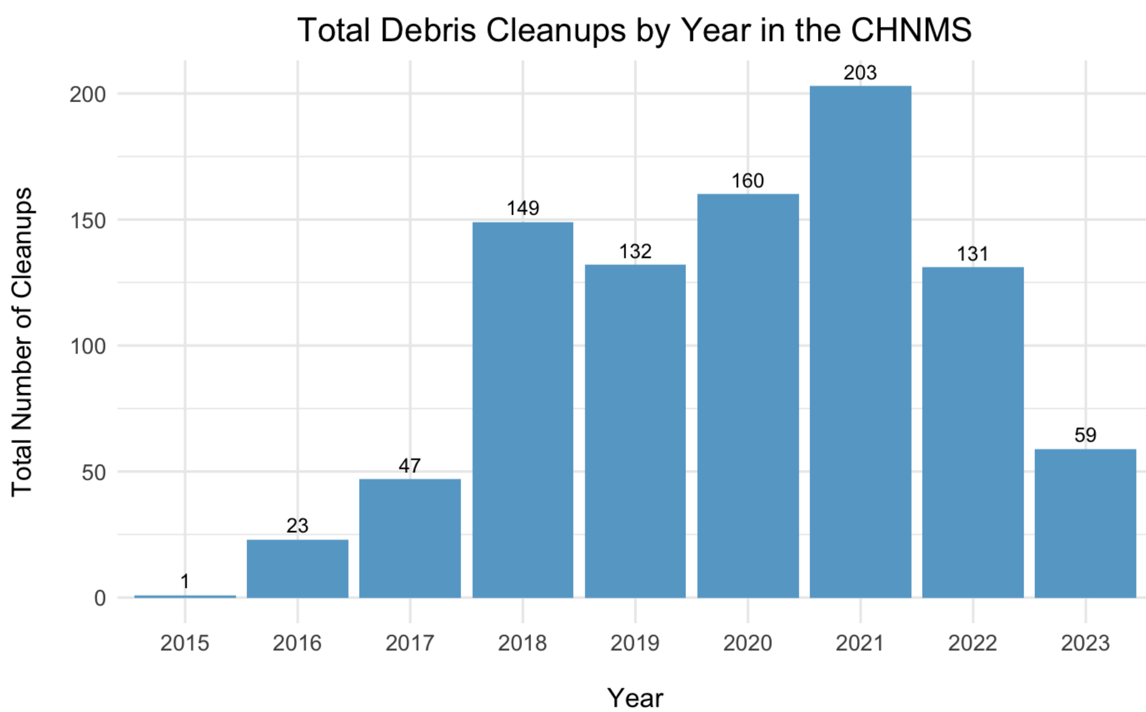



***Figure 3:*** *Total debris cleanups by year in the CHNMS across all data sources.*

Across all years, 274,577 pieces of debris were collected. These debris were sorted into our 40 item type categories (Figure 4). See Appendix II for additional details on the classification of debris by item type, material type, and source activity.

Of the debris found, the five most frequently-found item categories across all datasets were plastic fragments (18.7 percent of total items), wrappers (11.0 percent of total items), bottle caps (7.7 percent of total items), bottles (5.6 percent of total items), and glass fragments (4.9 percent of total items). These top five item categories comprised

47.9 percent of the total items found by count. Further, each top five item comprised roughly the same percentage of the total items each year, indicating their persistence over time.

We also identified the most frequently found items within each of the four original datasets, and we found similar results (Table 1). These item categories represent the original item categories for each respective dataset, prior to our harmonization. Cigarette butts are the most frequently-found item in the two largest datasets, and also appear in the top five of the third-largest dataset. Plastic fragments in various forms, including foam, hard plastic, plastic film, plastic pieces, or plastic fragments of various sizes, account for eight of the twenty categories listed. Food wrappers and bottle caps are also in the top item categories across all of the datasets.

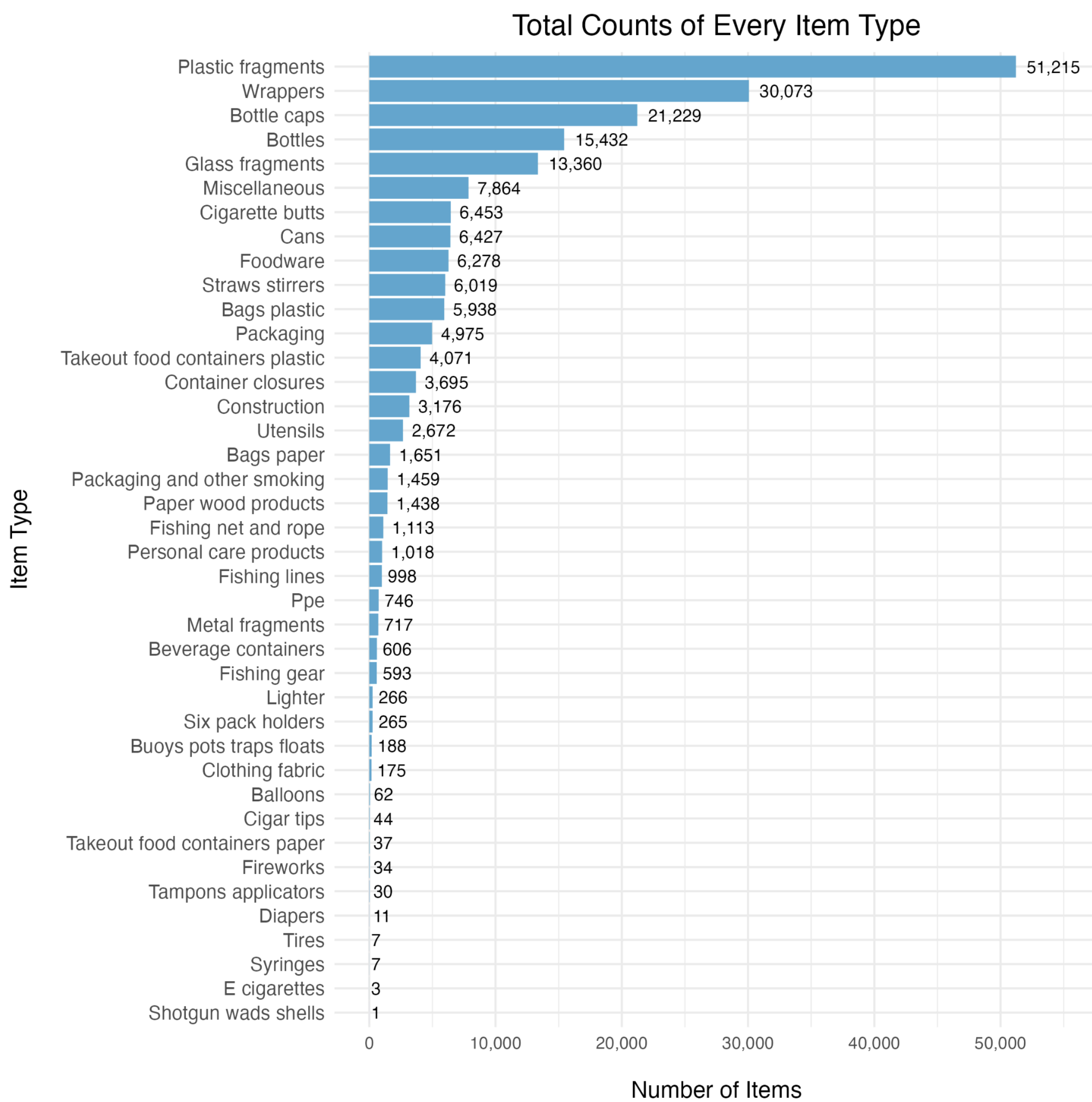


***Figure 4 (previous page):*** *Number of items found in each of the 40 item type categories across all years for our harmonized dataset.*

***Table 1:*** *The five most-found item types from each dataset. The numbers in parentheses next to the dataset name indicate the number of pieces of debris within each dataset from all years. The percentages after each item indicate the percentage of total debris that item makes up for that specific dataset.*

| **Rank** | **MDT (1,573 items)** | **TIDES (192,630 items)** | **Surfrider (18,448 items)** | **MDMAP (185 items)** |
|---|---|---|---|---|
| 1 (Most common) | Plastic fragments (44.1%) | Cigarette butts (37.0%) | Cigarette butts (34.1%) | Foam fragments (29.7%) |
| 2 | Food wrappers (13.9%) | Plastic pieces (19.1%) | Food wrappers (12.5%) | Hard plastic fragments (29.2%) |
| 3 | Cigarettes and cigars (10.1%) | Food wrappers (14.2%) | Plastic fragments larger than a dime (11.9%) | Bottle/container caps (11.4%) |
| 4 | Caps or lids (5.5%) | Bottle caps (5.8%) | Plastic fragments smaller than a dime (5.2%) | Plastic film fragments (6.5%) |
| 5 | Foam fragments (3.6%) | Beverage bottles (3.4%) | Bottle caps and rings (5.2%) | Food wrappers (4.9%) |

When debris were divided by material type, 77.5 percent of debris fell into the plastic material type category (Figure 5). Of our item type categories, 30 included plastic material. Of the 286 item categories we reclassified into our harmonized dataset, 166 were categorized as plastic. Less than one percent of debris items were in the cloth material type category. The remaining categories were: 7.7 percent glass, 5.9 percent metal, 5.3 percent mixed, and 2.3 percent paper or wood items.

When debris were categorized by activity type, the three most common categories were eating and drinking (36.7 percent), smoking (29.2 percent), and various (28.7 percent; Figure 6). The four remaining activity type categories all accounted for approximately 1 percent of debris found: 1.3 percent dumping, 1.1 percent fishing, 1.1 percent recreation, and 0.9 percent personal hygiene.

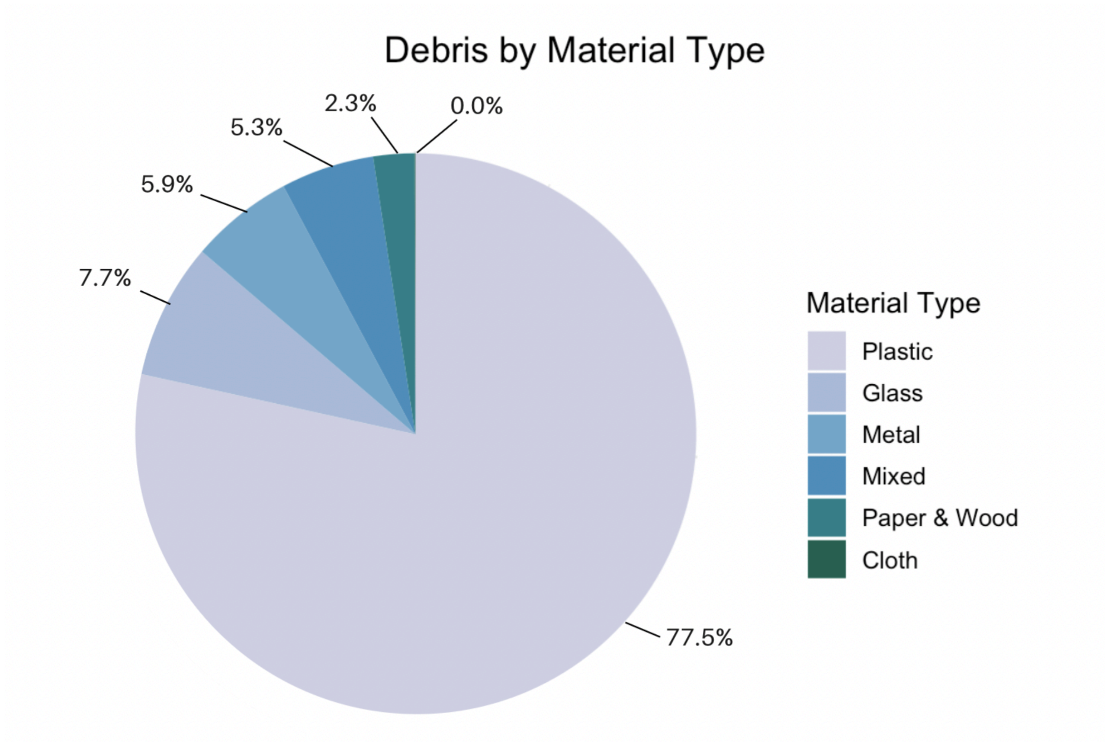



***Figure 5:*** *The breakdown of all debris by material type category.*

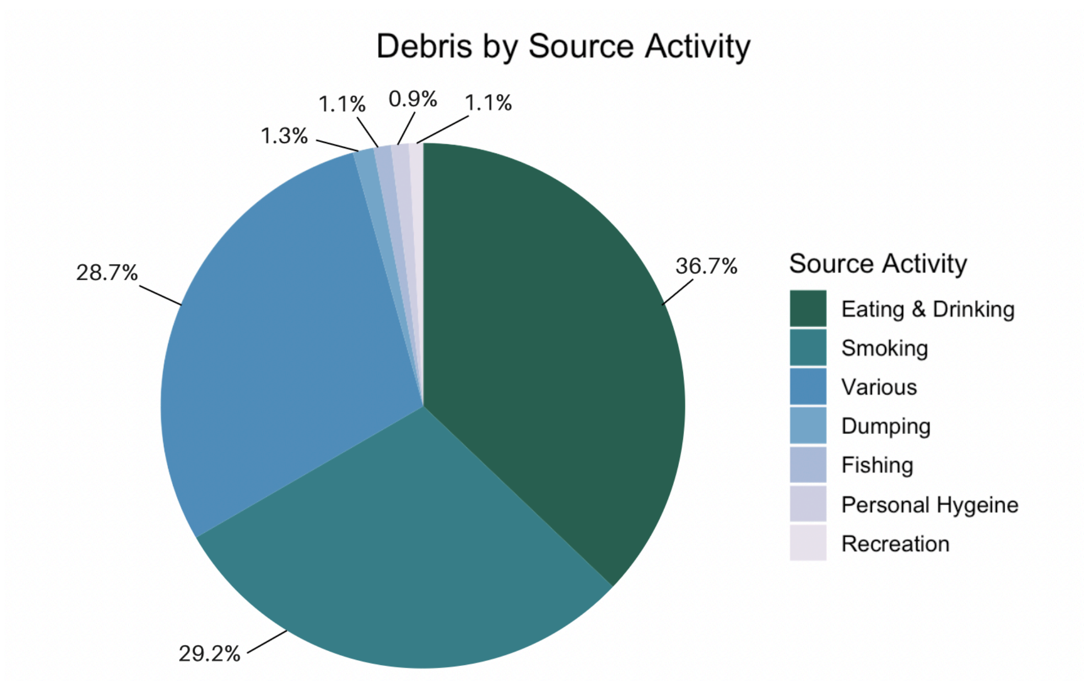



***Figure 6:*** *The breakdown of all debris by activity source category.*

We also identified the most frequently-found items within the eating and drinking category from each of the four original datasets (Table 2). The two most frequently-found item categories across all four datasets were wrappers and bottle caps. Glass or plastic bottles were also in the top five for all four datasets. Other items in the top five included plastic cups and napkins.

***Table 2:*** *Within the eating and drinking category, the top five item types from each dataset. The numbers in parentheses next to the dataset name indicate the number of pieces of debris within the eating and drinking category for each dataset. The percentages after each item indicate the percentage of total debris that item makes up for that specific dataset.*

| Rank | MDT (600 items) | TIDES (89,965 items) | Surfrider (10,031 items) | MDMAP (46 items) |
|---|---|---|---|---|
| 1 (Most common) | Plastic food wrappers (36.3%) | Food wrappers, candy, chips, etc (30.4%) | Plastic food wrappers (23.1%) | Bottle/container caps (45.7%) |
| 2 | Plastic caps/lids (14.3%) | Plastic bottle caps (12.5%) | Plastic bottle caps/rings (9.5%) | Food wrappers (19.6%) |
| 3 | Plastic bags (8.3%) | Metal bottle caps (9.0%) | Glass beverage bottles (9.5%) | Plastic beverage bottles (15.2%) |
| 4 | Paper cups, plates, napkins (6.8%) | Glass beverage bottles (7.7%) | Metal bottle caps (8.5%) | Plastic other jugs or containers (6.5%) |
| 5 | Plastic bottles (5.8%) | Plastic beverage bottles (7.3%) | Paper napkins (7.7%) | Plastic cups (4.3%) |

### 5.2. Hotspot Analysis

Hotspot analysis results revealed that the most consistent hotspot regions within the sanctuary were the Morro Bay, Five Cities, Avila Beach, and Gaviota areas (Figure 5). The Morro Bay and Gaviota coast hotspot segments consistently had high debris densities across hotspot methodologies, while the Five Cities area segment alternated with the Avila Beach segment for having more debris, depending on the hotspot methodology utilized. Consequently, we combined the two segments that cover the Five Cities area and the Avila Beach area into one larger hotspot.

The hotspot analysis also suggested that the areas with the least debris were most likely the Vandenberg Space Force Base and TNC's Jack and Laura Dangermond Preserve areas. This result shows a difference between private and public-access beaches. Beaches with easy public access had the greatest amounts of debris, while the stretches of coast that are private access and inaccessible to the public had the least. Similarly, the areas with the greatest amounts of debris also often had the greatest number of people living in the neighboring census tracts (U.S. Census Bureau, 2020). This trend was the case for the Morro Bay and Avila Beach/Five Cities hotspots. The Gaviota hotspot area had a lower population density. Additionally, the amount of debris was in some instances 100 times greater in the areas with the most debris than in the areas with the least debris. These results were mirrored in the trash density analysis as well.

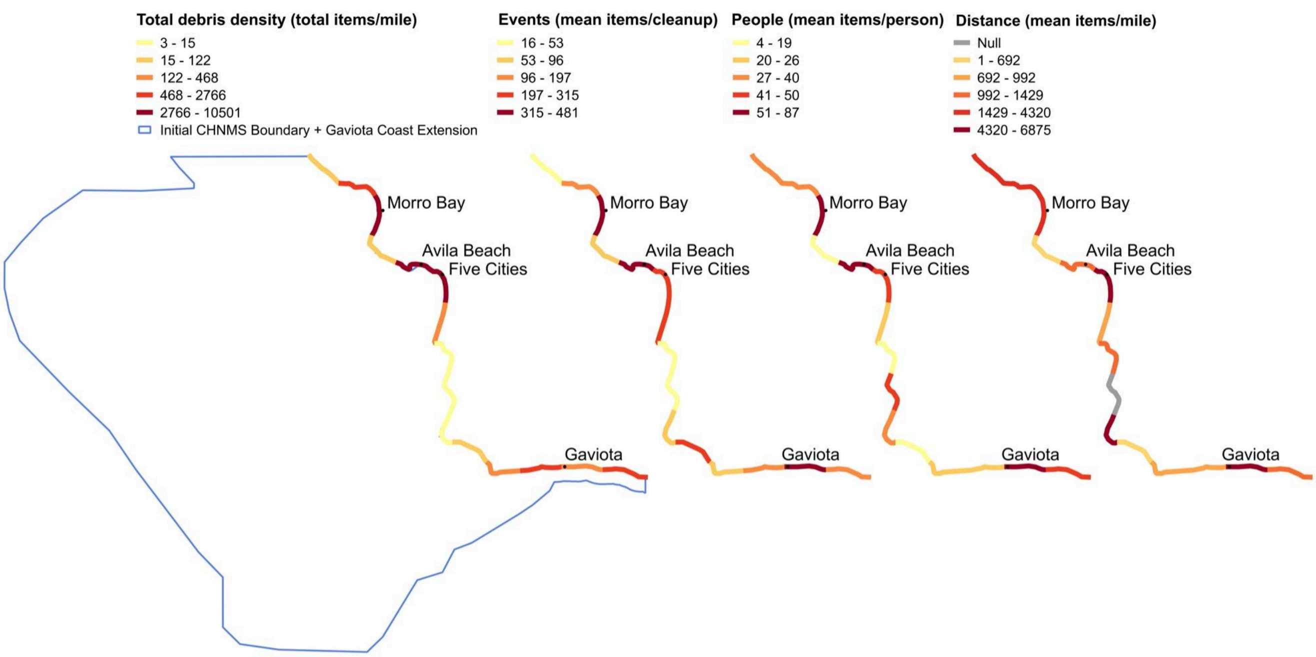



***Figure 7.*** *Hotspot analyses of debris across the study area. Across all of the maps, the dark red represents more debris and the light yellow represents less debris. The left map visualizes debris density. The next three maps each show a hotspot methodology. The first (second from left) uses events to account for effort, the second (second from right) uses people to account for effort, and the third (right) uses distance to account for effort using only the TIDES and MDMAP data.*

The breakdown of material type by hotspot area shows that plastic is overwhelmingly the most common type of debris across the hotspots (Table 3). Furthermore, there was a significant difference in the material type breakdown between hotspot segments ($x^2$ (8) = 856.6, $p < 2.2e-16$).

There was also a significant difference in the source activity breakdown between hotspot segments ($x^2$ (12) = 3217.2, $p < 2.2e-16$; Table 4). Eating and drinking was the largest source activity in the Avila Beach/Five Cities and Gaviota hotspots, while smoking was the largest source activity in Morro Bay. Smoking was less common in Gaviota than in the other two hotspots, while eating and drinking was more common in Gaviota than in the other two hotspots. Fishing also contributed to more debris in the Gaviota hotspot than in the other two hotspots, while dumping contributed to more in the Avila Beach/Five Cities hotspot than in the other two hotspots.

***Table 3:*** *The percentage breakdown of debris by material type for the three most likely hotspot segments: Morro Bay, the Avila Beach/Five Cities area, and Gaviota. There was a significant difference in material type breakdown between hotspot sites ($x^2$ (8) = 856.6, $p < 2.2e-16$).*

| Hotspot | Plastic | Glass | Metal | Mixed | Paper & Wood | Cloth |
|---|---|---|---|---|---|---|
| Morro Bay | 81.3% | 7.5% | 4.1% | 3.5% | 2.5% | 0.0% |
| Avila Beach/Five Cities | 76.8% | 8.1% | 6.5% | 4.9% | 2.5% | 0.1% |
| Gaviota | 74.9% | 6.4% | 6.5% | 7.8% | 1.3% | 0.0% |

***Table 4:*** *The percentage breakdown of debris by source activity for the three most likely hotspot segments: Morro Bay, the Avila Beach/Five Cities area, and Gaviota. There was a significant difference in source activity breakdown between hotspot sites ($x^2$ (12) = 3217.2, $p < 2.2e-16$).*

| Hotspot | Eating & Drinking | Smoking | Various | Dumping | Fishing | Personal Hygiene | Recreation |
|---|---|---|---|---|---|---|---|
| Morro Bay | 29.9% | 32.5% | 32.0% | 1.1% | 2.0% | 0.8% | 0.7% |
| Avila Beach/Five Cities | 38.5% | 30.7% | 26.3% | 9.0% | 0.6% | 0.9% | 1.0% |
| Gaviota | 44.5% | 13.9% | 32.9% | 1.1% | 3.4% | 0.8% | 0.4% |

### 5.3. Policy Analysis

Through our policy research, we identified several local, county, and state-level policies that may affect marine debris along the coast. Policies addressing solid waste have increased in popularity throughout California over the past ten years, and many of them focus on single-use plastics such as styrofoam containers, plastic bags, and straws (Ordinance No. 600, 2016; Ordinance No. 5636, 2013; SB 270, 2014).

Results from our time series analyses on Ordinance No. 18-01 for Grover Beach, Ordinance No. 2019-1 for SLO County, and AB-1884 for the state of California were inconclusive. Due to unclear trends when visualizing time series graphs for these three policies (Figure 8), further modeling to assess policy effectiveness was infeasible. There was too much inexplicable noise, and cleanup effort was too variable for each spatial scale, for any discernible trend to be identified. Further, inaccurate or nonsensical distance measurements (i.e., cleaning 0.0062 miles or 15.00 miles of coastline) limited the accuracy of density estimates across all three policies. In addition, there were not enough data, particularly before policy implementation, for a model to accurately assess Ordinance No. 18-01 for Grover Beach.

However, visualizations still provide insights. For Ordinance No. 18-01 for Grover Beach, plastic takeout container density appears to have actually increased after policy implementation. Cleanup effort also generally increased afterwards. For Ordinance No. 2019-1 in SLO County, there is not a clear shift in plastic takeout container density after policy implementation, although cleanup efforts seem to have decreased. For AB-1884 for the state of California, there is an increase in straw and stirrer density after policy implementation in some months, while cleanup effort generally decreased.

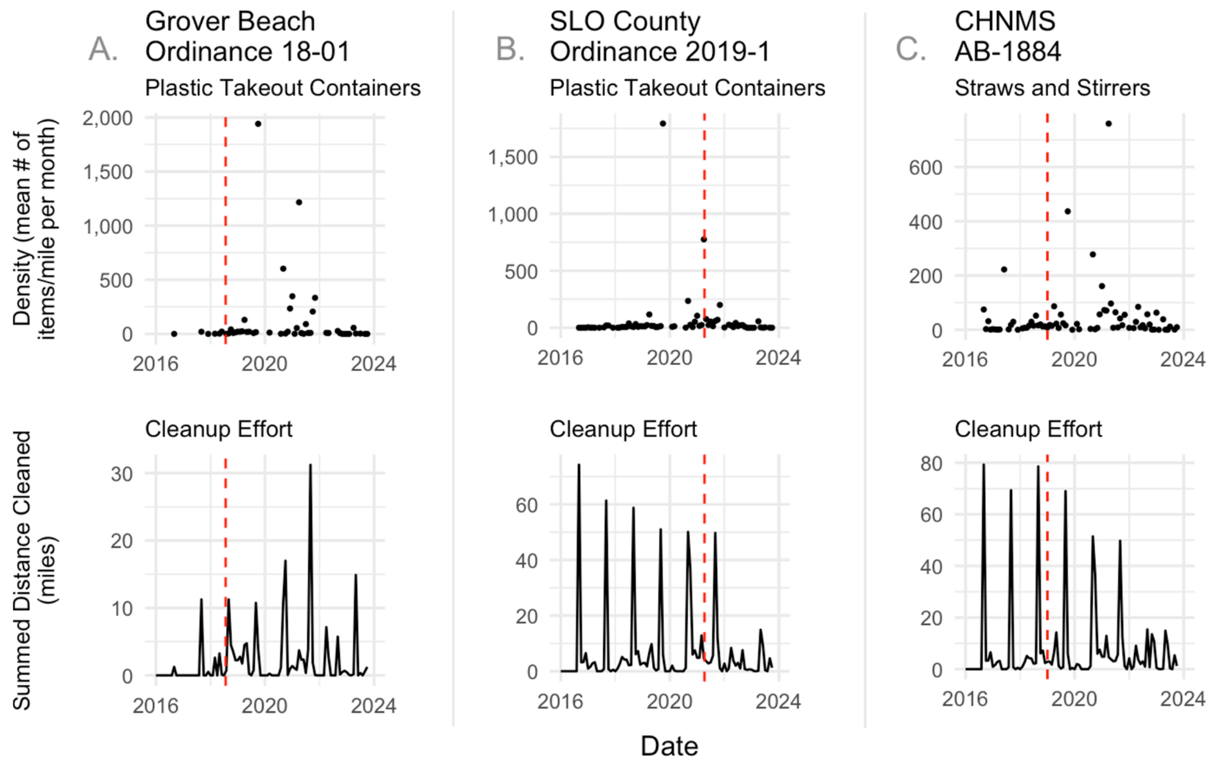



***Figure 8:*** *Policy analysis results for the three assessed policies. Panel A represents the Grover Beach area, which is impacted by Ordinance No. 18-01. Panel B represents SLO County, which is impacted by Ordinance No. 2019-1. Panel C represents the entire proposed CHNMS study area, which is impacted by AB-1884. The top row of graphs shows the density (mean number of items per mile per month) for the item category affected by each respective policy. The bottom row of graphs shows the cleanup effort across time (summed distance cleaned in miles per month) for each respective area. The date each policy was implemented is indicated by the dashed red line.*

### 5.4. Interviews

Twelve interviews and one written response to our interview questions were completed during the course of the project. Overarching themes and concerns included strong concern regarding the issue of marine debris within both interviewees' organizations and local communities. Despite already conducting community efforts like beach cleanups to handle the problem, many interviewees also advocated for larger scale solutions relating to policy or government action. A common debris concern was plastic, with a few mentions relating to takeout food waste and cigarette butts. Several interviewees mentioned specific locations of concern, including Avila Beach. Specific themes are discussed by question below.

### *5.4.1. How concerned is your organization/Tribe about marine debris?*

Words used to describe interviewees' groups/organizations/communities attitudes towards marine debris included "alarmed," "concerned," "pretty concerned," "very concerned," "extremely concerned," and "incredibly concerned." Two interviewees explicitly expressed their concern for the impacts of marine debris on coastal resources, including different types of coastal habitat and wildlife. Three explicitly expressed concern for plastic debris and microplastics.

### *5.4.2. Do you have an example you could share that reflects that concern?*

Examples of marine debris that reflected interviewees' levels of concern can be categorized into four main themes: 1) impacts to coastline and wildlife; 2) impacts of marine debris on upstream systems including creeks and storm drainage; 3) specific volumes and types of debris; and 4) policies or actions to address marine debris concerns. Five interviewees gave examples of specific impacts to coastlines and wildlife, including marine life ingesting microplastics and becoming entangled in fishing line, and larger threats to sensitive and culturally important ecosystems in this region. One highlighted upstream sources of debris. Five focused on specific types of debris, including agricultural plastic, debris generated from offshore wind farm development, fishing-related debris, large debris including tractor tires, and micro-debris including microplastics. Two mentioned policies or actions their organizations have implemented to address concerns about marine debris, including regulatory requirements for permits, and beach cleanups in both creeks and coastal areas that collected 10,000 pounds of debris.

### *5.4.3. Are there any types of debris that you're particularly concerned about?*

Six interviewees identified food wrappers, packaging, or takeout food containers as debris items of concern. Seven highlighted plastic as a material type of concern, and three mentioned expanded polystyrene or Styrofoam. Four interviewees mentioned microplastics or "microtrash," and three mentioned cigarette butts. Two mentioned tires, one specifically in the context of vessel docking equipment. Two interviewees expressed concern for upstream sources of debris such as agriculture and irrigation. Two interviewees expressed concern for fishing related debris, and another was concerned about rusted metal materials as well as glass. Other items mentioned once included mylar balloons.

### *5.4.4. Can you tell us about the marine debris efforts your organization/Tribe conducts currently?*

The majority of interviewees highlighted both informal and organized inland and beach cleanup events as part of their organization's marine debris monitoring and mitigation or community stewardship efforts. Some organized beach or land cleanup events for the public or community groups, while others did internal tracking and identification of debris through beach or land cleanups and debris removal from storm drains. Two interviewees mentioned the Clean Swell app, which contributes to the TIDES database, as their cleanup tracking protocol. Other efforts such as public education and outreach; collaboration across agencies, community groups, and Tribes; and supporting or enforcing marine debris-related policies were also frequently mentioned.

### *5.4.5. What do you see as the gaps in solving marine debris issues in this area?*

Four interviewees discussed addressing marine debris at the source, which was identified as both producers and consumers. Seven interviewees talked about the need to educate consumers on how products contribute to marine debris issues, and to shift behavior away from mass consumption and to educate the public more broadly on the impacts of marine debris. Six of these interviewees specifically highlighted the need for community awareness, education, and engagement efforts. Three interviewees said additional and stricter policies should be put in place to address marine debris. Two also identified upstream sources including urban areas and industries such as agriculture as problems. Two said standardized data collection, organization, and harmonization across studies that conduct marine debris research was needed, and another suggested implementing more cleanups in areas with rocky coastlines as well as on beaches. Two interviewees also highlighted the specific need for cultural education, as well as the lack of public awareness of culturally important resources to Indigenous communities that are threatened by marine debris.

### *5.4.6. What do you see as areas of opportunity for establishing monitoring to address marine debris within the proposed CHNMS?*

Six interviewees identified local community education and engagement as important areas of opportunity, including activities like continued community science beach cleanups and engaging with the younger generation to promote environmental stewardship. Three interviewees also suggested pairing beach cleanup data with stormwater monitoring data to create more complete assessments of marine debris, and a fourth suggested increasing fines for municipalities with poor storm drain systems or providing state grant assistance to these towns to help with storm drain improvements that would reduce marine debris loads into coastal environments. Two interviewees suggested having designated sanctuary personnel to monitor and analyze marine debris data, and to coordinate marine debris mitigation efforts. Another two suggested increasing satellite monitoring and remote sensing of marine debris, along with ocean monitoring and floating plastic surveys. Five interviewees highlighted the need for partnerships between the sanctuary and local organizations and communities, and local community involvement more broadly in marine debris monitoring and mitigation efforts. Two interviewees spoke about amplifying public pressure on plastic production sources and brands that generate marine debris. Another three highlighted local government awareness and action, and broader policy implementation to address marine debris, including take-back programs for various materials, container deposit programs, and other economic incentives to prevent trash from entering the environment. Three interviewees suggested addressing upstream sources of debris. Three interviewees highlighted the importance of preserving and protecting important coastal resources and habitat, including Point Conception. Two also highlighted the cultural importance of this marine area to local Indigenous communities, and one suggested establishing cultural centers throughout the region to educate the public on the cultural and natural value of this area and of the stewardship needed to protect it. Another suggested that ocean advocacy agencies and environmental groups should partner with coastal Tribes to develop processes that reduce ocean pollution.

#### *5.4.7. Are there any other monitoring/mitigation efforts you think should be implemented or prioritized within the proposed CHNMS?*

In addition to the main identified areas of opportunity, most interviewees provided additional suggestions. Seven spoke about different avenues of research and monitoring, including continued stormwater and sediment transport modeling to track debris movements in upstream systems, remote sensing of marine debris, monitoring debris and chemicals from offshore wind construction and oil well decommissioning, and monitoring ecosystem health more broadly. One suggested standardizing cleanup collection methods. Another highlighted the need for funding for marine debris monitoring and financial incentives to reduce plastic production and consumerism. Another four interviewees focused on community engagement and education. One specifically highlighted the need to maintain and improve public coastal access. Two highlighted the importance of gathering Indigenous input, creating dialogue with Indigenous communities, and integrating Indigenous perspectives and culture into marine debris management.

### *5.4.8. Grouped Responses*

Interview responses were also sorted by affiliation into one of four broad groups including community organizations, agencies, research institutions, and Indigenous communities. Due to time and interview availability constraints, the number of interviewees associated with each group varies. Specific names of these groups/communities are excluded from these results to be consistent with our IRB approval that grants interviewees personal and professional anonymity.

Of our 13 interviewees, five were considered to be affiliated with local organizations, four were affiliated with agencies, one was affiliated with a research institution, and two identified with Indigenous communities. See Table 5 for a comparison of grouped results for four main interview questions.

***Table 5:*** *Comparison of responses for four interview questions between interviewees representing four different groups (agencies, local organizations, research institutions, and Indigenous communities). The blue row at the top of the table indicates how many groups had overlapping responses to the four questions listed in the left-most column of the table.*

| Interview Question | 1 Group | 2 Groups | 3 Groups | 4 Groups |
|---|---|---|---|---|
| Examples of concern | • Specific types of debris like tractor tires and microplastics<br>• Large quantities of debris picked up in cleanup events<br>• Incorporating plastic pollution reduction into regulatory work<br>• Upstream debris from storm drain capture, ag. debris<br>• Pollution from offshore wind farms | No overlap | • Impacts of marine debris on wildlife and ecosystems with specific examples | No overlap |
| Debris types of concern | • Mylar balloons<br>• Bottles<br>• Plastic bags<br>• Tires and rubber<br>• Plastic fragments | • Food wrappers<br>• Microplastics<br>• Single use plastic<br>• Fishing | • Expanded polystyrene foam<br>• Cigarette butts | • Plastic |

| Interview Question | 1 Group | 2 Groups | 3 Groups | 4 Groups |
|---|---|---|---|---|
| | • Disposable plastic<br>• Large debris items that block storm drains<br>• Glass<br>• Rusted metals | related-debris<br>• Debris from upstream sources including storm drains | | |
| Current solution gaps | • Need more information on sources and types of debris<br>• Need solutions that address debris types of high impact and quantity<br>• Lack of cleanups in rocky areas of coastline<br>• Preventing storm drain obstructions<br>• More upstream concern and prevention efforts<br>• Not enough time and resources for marine debris assessments<br>• Educating people on the Indigenous cultural values of the Central Coast ecosystem and the importance of respecting these ecosystems | • Standardized data collection and harmonization methodologies<br>• Public responsibility and accountability<br>• Policies aimed at plastic producers and consumers | No overlap | No overlap |
| Areas of opportunity | • Dedicated sanctuary and community personnel and funding for marine debris monitoring<br>• Maintaining and | • Meaningfully involving Indigenous communities as co-stewards and educating the public on their values of | • Policies that address sources of debris at the production level<br>• Marine debris monitoring and | No overlap |

| Interview Question | 1 Group | 2 Groups | 3 Groups | 4 Groups |
|---|---|---|---|---|
| | improving coastal access<br>• Monitoring stormwater systems in addition to cleanup data<br>• Remote sensing of marine debris in addition to fieldwork to assess trash loads and pathways<br>• Upstream monitoring and watershed analysis<br>• Monitoring debris and chemicals that may come from offshore wind construction and oil well decommissioning<br>• Increased and extended refunds for take-back programs for all plastic, aluminum, and glass containers<br>• Incentives for conducting beach cleanups<br>• Higher fines for cities with poor sewer systems, or CA grant assistance for sewer system improvements<br>• Development of biodegradable cigarette butts | the ecosystem<br>• Continued community science cleanup efforts that contribute to sanctuary monitoring of marine debris<br>• Educating the public and spreading awareness of local marine debris issues<br>• Engaging youth | mitigation partnerships between the sanctuary, Tribes, local communities, and environmental agencies and advocacy groups | |

## 6. Discussion

### 6.1. Data Harmonization

There is no standard collection and documentation methodology for community science beach cleanups, as each one categorizes debris differently and requests different information, such as the number of people involved in a cleanup and cleanup distance. This lack of standardization is a recurring challenge for marine debris data analysis both in California and globally, requiring harmonization between datasets before analysis can occur (Ambrose, 2021; Krone et al., 2023). Our harmonization process was complicated and iterative, and the categories we used impacted our results and conclusions. However, since they are comparable to and built on MBNMS's harmonized data categories, our categories help to form the foundation for future marine debris data harmonization and analysis for the west coast.

The continued utilization of similar data categories for future marine debris analyses in MBNMS and in the proposed CHNMS, as well as for other locations along the west coast, is essential. This standardization allows for comparability across time and between locations. However, based on our analysis, we conclude it would be even better to standardize at the community science cleanup app level. Standardized categories would ideally look similar to those utilized by this study and by MBNMS, or they could be agreed upon between community science cleanup programs. Consensus at this community science level, although likely challenging, would allow for more accurate and efficient analyses as well as better comparisons between regions beyond the west coast.

### 6.2. Debris Types

Of the debris found on the beach, there were clear patterns with respect to activity and material type. The plastic material type category included the largest number of items by far, and plastic items were found in each of the activity type categories. Further, plastic debris made up more than three quarters of all of the debris found, and plastic fragments were the most common item type. Plastic was also consistently the largest material type across hotspot regions. These findings are consistent with the breakdown of debris in the MBNMS, where just under three quarters of the debris found were plastic, and plastic fragments made up approximately a quarter of all debris (Krone et al., 2023). This concern, along with the consistent, high distribution of plastic debris along the coast of California, as well as across other regions (Galgani et al., 2015, McLaughlin et al., 2023), suggests that continued focus on plastic debris monitoring and mitigation across local, regional, and broader scales is necessary. For example, as research has shown a significant correlation between increased macroplastic debris and a lack of beach services, ensuring beaches have trash cans that are maintained could help to reduce macroplastic debris (Masiá et al., 2021).

Further, plastic is persistent: once it makes its way to the beach, it is more likely to remain in the environment than other materials that might decompose over time, such as paper (Iñiguez et al., 2016; Portman and Brennan, 2017). Plastic materials break down into smaller fragments and microplastics, making up an important category of debris (Galgani et al., 2015). However, a microplastics analysis is infeasible with community science data, so it was beyond the scope of this study. Instead, other collection method and analysis methods should be investigated in order to better understand microplastic debris within the CHNMS (Coppock et al., 2017; Hidalgo-Ruz et al., 2012; Van Cauwenberghe et al., 2015).

With regard to activity type, three of the seven categories accounted for almost all of the debris: eating and drinking, smoking, and various. Less than five percent of debris came from the other activity categories. Similar to MBNMS, where the various category was the largest (Krone et al., 2023), the various category presents a management challenge for the CHNMS because these items cannot be tied to one specific activity. For example, many of the item types included in this category are fragments, which are also amongst the most commonly-found item categories (plastic fragments and glass fragments). Fragments have consistently made up a similar proportion of the total debris each year, indicating that further management is necessary despite the challenge of identifying their sources. One option would be to focus efforts on larger, identifiable debris, and prevent them from entering the marine system to begin with, as fragments are likely the result of breakdown from larger items (Galgani et al., 2015). Many interviewees expressed a need for and support of this idea, suggesting that policies that reduce marine debris, and specifically plastic debris, at the producer and consumer levels would be beneficial.

On the other hand, the largest category, eating and drinking, can be linked to specific item groups. Within the eating and drinking category, many of the items are single-use items (e.g., paper cups and plates), beverage containers and lids, or wrappers. Wrappers, bottles, and bottle caps are also in the top five most commonly-found item types, and wrappers were an area of concern for multiple interviewees. The continued prevalence of these types of items suggests that food- and beverage-related waste is still a major component of the waste stream, although policies have been implemented at various scales in an effort to reduce the sources of these items with undetermined levels of success (Ordinance No. 18-01, 2018; Ordinance No. 2019-1, 2019; Assembly Bill No. 1884, 2018). Further, while MBNMS found that eating and drinking made up a smaller percentage of marine debris in the MBNMS than we found in the CHNMS, they still found that over a quarter of debris came from this source activity (Krone et al., 2023). Consequently, further mitigation efforts that target eating- and drinking-related debris, such as policies and initiatives that target debris sources as well as efforts that target the items being used on the beach, are necessary, both locally and at larger scales (Willis et al., 2017). For example, efforts that educate, enable, or otherwise influence beach visitor behavior, as well as ensuring proper disposal receptacles are available and maintained, could be strategies to reduce debris from eating and drinking on the beach itself (De Kort et al., 2008; Portman and Brennan, 2017; Robinson 2023; Sheavly and Register, 2007).

Similarly, our second largest source activity category, smoking, which made up 29.2 percent of all debris found, can be linked to specific item types. Cigarette butts were the seventh most common item type and one of the most-frequently found items across all datasets. They were also an item of concern for interviewees. There was also concern about smoking debris and cigarette butts within MBNMS, where smoking debris similarly made up approximately a quarter of all debris (Krone et al., 2023). Across California, policies exist that ban smoking activities in some public spaces like beaches and parks. Notably, as of October 2017, smoking was banned on beaches in multiple municipalities, including SB County and the City of Pismo Beach (American Nonsmokers' Rights Foundation, 2017). In October 2019, California promulgated Senate Bill 8, banning smoking and vaping in most areas of state beaches (SB No. 8, 2019). MBNMS found that, after the state law went into effect, the number of cigarette butts found on state park beaches dropped more drastically than the number of cigarette butts found on other beaches, although there were fewer cigarette butts on other beaches as well (Krone et al., 2023). However, cigarette butts were still present across beaches after policy implementation. Due to the persistence of smoking-related debris along the coast and interviewee concern with cigarette butts, education and enforcement could be implemented in tandem with existing cigarette bans to potentially reduce smoking-related debris on the coast (Currie and Stack, 2021).

While we did not do a state park beach versus other beach smoking analysis in our study due to the additional local policies banning smoking on beaches, there was a difference in the amount of smoking debris found between hotspot locations in the CHNMS. Smoking accounted for 32.5 percent of debris in the Morro Bay segment, 30.7 percent in the Avila Beach/Five Cities segment, and only 13.9 percent in the Gaviota segment. Commonly visited beaches within the Gaviota segment are state park beaches. The Morro Bay and Avila Beach/Five Cities segments may have a smaller proportion of state park coastline compared to Gaviota. This difference could potentially be contributing to the lower percentage of smoking debris found in the Gaviota hotspot. Further, cigarette butts are both transported to the coast from urban areas as well as directly deposited on the beach (Araújo and Costa, 2019), so the larger urban areas in the Morro Bay and Avila Beach/Five Cities segments could also be contributing to the higher percentages of smoking-related debris in those segments. However, further research is needed to understand exactly why the differences between hotspots are occurring.

### 6.3. Debris Hotspots

Initial data analyses suggest that Morro Bay, the Avila Beach/Five Cities, and the Gaviota coast are marine debris hotspots within the proposed sanctuary. These are also the areas with the greatest number of cleanups and the most debris from the trash density analysis, suggesting there might be correlations between publicly accessible beaches and increased amounts of debris. For Morro Bay and the Avila Beach/Five Cities areas, this research also suggests that areas with greater population densities are correlated with increased amounts of debris, mirroring previous research (Hardesty et al., 2016). This finding suggests that the beaches that are likely getting more use end up having more debris on them, in turn indicating that debris may often come from local, land-based sources (Willis et al., 2017). However, it is also important to note that these correlations may also just suggest that, because the metrics for measuring effort are imperfect, more debris is found in these locations because they are where more cleanups occurred. This uncertainty was not only a consideration in the CHNMS, but also in the MBNMS, where hotspots were partially identified based on trash densities and therefore influenced by the number of cleanups (Krone et al., 2023).

For the Gaviota hotspot, although the debris density was high across all three methodologies, it has a low population density. This suggests that people may be coming from nearby cities such as Santa Barbara and depositing debris, debris are coming from upstream sources or watersheds, or debris are primarily coming from marine sources. Further analysis of sources could provide more insight into what is happening with debris in Gaviota. However, it is also important to note that there were only ten cleanups in this segment, compared to the 100-plus cleanups in the other hotspots. More cleanups and data would help to understand how much debris is actually in this area.

However, despite these differences and the significant difference in the material type breakdown between hotspots, there are still regional trends in the most common debris types: primarily plastic; followed by glass, metal, and mixed; and then paper/wood and cloth coming in last. This suggests that regional approaches to debris monitoring and mitigation are still valuable. However, the significant difference in source activity between hotspots suggests that there are some local differences between debris types and sources, although future analysis of debris sources would be necessary to explain why there is variation. Still, knowing the differences in debris sources between hotspots could be useful for focusing mitigation efforts. For example, since Morro Bay had the most debris from smoking, mitigation could focus more specifically on smoking in that region. Similarly, since Gaviota has the most debris from eating and drinking, mitigation could focus more specifically on eating and drinking in that region.

The hotspot analysis also suggested areas with the least amounts of debris. These initial data analyses suggest that the segment between Morro Bay and Avila Beach, as well as potentially Vandenberg Space Force Base and TNC’s Jack and Laura Dangermond Preserve, are the areas with the least amount of debris. However, there is more uncertainty with these conclusions because there were very few data for these segments; analyses relied on one to three cleanups per segment. There are likely fewer cleanups in these segments because the coast is harder to access, although it could also be because there is less debris in these areas and so fewer cleanups occur. Since there are so few cleanups in these segments, inaccuracies in reporting, differences in amounts of debris based on storms and seasonality, and changes in cleanup effort therefore have a much greater impact on these segments’ results than in segments with more cleanups (Hardesty et al., 2017). Further, this lack of data led to differing results between the hotspot methodologies. For example, when the number of items per mile was used to assess effort, one segment of Vandenberg Space Force Base was a hotspot; however, when the number of items per event was used to assess effort, the segment was one of the areas with less debris. This discrepancy highlights the need for additional data collection and analysis to get a more accurate understanding of debris along that stretch of coast.

However, the general trend shows that areas that are harder to access or are private have fewer cleanups and generally less debris. As long as future cleanups confirm there is less debris on these private stretches of coast, this analysis suggests that much of the debris along the shoreline comes from local land-based sources. However, if future cleanups find high densities of debris in these areas, it suggests that these areas are simply hard to get to and under surveyed, as opposed to having less debris. This in turn could suggest that debris is potentially coming from more marine or regional sources than local land-based sources.

Due to the aforementioned limitations, definitive conclusions cannot yet be drawn about where marine debris hotspots are within the proposed CHNMS; however, this research suggests that hotspots where monitoring and mitigation efforts could focus for more impact include the publicly accessible, more populated areas of Morro Bay and the Avila Beach/Five Cities areas. Further, the Avila Beach/Five Cities area was an area of concern in interviews and from conversations with community members. Focusing on these areas would not only potentially have the greatest impact due to larger amounts of debris but would also likely be easier, as these areas are easily accessible and are home to communities and individuals already committed to conducting beach cleanups. Additionally, future efforts should focus on debris data collection along less populated or accessible areas to provide more robust data for analyses (Hardesty et al., 2017). Future efforts should also be sure to record the number of people conducting the cleanup, the distance cleaned, and the GPS starting and stopping coordinates, to enable more precise analyses (Serra-Goncalves et al., 2019).

### 6.4. Regional Comparison

MBNMS's recently completed marine debris assessment (Krone et al., 2023) allows us to draw important comparisons on marine debris data harmonization, and quantities, types, and distributions of marine debris between regions of the California coast.

This study closely followed Monterey Bay's data harmonization methodology of categorizing different sources of beach cleanup data into common item type, material type, and source activity categories. While our data sources and categories differed slightly from Monterey Bay's, the harmonization steps provided by Krone et al. (2023) were a useful resource in creating our own harmonized data. Since existing marine debris data comes from numerous sources and collection methodologies, future regional assessments of marine debris should consider using these reports as a roadmap for data harmonization, with similar item type, material type, and source activities so comparisons can be made on regional, state, national, and even international scales.

In the Central Coast region within both the MBNMS and the proposed CHNMS, plastic was the most prevalent material type of debris, and plastic fragments were the most common item. In MBNMS, the various activity category, which contained items that could have come from one or more of the other identified source activities, contributed to almost 43 percent of all collected debris, while in the proposed CHNMS, eating and drinking was the highest source activity, contributing to almost 37 percent of all collected debris. In both studies, eating and drinking, smoking, and various were the top three activity categories.

We also followed Monterey Bay's hotspot determination methodology using both distance and effort as measures to calculate debris density, as both of our datasets included some data sources that recorded the distance of beach cleaned and the number of people participating in a cleanup, while some data sources did not. In

MBNMS, the three segments that ranked highly for both debris density and effort included areas with popular beaches, many of which were close to urban areas, including Santa Cruz. Similarly, in the proposed CHNMS, hotspots of debris across density and effort measures were consistently located in segments containing accessible beaches close to cities.

However, little data exists in the proposed CHNMS compared to other parts of the Central Coast. Outlier data points, short distances surveyed, and infrequent cleanups can greatly influence density calculations and hotspot maps (Krone et al., 2023). Overall, studies in other regions of the world that have calculated debris densities classify 0-5,000 items/km areas as low density areas, while higher density areas range from 125,000-250,000 items/km (Serra-Goncalves et al., 2019). Comparatively, Krone et al. (2023) characterized MBNMS debris density as low overall, and the proposed CHNMS could also be considered as low. More distance-specific debris data is needed throughout the Central Coast to more accurately calculate debris density and highlight hotspots of debris.

Ultimately, this regional comparison suggests there are similarities in debris characteristics and patterns across the Central Coast of California. Plastic debris; debris from smoking, eating, and drinking; and fragments should be regional priorities. When looking at debris from a state-wide perspective, these findings should be compiled with studies from Southern and Northern California to guide management decisions. Further, due to the high prevalence of these debris along the Central Coast despite varied geographic and population characteristics, focusing on these types of debris in other west coast regions could potentially serve as a starting point for marine debris monitoring, mitigation, and research until local-based studies can be completed. However, since results were not exactly the same between the MBNMS and the CHNMS, there is still value in conducting local research to inform local management best practices along the west coast.

### 6.5. Policy

The effect of policies on coastal debris was difficult to determine due to significant data limitations. While it may seem as though foam takeout container density increased in the Grover Beach area after Ordinance No. 18-01 banning polystyrene was promulgated - suggesting the policy may not be effective at reducing foam takeout containers in the area - this increase in density is not necessarily true. Cleanup effort also increased after the regulation was implemented, so an increase in takeout containers could be because of that increased cleanup effort. Furthermore, the category we analyzed was “plastic takeout containers,” which included but was not limited to foam takeout containers. Specifically focusing on only foam takeout containers was not feasible with our item categories, although future analyses could prioritize isolating foam takeout containers and/or other foam products for analysis, especially because foam was an area of concern for interviewees. In addition, there were not sufficient data to model a single item category at the segment level, and monthly density estimates were skewed by inaccurate distance measures. Consequently, it is hard to say whether or not the policy was effective in reducing foam takeout container debris along the coastline. This uncertainty suggests that, as in other environmental research, improving community science data quality is important for future analyses and for reaching definitive conclusions (Aceves-Bueno et al., 2017; Callaghan et al., 2019). For marine debris monitoring, standardizing data categories and recording accurate distance metrics in community science cleanups would improve data quality and allow for more robust analyses.

Similar limitations were present for the policy analyses related to SLO's Ordinance No. 2019-1 and California's AB-1884. Although both of these regulations allowed us to use more of our data, the other limitations still prevented conclusions from being drawn. For AB-1884, the ban was specifically on single-use plastic straws, but our data category was "straws and stirrers," which included both straws made of other materials and stirrers. This could skew results. For example, a switch to biodegradable or compostable straws might have occurred, so there might not be a reduction in the overall number of straws, as these straws are still not degradable in a marine environment. Therefore, based on the methodologies the community science beach cleanup apps used, more detailed analysis was not possible as they did not have more specific categories. Further, the policy specifically targets full-service restaurants; other establishments that use straws are exempt. The impact of this policy may therefore be hard to visualize with the available data as the scale of impact is too small. While it may seem that plastic straws increased after the regulation, despite a decrease in cleanup effort, due to these limitations this increase may not actually be accurate. Once again, further analysis and better data are needed to reach any conclusions.

For Ordinance 2019-1, there was not a clear shift in the density of plastic takeout containers after the policy was promulgated. However, based on the aforementioned data limitations, additional information would be needed before reaching a definitive conclusion.

Despite these limitations, which prevented more robust policy data analysis, community science data can still provide some broad insights into marine debris spatial and temporal patterns (Gacutan et al., 2022). Based on our policy visualizations, there is still not a clear decrease in marine debris after existing waste policies are implemented.

This persistence in debris despite policy implementation suggests that policies are not necessarily reducing marine debris along the coastline. Consequently, policies could likely be better at reducing sources of debris, as research has shown that robust and targeted source reduction policies abroad, in tandem with education, can have significant impacts on reducing marine debris (Serra-Gonçalves et al., 2023). For example, AB-1884 could target more than just full-service restaurants and include all businesses that use straws. Therefore, developing more innovative and targeted policies is also likely necessary for reducing marine debris, in tandem with recording better data for analyses.

### 6.6. Interviews

Our interviews suggest that there is a shared and strong concern regarding marine debris across agencies, local organizations, research institutions, and Indigenous communities that live and work within the proposed CHNMS region. Interviewees also shared concern for specific debris types, most notably plastic, with 10 out of 13 interviewees identifying a range of plastic items including takeout food containers, plastic bags, and microplastics as concerning. This focused concern on plastic is reflected in the results of our analysis, with plastic being the most prevalent material type in our debris data. Many interviewees also advocated for larger scale solutions relating to plastic pollution specifically, suggesting that policies or government action should aim to reduce plastic pollution at the consumer and producer sources.

Many interviewees also discussed existing efforts within their agencies/organizations/research institutions/communities to address marine debris, with beach cleanups being the most popular action across groups. Three interviewees mentioned specific locations of concern, including Avila Beach near the Five Cities area, which is highlighted in the hotspot analyses as an area of high debris density. Anecdotes from multiple interviewees speculated that the high levels of debris in these areas are due to nearby college campuses and the fact that these beaches are popular for community gatherings. These types of comparisons between anecdotes and quantitative data further informed and strengthened our recommendations, which focus on local concerns that can and should be achieved through continued effective community engagement practices (González, 2020).

In some instances, answers varied between agencies, organizations, and Indigenous communities. Two local Tribal members emphasized the cultural importance of this region in addition to preserving traditional ecological knowledge for future generations. There was a strong emphasis placed on engaging and educating the public about the Indigenous cultural value of coastal environments within this region. These perspectives differed from those of interviewees affiliated with agencies and research institutions, who focused more on improving marine debris research and regulatory work. However, interviewees from local organizations, research institutions, and Indigenous communities all emphasized the need for partnerships between groups that do marine debris work to develop more effective and inclusive processes for reducing marine debris.

One limitation of these qualitative data was the challenge of scheduling interviews with a representative sample of the Tribes, organizations, and agencies that live and work in this region. Community capacity varies between groups and involves a multitude of "developmental stages," like informing and consulting communities, to build capacity and ensure effective engagement (González, 2020). Many Indigenous contacts in particular had a lack of capacity due to numerous existing engagements and work to advance the sanctuary designation process. With the time constraints of our project, as well as a limited budget from which to equitably compensate interviewees for their time, the interview sample size is small, and the number of participants from each main representative group (agencies, research institutions, local organizations, and Indigenous communities) is unequally distributed. These limitations highlight the importance of continuing  to incorporate Indigenous communities' perspectives into projects from the beginning, and providing equitable compensation for these groups' time. More work will need to be done to respectfully honor these groups' values and knowledge when managing marine debris in the proposed sanctuary.

# 7. Recommendations

## 7.1. Data Collection and Analysis

We recommend using streamlined collection protocols with standardized debris categories and effort metrics across both community beach cleanups and scientific data collection events.

### *7.1.1. Community Science Beach Cleanup Standardization*

Regarding collection protocols for community science beach cleanup events, we recommend that event organizers consider the Clean Swell app, which feeds data into the TIDES database. This protocol consistently includes a distance metric, which is important for debris density and policy impact analyses. Alternatively, we recommend that other beach cleanup apps incorporate and require a distance metric. We also recommend that event organizers provide a tutorial on data entry to ensure consistency in how debris is being recorded, as well as to emphasize the importance of including an accurate distance metric. Many cleanup events had inaccurate distance metrics (the distance measures were recorded as zero or the measures were labeled as NA), so ensuring that information is accurately reported is imperative for running accurate time series and hotspot analyses. Further, we recommend that community science beach cleanup apps record GPS coordinates for the starting and stopping locations for every cleanup. This automatic recording of starting and stopping points is common practice in many wildlife and bird recording apps, such as iNaturalist and eBird, and a similar system could be utilized by beach cleanup apps to greatly enhance the impact of cleanup data (McKee, 2022). This information is imperative for running time series models as they require information about when a particular stretch of coastline was last cleaned to ensure greater precision. We also recommend that MDT includes the number of people participating in future cleanup events, as the number of people is another important metric for measuring effort.

### *7.1.2. Scientific Data Collection Standardization*

For scientific data collection, including future marine debris monitoring efforts within the sanctuary, we recommend using the MDMAP protocol. This protocol is more scientifically rigorous and allows for accurate repeat sampling of sites over time (Burgess et al., 2021). Additionally, the MDMAP database is a user-friendly platform to compare data across large spatial scales, which is useful for comparing debris data within the sanctuary area as well as between sanctuaries across the west coast and United States. MDMAP is in the process of creating a robust, national-scale database, to which sanctuary monitoring efforts of marine debris can contribute significantly (Kehoe, pers. comm, July 2023).

### *7.1.3. Data Categorization*

We recommend that data categories for classifying debris be standardized at the community science beach cleanup program level. This standardization for item, material, and source activity categories is imperative for all types of marine debris analysis, and standardizing at the community science beach cleanup program level would allow for the most accurate and simplest data analysis. Our analysis, in tandem with the MBNMS marine debris report (Krone et al., 2023), could act as a foundation for this standardization.

Together, these data collection and process recommendations will allow for more efficient, detailed, and accurate hotspot and policy analyses, and support additional types of marine debris analyses that will allow decision makers to draw more effective insights from prior management actions.

## 7.2. Policy

For more detailed and effective policy analysis, the aforementioned data collection recommendations are necessary. Once better data are available and analyses are run, policies that prove to be effective at reducing debris should be implemented in more areas and at broader spatial scales.

However, we also recommend that the types of policies implemented and their scopes be thoroughly considered. Although we were unable to formally analyze existing policies, visualizations suggest that existing policies may not be effective in reducing the prevalence of targeted marine debris item types. Policies that are new and innovative or have broader scopes—such as focusing on more than just foam containers, but foam and plastic containers; regulating the use of plastic straws at a broader range of vendors instead of just at full-service restaurants; or expanding policies outside of individual municipalities—may be necessary to effectively reduce marine debris. CHNMS sanctuary management should partner with local and regional governments to create policies and accompanying educational materials that may better target marine debris.

Future policies could also focus on targeting hotspots of debris throughout the study area, such as Morro Bay, Avila Beach/Five Cities, and the Gaviota Coast, and prevalent items, material types, and source activities in these areas. Additionally, because prevalent debris material types are similar between hotspots in this area, regional policies should target plastic production and use. Similarly, as eating and drinking was a common source of debris across the hotspots and the whole sanctuary, policies should target activities related to eating and drinking at the shoreline. In the Morro Bay and Avila Beach/Five Cities areas, smoking also contributed to a large amount of the debris, so policies in those localities could also target smoking activities.

### 7.3. Co-Stewardship and Community Engagement

The US government uses the term co-stewardship to describe working agreements between Tribes and the federal government. We recommend that both federally recognized and non-federally recognized Tribes are formally included in co-stewardship sanctuary management. All future research and monitoring projects should be meaningfully involved from the beginning stages of the project to completion, and projects should focus on addressing and supporting community needs. Multiple Indigenous contacts for this project expressed concerns about health impacts from coastal pollution in underserved areas that are home to Indigenous communities, such as Oceano Dunes in the Five Cities area. The focus of future mitigation efforts should address these concerns.

Within the Water Quality Action Plan, marine debris monitoring and mitigation efforts, and particularly data collection, can and should involve these groups. One Indigenous interviewee said that including Indigenous youth in beach cleanups is an important way for them to engage with and connect to their ancestral ties to the coast. Additionally, incorporating Indigenous and local knowledge of coastal processes can help inform sites for data collection, and Indigenous and local knowledge of communities and their social and cultural characteristics can help create effective mitigation strategies.

Future sanctuary management should continue to prioritize long-term involvement and engagement with a variety of stakeholders. Different interests within these groups may raise unique concerns. This breadth of viewpoints supports a comprehensive, community-centered management approach.

### 7.4. Additional Research

In addition to collecting regular, more detailed beach cleanup data for monitoring purposes, we also recommend supplementing these data with stormwater monitoring and watershed analyses, to understand how much debris enters watersheds adjacent to the sanctuary and flows downstream into coastal waters, and a debris source and transport analysis, to understand how oceanic and coastal processes may contribute to coastal debris accumulations. We also recommend a more robust policy analysis to better measure the effectiveness of existing policies within the sanctuary area at the local and county level.

### *7.4.1. Watershed Analysis*

Waterways are the main pathway by which trash is transported from inland sources to marine environments (McLaughlin et al., 2023). In the Central Coast, there are over 17,500 miles of rivers and streams (SWAMP, 2018), and within the sanctuary area, two major river watersheds, the Santa Ynez and Santa Maria, drain into coastal waters. Much of the lower watersheds in this region are primarily agricultural lands, while the upper parts of the watersheds are mostly National Forest (SWAMP, 2018). Several interviewees also expressed concern for upstream sources of debris transported into coastal waters. To address these concerns and better understand inland sources and quantities of debris that drain through these types of coastal watersheds into the ocean, we recommend conducting an assessment of watersheds within the sanctuary area. This assessment would identify the size, flow rates, and water quality of all watersheds that flow into the sanctuary area, as well as quantities, types, and spatial extents of trash in these watersheds. See McLaughlin et al.'s (2023) trash assessment in Southern California coastal watersheds for specific methodologies on trash survey and analysis methods.

Additionally, we recommend conducting regular water quality monitoring to understand microplastic and other contaminant loads. Weathering and fragmentation of plastic debris from land-based sources in terrestrial and riverine environments is a mechanism of microplastic contamination entering the marine environment (McLaughlin et al., 2023). Therefore, identifying areas where both trash and microplastic levels are high can help guide where watershed cleanups should be prioritized.

### *7.4.2. Stormwater Monitoring*

There is growing concern regarding pollution of coastal waters from urban watershed sources, and urban stormwater is considered to be a primary source of marine debris (Holt et al., 2017; McLaughlin et al., 2023). Storm drain contaminants impact coastal waters in a variety of ways, including altering the physical and biogeochemical makeup of the water, and causing health hazards for both humans and marine life (Holt et al., 2017). Across Central and Southern California, stormwater runoff from rain events has increased over time, largely due to increases in impervious (e.g. paved) land surfaces associated with population growth and development (Holt et al., 2017). The episodic nature of rain events alongside the increase in impervious surfaces allows pollutants, including anthropogenic debris, to accumulate in urban areas and in storm drains during the dry months of the year (roughly April to September), which leads to increased pollution loads and debris discharged into coastal waters through storm drains during storm events (Holt et al., 2017; McLaughlin et al., 2023).

In the proposed CHNMS, there are a number of urban centers, especially in the northern half of the sanctuary area from the Five Cities area to Cambria, that could contribute to stormwater debris loads entering the coastal environment. To monitor and mitigate the effects of stormwater runoff into coastal waters in the proposed CHNMS, we recommend the following:

- Stormwater traps have been shown to significantly reduce debris entering the coastal environment (McLaughlin et al., 2023). Sanctuary staff and local partners should conduct a review of municipal storm drain debris catchment systems. The sanctuary should support municipalities that lack catchment systems in identifying and acquiring sources of funding to install these devices.
- Municipal water and waste management staff, in partnership with sanctuary staff and local research institutions, should conduct regular pre- and post-storm assessments of debris caught in storm drain systems categorized by item type, material type, and source activity, to better understand quantities and sources of debris entering stormwater systems before and after rain events.
- Sanctuary staff, in partnership with ocean monitoring organizations in the area, should consider analyzing satellite imagery to detect stormwater plumes entering the ocean after storm events (Holt et al., 2017). This type of remote sensing would help determine the magnitude of stormwater runoff events and associated debris loads, as well as the direction of debris drift once it enters the ocean in these events.
- Land-based cleanups in urban areas and watersheds, along with regular municipal street sweeping should continue in order to reduce upstream sources of debris (Stickel et al., 2012). These measures would help prevent debris from entering stormwater systems and subsequently being transported to the coast.

These suggested stormwater analyses could inform specific local ordinances that address stormwater debris types and source activities (Stickel et al., 2012).

### *7.4.3. Coastal and Oceanic Sources and Transport of Debris*

In addition to assessing inland sources of debris and watershed and stormwater transport of this debris into coastal waters, we also recommend researching coastal and oceanic sources and transport of debris (Willis et al., 2017). Specific focuses of research could include:

- Comparing debris densities on beaches within the sanctuary area that have different geomorphologic characteristics such as beach slope, exposure to fetch, orientation to prevailing winds, currents, and longshore drift, and features such as natural streams or stormwater outflows that may impact debris density and composition (Willis et al., 2017; Krone et al., 2023).
- Analyzing directions and flows of offshore currents along the sanctuary area to gain insight into likely debris deposition and accumulation sites (van Sebille et al., 2020).
- Building on the work of the 2023 Bren School Group Project titled “Assessing Lost Gear Removals in Southern California by a Non-Profit” and partnering with nonprofits like Ocean Defenders Alliance to remove and analyze ocean-based sources of debris (Lam, et al., 2023).
- Identifying potential “indicator species” of debris that 1) may be more likely to come from ocean-based sources, and 2) may be more likely to come from land-based sources, and compare spatial densities between the two in order to get a better understanding of likely debris sources across the sanctuary (Jerde, pers. comm, January 2024). Ocean-based sources could be fishing gear (Pawar et al., 2016), while land-based sources could be items from our eating and drinking category.
- Sampling of beaches in remote areas such as TNC’s Jack and Laura Dangermond Preserve and the Vandenberg Space Force Base to better understand types and sources of debris in these areas. This sampling will provide insight into differences in debris composition and quantities between remote areas and more populated areas, which could in turn provide insight into debris sources.

### *7.4.4. Policy Analysis*

In addition to collecting better-quality data and developing innovative policies, we also recommend conducting more robust analyses to better measure the effectiveness of existing local, county, and state policies at reducing marine debris. Based on available data and conversations with experts, we recommend two approaches:

- *Before-After-Control-Impact (BACI) Analysis:* This analysis would provide insight to whether or not a policy was effective at reducing a targeted type of marine debris, such as expanded polystyrene, as it compares changes in debris density in a location where a policy is enacted to a location without the policy before and after policy implementation.

- *ARIMA Model:* ARIMA models use time series data to predict future trends and to test the significance of important events, and have been used to forecast environmental changes in a number of studies (Liu et al., 2023). ARIMA models have also been used in two recent studies to analyze future spatial and temporal trends in both plastic marine debris (Gao et al., 2022) and microplastics (Liu et al., 2023). In the proposed CHNMS, an ARIMA model could be used on the harmonized data supplied by this report to predict future trends in debris density as well as to test for significance of a policy in influencing trends in marine debris density. Just as a BACI analysis could focus on a particular policy or debris type, an ARIMA model could be fit to time series data for a particular debris type in a particular locality.

In order for these approaches to successfully identify any changes based on the implementation of a policy, there needs to be significant time series data both before and after the policy implementation, as well as minimal inexplicable noise. More precise data collection may therefore be necessary to utilize these approaches going forward.

## 8. Conclusion

Marine debris in the proposed CHNMS is prevalent and variable, with hotspots centered around Morro Bay and the Avila Beach/Five Cities area in the northern area of the sanctuary, as well as Gaviota in the south. Plastic made up almost 80 percent of debris, with plastic fragments being the most collected item across the data. Eating/drinking and smoking were the source activities that contributed the highest amounts of debris. Agencies, research institutions, local organizations, and Indigenous communities all expressed concern for marine debris in this region, and voiced support for continued and improved mitigation, research, and policy efforts. The effectiveness of existing policies in this region was difficult to meaningfully analyze due to data constraints including lack of category specificity and consistent distance metrics, but the lack of a clear difference in debris density before and after policy implementation also suggests that more specific and targeted policies with fewer exceptions are needed in this region. More standardized debris categories and collection protocols that include distance measurements would also improve both the harmonization of marine debris data across community science datasets, and future hotspot and policy analyses. As this proposed sanctuary continues through the designation and implementation process, we also recommend a number of additional research topics that would better inform the sanctuary's understanding of marine debris issues across this region. Indigenous perspectives and people should be consulted and included in these research, monitoring, and mitigation efforts in every step of the process.

## References


Aceves-Bueno, E., Adeleye, A. S., Feraud, M., Huang, Y., Tao, M., Yang, Y., & Anderson, S. E. (2017). The Accuracy of Citizen Science Data: A Quantitative Review. *Bulletin of the Ecological Society of America 98*(1), pp. 278–290. https://doi.org/10.1002/bes2.1336

Agamuthu, P., Mehran, S. B., Norkhairah, A., and Norkhairiyah, A. (2019). Marine debris: A review of impacts and global initiatives. *Waste Management and Research, 37:10*. https://doi.org/10.1177/0734242X19845041

Allen, S., Allen, D., Phoenix, V. R., Le Roux, G., Jiménez, P. D., Simonneau, A., Binet, S., and Galop, D. (2019). Atmospheric transport and deposition of microplastics in a remote mountain catchment. *Nature Geoscience 12*, pp. 339–344. https://doi.org/10.1038/s41561-019-0335-5

Ambrose, K. K. (2021). Coordination and harmonization of a marine plastic debris monitoring program for beaches in the Wider Caribbean Region: Identifying strategic pathways forward. *Marine Pollution Bulletin 171*, p. 112767. https://doi.org/10.1016/j.marpolbul.2021.112767

American Nonsmokers' Rights Foundation. (2017). "Municipalities with Smokefree Beach Laws Enacted as of October 2, 2017." Accessed on 03/21/24 from https://no-smoke.org/wp-content/uploads/pdf/SmokefreeBeaches.pdf

Araújo, M. C. B., and Costa, M. F. (2019). A critical review of the issue of cigarette butt pollution in coastal environments. *Environmental Research 172*, pp. 137–149. https://doi.org/10.1016/j.envres.2019.02.005

Assembly Bill No. 1884. (2018). An act to add Chapter 5.2 (commencing with Section 42270) to Part 3 of Division 30 of the Public Resources Code, relating to food facilities, Assembly Bill No. 1884 Chapter 576. *California Legislative Information.* https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB1884

Association of Science and Technology Centers. (2021). "Introduction to Community Science - Community Science Initiative. Community Science Initiative." Accessed on 02/09/24 from https://communityscience.astc.org/overview/

Barnes, D. K. A., Galgani, F., Thompson, R. C., and Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B 2009: 364,* pp. 1985–1998. https://doi.org/10.1098/rstb.2008.0205

Beaumont, N. J., Aanesen, M., Austen, M. C., Börger, T., Clark, J. R., Cole, M., Hooper, T., Lindeque, P. K., Pascoe, C., and Wyles, K. J. (2019). Global ecological, social, and economic impacts of marine plastic. *Marine Pollution Bulletin 142*, pp. 189–195. https://doi.org/10.1016/j.marpolbul.2019.03.022

Bureau of Land Management (BLM). (2022). "BLM Publishes Tribal Co-Stewardship Policy, Reaffirms Commitment to Work with Tribes to Manage Public Lands." Accessed on 12/06/23 from https://www.blm.gov/press-release/blm-publishes-tribal-co-stewardship-policy-reaffirms-commitment-work-tribes-manage

Burgess, H., Herring, C. E., Lippiatt, S., Lowe, S., and Uhrin, A. V. (2021). "NOAA Marine Debris Monitoring and Assessment Project Shoreline Survey Guide." Accessed on 07/13/2023 from https://marinedebris.noaa.gov/sites/default/files/publications-files/MDMAP_Shoreline_Survey_Guide_2021_TM_NOS-ORR_56.pdf

Callaghan, C. T., Rowley, J. J. L., Cornwell, W. K., Poore, A. G. B., & Major, R. E. (2019). Improving big citizen science data: Moving beyond haphazard sampling. *PLOS Biology 17*(6), e3000357. https://doi.org/10.1371/journal.pbio.3000357

Chumash Heritage National Marine Sanctuary. (2022). "About the Proposed Chumash Heritage Sanctuary." Accessed on 01/13/23 from https://chumashsanctuary.org/about/

Coppock, R. L., Cole, M., Lindeque, P. K., Queirós, A. M., and Galloway, T. S. (2017). A small-scale, portable method for extracting microplastics from marine sediments. *Environmental Pollution 230*, pp. 829–837. https://doi.org/10.1016/j.envpol.2017.07.017

Coyle, R., Hardiman, G., & Driscoll, K. O. (2020). Microplastics in the marine environment: A review of their sources, distribution processes, uptake and exchange in ecosystems. *Case Studies in Chemical and Environmental Engineering 2*, p. 100010. https://doi.org/10.1016/j.cscee.2020.100010

Currie, J. J., & Stack, S. H. (2021). Getting butts off the beach: Policy alone is not effective at reducing cigarette filter litter on beaches in Maui, Hawai'i. *Marine Pollution Bulletin 173*, p. 112937. https://doi.org/10.1016/j.marpolbul.2021.112937

De Kort, Y. A. W., McCalley, L. T., & Midden, C. J. H. (2008). Persuasive trash cans: Activation of littering norms by design. *Environment and Behavior 40*(6), pp. 870–891. https://doi.org/10.1177/0013916507311035

Department of the Interior. (2022). "First Annual Report on Tribal Co-Stewardship." Accessed on 12/6/23 from https://www.bia.gov/sites/default/files/dup/inline-files/doi_annual_report_on_co-stewardship.pdf

Donoghue, E. M., Thompson, S. A., and Bliss, J. C. (2010). Tribal-Federal Collaboration in Resource Management. *Journal of Ecological Anthropology* 14(1): pp. 22–38. https://digitalcommons.usf.edu/jea/vol14/iss1/2

Environmental Protection Agency (EPA). (2023). "Learn About Aquatic Trash". Accessed on 02/19/24 from https://www.epa.gov/trash-free-waters/learn-about-aquatic-trash

Federal Register. (2021). "Notice of Intent to Initiate Designation of CHNMS." Notices 86: 215, pp. 62512–62516. https://www.regulations.gov/document/NOAA-NOS-2021-0080-0001

Hardesty, B. D., Lawson, T., van der Velde, T., Lansdell, M., and Wilcox, C. (2017). Estimating quantities and sources of marine debris at a continental scale. *Frontiers in Ecology and the Environment 15*(1), pp. 18–25. https://doi.org/10.1002/fee.1447

Hardesty, B. D., Wilcox, C., Schuyler, Q., Lawson, T., and Opie, K. (2016). Developing a baseline estimate of amounts, types, sources and distribution of coastal litter; an analysis of US marine debris data. *Frontiers in Ecology and the Environment.* https://doi.org/10.1002/fee.1447

Hidalgo-Ruz, V., Gutow, L., Thompson, R. C., and Thiel, M. (2012). Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification. *Environmental Science and Technology 46*, pp. 3060–3075. https://doi.org/10.1021/es2031505

Hou, G., Zhao, X., Zhao, T., Wu, X., Pu, S, Tang, Z., and Wu, F. (2023). The adsorption of PAHs on microplastics and desorption in the simulated human digestive system. *Chemical Engineering Journal 473*. https://doi.org/10.1016/j.cej.2023.145157

Gacutan, J., Johnston, E. L., Tait, H., Smith, W., & Clark, G. F. (2022). Continental patterns in marine debris revealed by a decade of citizen science. *Science of The Total Environment 807*, p. 150742. https://doi.org/10.1016/j.scitotenv.2021.150742

Galgani, F., Hanke, G., & Maes, T. (2015). Global distribution, composition and abundance of marine litter. In M. Bergmann, L. Gutow, & M. Klages (Eds.), *Marine Anthropogenic Litter* (pp. 29–56). Springer International Publishing. https://doi.org/10.1007/978-3-319-16510-3_2

Gao, S. Li, R., and Yi, X. (2022). Analysis and Prediction of Marine Debris Plastic Pollution. *CAIBDA 2022; 2nd International Conference on Artificial Intelligence, Big Data and Algorithms*. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=10104405

Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). (2015). Sources, Fate and Effects of Microplastics in the Marine Environment: A Global Assessment. I*nternational Maritime Organization,* 96 pp. https://environment.ec.europa.eu/topics/marine-environment_en

Gilfillan, L. R., Ohman, M. D., Doyle, M. J., and Watson, W. 2009. Occurrence of plastic micro-debris in the California Current System. *Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography, UC San Diego.* https://escholarship.org/uc/item/34w4g0s0

González, R. (2020). “The Spectrum of Community Engagement to Ownership.” *Facilitating Power*. Accessed on 12/10/23 from https://communityscience.astc.org/resources/the-spectrum-of-community-engagement-to-ownership/

Good, T. P., Samhouri, J. F., Feist, B. E., Wilcox, C., and Jahncke, J. (2020). "Plastics in the Pacific: Assessing risk from ocean debris for marine birds in the California Current Large Marine Ecosystem." *Biological Conservation 250.* https://doi.org/10.1016/j.biocon.2020.108743

Holt, B., Trinh, R., and Gierach, M. M. (2017). “Stormwater runoff plumes in the Southern California Bight: A comparison study with SAR and MODIS imagery.” *Marine Pollution Bulletin 111*(1–2). https://doi.org/10.1016/j.marpolbul.2017.02.040

Iñiguez, M. E., Conesa, J. A., & Fullana, A. (2016). Marine debris occurrence and treatment: A review. *Renewable and Sustainable Energy Reviews 64*, pp. 394–402. https://doi.org/10.1016/j.rser.2016.06.031

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science 347*(6223), 768–771. https://doi.org/10.1126/science.1260352

Krone, P., Mejia-Munoz, J., and Hoover, B. (2023). Marine debris on the shoreline of Monterey Bay National Marine Sanctuary: An assessment of activities contributing to marine debris categories and composition, spatial distribution, and predictor variables.”*NOAA Office of National Marine Sanctuaries*. https://nmsmontereybay.blob.core.windows.net/montereybay-prod/media/resourcepro/reports/231020mbnms_marinedebris.pdf

Kenyon, K. W. and Kridler, E. (1969). Laysan Albatross swallow indigestible matter. *Auk* 86, pp. 339–343. https://doi.org/10.2307/4083505

Lam, S., Ossentjuk, L., Rao, M., Robinson, C., & Sanford, A. (2023). Assessing Lost Gear Removals in Southern California by a Nonprofit. *Bren School of Environmental Science & Management, University of California, Santa Barbara*. https://bren.ucsb.edu/projects/assessing-lost-gear-removals-southern-california-nonprofit

Landrigan, P. J., Stegeman, J. J., Fleming, L. E., Allemand, D., Anderson, D. M., Backer, L. C., Brucker-Davis, F., Chevalier, N., Corra, L., Czerucka, D., Bottein, M. D., Demeneix, B., Depledge, M., Deheyn, D. D., Dorman, C. J., Fénichel, P., Fisher, S., Gaill, F., Galgani, F., … Rampal, P. (2020). Human Health and Ocean Pollution. *Annals of Global Health*, 86(1). https://doi.org/10.5334/aogh.2831

Liu, S., Junaid, M., Sadaf, M., Ai, W., Lan, X., and Wang, J. (2023). A novel framework-based meta-analysis for in-depth characterization of microplastic pollution and associated ecological risks in Chinese Bays. *Journal of Hazardous Materials 444*(B). https://doi.org/10.1016/j.jhazmat.2022.130423

Marine Debris Act Amendments of 2012. (2012). 33 U.S.C § 1951. https://www.congress.gov/112/plaws/publ213/PLAW-112publ213.pdf

Marine Debris Research, Prevention, and Reduction Act. (2006). 33 U.S.C § 1951 *et seq*. https://www.congress.gov/109/plaws/publ449/PLAW-109publ449.pdf

Marine Debris Tracker. (n.d.). “Debris Tracker.” Accessed on 05/11/23 from https://www.debristracker.org/

Masiá, P., Ardura, A., Gaitán, M., Gerber, S., Rayon-Viña, F., and Garcia-Vazquez, E. (2021). Maritime ports and beach management as sources of coastal macro-, meso-, and microplastic pollution. *Environmental Science and Pollution Research* 28, pp. 30722–30731. https://doi.org/10.1007/s11356-021-12821-0

McKee, J. (2022). A Beginner’s Guide to Using eBird. *Audubon*. https://www.audubon.org/news/a-beginners-guide-using-ebird

McLaughlin, K., Mazor, R., Sutula, M., and Schiff, K. (2023). Regional assessment of trash in Southern California coastal watersheds, United States. *Frontiers in Environmental Science 11*. https://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/1332_RegionalAssessmentTrash.pdf

Moore, E. Lyday, S., Roletto, J., Little, K., Parrish, J. K., Nevins, H., Harvey, J., Mortenson, J., Greig, D., Piazza, M., Hermance, A., Lee, D. Adams, D., Allen, S., and Kell, S. (2009). Entanglements of marine mammals and seabirds in central California and the northwest coast of the United States 2001-2005. *Marine Pollution Bulletin 58*(7), pp. 1045–1051. https://doi.org/10.1016/j.marpolbul.2009.02.006

Moore, S. L. and Allen, M. J. (2000). Distribution of Anthropogenic and Natural Debris on the Mainland Shelf of the Southern California Bight. *Marine Pollution Bulletin 40*(1), pp. 83–88. https://doi.org/10.1016/S0025-326X(99)00175-7

National Oceanic and Atmospheric Administration (NOAA). (2023). Proposed Chumash Heritage National Marine Sanctuary: A Proposed Rule by the National Oceanic and Atmospheric Administration on 08/25/23. *Federal Register.* https://www.federalregister.gov/documents/2023/08/25/2023-18271/proposed-chumash-heritage-national-marine-sanctuary

NOAA Marine Debris Program (MDP). (2023a). "What is Marine Debris?" Accessed on 12/13/23 from https://marinedebris.noaa.gov/discover-marine-debris/what-marine-debris

NOAA MDMAP. (2021a). Survey Coversheet and Quick Reference. *NOAA MDP.* https://marinedebris.noaa.gov/datasheets/survey-coversheet-and-quick-reference

NOAA MDMAP. (2021b). Transect Survey Form. *NOAA MDP.* https://marinedebris.noaa.gov/datasheets/transect-survey-form

NOAA MDMAP. (2021c). Shoreline Site Characterization Form. NOAA MDP. https://marinedebris.noaa.gov/datasheets/shoreline-site-characterization-form

NOAA MDP. (2023b). “The Marine Debris Act.” Accessed from on 12/14/23 from https://marinedebris.noaa.gov/about-our-program/marine-debris-act

NOAA MDP. (2023c). National Marine Debris Emergency Response Guide. *NOAA Technical Memorandum NOS OR&R Marine Debris Emergency Response Guide 017a*. https://marinedebris.noaa.gov/sites/default/files/publications-files/US_Marine_Debris_Emergency_Response_Guide_2023.pdf

NOAA MDP. (2024). “Funding Opportunities.” NOAA Marine Debris Program. Accessed on 02/23/24 from https://marinedebris.noaa.gov/resources/funding-opportunities

NOAA MDP. (2022). “Partnering with Native Communities to Take On Marine Debris.” Accessed on 1/29/24 from https://blog.marinedebris.noaa.gov/partnering-native-communities-take-marine-debris

NOAA Office of National Marine Sanctuaries (ONMS). (2023). “Proposed Chumash Heritage National Marine Sanctuary Draft Management Plan.” Accessed on 12/10/23 from https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/chumash/2023-proposed-chumash-heritage-nms-draft-management-plan.pdf

NOAA ONMS. (2021). “Monterey Bay National Marine Sanctuary Final Management Plan.” *Monterey Bay National Marine Sanctuary*, 150 pp. https://nmsmontereybay.blob.core.windows.net/montereybay-prod/media/intro/mp/fmp/211110m bnms-fmp.pdf

NOAA ONMS. (2014). “Cordell Bank National Marine Sanctuary Final Management Plan.” *Cordell Banks National Marine Sanctuary*, 175 pp. https://nmscordellbank.blob.core.windows.net/cordellbank-prod/media/archive/management/cbn ms_fmp_december_2014.pdf

NOAA ONMS. (2009). “Channel Islands National Marine Sanctuary Final Management Plan/Final Environmental Impact Statement.” *Channel Islands National Marine Sanctuary*, 293 pp. https://nmschannelislands.blob.core.windows.net/channelislands-prod/media/archive/managemen t/manplan/cinms_fmp_2009.pdf OSPAR

NOAA ONMS. (2008). “Gulf of the Farallones National Marine Sanctuary Management Plan.” *Gulf of the Farallones National Marine Sanctuary*, 451 pp. https://nmsfarallones.blob.core.windows.net/farallones-prod/media/archive/manage/pdf/mgmtpla n/gfnms_fmp.pdf

Obbard, R. W. (2018). Microplastics in polar regions: the role of long range transport. *Current Opinion in Environmental Science and Health 1*, pp. 24–29. https://doi.org/10.1016/j.coesh.2017.10.004

Ocean Conservancy. (2021). “Ocean Plastic Pollution Facts and Figures.” Accessed on 12/13/23 from https://oceanconservancy.org/wp-content/uploads/2022/03/General-Ocean-Plastic_Oct-2021.pdf

Ocean Conservancy. (2023). “TIDES Trash Information and Data for Education and Solutions”. Accessed on 05/12/23 from https://www.coastalcleanupdata.org

Organization for Economic Co-operation and Development (OECD). (2023). "Chapter 2: Marine Litter" in *OECD Environmental Performance Reviews: United States.* https://doi.org/10.1787/47675117-en

Ordinance No. 5636. (2013). An Ordinance of the City Council of the City of Santa Barbara Amending the Santa Barbara Municipal Code by Adding Chapter 9.150 Pertaining to the Use of Single-Use Carry Out Bags at Certain Retail Food and Grocery Store Establishments Within the City. *The Council of the City of Santa Barbara.* https://santabarbaraca.gov/sites/default/files/documents/Environmental%20Services/Environmental%20Services%20/%20Trash%20%26%20Recycling/Single-Use%20Carryout%20Bag%20Ordinance.pdf

Ordinance No. 600. (2016). An Ordinance of the City Council of the City of Morro Bay, California Amending the Morro Bay Municipal Code By Adding Chapter 8.17 to Regulate the Use of Expanded Polystyrene Products Within the City. *The City Council, City of Morro Bay, California.* https://www.morrobayca.gov/DocumentCenter/View/9392/Expanded-Polystyrene-Regulation---Signed-Ordinance-No-600-?bidId=

Ordinance No. 2019-1. (2019). An Ordinance Regulating Polystyrene and Expanded Polystyrene (EPS) Food Containers and Products, Ordinance 2019-1. *San Luis Obispo County Integrated Waste Management Authority.* https://www.iwma.com/files/f824fb3da/Ordinance+No.+2019-1_1.pdf

Ordinance No. 18-01. (2018). An Ordinance of the City Council of the City of Grover Beach, California, Adding Chapter 7 to Article V of The Grover Beach Municipal Code to Regulate Expanded Polystyrene Products, Ordinance 18-01. *Grover Beach City Council.* https://static1.squarespace.com/static/54d3a62be4b068e9347ca880/t/5a692b3941920243675093f2/1516841787134/Grover+Beach+Polystyrene+Ordinance_Final.pdf

Pawar, P., Shirgaonkar, S. S., and Patil, R. (2016). Plastic marine debris: Sources, distribution and impacts on coastal and ocean biodiversity. *Publication of Biological Sciences 3*(1): 40–54. https://www.researchgate.net/publication/295919494_Plastic_marine_debris_Sources_distribution_and_impacts_on_coastal_and_ocean_biodiversity

Pellowe, K.E. and Leslie, H.M. (2021). Ecosystem service lens reveals diverse community values of small-scale fisheries. *Ambio 50*, 586–600. https://doi.org/10.1007/s13280-020-01405-w

Pettipas, S., Bernier, M., and Walker, T. R. (2016). A Canadian policy framework to mitigate plastic marine pollution. *Marine Policy 68*, pp. 117–122. https://doi.org/10.1016/j.marpol.2016.02.025

Plastic Pollution Prevention and Packaging Producer Responsibility Act. (2022). Article 1 § 42040 (b). *California Legislative Information.* https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=PRC&division=30.&title=&part=3.&chapter=3.&article=1

Portman, M. E., and Brennan, R. E. (2017). Marine litter from beach-based sources: Case study of an Eastern Mediterranean coastal town. *Waste Management 69*, pp. 535–544. https://doi.org/10.1016/j.wasman.2017.07.040

QGIS. (2023). QGIS Geographic Information System. *QGIS Association.* http://www.qgis.org

R Core Team. (2023). R: A Language and Environment for Statistical Computing. *R Foundation for Statistical Computing,* Vienna, Austria. https://www.R-project.org/

Robinson, T. (2023). The effects of bin location and abundance on disposal behavior at beaches. *Marine Pollution Bulletin 197*, p. 115697. https://doi.org/10.1016/j.marpolbul.2023.115697

Rosevelt, C. Huertos, M., Garza, C., and Nevins, H. M. (2013). Marine debris in Central California: Quantifying type and abundance of beach litter in Monterey Bay, CA. *Marine Pollution Bulletin 71,* pp. 299–306. https://doi.org/10.1016/j.marpolbul.2013.01.015

RStudio Team. (2020). RStudio: Integrated Development for R. *RStudio, PBC,* Boston, MA. http://www.rstudio.com

Rust, S. (2022). "Compromise on plastics ban comes under fire in California Legislature. Ballot fight likely." *Los Angeles Times, June 17, 2022.* https://www.latimes.com/environment/story/2022-06-16/plastics-ban-california-legislature-environmentalists-divided-ballot

Sams III, C. F. (2022). "Tribal Co-Management of Federal Lands". *Statement of Charles F. Sams III, Director, National Park Service, U.S. Department of the Interior, before the House Commitee on Natural Resources, Regarding Tribal Co-management of Federal Lands. Accessed on 12/6/23 from* https://www.congress.gov/117/meeting/house/114483/witnesses/HHRG-117-II00-Wstate-SamsIIIC-20220308.pdf

Save Our Seas 2.0 Act. (2020). 33 U.S.C § 4201 *et seq*. https://www.congress.gov/116/plaws/publ224/PLAW-116publ224.pdf

Save Our Seas Act of 2018. (2018). 46 U.S.C § 101 *et seq.* https://www.congress.gov/115/statute/STATUTE-132/STATUTE-132-Pg3742.pdf

Senate Bill (SB) No. 270. (2014). Chapter 850: An act to add Chapter 5.3 (commencing with Section 42280) to Part 3 of Division 30 of the Public Resources Code, relating to solid waste, and making an appropriation therefor. *California Legislative Information.* https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB270

SB No. 54. (2022). Chapter 75: An act to amend Section 41821.5 of, to add Chapter 3 (commencing with Section 42040) to Part 3 of Division 30 of, and to repeal Section 42064 of, the Public Resources Code, relating to solid waste. *California Legislative Information.* https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB54

SB No. 8. (2019). Chapter 761: State Beaches and Parks Smoking Ban. *State of California Department of Parks and Recreation.* https://esd.dof.ca.gov/Documents/bcp/2021/FY2021_ORG3790_BCP3388.pdf

Serra Gonçalves, C., Lavers, J., & Bond, A. (2019). Global Review of Beach Debris Monitoring and Future Recommendations. *Environmental Science and Technology 2019*, pp. 12158−12167. https://doi.org/10.1021/acs.est.9b01424

Serra-Gonçalves, C., Lavers, J. L., Fischer, A. M., Tait, H. L., & Bond, A. L. (2023). Stopping marine debris at the source: Effectiveness of Source Reduction Plans in Australia. *Marine Policy 155*, p. 105776. https://doi.org/10.1016/j.marpol.2023.105776

Shigeru, F. (2023). The drift lighter project—Estimation of drifting range and source of North Pacific marine litter using disposable lighters washed up on coasts. *Regional Studies in Marine Science 58*, p. 102761. https://doi.org/10.1016/j.rsma.2022.102761

Sheavly, S. B., & Register, K. M. (2007). Marine debris & plastics: Environmental concerns, sources, impacts and solutions. *Journal of Polymers and the Environment 15*(4), pp. 301–305. https://doi.org/10.1007/s10924-007-0074-3

Steele, C. L. W. and Miller, M. R. (2022). Temporal trends in anthropogenic marine macro-debris and micro-debris accumulation on the California Channel Islands. *Frontiers in Marine Science 9*. https://doi.org/10.3389/fmars.2022.905969

Stickel, B. H., Jahn, A., and Kier, W. (2012). "The Cost to West Coast Communities of Dealing with Trash, Reducing Marine Debris." *Prepared by Kier Associates for U.S. Environmental Protection Agency, Region 9, pursuant to Order for Services EPG12900098, 21 p. + appendices.* https://tamug-ir.tdl.org/server/api/core/bitstreams/d3e27cd8-921c-47bf-82b6-1447a07fcadb/content

Storrier, K. L., McGlashan, D. J., Bonellie, S., and Velander, K. (2007). Beach Litter Deposition at a Selection of Beaches in the Firth of Forth, Scotland. *Journal of Coastal Research 23* (4), pp. 813–822. https://www.doi.gov/ocl/marine-debris-impacts

Surface Water Ambient Monitoring Program (SWAMP). (2018). “Fact Sheet Region 3”. Accessed on 03/19/24 from: https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/regional/r3_factsheet_18.pdf

Surfrider Foundation. (2023). “Beach Cleanups.” Accessed on 05/11/23 from https://cleanups.surfrider.org/

Surfrider & Plastic Pollution Coalition. (2023). The Surfrider Foundation's U.S. Plastics Policy Map. Accessed on 03/09/24 from https://www.google.com/maps/d/u/0/viewer?ll=33.96556685236896%2C-118.4862382541009&mid=15xHcYQygDGYQnJPKraz7cInHT6mQYJND&z=8

Thompson, R. C. (2017). Future of the Sea: Plastic Pollution. *Foresight, Government Office For Science*, 39 pp. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/ 634433/Future_of_the_sea_-_plastic_pollution_final.pdf

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W. G., McGonigle, D, and Russell, A. E. (2004). Lost at Sea: Where is All the Plastic? *Science 304*, p. 838. 10.1126/science.1094559

Tribal Marine Stewards Network. (2022). “What we do”. Accessed on 1/29/24 from https://tribalmsn.org/our-network/tolowa-dee-ni-nation/

United Nations Environment Programme (UNEP). (2009). Marine Litter: A Global Challenge. Nairobi, Kenya, *UNEP*, 232 pp. https://wedocs.unep.org/handle/20.500.11822/7787;jsessionid=DB89BFA6DF00117DE3B93CA1 76DC14AE

U.S. Census Bureau. (2020). Census Demographic Data Map Viewer. https://maps.geo.census.gov/ddmv/map.html

Van Cauwenberghe, L., Devriese, L., Galgani, F., Robbens, J., and Janssen, C. (2015). Microplastics in sediments: A review of techniques, occurrence and effects. *Marine Environmental Research* 111, pp. 5–17. https://doi.org/10.1016/j.marenvres.2015.06.007

van Sebille, E., England, M. H., & Froyland, G. (2012). Origin, dynamics and evolution of ocean garbage patches from observed surface drifters. *Environmental Research Letters 7*(4), p. 044040. https://doi.org/10.1088/1748-9326/7/4/044040

van Sebille, E., Aliani, S., Law, K. L., Maximenko, N., Alsina, J. M., Bagaev, A., Bergmann, M., Chapron, B., Chubarenko, I., Cózar, A., Delandmeter, P., Egger, M., Fox-Kemper, B., Garaba, S. P., Goddijn-Murphy, L., Hardesty, B. D., Hoffman,

M. J., Isobe, A., Jongdijk, C. E…Wichmann, D. (2020). The physical oceanography of the transport of floating marine debris. *Environmental Research Letters 15*(2). https://iopscience.iop.org/article/10.1088/1748-9326/ab6d7d/meta

Webb, H. K., Arnott, J., Crawford, R. J., and Ivanova, E. P. (2013). Plastic Degradation and Its Environmental Implications with Special Reference to Poly(ethylene terephthalate). *Polymers* 5, pp. 1–18. https://www.mdpi.com/2073-4360/5/1/1

Weber, A. K., Weber, M. W., and Savoca, M. S. (2019). Quantifying marine debris associated with coastal golf courses. *Marine Pollution Bulletin* 140, pp. 1-8. https://doi.org/10.1016/j.marpolbul.2019.01.013

Willis, K., Denise Hardesty, B., Kriwoken, L., & Wilcox, C. (2017). Differentiating littering, urban runoff and marine transport as sources of marine debris in coastal and estuarine environments. *Scientific Reports*, *7*(1), 44479. https://doi.org/10.1038/srep44479

Wootton, N., Nursey-Bray, M., Reis-Santos, P., M. Gillanders, B. (2022). Perceptions of plastic pollution in a prominent fishery: Building strategies to inform management. *Marine Policy* 135. https://doi.org/10.1016/j.marpol.2021.104846

World Wildlife Fund. (2015). Living Blue Planet Report. Species, habitats and human well-being. Gland, Switzerland, *WWF,* 68 pp. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/5dqysd8gh6_Living_Blue_Plane t_Report_2015_Final_LR.pdf

Zhang, H. (2017). Transport of microplastics in coastal seas. *Estuarine, Coastal and Shelf Science* 199, pp. 74–86. https://doi.org/10.1016/j.ecss.2017.09.032

# Appendix I: MDMAP Resources

*A1.1. A blank example of the MDMAP Survey Coversheet and Quick Reference (NOAA MDMAP, 2021a)*

**NOAA Marine Debris Monitoring and Assessment Project**

## Survey Coversheet

Complete ONE per survey

Record data at https://mdmap.orr.noaa.gov

**SITE NAME:** ______________________

Name used for the 100-meter site in the MDMAP database

**DATE:** ______________________

MM/DD/YYYY

**PARTICIPANT INFORMATION:**

Name of all participants (include email if you wish to receive MDMAP updates from NOAA)

______________________

______________________

______________________

______________________

Record additional participant information in the notes

**TOTAL SURVEY DURATION:** ________

Include travel time to/from the site HH:MM

**K-12 GROUP?**

Is the team a student group?

☐ yes

☐ no

**TEAM COUNT:** ______________________

The total number of participants involved in the survey

**FIRST TIMERS:** ______________________

For how many participants is it their first MDMAP survey?

**RECREATORS:**

Upon arrival, how many people are in the 100-meter site?

☐ 0-10

☐ 11-50

☐ 51-100

☐ >100

**WEATHER NOW:**

(Check one)

☐ sunny

☐ partly cloudy

☐ mostly cloudy

☐ light rain/precip

☐ heavy precip

**DRAIN INPUT:**

Is there a storm drain, pipe, or channelized input within the 100-meter survey site?

☐ yes

☐ no

**TRASH CANS:**

Are trash cans present or not? If present, what condition are they in? (Check one)

☐ present and overflowing

☐ present and NOT overflowing

☐ not present

**NOTES:**

Describe interesting items from outside surveyed transects, abundance of debris smaller than 2.5 centimeters, changes to site, evidence of cleanup, sampling issues, etc.

______________________

______________________

______________________

______________________

______________________

**DEBRIS REMOVAL:**

Was debris removed from the 100-meter site (not just the survey transects)?

☐ all/most

☐ some

☐ none

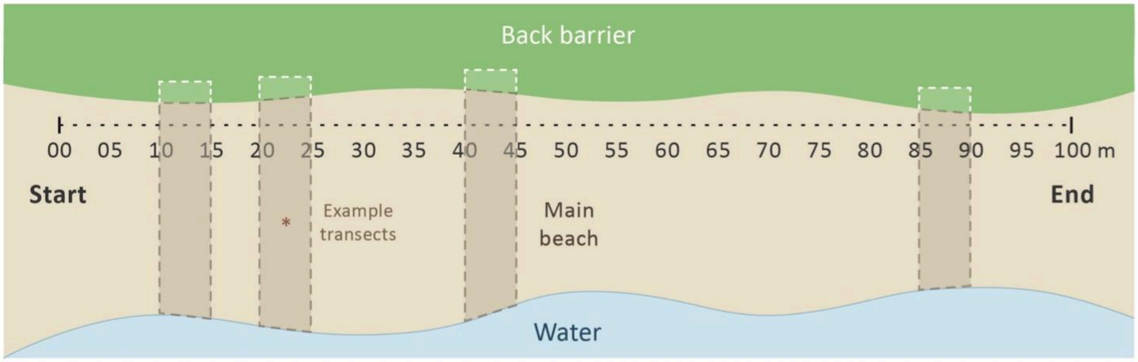
**SURVEY PHOTOS:**

List timestamp, photo number, or other information to keep track of photos from the survey

______________________

______________________

______________________




## SURVEY QUICK REFERENCE

Before beginning, refer to the Monitoring Toolbox and Survey Guide at https://marinedebris.noaa.gov/monitoring-toolbox

### Before you go:

- Select FOUR random transect start points
- Check the weather and tides (aim for a low or outgoing tide)
- Confirm that you have all datasheets, survey supplies, and safety gear

### At the survey site:

- Estimate the number of recreators within the 100-meter site as you arrive
- Record the survey coversheet data
- From the site start, use a measuring wheel or meter tape to find and mark the start of each of the four transects with a flag or other marker

### For each transect:

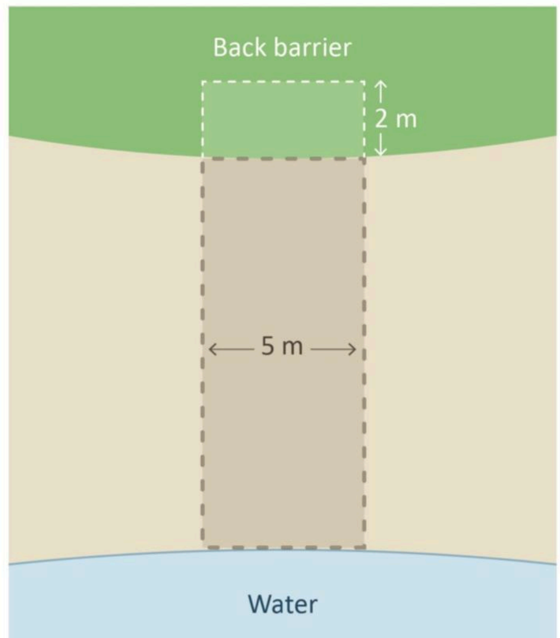
- Complete a transect datasheet (front and back)
- The search should be conducted by no more than two people walking the perimeter of the 5-meter transect and looking in
- Count and categorize debris that is at least 2.5 centimeters (bottle cap or larger) - smaller items can be described in the "notes"
- Record items 2 meters into the "back barrier" separately from the "main beach" (see diagram to right)

### Before leaving:

- Note the total survey duration on the *Survey Coversheet*
- Note where and how much debris was removed within the 100-meter site on the *Survey Coversheet* and *Transect Survey Forms*
- Gather all supplies

### When a new person joins the team:

- They should shadow transect set-up and search, and conduct a "consistency check" for debris categorization before collecting data independently




Example of a survey transect.

### Reminders:

- Fragments are unidentifiable broken items larger than 2.5 centimeters
- Material selection should be based on what is predominant on the surface of the item
- Surveys can be paired with beach cleanups, but wait until after data collection is completed

### We recommend photos of:

- All the debris laid out with a ruler for scale (one photo per transect) if debris is removed
- Close-ups of any unidentifiable, interesting, or difficult to categorize items
- Items that are too large to remove, as you found them
- **Include a ruler for scale!**

*A1.2. A blank example of the MDMAP Transect Survey form (NOAA MDMAP, 2021b).*

**NOAA Marine Debris Monitoring and Assessment Project**

## Transect Survey Form

Complete four per survey, one for each transect
Record data at https://mdmap.orr.noaa.gov

**SITE NAME:** ______________________ Name used for the 100-meter site in the MDMAP database

**DATE:** ______________________ MM/DD/YYYY

**TRANSECT START:** ______________________ 0-95 in 5 meter increments (0, 5, 10, etc.)

**BEACH WIDTH:** ______________________ Water's edge to the back barrier (meters)

**SLOPE:**
Standing at the water's edge the back barrier height is:

- ☐ knees and below
- ☐ knees to shoulders
- ☐ shoulders and above

**PRIMARY SUBSTRATE:**
Check the predominant substrate

- ☐ mud/silt
- ☐ sand
- ☐ pebble/gravel
- ☐ cobble
- ☐ other (describe in notes)

**BACK BARRIER:**
Landward limit of the site (check one)

- ☐ dune
- ☐ vegetation
- ☐ cliff
- ☐ wall/structure
- ☐ boulders
- ☐ dense driftwood
- ☐ parking lot
- ☐ other (describe in notes)

**SEARCH TEAM SIZE:**
Number of people searching for debris in this transect (no more than 2)

- ☐ 1
- ☐ 2

**DEBRIS REMOVAL:**
How much debris was removed from the transect?

- ☐ all/most
- ☐ some
- ☐ none

**CONSISTENCY CHECK:**
Was a consistency check conducted?

- ☐ yes
- ☐ no

Take close-up photos of items where there was not a consensus on categorization, and describe in the notes below.

**TRANSECT PHOTOS:**
List timestamps, photo number, or other information to keep track of photos from this transect

______________________

______________________

______________________

______________________

**NOTES:**
Describe unique or "Other/unclassifiable" items, pulses of debris items, large items left behind, etc.

______________________

______________________

______________________

______________________

## ITEM COUNTS (2.5 centimeters or larger)

**SEARCH TIME:** ____________ ____________
(Local time) Start HH:MM End HH:MM

| | PLASTIC | main beach | back barrier |
|---|---|---|---|
| FRAGMENTS | Film | | |
| | Foam | | |
| | Hard | | |
| SINGLE-USE | Bags | | |
| | Beverage bottles | | |
| | Bottle or container caps | | |
| | Cups (*incl. polystyrene/foam*) | | |
| | Food wrappers | | |
| | Other jugs & containers | | |
| | Straws | | |
| | Utensils | | |
| | Six-pack rings | | |
| TOBACCO | Cigar tips | | |
| | Cigarettes | | |
| | Disposable lighters | | |
| FISHERIES | Buoys & floats | | |
| | Lures & line | | |
| | Rope & nets | | |
| OTHER | Balloons (*mylar*) | | |
| | Personal care products | | |
| | Shotgun shells & wads | | |
| | Other plastic | | |

| CUSTOM | main beach | back barrier |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

| OTHER | main beach | back barrier |
|---|---|---|
| | | |

| METAL | main beach | back barrier |
|---|---|---|
| Metal fragments | | |
| Aerosol cans | | |
| Aluminum/tin cans | | |
| Other metal | | |

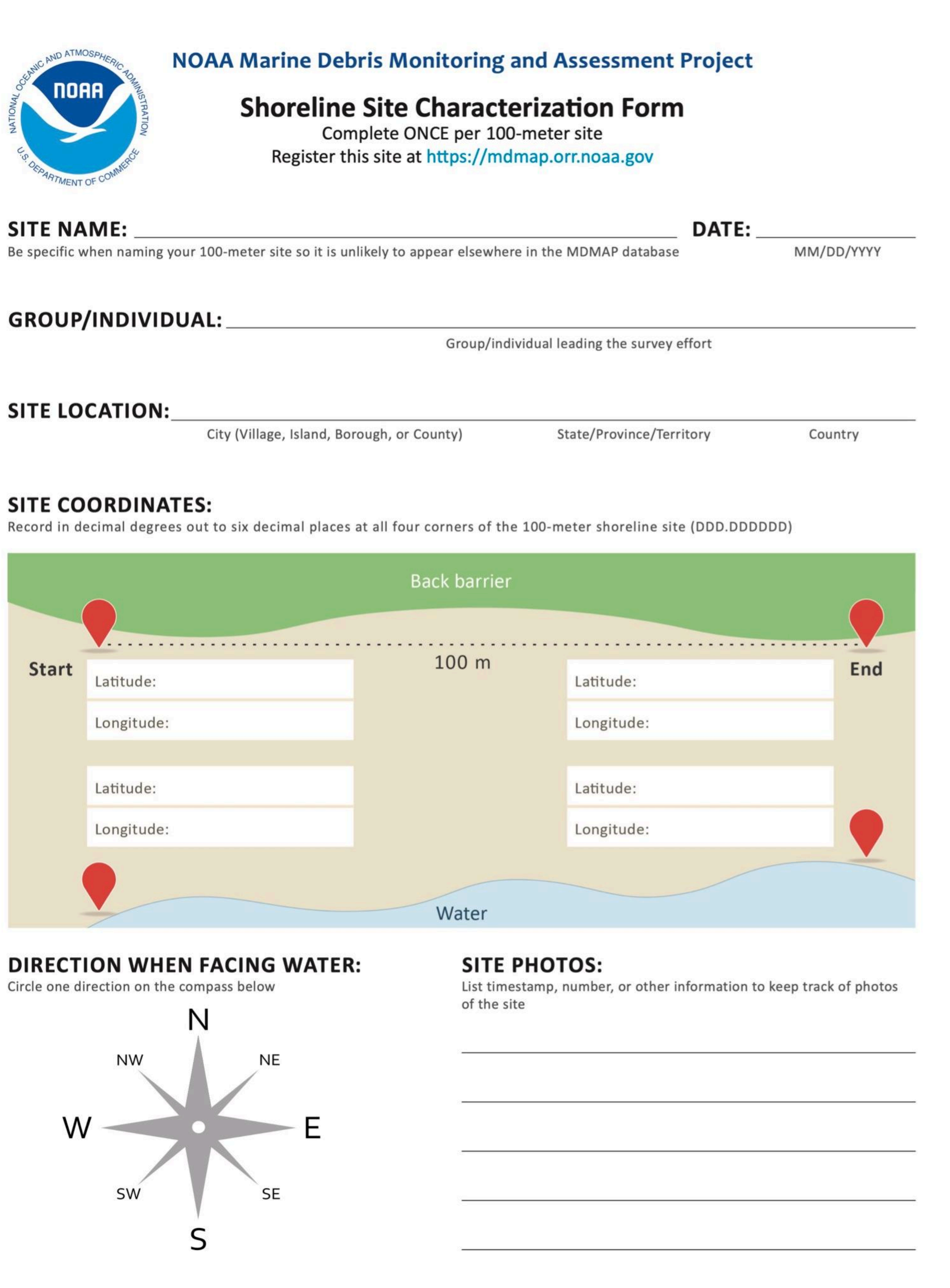
| GLASS | main beach | back barrier |
|---|---|---|
| Glass fragments | | |
| Beverage bottles | | |
| Jars | | |
| Other glass | | |

| RUBBER | main beach | back barrier |
|---|---|---|
| Rubber fragments | | |
| Balloons (*latex*) | | |
| Flip flops | | |
| Gloves (*rubber & latex*) | | |
| Tires | | |
| Other rubber | | |

| PROCESSED WOOD | main beach | back barrier |
|---|---|---|
| Cardboard cartons | | |
| Lumber & building | | |
| Paper & cardboard | | |
| Paper bags | | |
| Other processed wood | | |

| FABRIC | main beach | back barrier |
|---|---|---|
| Fabric fragments | | |
| Clothing & shoes | | |
| Face masks | | |
| Gloves (*non-rubber*) | | |
| Rope & nets (*natural fiber*) | | |
| Towels & rags | | |
| Other fabric | | |

***A1.3.*** *Blank example of the MDMAP Shoreline Site Characterization form (NOAA MDMAP, 2021c).*



NOAA Marine Debris Monitoring and Assessment Project

## Shoreline Site Characterization Form

Complete ONCE per 100-meter site

Register this site at https://mdmap.orr.noaa.gov

**SITE NAME:** ______________________ **DATE:** ____________

Be specific when naming your 100-meter site so it is unlikely to appear elsewhere in the MDMAP database — MM/DD/YYYY

**GROUP/INDIVIDUAL:** ______________________

Group/individual leading the survey effort

**SITE LOCATION:** ______________________

City (Village, Island, Borough, or County) — State/Province/Territory — Country

**SITE COORDINATES:**

Record in decimal degrees out to six decimal places at all four corners of the 100-meter shoreline site (DDD.DDDDDD)



**DIRECTION WHEN FACING WATER:**

Circle one direction on the compass below



**SITE PHOTOS:**

List timestamp, number, or other information to keep track of photos of the site

This portion can be completed offsite.

## NEAREST RIVER, STREAM, OR INLET:

______________________________

Name of nearest river, stream, or inlet

______________________________

Straight line distance from site in kilometers

## SITE REMOTENESS:

(Check one)

- ☐ parking within 1 kilometer (0.61 miles) of site access
- ☐ parking more than 1 kilometer away
- ☐ need a boat or plane to access

## SELECTION CRITERIA:

Why was this location selected to conduct surveys?
(Check all that apply)

- ☐ I like this beach
- ☐ convenience/easy access
- ☐ popular tourist/recreation area
- ☐ legacy of monitoring here
- ☐ suggested by MDMAP team
- ☐ I consistently see debris here
- ☐ near a suspected source of debris
- ☐ random
- ☐ secluded
- ☐ regulatory/legislative consideration
- ☐ no previous monitoring
- ☐ to answer a research question
- ☐ it is relatively clean
- ☐ other (describe in notes)

## NOTES:

Describe site features, including landmarks, coastal circulation patterns, offshore barriers, etc.

______________________________

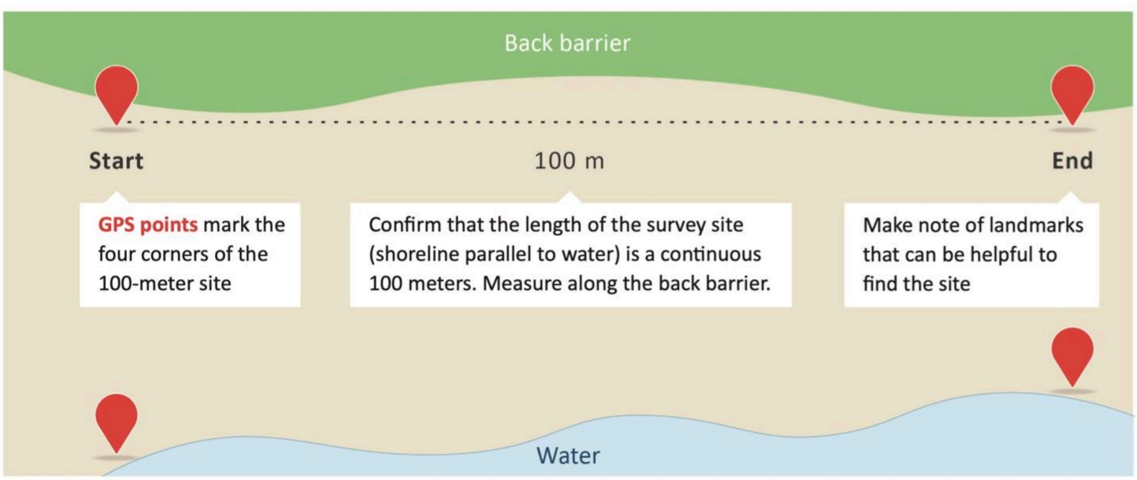
______________________________

______________________________

______________________________

______________________________

## TIPS FOR SELECTING AND ESTABLISHING A SHORELINE SITE:



## Appendix II: Data Harmonization Spreadsheet

***Data Harmonization Spreadsheet.*** *This table shows how each item from each primary dataset was reclassified into our categories.*

| Original Item | Material Category | Item Category | Source Activity Category | Dataset |
|---|---|---|---|---|
| rubber_tires | Plastic | Tires | dumping | MDMAP |
| plastic_other_irrigation_parts | Plastic | Miscellaneous | dumping | MDMAP |
| cloth_fabric_other_carpet | Cloth | Clothing/Fabric | dumping | MDMAP |
| metal_other_construction_material | Mixed | Construction | dumping | MDMAP |
| other_other_asphalt | Mixed | Construction | dumping | MDMAP |
| other_other_brick | Mixed | Construction | dumping | MDMAP |
| processed_lumber_building_material | Paper/Wood | Construction | dumping | MDMAP |
| processed_lumber_other | Paper/Wood | Paper/Wood Products | dumping | MDMAP |
| processed_lumber_other_creosote_treated_lumber | Paper/Wood | Paper/Wood Products | dumping | MDMAP |
| glass_other_light_bulbs | Glass | Miscellaneous | dumping | MDMAP |
| plastic_bags | Plastic | Plastic Bags | eating.drinking | MDMAP |
| plastic_beverage_bottles | Plastic | Bottles | eating.drinking | MDMAP |

| | | | | |
|---|---|---|---|---|
| plastic_bottle_or_container_caps | Plastic | Bottle Caps | eating.drinking | MDMAP |
| plastic_cups | Plastic | Foodware | eating.drinking | MDMAP |
| plastic_food_wrappers | Plastic | Wrappers | eating.drinking | MDMAP |
| plastic_straws | Plastic | Straws/Stirrers | eating.drinking | MDMAP |
| plastic_utensils | Plastic | Utensils | eating.drinking | MDMAP |
| plastic_6_pack_rings | Plastic | Six Pack Holders | eating.drinking | MDMAP |
| glass_beverage_bottles | Glass | Bottles | eating.drinking | MDMAP |
| glass_jars | Glass | Foodware | eating.drinking | MDMAP |
| metal_aluminum_tin_cans | Metal | Cans | eating.drinking | MDMAP |
| metal_other_metal_bottle_caps | Metal | Bottle Caps | eating.drinking | MDMAP |
| processed_lumber_bags | Paper/Wood | Paper Bags | eating.drinking | MDMAP |
| plastic_other_jugs_or_containers | Plastic | Beverage Containers | eating.drinking | MDMAP |
| plastic_fishing_lures_and_line | Plastic | Fishing Line | fishing | MDMAP |
| plastic_rope_and_nets | Plastic | Fishing Net and Rope | fishing | MDMAP |
| cloth_fabric_rope_and_nets | Plastic | Fishing Net and Rope | fishing | MDMAP |

| | | | | |
|---|---|---|---|---|
| plastic_rope_and_nets_yellow_poly_rope_snippets | Plastic | Fishing Net and Rope | fishing | MDMAP |
| plastic_other_crab_buoy_tag | Plastic | Fishing Gear | fishing | MDMAP |
| plastic_other_hagfish_trap_cones | Plastic | Fishing Gear | fishing | MDMAP |
| plastic_other_mesh_bait_bags | Plastic | Fishing Gear | fishing | MDMAP |
| plastic_other_oyster_spacers | Plastic | Fishing Gear | fishing | MDMAP |
| plastic_other_oyster_spacers_oyster_bags | Plastic | Fishing Gear | fishing | MDMAP |
| plastic_buoys_and_floats | Plastic | Buoys, Pots, Traps, Floats | fishing | MDMAP |
| plastic_personal_care_products | Plastic | Personal Care Products | personal.hygiene | MDMAP |
| rubber_gloves | Plastic | PPE | personal.hygiene | MDMAP |
| plastic_personal_care_products_combs_or_brushes | Plastic | Personal Care Products | personal.hygiene | MDMAP |
| plastic_personal_care_products_syringes | Plastic | Syringes | personal.hygiene | MDMAP |
| plastic_personal_care_products_toothbrushes | Plastic | Personal Care Products | personal.hygiene | MDMAP |
| rubber_flip_flops | Plastic | Clothing/Fabric | recreation | MDMAP |
| cloth_fabric_gloves | Cloth | Clothing/Fabric | recreation | MDMAP |

| | | | | |
|---|---|---|---|---|
| cloth_fabric_towels_rags | Cloth | Clothing/Fabric | recreation | MDMAP |
| cloth_fabric_clothing_and_shoes | Mixed | Clothing/Fabric | recreation | MDMAP |
| plastic_balloons | Plastic | Balloons | recreation | MDMAP |
| rubber_balloons | Plastic | Balloons | recreation | MDMAP |
| plastic_other_golf_balls_and_tees | Mixed | Miscellaneous | recreation | MDMAP |
| plastic_shotgun_shells_wads | Mixed | Shotgun Wads and Shells | recreation | MDMAP |
| plastic_other_fireworks | Mixed | Fireworks | recreation | MDMAP |
| plastic_other_toys | Plastic | Miscellaneous | recreation | MDMAP |
| processed_lumber_paper_and_cardboard_fireworks | Mixed | Fireworks | recreation | MDMAP |
| plastic_other_ribbon | Plastic | Miscellaneous | recreation | MDMAP |
| cloth_fabric_fragments | Cloth | Clothing/Fabric | recreation | MDMAP |
| cloth_fabric_other | Cloth | Clothing/Fabric | recreation | MDMAP |
| plastic_cigar_tips | Plastic | Cigar Tips | smoking | MDMAP |
| plastic_cigarettes | Plastic | Cigarette butts | smoking | MDMAP |

| | | | | |
|---|---|---|---|---|
| plastic_disposable_cigarette_lighters | Plastic | Lighter | smoking | MDMAP |
| other_other_terracota | Mixed | Miscellaneous | various | MDMAP |
| plastic_other_jugs_or_containers_bait_containers_lids | Plastic | Miscellaneous | various | MDMAP |
| plastic_fragments_film | Plastic | Plastic Fragments | various | MDMAP |
| plastic_fragments_foamed | Plastic | Plastic Fragments | various | MDMAP |
| plastic_fragments_hard | Plastic | Plastic Fragments | various | MDMAP |
| plastic_other | Plastic | Plastic Fragments | various | MDMAP |
| rubber_fragments | Plastic | Plastic Fragments | various | MDMAP |
| rubber_other | Plastic | Plastic Fragments | various | MDMAP |
| plastic_other_packing_bands | Plastic | Packaging | various | MDMAP |
| plastic_other_zipties | Plastic | Packaging | various | MDMAP |
| rubber_other_rubber_straps | Plastic | Packaging | various | MDMAP |
| glass_fragments | Glass | Glass Fragments | various | MDMAP |
| glass_other | Glass | Glass Fragments | various | MDMAP |
| metal_fragments | Metal | Metal Fragments | various | MDMAP |

| | | | | |
|---|---|---|---|---|
| metal_aerosol_cans | Metal | Cans | various | MDMAP |
| metal_other | Metal | Metal Fragments | various | MDMAP |
| other_other | Mixed | Miscellaneous | various | MDMAP |
| processed_lumber_cardboard_cartons | Paper/Wood | Packaging | various | MDMAP |
| processed_lumber_paper_and_cardboard | Paper/Wood | Paper/Wood Products | various | MDMAP |
| plastic_other_pens_pen_caps | Plastic | Miscellaneous | various | MDMAP |
| plastic_other_plant_pot_or_trays | Plastic | Miscellaneous | various | MDMAP |
| metal_other_propane_canisters | Metal | Miscellaneous | various | MDMAP |
| other_other_ceramic | Mixed | Miscellaneous | various | MDMAP |
| plastic_other_light_sticks | Plastic | Miscellaneous | various | MDMAP |
| rubber_tires | Plastic | Tires | dumping | MDT |
| paper_lumber_lumber_building_materials | Paper/Wood | Construction | dumping | MDT |
| paper_lumber_pallets | Paper/Wood | Paper/Wood Products | dumping | MDT |
| plastic_plastic_bags | Plastic | Plastic Bags | eating.drinking | MDT |

| | | | | |
|---|---|---|---|---|
| plastic_foam_or_plastic_cups_or_plates | Plastic | Foodware | eating.drinking | MDT |
| plastic_plastic_caps_or_lids | Plastic | Bottle Caps | eating.drinking | MDT |
| plastic_plastic_bottle | Plastic | Bottles | eating.drinking | MDT |
| plastic_straws | Plastic | Straws/Stirrers | eating.drinking | MDT |
| plastic_plastic_utensils | Plastic | Utensils | eating.drinking | MDT |
| plastic_plastic_food_wrappers | Plastic | Wrappers | eating.drinking | MDT |
| plastic_six_pack_rings | Plastic | Six Pack Holders | eating.drinking | MDT |
| plastic_foam_or_plastic_food_containers | Plastic | Takeout Food Containers (Plastic) | eating.drinking | MDT |
| glass_glass_bottle | Glass | Bottles | eating.drinking | MDT |
| glass_glass_jars | Glass | Foodware | eating.drinking | MDT |
| metal_metal_bottle_caps_or_tabs | Metal | Bottle Caps | eating.drinking | MDT |
| metal_aluminum_or_tin_cans | Metal | Cans | eating.drinking | MDT |
| paper_lumber_paper_food_wrappers | Paper/Wood | Wrappers | eating.drinking | MDT |
| paper_lumber_paper_bags | Paper/Wood | Paper Bags | eating.drinking | MDT |

| | | | | |
|---|---|---|---|---|
| paper_lumber_paper_cups_plates_napkins | Paper/Wood | Foodware | eating.drinking | MDT |
| paper_lumber_paper_food_box | Paper/Wood | Takeout Food Containers (Paper) | eating.drinking | MDT |
| plastic_other_plastic_jugs | Plastic | Beverage Containers | eating.drinking | MDT |
| fishing_gear_plastic_rope_or_net | Plastic | Fishing Net and Rope | fishing | MDT |
| fishing_gear_non_nylon_rope_or_net | Plastic | Fishing Net and Rope | fishing | MDT |
| fishing_gear_fishing_lures_and_lines | Plastic | Fishing Line | fishing | MDT |
| fishing_gear_fishing_line | Plastic | Fishing Line | fishing | MDT |
| fishing_gear_bait_containers | Plastic | Fishing Gear | fishing | MDT |
| fishing_gear_fishing_net | Plastic | Fishing Net and Rope | fishing | MDT |
| fishing_gear_buoys_and_floats | Plastic | Buoys, Pots, Traps, Floats | fishing | MDT |
| glass_other_fishing_gear | Glass | Fishing Gear | fishing | MDT |
| rubber_rubber_gloves | Plastic | PPE | personal.hygiene | MDT |
| plastic_personal_care_products | Plastic | Personal Care Products | personal.hygiene | MDT |
| plastic_condoms | Plastic | Personal Care Products | personal.hygiene | MDT |

| | | | | |
|---|---|---|---|---|
| plastic_feminine_hygeine_products | Mixed | Personal Care Products | personal.hygiene | MDT |
| plastic_mask | Plastic | PPE | personal.hygiene | MDT |
| plastic_wipes | Plastic | Personal Care Products | personal.hygiene | MDT |
| plastic_balloon_and_or_string | Plastic | Balloons | recreation | MDT |
| metal_gun_shells | Mixed | Shotgun Wads and Shells | recreation | MDT |
| other_fireworks | Mixed | Fireworks | recreation | MDT |
| rubber_flip_flops | Plastic | Clothing/Fabric | recreation | MDT |
| cloth_towels_or_rags | Cloth | Clothing/Fabric | recreation | MDT |
| cloth_non_rubber_gloves | Cloth | Clothing/Fabric | recreation | MDT |
| cloth_fabric_pieces | Cloth | Clothing/Fabric | recreation | MDT |
| cloth_clothing_and_shoes | Mixed | Clothing/Fabric | recreation | MDT |
| plastic_cigarettes_cigars | Plastic | Cigarette butts | smoking | MDT |
| plastic_tobacco_packaging_or_lighters | Plastic | Packaging and Other Smoking | smoking | MDT |
| plastic_plastic_film | Plastic | Wrappers | various | MDT |
| plastic_plastic_fragments | Plastic | Plastic Fragments | various | MDT |

| | | | | |
|---|---|---|---|---|
| plastic_other_plastic | Plastic | Plastic Fragments | various | MDT |
| plastic_foam_fragment | Plastic | Plastic Fragments | various | MDT |
| rubber_rubber_fragments | Plastic | Plastic Fragments | various | MDT |
| rubber_other_rubber | Plastic | Plastic Fragments | various | MDT |
| plastic_plastic_pellet | Plastic | Plastic Fragments | various | MDT |
| plastic_plastic_strapping_bands_or_zip_ties | Plastic | Packaging | various | MDT |
| glass_glass_fragments | Glass | Glass Fragments | various | MDT |
| glass_other_glass | Glass | Glass Fragments | various | MDT |
| metal_metal_fragments | Metal | Metal Fragments | various | MDT |
| metal_aerosol_cans | Metal | Cans | various | MDT |
| metal_other_metal | Metal | Metal Fragments | various | MDT |
| cloth_other_cloth | Cloth | Clothing/Fabric | various | MDT |
| other_other | Mixed | Miscellaneous | various | MDT |
| non_litter_item_test_item | Mixed | Miscellaneous | various | MDT |
| non_litter_item_organic_waste | Mixed | Miscellaneous | various | MDT |

| | | | | |
|---|---|---|---|---|
| mixed_materials_coated_paper board_container | Mixed | Packaging | various | MDT |
| paper_lumber_paper_and_card board | Paper/Wood | Paper/Wood Products | various | MDT |
| paper_lumber_other_paper | Paper/Wood | Paper/Wood Products | various | MDT |
| tires_number_891 | Plastic | Tires | dumping | Surfrider |
| treated_wood_i_e_pallets_not_d riftwood_number_875 | Paper/Wood | Paper/Wood Products | dumping | Surfrider |
| plastic_bottles_beverage_numb er_822 | Plastic | Bottles | eating.drinking | Surfrider |
| plastic_bags_shopping_grocery _number_820 | Plastic | Plastic Bags | eating.drinking | Surfrider |
| plastic_straws_number_832 | Plastic | Straws/Stirrers | eating.drinking | Surfrider |
| plastic_forks_knives_spoons_nu mber_827 | Plastic | Utensils | eating.drinking | Surfrider |
| plastic_cups_number_825 | Plastic | Foodware | eating.drinking | Surfrider |
| foam_cups_number_824 | Plastic | Foodware | eating.drinking | Surfrider |
| foam_take_out_food_containers _number_834 | Plastic | Takeout Food Containers (Plastic) | eating.drinking | Surfrider |
| plastic_lids_yogurt_lids_coffee_l ids_etc_number_829 | Plastic | Container Closures | eating.drinking | Surfrider |

| | | | | |
|---|---|---|---|---|
| plastic_food_wrappers_candy_chip_bags_etc_number_826 | Plastic | Wrappers | eating.drinking | Surfrider |
| x6_pack_holders_number_819 | Plastic | Six Pack Holders | eating.drinking | Surfrider |
| plastic_bags_other_zip_lock_trash_etc_number_821 | Plastic | Plastic Bags | eating.drinking | Surfrider |
| plastic_bottle_caps_rings_number_823 | Plastic | Bottle Caps | eating.drinking | Surfrider |
| plates_foam_number_830 | Plastic | Foodware | eating.drinking | Surfrider |
| plates_plastic_number_831 | Plastic | Foodware | eating.drinking | Surfrider |
| plastic_stirrers_number_833 | Plastic | Straws/Stirrers | eating.drinking | Surfrider |
| take_out_food_containers_plastic_number_835 | Plastic | Takeout Food Containers (Plastic) | eating.drinking | Surfrider |
| foam_coolers_number_863 | Plastic | Miscellaneous | eating.drinking | Surfrider |
| glass_bottles_beverage_number_885 | Glass | Bottles | eating.drinking | Surfrider |
| metal_bottle_caps_number_879 | Metal | Bottle Caps | eating.drinking | Surfrider |
| aluminum_cans_beverage_number_880 | Metal | Cans | eating.drinking | Surfrider |
| juice_boxes_number_828 | Mixed | Beverage Containers | eating.drinking | Surfrider |
| paper_bags_number_867 | Paper/Wood | Paper Bags | eating.drinking | Surfrider |

| | | | | |
|---|---|---|---|---|
| paper_cups_number_869 | Paper/Wood | Foodware | eating.drinking | Surfrider |
| paper_napkins_number_871 | Paper/Wood | Foodware | eating.drinking | Surfrider |
| paper_plates_number_872 | Paper/Wood | Foodware | eating.drinking | Surfrider |
| paper_straws_number_873 | Paper/Wood | Straws/Stirrers | eating.drinking | Surfrider |
| paper_take_out_food_containers_number_874 | Paper/Wood | Takeout Food Containers (Paper) | eating.drinking | Surfrider |
| wood_coffee_drink_stirrers_number_876 | Paper/Wood | Straws/Stirrers | eating.drinking | Surfrider |
| bait_bags_containers_number_852 | Plastic | Fishing Gear | fishing | Surfrider |
| fishing_line_1_yard_1_piece_number_854 | Plastic | Fishing Line | fishing | Surfrider |
| nets_number_857 | Plastic | Fishing Net and Rope | fishing | Surfrider |
| rope_1_yard_1_piece_number_859 | Plastic | Fishing Net and Rope | fishing | Surfrider |
| buoys_floats_number_853 | Plastic | Buoys, Pots, Traps, Floats | fishing | Surfrider |
| hooks_sinkers_lures_number_855 | Mixed | Fishing Gear | fishing | Surfrider |
| pots_and_traps_number_858 | Mixed | Buoys, Pots, Traps, Floats | fishing | Surfrider |

| | | | | |
|---|---|---|---|---|
| disinfectant_wipes_number_2216 | Plastic | Personal Care Products | personal.hygiene | Surfrider |
| latex_gloves_number_2217 | Plastic | PPE | personal.hygiene | Surfrider |
| syringes_number_847 | Plastic | Syringes | personal.hygiene | Surfrider |
| toothbrushes_number_849 | Plastic | Personal Care Products | personal.hygiene | Surfrider |
| toothpicks_floss_number_850 | Plastic | Personal Care Products | personal.hygiene | Surfrider |
| condoms_number_890 | Plastic | Personal Care Products | personal.hygiene | Surfrider |
| reusable_cloth_mask_number_2219 | Cloth | PPE | personal.hygiene | Surfrider |
| single_use_mask_with_filter_number_2218 | Mixed | PPE | personal.hygiene | Surfrider |
| reusable_gloves_number_2220 | Mixed | PPE | personal.hygiene | Surfrider |
| single_use_surgical_mask_number_2221 | Mixed | PPE | personal.hygiene | Surfrider |
| diapers_number_846 | Mixed | Diapers | personal.hygiene | Surfrider |
| tampons_tampon_applicators_number_848 | Mixed | Tampons/Applicators | personal.hygiene | Surfrider |
| balloons_number_889 | Plastic | Balloons | recreation | Surfrider |
| dog_poop_bags_number_2456 | Plastic | Miscellaneous | recreation | Surfrider |

| | | | | |
|---|---|---|---|---|
| shotgun_wads_number_2455 | Mixed | Shotgun Wads and Shells | recreation | Surfrider |
| fireworks_number_894 | Mixed | Fireworks | recreation | Surfrider |
| cigarette_butts_number_837 | Plastic | Cigarette butts | smoking | Surfrider |
| plastic_cigarette_lighters_number_838 | Plastic | Lighter | smoking | Surfrider |
| plastic_cigar_tips_number_839 | Plastic | Cigar Tips | smoking | Surfrider |
| vape_cartridges_number_2452 | Plastic | E-Cigarettes | smoking | Surfrider |
| single_use_weed_containers_number_2453 | Mixed | Packaging and Other Smoking | smoking | Surfrider |
| paper_cigarette_boxes_number_868 | Paper/Wood | Packaging and Other Smoking | smoking | Surfrider |
| nurdles_small_pre_production_plastic_pellets_number_844 | Plastic | Plastic Fragments | various | Surfrider |
| foam_fragments_larger_than_a_dime_number_1840 | Plastic | Plastic Fragments | various | Surfrider |
| foam_fragments_smaller_than_a_dime_number_842 | Plastic | Plastic Fragments | various | Surfrider |
| plastic_fragments_larger_than_a_dime_number_1841 | Plastic | Plastic Fragments | various | Surfrider |
| plastic_fragments_smaller_than_a_dime_number_843 | Plastic | Plastic Fragments | various | Surfrider |

| | | | | |
|---|---|---|---|---|
| large_foam_pieces_number_2454 | Plastic | Plastic Fragments | various | Surfrider |
| plastic_bottles_non_beverage_like_bleach_cleaners_oil_etc_number_862 | Plastic | Bottles | various | Surfrider |
| plastic_film_wrapper_non_food_or_unknown_number_864 | Plastic | Wrappers | various | Surfrider |
| zip_ties_number_865 | Plastic | Packaging | various | Surfrider |
| other_plastic_items_number_1907 | Plastic | Plastic Fragments | various | Surfrider |
| other_rubber_latex_items_number_892 | Plastic | Plastic Fragments | various | Surfrider |
| glass_fragments_number_886 | Glass | Glass Fragments | various | Surfrider |
| other_glass_items_number_887 | Glass | Glass Fragments | various | Surfrider |
| cans_other_metal_number_881 | Metal | Cans | various | Surfrider |
| metal_fragments_number_882 | Metal | Metal Fragments | various | Surfrider |
| other_metal_items_number_883 | Metal | Metal Fragments | various | Surfrider |
| other_items_number_1908 | Mixed | Miscellaneous | various | Surfrider |
| paper_wood_fragments_pieces_number_870 | Paper/Wood | Paper/Wood Products | various | Surfrider |
| other_paper_wood_items_numb | Paper/Wood | Paper/Wood Products | various | Surfrider |

| | | | | |
|---|---|---|---|---|
| er_877 | | | | |
| tarps_number_895 | Plastic | Miscellaneous | various | Surfrider |
| light_sticks_number_856 | Plastic | Miscellaneous | various | Surfrider |
| foam_dock_pieces | Plastic | Construction | dumping | TIDES |
| tires | Plastic | Tires | dumping | TIDES |
| appliances_refrigerators_washers_etc | Mixed | Miscellaneous | dumping | TIDES |
| construction_materials | Mixed | Construction | dumping | TIDES |
| grocery_bags_plastic | Plastic | Plastic Bags | eating.drinking | TIDES |
| other_bags_plastic | Plastic | Plastic Bags | eating.drinking | TIDES |
| beverage_bottles_plastic | Plastic | Bottles | eating.drinking | TIDES |
| beverage_sachets_pouches | Plastic | Beverage Containers | eating.drinking | TIDES |
| bottle_caps_plastic | Plastic | Bottle Caps | eating.drinking | TIDES |
| cups_plates_foam | Plastic | Foodware | eating.drinking | TIDES |
| cups_plates_plastic | Plastic | Foodware | eating.drinking | TIDES |
| food_containers_foam | Plastic | Takeout Food Containers (Plastic) | eating.drinking | TIDES |

| | | | | |
|---|---|---|---|---|
| food_containers_plastic | Plastic | Takeout Food Containers (Plastic) | eating.drinking | TIDES |
| food_wrappers_candy_chips_etc | Plastic | Wrappers | eating.drinking | TIDES |
| straws_stirrers_plastic | Plastic | Straws/Stirrers | eating.drinking | TIDES |
| utensils_plastic | Plastic | Utensils | eating.drinking | TIDES |
| x6_pack_holders | Plastic | Six Pack Holders | eating.drinking | TIDES |
| beverage_bottles_glass | Glass | Bottles | eating.drinking | TIDES |
| beverage_cans | Metal | Cans | eating.drinking | TIDES |
| bottle_caps_metal | Metal | Bottle Caps | eating.drinking | TIDES |
| cups_plates_paper | Paper/Wood | Foodware | eating.drinking | TIDES |
| paper_bags | Paper/Wood | Paper Bags | eating.drinking | TIDES |
| lines_nets_traps_ropes_etc | Mixed | Fishing Gear | fishing | TIDES |
| fishing_net_pieces | Plastic | Fishing Net and Rope | fishing | TIDES |
| fishing_line_1_yard_meter_1_piece | Plastic | Fishing Line | fishing | TIDES |
| rope_1_yard_meter_1_piece | Plastic | Fishing Net and Rope | fishing | TIDES |
| fishing_buoys_pots_traps | Mixed | Buoys, Pots, Traps, | fishing | TIDES |

| | | | | |
|---|---|---|---|---|
| | | Floats | | |
| fishing_gear_clean_swell | Mixed | Fishing Gear | fishing | TIDES |
| condoms | Plastic | Personal Care Products | personal.hygiene | TIDES |
| syringes | Plastic | Syringes | personal.hygiene | TIDES |
| cotton_bud_sticks_swabs | Mixed | Personal Care Products | personal.hygiene | TIDES |
| diapers | Mixed | Diapers | personal.hygiene | TIDES |
| gloves_masks_ppe | Mixed | PPE | personal.hygiene | TIDES |
| tampons_applicators | Mixed | Tampons/Applicators | personal.hygiene | TIDES |
| personal_hygiene_clean_swell | Mixed | Personal Care Products | personal.hygiene | TIDES |
| clothing | Cloth | Clothing/Fabric | recreation | TIDES |
| footwear_shoes_slippers | Mixed | Clothing/Fabric | recreation | TIDES |
| balloons | Plastic | Balloons | recreation | TIDES |
| toys | Plastic | Miscellaneous | recreation | TIDES |
| fireworks | Mixed | Fireworks | recreation | TIDES |
| cigarette_butts | Plastic | Cigarette butts | smoking | TIDES |
| e_cigarettes | Plastic | E-Cigarettes | smoking | TIDES |

| | | | | |
|---|---|---|---|---|
| tobacco_products_lighters_cigar_tips_wrap | Plastic | Packaging and Other Smoking | smoking | TIDES |
| cigar_tips | Plastic | Cigar Tips | smoking | TIDES |
| cigarette_lighters | Plastic | Lighter | smoking | TIDES |
| tobacco_packaging_wrap | Plastic | Packaging and Other Smoking | smoking | TIDES |
| other_tobacco_packaging_lighter_etc | Mixed | Packaging and Other Smoking | smoking | TIDES |
| electronic_waste_phones_batteries | Mixed | Miscellaneous | various | TIDES |
| foam_packaging | Plastic | Packaging | various | TIDES |
| other_plastic_bottles_oil_bleach_etc | Plastic | Bottles | various | TIDES |
| strapping_bands | Plastic | Packaging | various | TIDES |
| other_plastic_waste | Plastic | Plastic Fragments | various | TIDES |
| plastic_foam_pieces | Plastic | Plastic Fragments | various | TIDES |
| other_plastic_foam_packaging | Plastic | Packaging | various | TIDES |
| foam_pieces | Plastic | Plastic Fragments | various | TIDES |
| plastic_pieces | Plastic | Plastic Fragments | various | TIDES |

| | | | | |
|---|---|---|---|---|
| glass_pieces | Glass | Glass Fragments | various | TIDES |
| other_waste_metal_paper_etc | Mixed | Miscellaneous | various | TIDES |
| other_packaging_clean_swell | Mixed | Packaging | various | TIDES |
| other_trash_clean_swell | Mixed | Miscellaneous | various | TIDES |

## Appendix III: Interview Instrument

**INTRODUCTION**

***Thank you*** so much for taking the time out of your busy schedule to meet with us. This shouldn't take more than 30 minutes.

***Introduce ourselves.***

***Remind them*** of the project we're working on.

As mentioned in our email, we are Masters students from the Bren School of Environmental Science and Management at UCSB working on assessing and managing marine debris along the shorelines within the proposed boundaries of the central coast of California.

We are contacting you to get an understanding of you and/or your organization's level of concern and monitoring and mitigation strategies for marine debris. Our hopes are that by talking with you and others we will gain an understanding of marine debris management techniques and strategies that we can then make recommendations for management.

We are also hoping that as a first contact you will be able to provide some connections with other sanctuary and coastal conservancy managers that we can get in touch with.

***Recording: *9 + 1 to confirm***

It would be helpful if we could record this discussion, since it will be difficult to capture all the great insights you'll be sharing. The recording and notes will remain confidential, and your name will never be associated directly with your responses. But if you are not comfortable with the recording, we also are able to take detailed notes instead. Which would you prefer?

START RECORDING/NOTES

**Q1: Demographics**

1. We want to take a few minutes to get to know you better; can you tell us a bit about what you do for [the name of the coastal conservancy organization/NMS/community you work with/for]?
2. How long have you been with this organization/community, and what are some of the projects/responsibilities you've had in different roles here?

**Q2: Monitoring & Mitigation Perceptions**

3. As mentioned, we're very interested in how others manage marine debris. How concerned is your organization/community about marine debris? Do you have an example you should share that reflects that? Are there any types of debris that you're particularly concerned about?
4. Can you tell us about the marine debris efforts your organization/community conducts currently?
5. What do you see as the gaps in solving marine debris issues in this area?
6. What do you see as areas of opportunity for establishing monitoring to address marine debris within the proposed CHNMS?
7. Are there any other monitoring/mitigation efforts you think should be implemented or prioritized within the proposed CHNMS?

**Q3: Closing**

8. Is there anything else you would like to add?
9. Do you have any questions for us?

Thank you again so much for your time. Please reach out to us if you have any questions. We're happy to share our final report with you.

STOP RECORDING

## Appendix IV: IRB Human Subjects Approval Letter

7/21/2023

VERIFICATION OF ACTION BY THE UCSB HUMAN SUBJECTS COMMITTEE

RE: HUMAN SUBJECTS PROJECT NUMBER 35

FROM: UCSB HUMAN SUBJECTS COMMITTEE

PROTOCOL NUMBER 35-23-0427

TYPE: NOTICE OF EXEMPT DETERMINATION IR

TITLE(S):

WASTE FREE WAVES INTERVIEW PROTOCOL

INVESTIGATOR(S):

Steven Gaines

Eleri Griffiths

Tatiana Bok

Elizabeth Braun

Anne Youngdahl

Heather Luedke

The above identified project may commence on 7/21/2023. Exempt protocols do not expire.

The research activities under this submission qualify as Exempt from the Federal Regulations at 45 CFR 46.104(d) under the following Categories: 2

Although your study qualifies as exempt research, investigators are expected to adhere to UCSB policies and conduct their research in accordance with the ethical principles of Justice, Beneficence, and Respect for Persons as described in the Belmont Report.

AMENDMENTS/MODIFICATIONS/CHANGES:

Any change in the design, conduct, or key personnel of this research must be reviewed by the UCSB HSC prior to implementation. This includes changes to the study procedures and/or documents (e.g., protocol, consent form, recruitment materials, addition of data points, addition or change of research sites) and changes to the research team. If you are unsure whether your changes constitute a protocol modification, contact the HSC for guidance.

UNANTICIPATED PROBLEMS/ADVERSE EVENTS

If any study subject experiences an unanticipated problem involving risk to subjects or others, and/or a serious adverse event, the UCSB HSC must be informed promptly. An e-mail or phone call must be received within 7 days. Further reporting requirements will be determined by the UCSB HSC at that time.

RECORDS RETENTION REQUIREMENTS

Please remember that signed consent forms must be maintained for a minimum of three years after the end of the calendar year in which the research is completed. Additional requirements may be imposed by your funding agency, your department, or other entities.

If you have any questions about the above, please contact the UCSB Human Subjects Committee Coordinator at:

(805) 893-3807; (805) 893-2611(fax); hsc@research.ucsb.edu

For more details on this protocol, go to the ORahs website: https://orahs.research.ucsb.edu/

**HSC approval does not include evaluation or approval of COVID-19 related safety procedures. You are expected to follow all applicable COVID-19 safety requirements to include, but not limited to, institutional, local, state, and government requirements, during the conduct of this research. It is the responsibility of the Principal Investigator to be informed of and follow the research policies and guidelines found here: https://www.research.ucsb.edu/human-subjects/covid-19-impact-human-subjects-research.**