



# Advances toward solutions for marine plastic pollution in southern California

Key recommendations of the white papers  
produced during the  
2021 Scripps-Rady Ocean Plastic Pollution Challenge

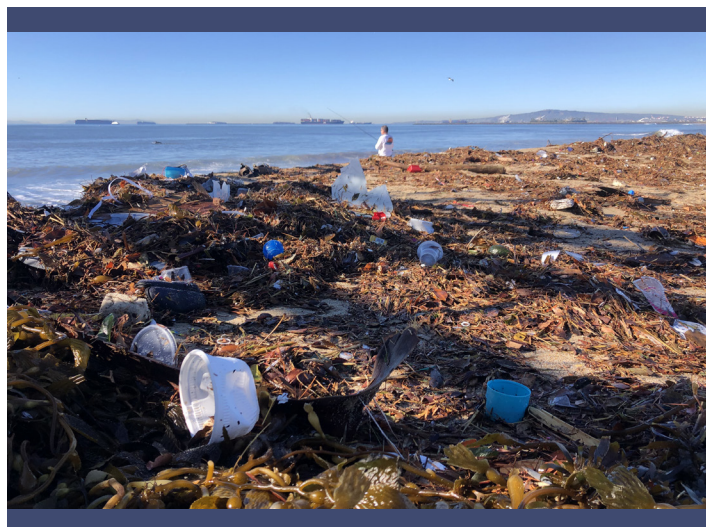


UC San Diego



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## **Acknowledgements**

The findings presented in this summary white paper are based on a suite of white papers produced during the Scripps-Rady Ocean Plastic Pollution Challenge in 2021. The 29 Challenge participants, 4 mentors, and 3 research assistants listed below are responsible for these novel findings.

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### **Support/Funding:**

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White papers referenced in this summary white paper can be found:

<https://cmbc.ucsd.edu/plastic-challenge-2021/plastic-challenge-2021-white-papers/>

The world's oceans define our planet and our environment. The oceans produce most of the oxygen we breathe, provide food to billions of people, and remain a source of inspiration for art and science alike. However, these products are not boundless; in this generation, we are facing the stark reality that sustaining ocean health is a prerequisite for sustaining ocean productivity and human livelihood.

Perhaps the most striking fingerprint of human impacts on ocean ecosystems is that of litter — drifting debris or bags on a beach in even the most remote parts of the ocean remind us that human expansion comes at a cost. This negative impact continues to accelerate with human innovation. Inventions that solved some limits of human industry are sometimes linked to blemishes on our ocean ecosystems. Such a contrast of benefit vs cost cannot be more clearly seen than in the hyperbolic growth of plastic production. Following all of the wonderful societal advances that have depended upon the invention of plastics is a cascading list of unintended consequences. The problem of ocean litter was changed categorically by the rise of plastics, especially commercial single-use plastics.

The statistics of the scope, scale, and growth of the ocean plastics problem are daunting. It is estimated that, globally, new plastic pollution is entering the ocean at a rate similar to one garbage truck load per minute, and the pace is still increasing. Responding to these trends, a generation of concerned citizens has engaged to seek out solutions, removing plastics from the ocean, and perhaps most importantly, working to prevent the introduction of new plastics into the ocean environment. These individuals come from all walks of life and share a common appreciation that the human innovation that created inventions like plastics should also have the ingenuity to invent solutions to manage the entire life cycle of these products.

But we all know that problems are challenging to solve, particularly globally pervasive ones. While our educational programs are built to promote skills in research and development for technological innovation, we have far fewer large-scale investments

in either programming or training to help our citizenry develop solutions to ocean plastic waste.

The Scripps-Rady Ocean Plastics Pollution Challenge was a pilot program designed to fill a gap in professional development. We sought to join the renowned experience in ocean sciences at Scripps Institution of Oceanography with the entrepreneurial and social perspectives from the Rady School of Management, both at UC San Diego. We found hundreds of community members worldwide with an interest in building their skill sets and empowered them as individuals to increase their impact in curbing ocean plastic pollution. The individuals were leading programs in their communities and recognized that multi-disciplinary training is tough to come by.

This report summarizes the research and creative thinking completed by our participants. We share this report, as the insights come at a time when the natural resource management community within the state of California is aiming to take aggressive measures to combat the ocean plastics problem. We celebrate the efforts of our participants, and share this report with humility and optimism that through collaborative efforts we can innovate for a better tomorrow.

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## I. Introduction

### The Origin of the Scripps-Rady Ocean Plastic Pollution Challenge

A 2020 [report](#) by The Pew Charitable Trusts and other partners warns that without drastic changes, the amount of plastic in the ocean will quadruple in the next 20 years, and the [Ellen MacArthur Foundation](#) warned that on the current trajectory of plastic production and waste, there could be more plastic than fish in the ocean by 2050. Plastic is a valuable, low cost material used in a variety of industries. While the elimination of plastics is therefore unlikely, it is imperative to prevent it from polluting our oceans. Marine plastic pollution is a complex problem that crosses borders: harming marine life, ecosystems, communities, human health, and our climate.

Plastic pollution is a global epidemic with profound impacts on local coastal communities. Data from the [Southern California Coastal Water Research Project](#) collected between 1989-2014 give an indication of the magnitude and extent of trash in streams and the nearshore waters in the Southern California Bight. Compared to 1994 seafloor surveys, the [2013](#) surveys revealed the amount of seafloor trash nearly doubled, and the extent of plastic material found increased threefold. The 2018 data is expected to show an increase again. Trash and marine debris were found in more than 75% of southern California streams and found along roughly 33% of the seafloor in the Bight. Plastic was the most prevalent debris material found in the last survey. These numbers are consistent with California Coastal Commission Cleanup Day [statistics](#) which indicate that almost 40% of ocean litter found in California is a form of single-use food and beverage packaging: food wrappers, bags, bottle caps, utensils, straws, and plastic bottles.

The impact of marine plastic pollution varies along California's coast, as do the types of plastic that become trash and the pathways plastics take into the ocean. Hence, a single, one-size-fits-all solution is unlikely to move the needle on this issue. Therefore, we need to develop tools to generate and evaluate the effectiveness of a suite of strategies and actions focused on reducing plastic pollution for different locations.

From beaches and kelp forests, to fish nurseries and maritime culture, California's coastal ocean is unique. Californians have worked to manage their unique coastal waters through a statewide network of 124 marine protected areas (MPAs) recognized for conserving marine life, protecting healthy habitats and fisheries and preserving cultural heritage. Despite serving as spaces where marine life and habitats can recover and thrive, California's MPAs are not protected from plastic pollution.



View of the San Diego-Scripps Coastal State Marine Conservation Area. Photo: Scripps Institution of Oceanography.

In response to this, the Center for Marine Biodiversity and Conservation (CMBC) at UC San Diego's Scripps Institution of Oceanography, and the Center for Social Innovation and Impact (CSII) at UC San Diego's Rady School of Management, formed a partnership dedicated to the generation of multidisciplinary, upstream, effective, and novel approaches to the issue of marine plastic pollution along California's coast. The Challenge was led by Stuart Sandin, professor and director of the CMBC, and Ayelet Gneezy, professor and faculty director of the CSII at Rady.

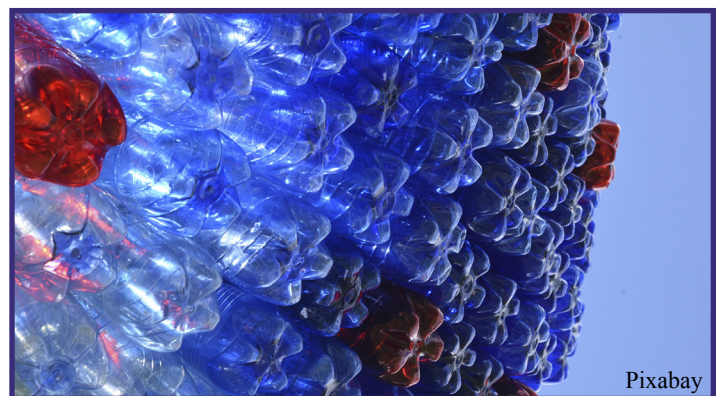
Launched in September 2020, the goal of the Scripps-Rady Ocean Plastic Pollution Challenge (Scripps-Rady Challenge) was to identify systemic, upstream approaches to prevent the flow of plastic into the ocean. Of the initial 300 applicants, 29 individuals participated in this unique, 6-month (January - June, 2021) accelerator program that included a series of [virtual short courses](#), followed by team-based research, and culminating in a two-day team-based competitive challenge to design solutions. By design, diverse teams were created, bringing together graduate students and professionals from different disciplines and with a wide variety of expertise and experience.

### **The Research White Papers**

A key component of the Scripps-Rady Challenge was team-based research from March - May, 2021. Each team was assigned one of the following research topics: changing human behavior, evaluating policy solutions, and data mapping. Working closely with their dedicated mentors, teams researched various aspects of their respective topics such as a review of past efforts and programs, an identification of key stakeholders, and an analysis of major knowledge gaps.

This document includes: 1) a synthesis of all the findings of the white papers, including a table that divides them by stakeholder groups, and 2) a summary of each paper's major findings and recommendations. The complete papers are available in an open access format on the Center for Marine Biodiversity and Conservation's [website](#).

Consistent with the systems-thinking approach to tackling the issues of marine plastic pollution, the **key findings of each white paper, taken together, contribute towards a suite of strategies** to help California curb the flow of plastic into its coastal ocean.



Plastic bottles.



## II. Key Findings Summaries

**A. Key opportunities to reduce ocean plastic pollution in southern California.** A synthesis of key findings from white papers produced during the 2021 Scripps-Rady Ocean Plastic Pollution Challenge; all white papers are available [here](#).

  
**Prevent**  
Plastic Waste

1. **Implement bans on single-use plastic items.** Data analysis shows bans work in California and elsewhere.
2. **Shift social norms away from single-use plastic.** Change the physical and social environment around consuming single-use plastic items.
  - a. **Improve availability and access to plastic-free alternatives.** Make purchasing plastic-free items easy; create an environment where consumers have cost-effective, sustainable alternatives that do not require large sacrifices to individual convenience.
  - b. **Model behavior change.** Businesses, community leaders, governments, and social influencers can model appropriate plastic waste disposal and consumption of alternatives to single-use plastic.
  - c. **Incorporate successful behavior-change strategies.** Leverage proven strategies for pro-environmental behavior, e.g. public commitments, provide incentives, apply non-adherence costs.
3. **Incentivize alternatives to single-use plastic.** Local and state decision makers can leverage the resources of the private sector by incentivizing investments in the development of plastic alternatives and businesses that can provide plastic substitutes to the market.

  
**Control**  
Plastic Waste

4. **Require consistent data collection and efficacy measures for plastic pollution policy.** This will prove essential to efficacy evaluations of solutions in the future, and not doing so may result in a misallocation of limited resources.
5. **Improve recycling capacity.** Improve availability and accessibility of recycling technologies, and increase requirements for recyclable materials or recycled content in products to improve the marketability of recycled plastics.
6. **Map and address recycling knowledge gaps.** Research the public’s knowledge regarding what can and cannot be recycled and design campaigns to address those gaps and reduce confusion.
7. **Improve the trash infrastructure in coastal areas visited by high numbers of tourists and residents.** Pay special attention to seasonal variability.

  
**Cleanup**  
Plastic Waste

8. **Standardize plastic pollution data across clean-up efforts.** Use consistent data labelling and terminology. This will enable clean-up programs and researchers to

contribute to region-wide data sets and generate the robust data needed to inform the design of future programs, policies, etc.

- 9. Investigate eelgrass and kelp forest habitats as focal points for plastic waste clean-up efforts.** Research shows that vegetated aquatic zones, such as eelgrass and kelp forests, can accumulate plastic waste. It is possible that the accumulation of plastic waste in San Diego eelgrass meadows and kelp forests would benefit from aquatic removal and enhance future trash removal efforts in the region.



- 10. Leverage universities and private sector resources to create a regional business innovation hub for plastic-free business development.** These could attract and grow businesses providing plastic-free goods and could leverage the innovation and scalability of private sector resources.

## **B. Key recommendations for stakeholder groups on plastic pollution reduction strategies.**

A synthesis of key findings organized for stakeholder groups from white papers produced during the 2021 Scripps-Rady Ocean Plastic Pollution Challenge; all white papers are available [here](#).



### **For Local and State Policymakers:**

- **Single-use plastic bans (bags, straws, cutlery, etc) can make a significant dent in plastic pollution.** As evident from initial data analysis, enacting single-use plastic bans can shift the social norm away from plastics and change perception, attitudes, and ultimately, behavior.
- **Require uniform efficacy measures, and consistent data collection to support program/policy evaluations.** Once developed, these requirements should be incorporated into plastic pollution policy to prevent resource misallocation and waste.
- **Provide appropriate waste and recycling infrastructure, promoting pro-environmental behavior at the individual and household levels.** Lack of infrastructure discourages pro-environmental behavior.
- **Improve trash infrastructure in coastal areas visited by high numbers of tourists and residents,** with special attention to seasonal variability.



### **For Nongovernmental Organizations (NGOs)**

- **Plastic pollution intervention programs should include built-in, consistent data collection** to aid in their evaluations and to aid in their integration into larger regional datasets.
- **Increase the salience and “realness” of ocean plastic pollution to communities within watersheds that are further away from the coast.** Residents in these areas may not have experienced ocean plastic pollution, which likely reduced their responsiveness to plastic pollution reduction campaigns and interventions.



- **Expand existing coalitions to advocate against plastic pollution.** Support environmental justice leaders and engage with communities that are disproportionately affected by plastic waste.
- **Support single-use plastic bans (bags, straws, cutlery, etc.).** Initial data analysis shows bans are working and can shift the social norm away from plastics and change perception, attitudes, and, ultimately, behavior.
- **Engage volunteers in meaningful activities** (e.g., monitor communal waste bins at Southern California Bight beaches and watersheds).



### For Businesses

- **Go Zero-Plastic-Waste:** eliminating single-use plastic (e.g., plastic bags, straws, cutlery) can help shift the social norm away from plastics and change perception, attitudes and, ultimately, behavior.



### For Leaders and Influencers

- **Exemplify appropriate plastic pollution-related behaviors** such as consumption of products made of alternative, eco-friendly materials and appropriate waste disposal.



### For Researchers

- **Understand impacts (historical and predicted) of plastic accumulation in valuable coastal ecosystems,** such as vegetated aquatic zones.
- **Investigate the influence of ocean currents on marine plastic distribution at a larger scale;** analyze potential impact on the San Diego MPAs. Develop prediction models and make data easily accessible. As the scale of global plastic pollution expands, waste influxes from other areas may increase along the coast of the western U.S.
- **Conduct region-specific analyses of the efficacy of plastic pollution interventions** in the Southern California Bight.
- **Conduct region-specific analyses of consumption-related behavior change interventions** and disposal-related interventions at beaches and public parks in the Southern California Bight.
- **Identify measurable methods for plastic waste removal from inland waterways,** prior to reaching the ocean.
- **Design consistent data labelling and terminology to aid data collection, management and analysis;** communicate and contribute to region-wide data sets.



### III. Evaluating the Efficacy of Current Approaches in Reducing Plastic Pollution

California is a world leader in the management of plastic pollution in the marine and coastal environment, with many approaches such as Coastal Cleanup Day, Total Maximum Daily Loads for wastewater, and over 296 state and local laws preventing the sale or use of single-use plastics. However, even with these measures, California is still plagued by plastic pollution. This leads to the question of the *effectiveness* of these efforts which consume large amounts of time, money, and energy. Efficacy evaluation of plastic pollution interventions is an often neglected part of the plastic pollution solution; yet, quantifying and weighing the future benefits of any proposal against the projected costs of implementation is prudent public policy and can be a useful tool for strategic decision making.



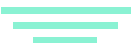

The white paper, *Evaluating Efficacy of Plastic Pollution Solutions in the Southern California Bight*, conducted an extensive literature review and analyzed 11 case studies of plastic pollution interventions within the Southern California Bight, examining the challenges of measuring efficacy and opportunities for improvement (Figure 1).

**Figure 1.** Plastic pollution intervention case studies analyzed in the the white paper, *Evaluating Efficacy of Plastic Pollution Solutions in the Southern California Bight*.

Solution Categories	Case Studies Analyzed
 <b>P r e v e n t</b> Plastic Waste	<ul style="list-style-type: none"> <li>• Responsible Disposal of Fishing Line</li> <li>• California Single Use Carryout Bag Ban</li> <li>• Extended Producer Responsibility Legislation</li> <li>• Education with the Moby Duck Campaign</li> <li>• University of California Santa Barbara 2020 Zero Waste Plan</li> </ul>
 <b>C o n t r o l</b> Plastic Waste	<ul style="list-style-type: none"> <li>• Behavior Regulation “Smoking Bans”</li> <li>• Total Maximum Daily Loads of Trash (Clean Water Act)</li> </ul>
 <b>C l e a n u p</b> Plastic Waste	<ul style="list-style-type: none"> <li>• Passive Surface Water Collection Devices, e.g., Mr Trash Wheel, Seabins</li> <li>• Fishing for Energy programs</li> <li>• International Coastal Clean-up Month</li> <li>• California Lost Fishing Gear Recovery Project</li> </ul>

Case studies and general literature indicate a lack of robust efficacy data for most plastic pollution interventions. However, based on available research and case studies, this white paper identified several recommendations to improve efficacy evaluations of plastic pollution solutions (Figure 2.)

**Figure 2.** Key recommendations to improve efficacy evaluations of plastic pollution solutions from the white paper, *Evaluating Efficacy of Plastic Pollution Solutions in the Southern California Bight*.

Plastic Pollution Solution Categories	Key Recommendations to Improve Efficacy Evaluations
<p><b>Policy</b></p> 	<p>To strategically prioritize and choose plastic pollution solutions with the greatest expected net benefit, consider the following:</p> <ul style="list-style-type: none"> <li>• Compare measures of efficacy <i>within the same solution category</i> rather than across categories</li> <li>• Require the collection of data to support efficacy evaluations; measures of efficacy that work well within each solution category are noted below</li> </ul>
<p><b>Prevent</b></p> 	<p><b>Measures of Efficacy</b></p> <ul style="list-style-type: none"> <li>• Deviations from modeled trajectories</li> <li>• Progress towards a specific goal (similar to California’s commitment to reduce atmospheric carbon pollution to 40% of 1990 levels by 2030)</li> <li>• A calculation of plastics removed from local market share when either eliminated or replaced with sustainable alternatives</li> </ul>
<p><b>Control</b></p> 	<ul style="list-style-type: none"> <li>• Evaluate resources spent on control systems to incentivize alternative upstream interventions</li> <li>• Measure plastic “leakage:” percent of plastic introduced to the system that is not recovered</li> <li>• Track cost of approaching 0% leakage; as the marginal cost of each additional item of plastic rises, consider alternative solutions</li> <li>• Create special closed-loop systems for high-priority plastics or give those plastics greater “weight” in the existing system</li> </ul>
<p><b>Cleanup</b></p> 	<ul style="list-style-type: none"> <li>• Employ standardized protocols for better accuracy and comparability of data (e.g., California Trash Monitoring Methods and Assessment Playbook or NOAA Marine Debris Program)</li> <li>• Compare the amount and type of plastic collected to the cost and labor expended</li> <li>• Calculate the impact of public education and outreach; apply special weight to behavioral changes</li> </ul>

This white paper concludes that progress is most likely to be achieved by a diversified portfolio of mutually supporting measures, and subsequently offers a hypothetical “diversified portfolio” of plastic intervention solutions and efficacy evaluations specific to the Southern California Bight (Figure 3). It is important to build flexibility into the larger strategy where possible, allowing for adaptation to changing conditions. Such adaptivity requires inclusion of efficacy measures into long-term strategies, providing data to make decisions.

**Figure 3.** Hypothetical Diversified Portfolio of Plastic Pollution Solutions for the Southern California Bight from the white paper, *Evaluating Efficacy of Plastic Pollution Solutions in the Southern California Bight*.

Plastic Pollution Solution Categories	Hypothetical Diversified Portfolio of Plastic Pollution Solutions for the Southern California Bight
<b>Policy</b>	<ul style="list-style-type: none"><li>• <b>Incentivize alternatives to single-use plastic:</b> local and state decision makers can leverage the resources of the private sector by incentivizing investments in the development of plastic alternatives and businesses that can provide plastic substitutes to the market.</li></ul>
<b>Prevent</b>	<ul style="list-style-type: none"><li>• <b>Create a business innovation hub for plastic-free business development:</b> such an institution could attract and grow businesses providing plastic-free goods and could leverage the innovation and scalability of private sector resources.</li><li>• <b>Leverage universities:</b> in addition to research centers, California’s universities can serve as testing grounds for plastic pollution reduction measures through progressive university zero-waste programs.</li></ul>
<b>Control</b>	<ul style="list-style-type: none"><li>• <b>Improve recycling capacity:</b> California can improve the availability and accessibility of recycling technologies, decrease public confusion around what can and cannot be recycled, and increase requirements for recyclable materials or recycled content in products to improve the marketability of recycled plastics.</li></ul>
<b>Cleanup</b>	<ul style="list-style-type: none"><li>• <b>Beach and waterway cleanups:</b> while cleanups focus on symptoms rather than causes, beach and waterway cleanups are popular and produce easily quantifiable results, like those already hosted locally by San Diego Coastkeeper and the San Diego Chapter of the Surfrider Foundation.</li><li>• <b>Passive collection devices:</b> such devices can complement cleanups by not only trapping plastics and generating data, but also functioning as visible community commitment to dealing with ocean plastics.</li></ul>



Plastic waste on Southern California beaches.



## IV. Evaluating Applications of Behavior Change Interventions in Reducing Plastic Pollution

Tackling the global problem of plastic pollution requires a systems change approach with multiple, coordinated stakeholders interacting to accelerate impact. The white paper, *Leveraging Behavioral Intervention Frameworks to Change Households' Plastic Consumption and Disposal Behaviors*, investigates the role of behavior change in the context of a systems thinking approach. In doing so, the paper focuses on household-level consumption and disposal of plastic packaging, the largest single sector contributing to global plastic pollution.

The white paper acknowledges that all recommended behavior changes in Southern California must be accompanied by manufacturer responsibility and increased availability of alternatives to plastic packaging.

Building on the relevant literature and on past behavior change interventions, the paper includes:

- A behavioral analysis to better understand what determines current plastic consumption behavior, including barriers and facilitators
- A analysis of past interventions targeting the reduction of plastic consumption
- A behavioral analysis to identify barriers to pro-environmental waste disposal behavior at the household level
- An analysis of the effectiveness of past interventions targeting the increase of appropriate sustainable waste disposal

This paper also presents a stakeholder map for Southern California, identifying respective attitudes, influence, and potential leverage points for contributing to solutions. Using these analyses, this white paper offers recommendations for reducing plastic consumption and improving appropriate disposal of plastic packaging in the context of the Southern California Bight (Figure 4). The analysis suggests that a greater emphasis should be placed on social norms, making appropriate plastic waste disposal “easy,” and the flipside, making purchasing plastic-free packaging “easy.”

Insights gleaned from relevant literature to address plastic consumption are mostly changes that improve access to low or no-plastic alternatives. These interventions change the physical and social environment around plastic for consumers, reducing the effort required to make more sustainable choices without large sacrifices to individual convenience. Examples include:

- Training schemes for designers and engineers to upskill and learn how to design recyclable or reusable packaging
- Building contracts with reusable services (e.g., caterers that use reusable cups or foodware) for government-funded and/or university-hosted events to set new social norms of not using single-use plastic
- Incentivizing stores to group plastic-free products together to make them easier for consumers to find
- Creating ‘zero-plastic’ standards to evaluate hospitality and other industries
- Engaging with business leaders to develop and implement plastic-related manufacturing standards
- Incentivizing/encouraging corporations to set ambitious plastic reduction goals
- Mandating disclosure and target setting for plastic reduction goals

Awareness campaigns and messaging should avoid utilizing phrases or images that emphasize how often individuals engage in “bad” plastic consumption and disposal behaviors. Campaigns can improve their effectiveness by having consumers pre-commit via e.g., public pledges or symbolic cost, to engage in specific “good” behaviors, such as purchasing a reusable alternative to single-use plastic. Monetary incentives can change one’s perception of the desired behavior change from internal motivation to external motivation. Thus,



small monetary incentives will be less effective, compared to no monetary incentive. Larger incentives are more effective than smaller incentives.

**Figure 4.** Recommendations for reducing plastic consumption and improving appropriate disposal of plastic packaging in the Southern California Bight from the white paper, *Leveraging Behavioral Intervention Frameworks to Change Households' Plastic Consumption and Disposal Behaviors*.



## Recommendations for Reducing Plastic Consumption and Improving Appropriate Disposal of Plastic Packaging

- **Enact single-use plastic pollution bans.** Increasing the number of single-use pollution bans (bags, straws, cutlery) in Southern California can shift the social norm away from plastics and change perception, attitudes, and, ultimately, behavior. The more widely available plastic items are, the easier they are to use and the more likely they are to be consumed.
- **Increase the salience and tangibility of ocean plastic pollution to communities within watersheds** that are further away from the coast. Residents further away from the coast may not have recent experiences with ocean plastic pollution and may not respond to plastic consumption reduction interventions. Making connections to local factors can help to address challenges associated with intangible, long-term benefits of pro-environmental behavior.
- **Expand existing coalitions to advocate against plastic pollution.** Provide funding for environmental justice leaders and programs to fight plastic pollution by engaging communities that are disproportionately affected by plastic waste.
- **Develop social norms.** Expand pro-environmental behavior by hosting surveys, challenges, competitions, and similar events (perhaps via electronic platforms or phone apps) that would provide feedback on a targeted environmental behavior change to positively reinforce the behavior.
- **Enable leadership.** Encourage community leaders or prominent social media figures to exemplify appropriate plastic waste disposal behaviors.
- **Create opportunities.** Engage volunteers in meaningful activities (e.g., monitor communal waste bins at Southern California Bight beaches and watersheds).
- **Provide appropriate waste and recycling infrastructure.** Encourage pro-environmental behavior by providing appropriate waste and recycling infrastructure. This is a huge factor in proper plastic waste disposal or recycling which can contribute to good habit formation; lack of infrastructure discourages pro-environmental behavior.



## V. Evaluating Data to Identify Coastal Plastic Pollution Hotspots in San Diego

Data mapping can be an ideal tool to enhance an understanding of the processes underlying the entry of plastic waste in marine systems as well as to quantify and analyze plastic waste across temporal and spatial scales. The white paper, *Identifying and Mapping Inputs and Hotspots of Plastic Waste into the Pacific Ocean and Marine Protected Areas in the San Diego Region in California, USA*, presents a variety of information regarding plastic pollution data related to San Diego Marine Protected Areas (MPAs). The work involved collecting data from various sources, ensuring quality of the data, and generating maps. This work intends to facilitate the development of local solutions in the San Diego region and can be used as a blueprint for data collection in other regions.

The main sources of data on plastic waste that this study examined were two citizen group data portals: The Coastal Cleanup Debris portal from the Ocean Conservancy and the Marine Debris tracker portal from the National Oceanic and Atmospheric Administration (NOAA). The data was combined with geographic data to produce a series of maps showing how plastic pollution correlates with a number of factors, including areas impacted by tourism, coastal geomorphology, aquatic environments, ocean currents, rivers, and streams. Additionally, the data was used to evaluate the effectiveness of government interventions to mitigate plastic pollution, including plastic bans and stormwater trash capture.

The San Diego region's coastal areas are highly susceptible to accumulation of plastic waste due to their popularity among residents, attractiveness as a site for public events, and as tourist destinations. The management of MPAs in San Diego County, and in particular the control of ecosystem disturbances, such as pollution or illegal fishing, is regulated and maintained via regional networks. Hence, regionality is a crucial factor in the development of solutions and regional data concerning plastic pollution needs to be acquired and analyzed to account for local characteristics influencing plastic pollution. To help fill a gap in the lack of small-scale models accounting for the environmental conditions where solutions need to be developed, the analysis in this white paper reveals plastic waste "hotspots" near and inside of MPAs. This study defines a plastic waste "hotspot" as an area with high potential for exposure to plastic waste inflows and accumulation.

The maps and data analyses in the white paper are displayed separately for four different topics, i.e., riverine plastic inputs (Figure 5), plastic waste correlated to socio-demographic features (Figure 6), government interventions to reduce plastic waste pollution, and marine-based plastic waste. Based on these detailed analyses and data mapping, this white paper has identified several key findings (Figure 7), and recommendations for future study (Figure 8).



Plastic waste on Southern California beaches.

**Figure 5.** Identification of potential plastic accumulation hotspots in and near MPAs related to submerged aquatic vegetation (SAV) and riverine plastic inflows. SAV, RiverStreams, MPA, RiverPlastic data sets.



**Legend**

- Kelp vegetation
- Eelgrass vegetation
- San Diego MPAs

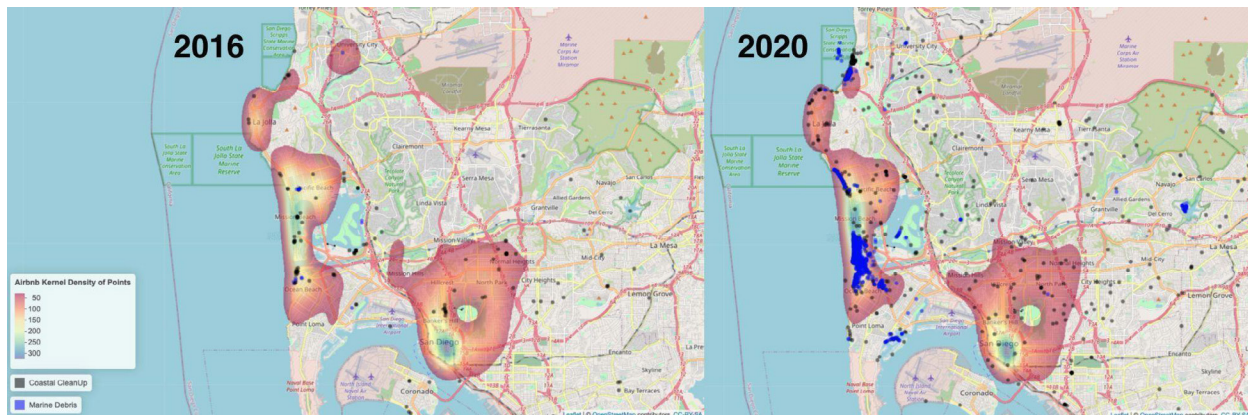
- Riverine plastic inputs  
Medium annual estimates (MT)
- 0,000000 - 0,001271
  - 0,001272 - 0,004389
  - 0,004390 - 0,010867
  - Rivers and streams

**Submerged aquatic vegetation (SAV)  
as a potential plastic hotspot in San Diego MPAs**

SanGIS, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS; Esri, NASA, NGA, USGS; Esri, FAO, NOAA; Esri, USGS  
Scripps-Rady Ocean Plastic Pollution Challenge  
May 2021



**Figure 6.** The amount of plastic waste (standardized) in relation to the kernel density of Airbnb listings in 2016 and 2020; as a proxy for tourism. Clean-up activity data was accessed via the Marine Debris Tracker and Coastal Cleanup data portals. Data sets: MarineDebris, CoastalCleanup, Airbnb.



**Figure 7.** Key findings from the white paper, *Identifying and Mapping Inputs and Hotspots of Plastic Waste into the Pacific Ocean and Marine Protected Areas in the San Diego Region in California, USA.*



## Key Findings

- **The geomorphology of the coast impacts the retention of plastic waste.** Plastic trapping efficiency is high for the coastal geomorphology types that exist in the San Diego area (rocky-, wave-, and tide-dominated).
- **Submerged aquatic vegetation (SAV) zones (e.g., kelp forests, seagrass beds) in and adjacent to MPAs in the San Diego region are potential hotspots for collection of riverine, land-based, and marine plastic waste.** This analysis shows that several SAV zones are inside and/or near to MPAs, some of which are directly influenced by riverine plastic fluxes. The plastic influxes to SAV zones and MPAs in the San Diego region represent a high potential impairment to the local ecosystems.
- **San Diego MPAs are susceptible to in-situ plastic waste generated by tourists;** and this study finds more trash and clean-up activities occurring closer to the MPAs than further away.
- **There is a significant amount of mismanaged waste related to tourism.** Because tourism is the third most important driver of the economy in the San Diego region, special attention should be given to reducing trash impacts in areas that experience high numbers of tourists.
- **There is a correlation between the implementation of plastic bag bans and the quantity of plastic bags collected in coastal clean-ups.** This is a highly encouraging result and strongly suggests that other government interventions (e.g., further bans on the use and sale of other plastic items) can have a significant impact in reducing the amount of plastic going into the marine environment.

**Figure 8.** Key recommendations for future study from the white paper, *Identifying and Mapping Inputs and Hotspots of Plastic Waste into the Pacific Ocean and Marine Protected Areas in the San Diego Region in California, USA*.



## Key Recommendations for Future Study

- **Plastic pollution data needs to be standardized across cleanup efforts** by various citizen groups' cleanup programs to contribute to region-wide data sets and generate the quantity and power needed to answer larger strategic questions about plastic waste sources and fate.
- **Increase research on the effectiveness of and methods for removing plastic waste from inland waterways**, prior to it reaching the coast.
- **Investigate the potential impacts of plastic accumulation in valuable coastal ecosystems, such as vegetated aquatic zones.** It is possible that the accumulation of plastic waste in San Diego eelgrass meadows and kelp forests could be exploited to enhance future trash removal efforts in the region. Aggregations could foster the ability for aquatic removal, as eelgrass and kelp forest ecosystems become focal habitats for investment of time and money toward plastic waste cleanup efforts.
- **Investigate how to improve the trash infrastructure in coastal areas visited by high numbers of tourists and residents**, with special attention to seasonal variability, to help San Diego focus limited resources.
- **Extend and monitor plastic bans** within San Diego County and also include more items, such as plastic straws, food containers, etc.
- **Investigate the influence of ocean currents on marine plastic distribution at a larger scale and analyze potential impacts on San Diego MPAs.** Develop prediction models and make data easily accessible. As the scale of global plastic pollution expands, waste influxes from other areas may increase along the coast of the western U.S.



Pixabay

Trash flows down the beach into the ocean.