



RMP

REGIONAL MONITORING
PROGRAM FOR WATER QUALITY
IN SAN FRANCISCO BAY

sfei.org/rmp

RMP Microplastic Workgroup Meeting

Thursday, April 9, 2020

10:00 AM – 2:30 PM

REMOTE ACCESS

<https://zoom.us/j/5327336705>

Meeting ID: 532 733 6705

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AGENDA

1.	<p>Introductions and Goals for This Meeting (Attachment)</p> <p>The goals for this meeting:</p> <ul style="list-style-type: none"> • Present progress of stormwater conceptual model to date and obtain feedback; • Obtain recommendations on special study and SEP proposals for 2021 and ways to further refine proposals <p>Meeting materials: 2019 MPWG minutes (See pages 2 - 27)</p>	10:00 Melissa Foley
2.	<p>Discussion: Microplastic Strategy and Collaborations Update</p> <ul style="list-style-type: none"> • Summarize microplastic studies and collaborations SFEI team is involved in or pursuing and related work; • Feedback on external funding opportunities to support microplastic strategy and workgroup <p>Desired Outcome: Feedback to guide further work</p> <p>Meeting materials: Slides</p>	10:15 Diana Lin
3	<p>Discussion: State Water Board Definition of Microplastics in Drinking Water</p> <ul style="list-style-type: none"> • Summarize proposed definition of microplastics in drinking water <p>Desired Outcome: Feedback on proposed definition</p> <p>Meeting materials: Slides</p>	10:45 Scott Coffin
	Short Break	11:00
4.	Information: Stormwater Conceptual Model	11:05

	<ul style="list-style-type: none"> Present preliminary developments of conceptual models <p>Desired outcome: Feedback to guide further work Meeting materials: Slides</p>	Alicia Gilbreath
5.	<p>Information: The ecological impacts of microplastics in the environment Dr. Chelsea Rochman will present on state of the science on understanding toxicity of microplastics and ongoing research projects on microplastic impacts</p> <p>Desired outcome: Informed workgroup Meeting materials: Slides</p>	11:40 Chelsea Rochman (U Toronto)
	Lunch Break	12:00
6.	<p>Discussion: Microplastic Proposals for 2021 Proposal for special study ideas for 2021 will be presented. The workgroup will ask questions, discuss, and provide feedback.</p> <p>2021 Special Study Proposals include:</p> <ul style="list-style-type: none"> Microplastic effects workshop Microplastic stormwater conceptual model, part 2 Microplastic sediment cores Microplastics in sport fish (archived samples) <p>Desired outcome: Gather feedback on the merits of each proposal and how they can be improved Meeting materials: MPWG Special Study Proposals (See pages 27 - 49)</p>	1:00 Diana Lin
7.	<p>Closed Session - Decision: Recommendations for 2021 Special Studies Funding RMP Special Studies are identified and funded through a three-step process. Workgroups recommend studies for funding to the Technical Review Committee (TRC). The TRC weighs input from all the workgroups and then recommends a slate of studies to the Steering Committee. The Steering Committee makes the final funding decision.</p> <p>For this agenda item, the MPWG is expected to decide (by consensus) on a prioritized list of which studies to recommend to the TRC. To avoid an actual or perceived conflict of interest, the Principal Investigators for proposed special studies are expected to leave the room during this agenda item.</p> <p>Desired Outcome: Recommendations from the MPWG to the TRC regarding which special studies should be funded in 2021 and their order of priority.</p>	2:00 Eric Dunlavy
8.	Report out on Recommendations	2:20
	Adjourn	2:30



RMP Microplastic Workgroup Meeting

May 22, 2019

San Francisco Estuary Institute
4911 Central Avenue, Richmond, CA

Meeting Summary

Attendees

Science Advisor	Affiliation	Present
Kara Lavender Law	Sea Education Association	Yes
Chelsea Rochman	University of Toronto	Yes
Anna-Marie Cook	US Environmental Protection Agency	Yes

Others Present

Anna Cummins (5 Gyres)
 Autumn Cleave (SFPUC)
 Barbara Baginska (SFB RWQCB)
 Cambria Bartlett (Heirs to Our Ocean)
 Cameron Kostigen Mumper (City of Sunnyvale)
 Carolynn Box (5 Gyres)
 Chris Sommers (BASMAA)
 Dale Bowyer (SFB RWQCB)
 David Williams (BACWA)
 Diana Rosenberg (Gap)
 Emily Bartlett (Heirs to Our Ocean)
 Emma Hinojosa (City of Sunnyvale)
 Eric Dunlavey (San Jose)
 Holly Wyer (Ocean Protection Council)
 Karin North (Palo Alto)
 Kelly Moran (TDC Environmental)
 Kevin Messner (Association of Home Appliance Manufacturers)
 Krystle Moody Wood (materEVOLVE)
 Lorien Fono (BACWA)
 Luisa Valiela (USEPA)
 Mary Lou Esparza (CCCSD)
 Nirmela Arsem (EBMUD)
 Reinhard Hohlwein (CalRecycle)
 Robert Nuñez (Californians Against Waste)

Rusty Holleman (University of California Davis)
 Samantha Harper (SFB RWQCB)
 Scott Coffin (SWRCB)
 Shelly Moore (SCCWRP)
 Simona Balan (DTSC)
 Stephanie Karba (Patagonia)
 Sutapa Ghosal (CDPH)
 Adam Wong (SFEI)
 Alicia Gilbreath (SFEI)
 Amy Franz (SFEI)
 Becky Sutton (SFEI)
 Diana Lin (SFEI)
 Don Yee (SFEI)
 Jay Davis (SFEI)
 Meg Sedlak (SFEI)
 Melissa Foley (SFEI)
 Tony Hale (SFEI)
 Warner Chabot (SFEI)
 Amy Herrin - Remote (Milwaukee and Jinan University)
 Katie Graham - Remote (Sanford University)
 Miriam Diamond - Remote (University of Toronto)
 Violet Renick - Remote (Orange County Sanitation District)

The last page of this document has information about the RMP and the purpose of this document.

1. Introductions and Welcome

Melissa Foley commenced the Microplastic Workgroup meeting by reviewing the meeting's agenda and summarizing the context of the Microplastic Workgroup within the San Francisco Bay Regional Monitoring Program. Brief introductions followed.

2A. Information: Overview of Moore Microplastic Deliverables and Timeline

Meg Sedlak gave an overview of the microplastics work, providing the context for the Moore Microplastic project and the Bay RMP's role within this broad issue. She summarized the Moore project deliverables and timeline and foreshadowed an important discussion topic for the day: method development and quality assurance for microplastic analysis.

2B. Information: Overview of Methods and Nomenclature

Dr. Chelsea Rochman presented definition of microplastic including morphology, size, and polymer types, and extraction and analysis methods used for the Moore project. She provided an overview of best practices used by her lab, including quality assurance techniques as well as the training protocols used to standardize their methods. The Rochman lab aims for spike recovery of 80% of artificially-made particles. She walked through their workflow: (1) extraction and size fractionation, (2) characterization and quantification, (3) and spectroscopy using the Raman (smaller particles) and Fourier Transform Infrared (FTIR) technology (larger particles). Results are reported by quantity, size, color, morphology, and polymer identification (on a subset of particles). Chelsea highlighted several challenges associated with microplastic analysis, including working with fibers, spectrometry challenges, time-intensivity of the analyses, and the potential for bias among technicians. Chelsea and her lab have developed a polymer library for Raman spectroscopy and will make this library open-access and free of charge.

Chelsea answered several clarifying questions regarding method specifics and referred to the Moore project report for further information. Topics included decisions made during method development, Raman automation, fibers, and classification of particles with multiple polymer signals. Participants were eager to further discuss how field techniques affect particle characterization.

3. Discussion of Pathways: Wastewater and Stormwater

Meg Sedlak presented key findings from the "Microparticles in Effluent" chapter of the draft Moore project report. Effluent was collected during two separate events from eight wastewater treatment plants (WWTP) with varying flow, treatment, and spatial location. All facilities had

microparticles in their effluent. Fibers were the most common morphology (55%) followed by fragments (23%). The findings suggested that, annually, an estimated 47 billion microparticles are discharged from Bay treatment plants, 21 billion of which are likely to be plastic.

Dave Williams recommended collecting flow-weighted samples in the future to gain a more accurate estimate of microparticles released in wastewater effluent and noted that, because the samples from the present study omit this consideration, the estimates are likely conservative.

Alicia Gilbreath summarized results from the “Microparticles in Stormwater” draft chapter of the Moore project report. Twelve watersheds, representing 11% of the total Bay Area watershed, were sampled; the watersheds represented a range of sizes, land uses, and geographical locations. Microparticles were present in all samples. Annual estimated loads to the Bay were around 10.9 trillion microparticles (about 200x higher than effluent) with plastics comprising anywhere from 63–90%. Rubber fragments comprised 47% of microparticles, which are suspected to originate from tires. Use of these data as inputs to the Regional Watershed Spreadsheet Model suggest that industrial areas may account for a disproportionately high fraction of the load.

A question was asked on how the Rochman lab handles disintegration of brittle particles to which Chelsea indicated that this has not been a significant issue in her lab and, when encountered, those particles that shatter are ignored in results. Most of the discussion focused on the black rubber particles: what management action could entail, uncertainty in whether these particles originate from tires, and possible sources and transport of these particles to the Bay. Kelly Moran mentioned that based on the development of a conceptual model aimed at understanding transport of metals in tire due to vehicle wear, she thought that the size of rubber particles observed in the Moore study are too large to be transported by air and are likely to stay close to their source. She also indicated that they are too small to be effectively captured during cleaning methods like street sweeping. She emphasized the difficulty in understanding the linkages between observed rubber particles and tires due to gaps in literature, complexity of tire composition, and industry involvement.

Action Items:

- Address external review comments made on the effluent chapter of the Moore report from the Microplastic Workgroup. (Meg Sedlak, 6/30/19)
- Address external review comments made on the stormwater chapter of the Moore report from the Microplastic Workgroup. (Alicia Gilbreath, 6/30/19)

4. Discussion: Surface Water and Small Fish

Carolynn Box presented preliminary results from the surface water samples collected as part of the Moore project. The main objectives were to understand ambient conditions and to assess

spatial and temporal variations in surface water. Samples were collected during wet and dry seasons at 16 Bay sites and 11 sanctuary sites using a manta trawl and one-liter grab samples. Results revealed the highest abundances of microparticles in Central and South Bay and showed an increase in microparticle occurrence during wet weather. Carolyn indicated that the draft surface water chapter would be released for workgroup review soon.

The absence of tire rubber microparticles led participants to suspect that particles large enough for analysis (>125 μm sieve screen) are settling to sediments. Sediment samples and modeling will help elucidate the fate of rubber particles. Dr. Kara Lavender Law cautioned against quantifying fibers in manta trawl samples as the trawls were not designed to capture fibers (i.e., the orientation of the fiber influences whether it is caught on the net). However, if fibers in Manta trawls are discussed in the report, she recommended that the fiber discussion be kept separate from the other morphologies. In addition, she recommended seeing whether the presence of biological matter noted in field notes correlated with more fibers were observed in the net (i.e. clogging the net would increase numbers of particles captured). Kara was pleased to hear that there were one-liter grab samples from which concentrations of fibers will be quantified.

The group noted the disconnect between identification of foam particles in surface water samples and near absence in stormwater samples. Several workgroup members speculated that stormwater sampling methods (i.e., size of the pump mouth and sub-surface depth integrated sampling) might be a cause; however, it is more likely that trash discharged to tributaries weathers in the Bay and undergoes fragmentation in the Bay as the time in the tributaries is relatively short. This caused another participant to suggest that wastewater samples which were not depth-integrated could yield unrepresentative, heterogeneous results if they are sampled from a quiescent layer.

Diana Lin presented preliminary results from the analysis of approximately 160 prey fish collected as part of the Moore project from six sites in the Bay and two sites in a reference area to the north of San Francisco Bay (Tomales Bay). Ten fish of two species (anchovy and topsmelt) were collected at each site and the digestive tract analyzed for the presence of microparticles. The main objectives were to quantify abundance of microparticles in prey fish, characterize their composition, and identify sites of concern. Microparticles were detected in 99% of prey fish and fibers comprised 85% of these particles. There was no observed spatial fluctuations in microparticle concentration within the Bay; however, Bay fish had significantly higher counts of microparticles than fish from the control site at Tomales Bay.

Discussion took place around fish diet (anchovy vs topsmelt), differences in fiber composition compared to other matrices (e.g., higher fraction of anthropogenic unknown fibers), and similarity in morphologies observed in both species. Others commented that similar studies also found no distinction between different species regarding contaminant concentrations such as mercury and PFOS. One participant recommended comparing the compositions seen in the prey fish to those of the 1 L surface-water samples. Another noted that surface water and sediment were sampled but water column samples are a data gap in this study.

5. Discussion: Identification of Source Contribution

Chelsea presented preliminary findings from a masters student from Chelsea's lab, Alice Zhu, who has modeled existing data to assess potential sources of microplastic to the Bay using principal component analyses and other similar methods. Her main objectives were to (1) assess any patterns in surface water sites that vary by season, depth, and velocity, and (2) characterize any relationships among surface water samples and the two monitored pathways: WWTP effluent and stormwater. She determined there are patterns among surface water sites and wet- and dry-season samples: season was correlated with different morphologies but not color. She reaffirmed that fibers are the most ubiquitous morphology found across all matrices and highlighted the importance of analyzing sediment samples to provide an idea of accumulation of microparticles over time.

6. Update from Stakeholders

Several microplastic stakeholders provided brief overviews on current, related microplastic work:

- Holly Wyer with the Ocean Protection Council (OPC) explained that, in 2018, California passed a bill that mandated the OPC develop both a comprehensive research plan and a risk assessment framework for microplastic by 2021. In addition, the OPC is required to facilitate method standardization and validation for measuring microplastic in the environment. Shelly Moore and her colleagues are leading a study to evaluate laboratory analytical methods for microplastics to help standardize laboratory methods.
- Shelly Moore with the Southern California Coastal Water Research Project (SCCWRP) spoke about how SCCWRP's two-day microplastic workshop revealed the need for method development and standardization. Subsequently, SCCWRP embarked on developing a laboratory intercomparison exercise with, to date, twenty labs to evaluate five different microplastic-analysis methods: microscopy, microscopy with stain, Raman, FTIR, and Pyrolysis-gas chromatography-mass spectrometry (GC-MS). Methods are being tested on clean and dirty water, sediment, and fish tissue. SCCWRP hopes to finish the methodology within the two-year deadline and is purchasing equipment to become a training facility for any interested labs. Lastly, Shelly solicited submission of any related applied spectroscopy papers for an upcoming special issue in the journal *Applied Spectroscopy* (shellym@sccwrp.org).
- Dr. Anna-Marie Cook with the US Environmental Protection Agency (USEPA) presented on the EPA's microplastic method development for analysis of influent and effluent of primary, secondary, and tertiary treatment plants. The USEPA is working to get this method ASTM certified. As such, the agency is working with a microplastic subcommittee put together by the ASTM D-19 (wastewater) committee and the D-1906 (organics) committee to develop three best practices on sample collection, preparation, and reference samples, and a methodology that includes three different

polymer-identification methods: Raman, FTIR, and Pyrolysis-GC-MS. The EPA's intention is to have an internationally-applied method available by 2020 and that commercial labs and treatment plants will refine the method over the coming five years.

- Cambria Bartlett with Heirs to Our Oceans, a global youth empowerment organization focused on empowering incoming generations to protect our oceans, provided a summary of current and planned work. Heirs to Our Oceans focuses on policy, testifying at local, state, and federal levels, as well as education. Heirs to Our Oceans convenes international youth to learn about global aquatic issues and strategize on how to best address these issues. This year's camp is in California and will have a focus on microplastics. Cambria's email is cambria@heirstoouroceans.org for those who may know of someone who might be interested in their camp.

7. Discussion: Modeling Results to Date

Rusty Holleman summarized recent work on incorporating microplastic data into a Bay and Coastal Ocean model. The aims of this task are to (1) link measured pathways to ambient conditions, (2) understand the regional microplastic budget, and (3) highlight potential hotspots, sources, and sinks. Dr. Holleman used empirical relationships generated by Walschlägger and Schüttrumpf, 2019, to estimate settling velocities of different morphologies in order to understand the fate of microplastic that has entered SF Bay. Rusty used the Bay hydrodynamic model to visually demonstrate the transport and fates of microplastics with a range of buoyancies released in Central Bay. His findings showed that the buoyancy of the particles has large implications on their fate. He determined settling particles such as rubber fragments and fiber bundles most frequently found in stormwater samples primarily sink and tend to stay in the Bay, whereas foams, films, and some fibers found in WWTP effluent that typically float can have widely distributed fates, including export to the open ocean. Results will be presented in a draft report to be distributed in July. The ultimate goal of the modeling effort is to simulate, simultaneously, realistic unit concentrations from actual release points to gain a more quantitative understanding of microplastic budgets.

Discussion centered around how to model resuspension of particles, challenges and limitations associated with the model, and other release scenarios in addition to the demonstrated Central Bay release. Rusty explained that the farther a release is from the mouth of the Bay, the more likely particles are to be trapped in Bay. Some participants recommended analyzing microplastics in sediment cores to elucidate long-term temporal trends. This idea could also help understand other factors like burial rate and resuspension.

8. Discussion: Policy Issues and Communications

Carolynn Box reported out on ten science-based policy recommendations developed by an advisory committee comprised of twenty-two partner organizations. These recommendations covered policy options as well as recommended innovations, product design, research needs, and household interventions. They are summarized as follows:

1. Develop microfiber sheddability standards
2. Prioritize microfiber filtration intervention points
3. Better understand microplastic sources and pathways within stormwater systems
4. Support a Bay area and statewide comprehensive packaging bill
5. Explore green stormwater infrastructure (GSI) to reduce microplastic entering SF Bay
6. Better collaboration between trans and microplastic efforts
7. Support innovation to address microplastic pollution in SF Bay
8. Address additional research needs
9. Educate consumers to decrease microfibers entering SF Bay
10. Support SF Bay Microplastic Management Strategy to reduce microplastic

Deliverables resulting from this effort will include a SF Bay Microplastic Policy Recommendations Report, a SF Bay Microplastic Policy Brief, educational materials, and a project fact sheet. Final steps include incorporating comments and finalizing the Policy Recommendations report, discussing results at the October 2019 Microplastic Symposium, and disseminating conclusions to partners through factsheets, a policy brief, and distribution of educational resources.

Krystle Moody with materEVOLVE reported that in the week preceding this meeting, the American Association of Textile Chemists and Colorists (AATCC) developed a cross-industry agreement with the European apparel industry to prepare a standardized test method for microfibers shedding on fabrics. Krystle indicated that the California chapter of the AATCC will host a conference in October 2019 (after SFEI's microplastic symposium) to discuss fiber biodegradability, standards, and current testing methods. The AATCC will engage SFEI and 5 Gyres to share their findings.

Kelly Moran shared two thoughts on microplastic management action. The first was an observation that treatment (e.g., green stormwater infrastructure) is a common way for managers to address pollution. So, work to understand treatment is often prioritized over source identification. For microplastic, however, Kelly recommended that managers also prioritize studying sources because a more developed understanding of sources could lead to more effective pollution management. The second idea stems from the potential for small microplastics, with relatively large surface areas, to transfer chemical pollutants into the environment and organisms. The formulation of products has huge environmental implications so, while issues of distribution and exposure to microplastic are important, work to understand the reformulation of products should also be considered and elevated. Kelly also mentioned that the California Stormwater Quality Association filed a petition to request that the Department of Toxic Substances Control (DTSC) requires manufacturers to examine alternatives to zinc in tires. As part of the petition-evaluation process, DTSC is broadly examining zinc in tires, specifically its resulting environmental exposure and bioavailability.

Anna-Marie highlighted the importance of developing methods that report both synthetic and natural particle types; and assessing the ultimate fate and accumulation of microplastic through analysis of sediment samples. Anna-Marie indicated that a large fraction of microplastic particles identified in the environment are polyethylene and polypropylene and she wondered whether efforts could be made to assess which products these plastics are used in to target source control or reformulation.

Workgroup participants provided the following comments on the report:

- Besides recommending policies, will the report address the suitability of policies that have been proposed, such as microfiber shedding warning labels on clothing, or biodegradable textiles?
- Re-word recommendation #1 to ensure the recommendation is for *all* relevant parties to work together to develop *and standardize* sheddability standards rather than the current wording which could vaguely imply a 5-Gyres-led effort.
- Add a recommendation to invest in microplastic source identification.
- Add a recommendation to investigate whether products should be reformulated to phase out the use of more harmful chemicals.
- Explicitly state why presence of microplastics is a problem. Mention climate impacts, persistence, and uniqueness; and include arguments around toxicity and uncertainty used by the European Union (EU) to classify microplastics as a “non-threshold contaminant.” Summarize the current state of knowledge around ecological harm.
 - Recommend next steps around hazard assessment and describe the scientific needs necessary to develop methods aimed at understanding toxicological risk and subsequent impacts on human health and ecological harm.
- Provide a brief blueprint on how these recommendations came to fruition and the uniqueness of the process, including linking a regional scientific study with efforts to engage a diverse stakeholder group to develop policy recommendations. Other regions can learn from this process.

Action Item

- Address comments provided by the Microplastic Workgroup. (Carolynn Box, 6/30/19)

9. Discussion: Microplastic Strategy and Multi-Year Plan

Meg Sedlak presented on the revised Microplastic Strategy. Meg summarized the RMP’s tiered risk framework used to assess contaminants of emerging concern (CEC) and highlighted that microplastic currently falls in the “possible concern” category. Considering the EU’s recent determination of microplastic as a “non-threshold contaminant,” as well as the projected increase in the global manufacture of plastics, increased public awareness and concern, microplastic persistence, fragmentation, bioaccumulation, and difficulty associated with removal

of microplastics, the RMP recommended moving microplastic up to the “moderate concern” category. Workgroup participants supported the recommendation. Further discussion occurred after the meeting (see appendix).

For the Multi-Year Plan, discussion centered on the planning budget. Participants were eager to re-assess what could be brought to the TRC with the \$120,000 planning budget for 2020. The workgroup discussed whether and how the RMP could sustain a microplastic monitoring effort and called for discussion and determination of long-term goals and related study priorities. Participants recommended seeking out funding from other sources, possibly from interested parties in the textile industry like Patagonia.

Decision

- Move microplastic to the “moderate concern” category in the RMP’s tiered risk framework for CECs (Consensus).

10. Discussion: Microplastic Proposals for 2020

Meg Sedlak presented on the \$10,000 microplastic strategy proposal, followed by the \$78,400 proposal for analysis of microplastic in San Francisco Bay sport fish. Then Alicia Gilbreath presented on a \$30,000 study to develop a stormwater conceptual model for microplastic, which was written as a proposal targeted for Supplemental Environmental Project (SEP) funds.

Discussion mostly focused on the three proposals brought forward to the workgroup. However, Chelsea suggested an additional study idea which gained interest but ultimately was not prioritized for 2020 funding: development of guidance around field collection best practices. This would include a description of the methods used, lessons learned, and recommendations for similar monitoring. Chelsea mentioned that additional quality assurance analyses could and should be done to aid in the development of this guidance document. This guidance could dovetail nicely with SCCWRP’s effort to develop standardized methods for microplastic analysis. Interest in the utility of this type of guidance was re-expressed during the closed session.

The budget for the Microplastic Strategy was doubled (from \$10,000 to \$20,000) to plan future ecological impact work, maintain an awareness of current work, and collaborate with relevant partners.

Participants considered the conceptual model an urgent need necessary to inform future work. Discussion led to realizing this conceptual model as a key piece necessary to develop a longer-term microplastic strategy and subsequent ranking of time-sensitive projects. The workgroup decided to prioritize the conceptual model second (after the microplastic strategy). Kelly Moran offered to help with the redrafting and highlighted the alignment of this conceptual model with the ongoing CECs in stormwater study. Recommended revisions included:

- Do not focus solely on stormwater. The aim should be to understand sources and products to inform policy and regulation that could ultimately reduce negative impacts caused by microplastic. Include wastewater and air deposition as pathways to be investigated. Change the title to reflect this shift and better appeal to regulators.
- Provide a more detailed and robust description of study objectives, intended tasks, and deliverables. Tasks could include extensive literature work on sources, transport, and fate; numerical modeling; production of drawings of sources and different microplastic categories; and development of future monitoring recommendations. A deliverable should address linkages to microplastic management opportunities and identify key scientific questions that would help inform management decisions.
 - Consider planning a study that compares microplastic runoff from impervious surfaces with outflow from GSI (*proposed during closed session*).
 - Consider zero waste initiative included in the municipal separate storm sewer systems (MP4) permit for 2026 and how RMP microplastic work could accompany this goal. (*proposed during closed session*).
- Rewrite the proposal as a typical RMP special study to be in the running for RMP funds.
- Phase over two years with a \$30,000 budget each in 2020 and 2021 (\$60,000 total).

Participants were also interested in prioritizing the sport fish work to better understand human exposure to microplastic and to fill a data gap that would help round-out the Moore project. The workgroup recommended phasing this study over two years in order to give it a decent shot of 2020 funding and immediate analysis of sport fish samples.

Action Items

- Revise the microplastic strategy to include description planning for ecological studies. (Meg Sedlak, 6/3/19)
- Revise stormwater conceptual model based off of recommendations listed in the discussion. (Alicia Gilbreath, 6/3/19)
- Revise the sport fish proposal by phasing it between 2020 and 2021 (follow notes in the table below). (Meg Sedlak, 6/3/19)

11. Closed Session - Decision: Recommendations for 2020 Special Studies Funding

Project leads exited the conference room and Eric Dunlavey led the closed session discussion. Studies were prioritized as summarized in the table below. One participant recommended listing the conceptual model on the microplastic multi-year plan to allow maximum chances for RMP funding.

Priority	Study Name	Budget	Modified Budget	Comments
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1	Microplastic strategy	\$10k	\$20k	Increased budget to allow for scoping and planning the ecological impact study slated in 2021; stay up-to-date on current science; and continue to track OPC efforts on field sampling methods.
2	Stormwater conceptual model for microplastics	\$30k	\$30k x 2	Expanded effort? Include linkage to air? Expand proposal to hone in on sources that enter stormwater pathway. Phase over two years - \$30k per year.
3	Microplastics in SF Bay sport fish	\$79k	\$57k	Analysis in year 1 (\$57k) and data analysis and report writing in year 2 (\$22k); save additional samples from 2019 for additional analyses. Should be rewritten as a SEP if not prioritized for 2020 funding.

About the RMP

RMP ORIGIN AND PURPOSE

In 1992 the San Francisco Bay Regional Water Board passed Resolution No. 92-043 directing the Executive Officer to send a letter to regulated dischargers requiring them to implement a regional multi-media pollutant monitoring program for water quality (RMP) in San Francisco Bay. The Water Board's regulatory authority to require such a program comes from California Water Code Sections 13267, 13383, 13268 and 13385. The Water Board offered to suspend some effluent and local receiving water monitoring requirements for individual discharges to provide cost savings to implement baseline portions of the RMP, although they recognized that additional resources would be necessary. The Resolution also included a provision that the requirement for a RMP be included in discharger permits. The RMP began in 1993, and over ensuing years has been a successful and effective partnership of regulatory agencies and the regulated community.

The goal of the RMP is to collect data and communicate information about water quality in San Francisco Bay in support of management decisions.

This goal is achieved through a cooperative effort of a wide range of regulators, dischargers, scientists, and environmental advocates. This collaboration has fostered the development of a multifaceted, sophisticated, and efficient program that has demonstrated the capacity for considerable adaptation in response to changing management priorities and advances in scientific understanding.

RMP PLANNING

This collaboration and adaptation is achieved through the participation of stakeholders and scientists in frequent committee and workgroup meetings (see Organizational Chart, next page).

The annual planning cycle begins with a workshop in October in which the Steering Committee articulates general priorities among the information needs on water quality topics of concern. In the second quarter of the following year the workgroups and strategy teams forward recommendations for study plans to the Technical Review Committee (TRC). At their June meeting, the TRC combines all of this input into a study plan for the following year that is submitted to the Steering Committee. The Steering Committee then considers this recommendation and makes the final decision on the annual workplan.

In order to fulfill the overarching goal of the RMP, the Program has to be forward-thinking and anticipate what decisions are on the horizon, so that when their time comes, the scientific knowledge needed to inform the decisions is at hand. Consequently, each of the workgroups and teams develops five-year plans for studies to address the highest priority management questions for their subject area. Collectively, the efforts of all these groups represent a substantial body of deliberation and planning.

PURPOSE OF THIS DOCUMENT

The purpose of this document is to summarize the key discussion points and outcomes of a workgroup meeting.

Appendix

Microplastic: Moderate Concern?

Comments from Advisors:

There was unanimous support from the advisors to move microplastic to the moderate concern category. Below are the individual responses.

Dr. Anna-Marie Cook

This designation is not easy in my mind, and I've written down some "stream-of-consciousness" thoughts that I've grappled with over the past few years of attempting to tackle the question of microplastic risk from the EPA Superfund perspective (keeping in mind I come at this not as a toxicologist or ecologist, but from years of dealing with risk management).

Using the RMP risk framework definitions of levels of concern,

- High Concern – Bay occurrence data suggest a high probability of a moderate or high level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the EC10[1]).
- Moderate Concern – Bay occurrence data suggest a high probability of a low level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the PNEC[2] or NOEC[3] but less than the EC10 or another low level effects threshold).
- Low Concern – Bay occurrence data suggest a high probability of minimal effect on Bay wildlife (i.e., Bay concentrations are well below toxicity thresholds and potential toxicity to wildlife is sufficiently characterized).
- Possible Concern – Uncertainty in toxicity thresholds suggests uncertainty in the level of effect on Bay wildlife. Bay occurrence data exist; in some cases, they may be constrained by analytical methods with insufficient sensitivity.

Microplastic as a contaminant appears to simultaneously meet both the designations of "moderate" and "possible": occurrence/exposure is almost guaranteed to continue to increase in the Bay, yet uncertainty in toxicity thresholds is likely to remain.

There have been no microplastics toxicity thresholds established and it's difficult to imagine that any can be: I believe that the approach the EU has taken is the only practical approach, i.e. the threshold is zero:

- Establishing a risk threshold would be a massive undertaking given the confounding factors of polymer type, age of plastic, entrained plasticizer toxicities, preferentially sorbed POPs toxicities, varying toxicities/physiological-inflammations (along the lines of asbestos fibers) related to size of particles, exposure pathways varying by media and by receptor, etc;
- Teasing out measurable and environmental representative adverse impacts that can definitively be attributed to plastic exposure versus other exposures is very challenging and with current methodologies perhaps not possible;
- Deciding how many particles, of what type and size, and contaminated with what chemicals could constitute the “acceptable” lower boundary, and determining how to evaluate those threshold levels for adverse impacts on coral reefs against the threshold levels for adverse impacts on sport fish and on humans for example is daunting. Usually we set a threshold value for a single contaminant in each media to protect the most sensitive receptors, but in this case the adverse impacts can potentially be more wide-ranging and species-specific than anything we have dealt with (e.g. size of particle may be the most critical factor for some receptors (e.g. coral) while sorbed or entrained chemicals may be critical for others (e.g. Hawaiian Monk Seal)).
- The SFEI study shows an abundance of plastic particles in the Bay. Demonstrating a correlation between the types and sizes of plastic found in 1) the water column samples taken from stormwater inputs after rain events and the fish feeding from the water column (pelagic? although nearshore) in the Bay, and 2) in sediment data and demersal fish, would show exposure (although not necessarily adverse impact) on Bay wildlife even in the absence of having any toxicity threshold to measure.

As the EU report points out, the quantity of this contaminant is only going to increase in the environment. SFEI can support this assertion by continuing periodic sampling of the Bay showing temporal trends. Plastic essentially has no half-life and cannot be considered inert which would seem to make it an increasing threat, however that is defined. I remain supportive of considering this a contaminant of moderate concern.

Dr. Chelsea Rochman

I agree with Anna-Marie that I am supportive of the "moderate" classification.

I am not sure I agree with the EU about a non-threshold, but that is because it's impossible to keep all microplastics out of the environment and out of our drinking water. They have become part of the dust with all of our plastic-usage in everyday life. I'm sure there is actually a threshold, although I agree with Anna-Marie that it's complicated and will vary by type, shape, mixture of additives, etc...

I have no doubt about the large concentrations (obviously! - given I have 20 students counting this stuff because there is so much plastic), increasing concentrations and their persistence. I also

agree with potential for impact. My student and I just completed a systematic review and meta-analysis about the impacts of plastic pollution, with a focus on microplastics, and there is certainly evidence of effect across all levels of biological organization. BUT, there is also plenty experiments that do not detect an effect and thus I don't agree with the non-threshold. I think it's too simplistic.

BUT for SFEI, I do agree with the jump to moderate based on these things aside from the EU decision of how to consider it.

Dr. Kara Lavender Law

I very much appreciate Anna-Marie's thoughtful discussion of her thought process on this classification decision, as well as Chelsea's comments, which are important and well-taken.

At the stage, given the very high concentrations of microplastics in the Bay and the strong likelihood that this will increase, I see a high probability of encounter with (contamination by) microplastics by Bay wildlife. Yet, clearly there is uncertainty in the level of effect, as both Anna-Marie and Chelsea point out, with little hope for a broadly applicable set of toxicity thresholds given the heterogeneous nature of the contaminant (and the wildlife that encounter it).

Because I do not come from a background in toxicology or risk management, I have to defer to my colleagues and their expert opinion in support of the "moderate" classification. I think there is sufficient reason for concern to justify this classification.

Dr. Derek Muir

Thanks for including me in the discussion. It is an interesting case. On the one hand MPs don't fit the "moderate" definition very well ie high probability of a low level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the PNEC[2] or NOEC since there are presumably no threshold values for the polymer particles themselves). On the other hand I gather from reading a Chemical Watch article on this (I don't have the actual ECHA dossier) the decision refers to extreme persistence in the environment and degradation through the formation of nanoplastics. Also the presence of additives at parts per thousand or % levels needs to be considered. In fact some possible additives (alkyl phenols) are already on the moderate list for other reasons while others (BPA, phthalates) are listed in Table 2B as possible concern. So all things considered I think it argues for "moderate".

Dr. Kelly Moran

While I'm no microplastics expert, I've been trying to organize my thinking about how to approach microplastics hazards. Here are some thoughts for your consideration (and for the group's reactions if they like).

As I see it, on a very simple level, microplastics raise two kinds of issues:

(1) They are small physical things littering the environment.

As small physical things, they pose two hazards:

(a) Their physical presence degrades the aesthetic and potentially other qualities of aquatic ecosystems. This is akin to the Water Board's thinking about trash. The fact they don't belong is more than aesthetic, but like trash, aesthetics can drive the public policy reaction to them. (There is the yuck factor of knowing they are in fish we eat or water we drink, and the shock of seeing beaches with itty bitty colored plastic particles among the sand grains). The SF Bay Water Board members voted to make trash a priority based primarily on policy (aesthetics). Many people in the regulated community continue to question whether one can prove that the simple presence of trash actually harms ecosystems, even though there are plentiful data that some of it harms individual organisms. Trash has the same problem of no PNEC or NOEC for either individual species or whole ecosystems.

(b) Unlike trash, the microplastics can be a food substitute. Ignoring the contaminants they contain for the moment, microplastics pose the hazard of reduced nutrition for organisms that consume things in the microplastic size class. [You can tell from this sentence that I'm a chemist and not a biologist ;-)]. Again, at this point, we don't have a threshold concentration for individual species or ecosystem harm from this food-substitute physical hazard.

(2) They are transport pathways for contaminants inside their source material.

As Derek mentioned, some plastics contain relatively high concentrations of CECs on the Moderate and Possible concern lists. I'd add the currently unknown tire ingredient causing pre-spawn mortality to Coho salmon to that list (when Ed & Jen figure it out *<referring in part to stormwater work at University of Washington that the RMP is helping to fund>* [I'm assuming they will because they are both clever and persistent], that pollutant will probably be on the "moderate" list at least for creeks). Until we understand the sources of plastics in the ecosystem and the chemical formulations of the sources, we can't identify all the pollutants that are involved in the microplastics exposure pathway.

For this hazard, microplastics are part of an exposure pathway. They aren't the original source (that's the product they came from), nor are they the ultimate hazard (that's the toxic chemical they contain). They have several ways of facilitating organism exposure to the toxic chemicals they contain:

- They are small, so they move readily through watersheds and into the Bay
- They have a lot of surface area, which makes it easy for the chemicals they contain to become bioavailable in water, sediment, or inside organisms
- They can be taken up by organisms, providing a direct exposure to the pollutants they contain

- They can fall into sediments, where sediment-dwelling organisms can be exposed through consumption and/or leaching into sediment pore water

The fact that they are a pathway rather than an individual pollutant is one of the challenges I'm having with wrapping my mind around the RMP concern level.

Whatever the formal classification of them (although I support "moderate concern," they might merit a special classification due to their unique and combined hazards), understanding microplastics better seems essential if we are to identify the full threat that CECs pose in SF Bay. Plus, if someone asked policy makers "should we minimize microplastics?" I'm pretty sure they would say "yes" for the reasons in #1.

Although we don't know the priorities because of the shortage of information linking plastics to their original sources and not knowing which of these contain the most hazardous pollutants, the control options all fit within the existing Bay & watershed frameworks:

- Source control - safer formulations once we know the pollutants of concern (e.g., tires), reducing plastics
- Treatment control - already a long-term goal for urban runoff (green infrastructure), maybe some new pathway interventions (e.g., washer filters, better dryer lint control)

As I'm still very much a microplastics novice, I'm curious if this thinking aligns with the experts' knowledge of the topic - and I would love to be straightened out if my simplistic approach isn't right!

Dr. Miriam Diamond

My reasons align with what's been said:

- high persistence
- fate leads to fragmentation into nanoplastics rather than true degradation
- modelling presented at the meeting shows net accumulation in the Bay as opposed to loss through flushing through ocean currents (which is solving the problem of pollution through dilution). Rather, the "loss" process in the Bay is accumulation in sediment which enables exposure to both pelagic and benthic communities. In addition, emissions are projected to increase. In total, these two factors suggest increases in microplastic and nanoplastic concentrations of time, and hence likelihood of increased exposures.
- as Derek pointed out, some microplastics are conveyors of elevated concentrations of some compounds already assigned as moderate concern or that are on the "watch list". These are the plastic additives that are most likely to transfer to biota upon ingestion (as opposed to chemicals that sorb to the plastics from ambient waters and are unlikely to transfer to biota).

Here are my additional reasons:

History should teach us to be cautious about a ubiquitous, persistent pollutant for which adverse effects are difficult to determine. Risk assessment is a useful but uncertain instrument to guide decision making. We seldom probe the uncertainty of risk assessment (RA) decisions. However, we do know that some RA decisions can yield "protective" decisions based on traditional toxicity assessments, that stand in contrast to field and epidemiological studies that suggest otherwise (e.g., evidence of adverse effects to populations at ambient exposures). Risk assessment is unable to deal with the complexities of real exposures of mixtures to wild animal experiencing "real life" multiple stresses.

I suspect that finding "reliable" toxicological benchmarks for, microplastics, which is a complex mixture of polymers and additives, will be elusive. We want to find that benchmark(s) so that we can fit a decision into our risk assessment paradigm for decision making.

So at this point, I believe in making a precautionary decision to treat microplastics as a moderate concern, to trigger abatement and remedial actions, rather than waiting for the risk assessment answer. I believe a precautionary decision is warranted based on the points summarized from this thread.

Review of the ECHA Annex XV Restriction Proposal Report -Validity of toxicological conclusions

ECHA's initial literature screen identified approximately 900 articles (from the scientific and grey literature) relevant in some respect to the risk assessment of microplastics. They also held discussions with stakeholders and scientific experts during the report development to identify additional relevant studies that were not highlighted in the literature screening, particularly recently published studies. While they may have missed some literature by using only Scopus and not cross-checking with other scientific databases, this potential issue is offset by their consultation with experts.

From the approximately 900 article identified in the literature screening, a more detailed analysis of key review papers on the topic (both from the peer reviewed and grey literature) and the 25 most influential primary research articles (chosen by number of citations, cross referencing with reviews, and reporting effects in organisms related to microplastic exposure). These articles were chosen objectively using established, peer-reviewed methods, and while identifying influential articles based on citations gives preference to older articles, this limitation is acknowledged and balanced with the use of recent reviews and discussion with scientific experts. Each of the reviews and influential articles are evaluated individually (details in the Annex to the Annex XV Restriction Report), and a weight of evidence approach was used when synthesizing information across the studies. This is the preferred approach for considering risk in ecological assessments,

especially when considering data from nonstandard toxicity testing experiments, which is the case for nearly all current microplastics toxicity studies.

Studies that report results contrary to the majority (e.g., reports of no effects at high exposure concentrations) are presented along with the majority conclusions, indicating no cherry-picking of results. Similarly, discussion of published species sensitivity distributions (SSDs) includes not only why the calculated hazard thresholds (e.g., HC5s or hazardous concentration for 5% of species, PNECs) do not meet REACH criteria, but also which species and analyses were included and usefulness of the results. Many data gaps are identified to help support the conclusion that there is not enough evidence to prove a lack of risk at any exposure (few reported dose-response curves, little chronic data, little translation from lab studies to field effects, few species studied, little work in freshwater and terrestrial systems, little work on nanoplastics, etc.).

The recommendation to classify microplastics as non-threshold contaminants is based not only on the lack of ecotoxicity data for calculation of risk thresholds, but also includes clear evidence of microplastic persistence and uncertainty in regards to bioaccumulation potential. Under REACH, other contaminants have been assessed for risk based on the PBT/vPvB (persistent, bioaccumulative, and toxic / very persistent and very bioaccumulative) perspective, so this logic is not new or unprecedented. ECHA is also careful to define the scope of microplastics covered by the recommendations in terms of size, material composition, origin, and degradability.

Note: Section 1.4.1 Approach to risk assessment. states *“It should also be noted that SAPEA [Science Advice for Policy by European Academies] are due to publish an ‘evidence review report’ on microplastics in nature and society in January 2019 as part of the European Commission Group of Chief Scientific Advisors work on microplastics. This review has been conducted independently from the assessment presented in this report and should be considered as complementary to it.”* This report, A Scientific Perspective on Microplastics in Nature and Society, can be found on SAPEA’s website here: <https://www.sapea.info/topics/microplastics/>

About the SAPEA report:

A review of the scientific literature on occurrence, fate, and effects of microplastics is included (Chapter 2). However, unlike in the ECHA report, it is unclear how the literature was mined or which studies were given highest weight. The science is discussed in terms of what is known and unknown, and there is more emphasis on recent literature and modeling efforts than in the ECHA report. SAPEA’s overall conclusions match ECHA’s: even though ‘high quality’ risk assessment is not yet feasible, action to reduce/prevent/mitigate microplastic pollution is suggested to be needed, as well as development and use of risk assessment approaches to be able to prioritize mitigation actions. This report also includes a review of social and behavioral sciences and how

this research can inform microplastic policies and pollution prevention (Chapter 3) and a review of existing, emerging and potential future regulatory and legal frameworks of relevance to microplastics (Chapter 4). In a follow-up report (Environmental and Health Risks of Microplastic Pollution, April 2019), SAPEA provides another summary of the literature and provides science-driven recommendations for policy. Both reports appear to impartially present the current state of knowledge and important data gaps necessary for risk assessment.

Individual responses to comments from Tom Mumley:

Tom's concerns (copied from email) are written in *Caveat*. SFEI's responses are presented in Times New Roman. The toxicological portions of this response were prepared by Dr. Liz Miller, our recent addition to the SFEI team. Her area of expertise is ecotoxicology. Any mistakes or omissions are mine.

- The primary basis of the recommendation is the European Union proposal to evaluate microplastics as non-threshold contaminants, meaning any discharges to the environment would be considered harmful.

The proposed designation as a non-threshold contaminant means that increases in the environmental stock from discharges to the environment correspond to an increased risk. Risk is different from harm; harm is damage, whereas risk is the possibility to cause harm. The non-threshold contaminant designation is because a thorough scientific analysis concluded there is currently not enough data to be able to justify a conclusion that risks are adequately controlled, based on current exposures in the environment or exposures that are forecast to occur in the future. ECHA is therefore proposing that the EU take a precautionary approach because the risks arising from intentional uses of microplastics that result in releases to the environment are not currently adequately controlled. While the risks posed by microplastics in the environment are currently considered as uncertain, ECHA expects that the understanding of risks will increase significantly over the next 10 years as microplastics, nanoplastics, and their impacts continue to be further studied. As microplastics are extremely persistent and are practically impossible to remove from the environment once released, the report argues it is appropriate to take cost-effective action now, despite these uncertainties. They also assessed the risk reduction potential and socio-economic impacts of several restriction options. The proposed restrictions are considered to be proportionate to the risk, with cost effectiveness similar to previously implemented REACH restrictions.

- That's a policy-based rather than a science-based decision.

ECHA is still in the process of evaluating microplastics risks and has proposed, but not implemented, policy changes to address these risks. The Annex XV Restriction Proposal Report,

while designed to inform policy, is science-based. The report was written in cooperation with the EU Group of Chief Science Advisors, which are part of the EU Scientific Advice Mechanism and provide the Commission with independent scientific advice on specific policy issues. The report includes a comprehensive literature screening and review, and the risk assessment was conducted using a weight of evidence approach, which is the accepted scientific standard for risk assessments when conventional toxicity studies are not available or not comprehensive.

- *We can make a similar argument for other classes of contaminants, e.g., pesticides and pharmaceuticals.*

Risk assessment of chemicals under REACH can be performed in several ways, depending on the hazard properties of the substance. As the hazard properties of microplastics are complex and in many instances uncertain (e.g., issues surrounding particle size, persistence, degradation), the report considered a range of risk assessment paradigms, including ‘conventional’ (eco)toxicological risk assessment based on the derivation of an effects threshold (PNEC) and quantitative risk characterization (PEC/PNEC or RCR approach), PBT/vPvB (persistent, bioaccumulative, and toxic / very persistent and very bioaccumulative) perspective, and case-by-case assessment according to para 0.10 of Annex I of REACH. Other environmental contaminants (such as pesticides and pharmaceuticals) must undergo the same scientifically-driven risk assessment process before policy decisions are made. The difference is that in the case of microplastics, ECHA has determined that since there is not enough data to determine adverse effect thresholds for risk assessment, and due to their extreme persistence and lack of remediation possibilities, microplastics should be treated in a similar manner to PBT/vPvB substances, whereas most other emerging contaminants are not as persistent and/or have more readily available toxicology data (especially in regards to dose-response relationships for multiple species), and can therefore be assessed using ‘conventional’ methods.

- *The non-threshold assertion that any discharges of microplastics to the environment would be considered harmful would justify classifying microplastics as a “High Concern”.*

Definition of High Concern – Bay occurrence data suggest a high probability of a moderate or high level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the EC10).

The non-threshold assertion does not mean that any discharges would be considered harmful because risk is not the same thing as harm. The non-threshold designation is because we do not currently have enough data to calculate safe thresholds and we know microplastics are extremely persistent. Discharges of microplastics to the environment therefore alter the relevant risk characterisation in terms of **when** safe thresholds will be exceeded, rather than **if** safe thresholds

will be exceeded. A designation of high concern would only be warranted if we knew that microplastic concentrations were already high enough to be likely to cause “moderate or high level” adverse effects.

- The “Moderate Concern” tier is for contaminants with exposure (Bay) levels below (but approaching) harmful levels.

Definition of Moderate Concern – Bay occurrence data suggest a high probability of a low level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the PNEC or NOEC but less than the EC10 or another low level effects threshold).

Current scientific consensus is that the best available evidence suggests microplastics and nanoplastics do not currently pose a widespread risk to humans or the environment, but that evidence is limited and the risks are unknown. We do know that the trend for plastic waste is on a steep upward trend and that removal of these microscopic particles from the environment is for all intents logistically impossible and cost-prohibitive. In addition, as Kelly mentions in her response, we have evidence that stormwater from roadways is causing toxicity to a species of interest (salmon). We do not understand the mechanism but we believe there is sufficient evidence to warrant moderate concern as we support those who are sleuthing out the mechanism.

- “Microplastics” is a broad term encompassing lots of different types and different of synthetic materials, and their exposure, fate and effects vary or likely vary by type and shape.

The ECHA Annex XV Restriction Proposal Report acknowledges the complexity of the term “microplastics.” There is no standardized understanding of what substances, and in what physical form, the term microplastics actually refers to. ECHA defines microplastics as a material consisting of solid polymer-containing particles, to which additives or other substances may have been added, and where $\geq 1\%$ w/w of particles have (i) all dimensions $1\text{nm} \leq x \leq 5\text{mm}$, or (ii), for fibres, a length of $3\text{nm} \leq x \leq 15\text{mm}$ and length to diameter ratio of >3 . Polymers that occur in nature that have not been chemically modified (other than by hydrolysis) are excluded, as are polymers that are (bio)degradable. The EU is specifically focused on intentionally added microparticles (“primary” microplastics), not microplastics formed in the environment (“secondary” microplastics), as these can be regulated and also have been the subject of more (eco)toxicological hazard assessments. However, the ECHA literature review documented in the Restriction Proposal Report considered studies on both primary and secondary microplastics in their recommendation to classify microplastics as a non-threshold contaminant.

- Lumping all microplastics into the moderate (or high) concern tier could result in diluting attention on certain microplastics that merit more attention than others.

Until we have enough scientific understanding to distinguish risks from different types of microplastics, why not keep them as one category? We do not currently have enough scientific evidence to know which types of microplastics are most harmful. Also, it is likely that mixture effects will be important in any adverse effects to ecosystems.

- **Microplastic Workgroup participants and advisors have limited knowledge of and experience with the Framework, particularly its scientific basis.**

Many MPWG and ECWG stakeholders and meeting attendees overlap, so this may be less of an issue. As you can see from the input from our three MP advisors and three ECWG advisors, microplastics are a somewhat unique contaminant given its diversity in size, morphology and composition. However, I think the advisors have made a compelling argument based on the science as to why we should list microplastics as of moderate concern.

- **Any recommendation that affects the Framework should be vetted by the Emerging Contaminants Workgroup.**

We have asked for the three ECWG advisors who have experience with microplastics to weigh in on this issue (see responses above). In addition, we would be happy to share this email with the ECWG if you think it would be informative.

- **There may be an expectation that microplastics will get more attention if we classify them as "Moderate Concern", but they are already getting a lot of attention.**

As you note, microplastics are getting a lot of attention (and regulatory actions both in California and the EU) which is part of the driver for us to consider how to prioritize this chemical in our framework. That is there may be times when there is interest in a contaminant such as PBDEs or pyrethroids for which we have evaluated the risk to the Bay and determined that for us it is not warranted that these chemicals be placed in a higher tier category. The RMP community is looking to us to provide some guidance based on the state of the science.

- **It certainly doesn't mean the RMP will commit more funding to microplastics, given the reality that the RMP has insufficient resources to attend to the other moderate concern contaminants.**

It is widely acknowledged that the RMP has limited dollars and cannot begin to address all of the monitoring and research needs for all of the contaminants that are of concern. However, we very often seek external funding for our projects to augment RMP funds and as such the external funders are looking to us to see how we have prioritized this class of compounds. If our tiered framework does not reflect our concern for this contaminant, it makes it challenging or at least confusing to external funders as to why we perceive this to be an issue of concern.

- We also have to consider that a moderate concern classification will likely invite scrutiny of the classification by naysayers and could undermine the current level of attention and management efforts.

The rationale for the classification is based on science and in keeping with the EC strategy document to use threshold values derived by other scientific institutions (e.g., ECHA). The value of the RMP is an honest and open dialogue about the science of these contaminants. We are happy to engage the naysayers and to have a discussion about this. We are committed to the scientific process that promotes open and transparent dialogues.

- The Draft Policy Recommendations Document contains an incorrect statement = "if the RMP identifies microplastics to be a Moderate Concern, the Regional Water Quality Control Board would lead development of a regional Action Plan". The Framework lists "action plan/strategy" as a water quality management action, but as an author of the management action aspects of the Framework, I can state with certainty that it does not mean the Regional Board would lead development of a regional Action Plan. We are not prepared nor able to do so for microplastics even if we wanted to.

We will revise this statement; Barbara Baginska also brought this inaccurate language to our attention.

- Another issue is whether the RMP can or will sustain a separate microplastics strategy rather than incorporating into its emerging contaminants strategy given the limited resources available for workgroups and special projects.

This is a good point and is something that we should discuss further as it relates to workloads, funding, opportunities to reach a diverse and new set of stakeholders, external, expertise, etc.

Special Study Proposal: Convening an Expert Workshop on the Ecotoxicological and Human Health Impacts of Microplastics

Summary: SFEI and SCCWRP will work together to convene world experts on microplastic environmental and human health toxicology for a three-day workshop aimed at summarizing the current state of scientific knowledge on the potential risks of microplastics to aquatic life and humans. Through this project, we will identify environmentally relevant exposure information for different particle types, and develop a roadmap describing what additional research should be prioritized to give managers the relevant insights they need to develop a comprehensive risk management plan. This project would fund SFEI staff time to facilitate the workshop and write follow-up documents, and leverages significant contributions from SCCWRP in planning and hosting the workshop.

Estimated Cost: \$35,950 (with \$56,000 matching funds from SCCWRP)

Oversight Group: Microplastic Workgroup

Proposed by: Ezra Miller, Diana Lin, SCCWRP staff

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	<i>Due Date</i>
Task 1. Facilitate workshop	October 2020
Task 2. Draft summary reports	January 2021
Task 3. Final summary reports	February 2021
Task 4. State of the science manuscripts	July 2021

Background

Microplastics, tiny pieces of plastic smaller than 5 millimeters, are recognized as a pervasive and preventable global threat to the health of aquatic ecosystems. There are a myriad of sources of microplastics, including the breakdown of plastic debris, plastic products such as tire wear and artificial turf, and fibers from textiles. These tiny particles can be transported long distances, and are ubiquitous and persistent pollutants in the ocean. As a result, aquatic organisms at every trophic level, as well as the terrestrial animals and humans that consume them, are exposed to microplastics.

A growing body of research indicates that microplastics have the potential to threaten the health of a wide range of organisms, from zooplankton to humans. However, the health risks from microplastic exposure remain uncertain. Ingested microplastics can potentially impact the biochemical and physiological processes of many different types of animals. Their toxicity likely varies based not only on species, but also on the particle's chemistry, shape, size, and concentration. Potential modes of action include creating a false sense of satiation upon ingestion, blocking gastrointestinal tracts, and triggering cellular-level toxic response.

Microplastics can also expose organisms to potentially harmful chemicals, especially plastic additives such as flame retardants, plasticizers, or dyes.

While some progress has been made toward characterizing the extent, transport, and fate of microplastics in aquatic environments, research to understand the toxicological effects of microplastics on wildlife and humans is still in its infancy. In particular, microplastics researchers have not yet reached consensus on how to correlate exposure to health risk, especially the nuances of how different particle materials, sizes, and shapes influence exposure risk for different types of organisms. Furthermore, many toxicological investigations are not yet focused on environmentally relevant exposure scenarios.

In 2018, the California State Legislature enacted Senate Bill 1263 requiring the California Ocean Protection Council (OPC) to adopt and implement a statewide strategy to evaluate the ecological risks of microplastics in marine environments by 2025. California also enacted Senate Bill 1422 (Portantino, 2018), requiring the testing and reporting of microplastics in drinking water. In order to understand the scale of the microplastic problem in California, it is crucial to develop a better understanding of the risks posed by microplastic exposure. There is, therefore, a need for microplastics researchers to come together to develop consensus around the state of the science and agree on what additional research should be prioritized to support development of a comprehensive risk evaluation strategy.

Although researchers are studying microplastics exposure risk from a variety of perspectives, the proposed workshop will have a focus on reaching consensus on environmentally relevant exposure scenarios, including different microplastic particle types (i.e., size, shape, and chemical composition) that represent potential threats to aquatic life and human health. Workshop participants will also synthesize knowledge about which factors may affect these thresholds (e.g., how sensitive certain biota may be, and in particular which toxicity endpoints appear to be the most important). From this synthesis, we will gain insights into the current state of knowledge on the toxicological relevance of occurrence – that is, whether a given level and type of particles at a specific site can be expected to impact biota and, if so, how. Because research on microplastic environmental and human health impacts is still in its infancy, the workshop will also help develop clarity and consensus around which future studies will give managers relevant, actionable insights to enhance understanding of the effects of microplastics on biota. This will in turn inform OPC microplastics strategy development and implementation.

Study Objectives and Applicable RMP Management Questions

The proposed workshop will bring together leading global experts on microplastic ecotoxicology and human health to discuss and develop consensus on how to approach and develop a microplastic ecotoxicological and human health risk evaluation strategy. The three-day workshop, which will be co-facilitated by SFEI and SCCWRP and hosted at SCCWRP, will begin with a day of public presentations by leading international experts in the toxicology of microplastics. The remaining two days will consist of invitation-only working groups charged with 1) outlining review documents summarizing the current state of knowledge in the field (one for wildlife, one for human health); and 2) developing a list of

research priorities necessary to fill the knowledge gaps they have identified to direct future research.

Table 1. Study objectives and questions relevant to RMP Microplastic Strategy management questions (Sutton and Sedlak 2017).

Management Question	Study Objective	Example Information Application
1) How much microplastic pollution is there in the Bay?		
2) What are the health risks?	Summarize current knowledge of microplastic effects on wildlife and human health	Identify research needs; Develop risk assessment framework for microplastics
3) What are the sources, pathways, loadings, & processes leading to microplastic pollution in the Bay?		
4) Have the concentrations of microplastic in the Bay increased or decreased?		
5) Which management actions may be effective in reducing microplastic pollution?	Identify research needs	Inform OPC's statewide microplastics strategy and the State's microplastics drinking water requirements

Approach

SFEI and SCCWRP will work with representatives from OPC and the State Water Board to develop a list of workshop participants and invitees. The first day of the workshop (expert presentations) will be open to the public, while the second and third days (working groups) will be limited to the invited experts, along with selected participants from State agencies that will provide perspective on management needs and priorities.

During the workshop, participants will develop a list of research priorities necessary to fill the knowledge gaps they identify. After the workshop, SFEI and SCCWRP staff will work with workshop participants to prepare review documents summarizing the workshop outcomes and the current literature, including a manuscript on the state of knowledge on ecotoxicological and human health risks associated with microplastics, with a delineation of the uncertainties in this knowledge. The OPC and State Water Board will be able to use these review documents as the basis for developing their strategic plans.

This project leverages significant contributions from SCCWRP. SFEI and SCCWRP staff will co-facilitate the workshop and work together to write the follow-up documents. SCCWRP will provide the meeting facilities and support the travel expenses of the workshop's invited experts. The SCCWRP portion of the total workshop budget (approximately \$56,000) is therefore not included in the estimated project budget below, which is just for SFEI staff time.

Budget

The following budget represents estimated costs for this proposed special study (Table 2).

Table 2. Proposed Budget.

Budget Item	Hours	Budget
Workshop Attendance by two SFEI Staff	66	\$9,240
Report Writing	54	\$7,430
Manuscript Writing	120	\$17,200
Direct Expense - Travel		\$2,080
Total		\$35,950

Budget Justification

Workshop Attendance

Workshop attendance budget is based on labor hours for two SFEI personnel to attend three days at the workshop including travel time. Because the workshop is being planned for October 2020, funds would need to be released prior to 2021. Direct travel costs are estimated separately below. The workshop will be held at SCCWRP, which will eliminate the need for facility rental charges. SCCWRP offers state-of-the-art meeting facilities, including the ability to live-stream the public presentations on the web.

Report Writing and Manuscript Writing

The report writing budget is based on labor hours for SFEI staff to collaborate with SCCWRP staff to write a report for OPC summarizing the results from the workshop. The manuscript writing budget is based on additional labor hours for SFEI staff to collaborate with SCCWRP staff to convert the summary report into a manuscript. The project budget could be reduced by reducing or removing the manuscript writing budget.

Direct Expense

Direct expense travel costs include round-trip flights, lodging, and per diem for two SFEI staff to attend the workshop.

Leveraged Value

SCCWRP is contributing significantly to the cost of running the workshop, including travel expenses (airfare, accommodations, local transport, etc.) for 20 invited experts (\$24,000), SCCWRP staff time to organize and facilitate the workshop and draft follow-up reports (\$32,000), and in-kind facilities support.

Reporting

The first day of the workshop will be recorded and made available to the public. The results of the second and third day working group discussions will be summarized in a manuscript prepared by SFEI and SCCWRP. In addition, the results will be documented in reports to OPC and the State Water Board.

References

Sutton, R and M Sedlak. 2017. Microplastic Monitoring and Science Strategy for San Francisco Bay. Contribution 798. San Francisco Estuary Institute. Richmond, CA.

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Special Study Proposal: Development of a Stormwater Conceptual Model for Microplastics (Year 2)

Summary: The recently completed study of microplastics in San Francisco Bay identified stormwater to be a major pathway. Given this finding, the Microplastics Workgroup has prioritized the development of a stormwater conceptual model for microplastics. A first year of work focused on black rubbery fragments that were the most abundant type of microplastic in stormwater. This proposal is for a second year of funds to further develop the conceptual model by focusing on other prioritized microplastics, such as fibers, which were the second most abundant type of microplastic in stormwater. Development of the conceptual model for microplastics in stormwater will help inform available management actions to address microplastic pollution and identify data gaps and monitoring data needs to address Workgroup management questions, and to inform the Ocean Protection Council's state-wide microplastic strategy.

Estimated Cost: \$30,000

Oversight Groups: Microplastic Workgroup (MPWG) and Sources Pathways and Loadings Workgroup (SPLWG)

Proposed by: Diana Lin, Alicia Gilbreath, and Rebecca Sutton (SFEL); Kelly Moran, TDC Environmental

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	<i>Due Date</i>
Task 1. Literature review and discussion with experts	November 2020 - March 2021
Task 2. Present update on findings at MPWG and SPLWG	May 2021
Task 3. Draft Conceptual Model Report to MPWG and SPLWG	July 2021
Task 4. Final Conceptual Model Report completion	September 2021

Background

Plastic is ubiquitous in modern life. Global plastic production was estimated to be 299 million tons in 2013 (Gourmelon, 2015). For the last two decades, society has focused on macroplastic in the ocean, such as the Pacific Ocean Garbage Patch, but recently attention has turned to the plastic particles < 5 mm in diameter, referred to as microplastics. In 2018, the California State Legislature enacted Senate Bill 1263 requiring the California Ocean Protection Council (OPC) to adopt and implement a statewide strategy to evaluate the ecological risks of microplastics in marine environments.

The recently completed San Francisco Bay Microplastics Project identified stormwater as a major pathway for microplastics to enter the Bay (Sutton et al., 2019). Based on the first regional measurements of microplastics in stormwater, a load of 10.9 trillion microparticles to the Bay per year from small tributaries was estimated using a previously developed

Regional Watershed Spreadsheet Model (RWSM). Approximately two-thirds of those particles were estimated to be microplastic (not all microparticles are plastic based on chemical analyses conducted on a subset of microparticles). The stormwater microplastics estimate is over 300 times greater than the microplastics load estimated from wastewater. Based on these results, the Microplastic Workgroup has identified stormwater as a priority for additional investigations based on recent findings (Sedlak et al., 2019).

The most abundant microplastics in stormwater were fragments (59%). Most of the fragments were black and rubbery, and tire wear is a suspected major source of these black rubbery particles. Tire ingredients are also being investigated as a source of toxic contaminants in stormwater, through a major CEC stormwater monitoring effort by the RMP.

Last year, the Microplastic Workgroup partially funded the special study proposal to develop a conceptual model of sources and sub-pathways of microplastics into stormwater, and the patterns that may exist among different landscape factors (e.g., land use, imperviousness). Recent designation of microplastics as an emerging contaminant of Moderate Concern to the Bay (Sedlak et al., 2019), based on the RMP's tiered risk-based framework (Sutton et al., 2017), emphasizes the urgency of developing a robust conceptual model to understand the sources, pathways, loadings, fate and effects of microplastics to the Bay. To date, the conceptual model has focused on sources of the black rubbery particles present in stormwater samples.

Fibers (39%) were the second most abundant morphology in stormwater samples. Fibers in stormwater were composed of a variety of polymers; the most abundant polymers identified were polyester, cellulose acetate, and polypropylene. In all other Bay matrices monitored (Bay surface water, sediment, prey fish, bivalves, and wastewater effluent), fibers were the most abundant shape of microplastics. Fibers made up the vast majority of microplastics ingested by prey fish (86%) and bivalves (98%). Polyester, acrylic, and cellulose acetate were the most abundant fiber polymer in Bay tissue samples.

Abraded fibers from textiles and clothing are expected to be major sources of microfibers. A recent study suggested that direct release of microfibers from clothing to the air during wear is similar to releases to water (De Falco et al., 2020). There are a number of other potential sources of fibers to stormwater, including degradation of cigarette filters (made of cellulose acetate), geotextiles in engineering, industrial laundromats and residential dryers expelling fibers into the air, abrasion of fibers from textiles and clothing in the outdoor environment, atmospheric fallout, food packaging, and food containers. Fibers are often embedded with chemicals with known or potential toxic effects, including dyes, flame retardants, and perfluorinated and polyfluorinated alkyl substances (PFAS); ingested microfibers may be a source of these contaminants to Bay wildlife.

We propose to further develop the conceptual model by focusing on sources and pathways of fibers.

Study Objectives and Applicable RMP Management Questions

The purpose of the conceptual model is to identify priority sources and sub-pathways for potential management action, assess data gaps, and prioritize monitoring data needs. It is expected that a microplastic stormwater monitoring study would be developed to evaluate prioritized data needs following completion of the conceptual model development.

Table 1. Study objectives and questions relevant to RMP Microplastic Strategy management questions (Sutton and Sedlak 2017).

Management Question	Study Objective	Example Information Application
1) How much microplastic pollution is there in the Bay?		
2) What are the health risks?		
3) What are the sources, pathways, loadings, & processes leading to microplastic pollution in the Bay?	Assess potential sources of microplastics to stormwater, and potential landscape attributes that may be related to higher levels of discharge.	Inform future monitoring efforts and gain insights into potential management actions.
4) Have the concentrations of microplastic in the Bay increased or decreased?		
5) Which management actions may be effective in reducing microplastic pollution?	Assess potential sources of microplastics to stormwater, and potential landscape attributes that may be related to higher levels of discharge.	Understanding the high leverage areas of microplastic pollution and point source discharges will be important for prioritizing appropriate management actions.

Approach

Through the second phase of this project, we propose to develop a conceptual model that describes additional prioritized sources of microplastics to stormwater. Sources of fibers to stormwater and the Bay are a priority because they were the second most abundant morphology in stormwater samples and composed nearly all of the microparticles in bivalve and prey fish samples.

The model will include a diagram depicting the sources and sub-pathways. An example of a conceptual model diagram is depicted in Figure 2. The conceptual model diagram will be accompanied by a report detailing the research behind each compartment of the model.

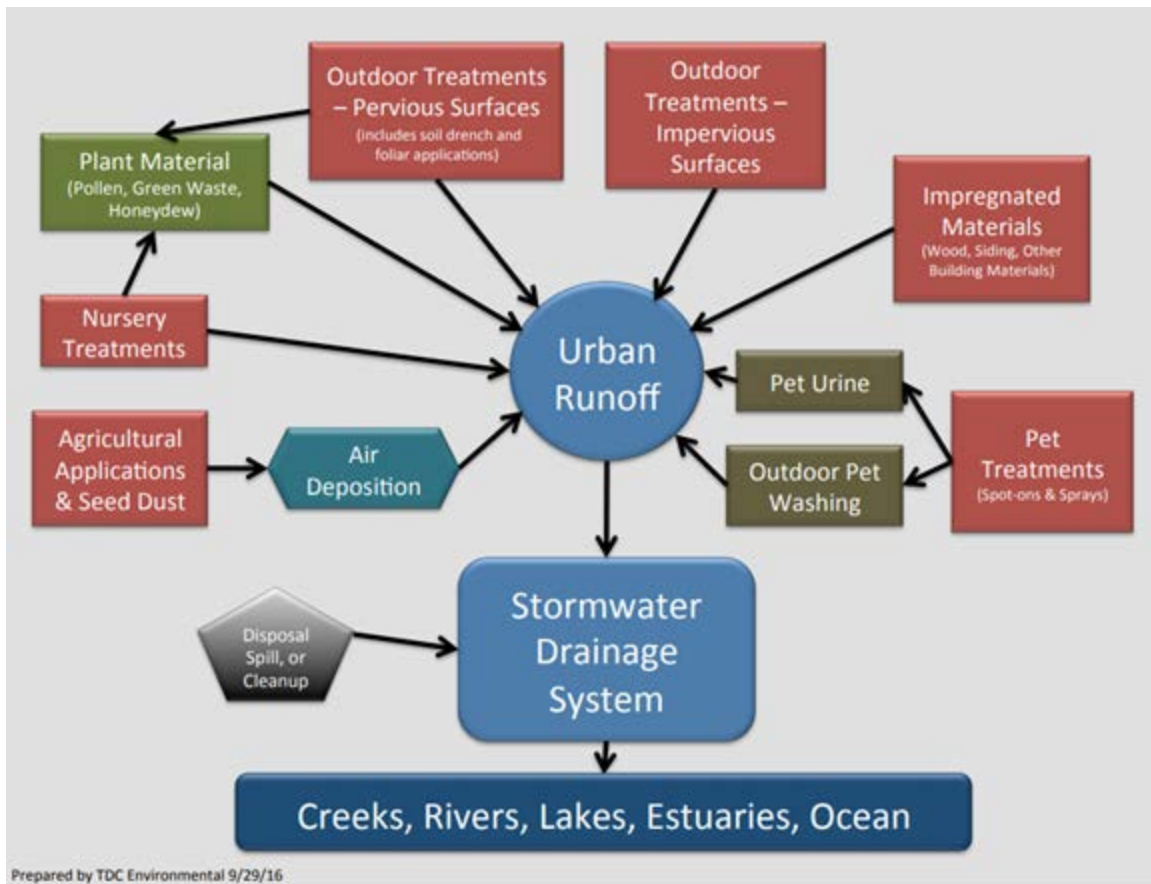


Figure 2. Conceptual model of imidacloprid in stormwater. Prepared by Kelly Moran, TDC Environmental (2016).

The model will be based on an in-depth review of the scientific literature on potential sources and landscape attributes linked to microplastics. Given that microplastics are a relatively new pollutant of concern across the globe and, therefore, appropriate literature may be limited, additional efforts will be made to draw inferences from contaminants with similar sources and/or transport-related properties, as well as to interview experts in the relevant fields. The main sources of information are likely to come from:

- Scientific peer-reviewed journal articles,
- Grey literature technical reports,
- Internet searches and industry publications, and
- Interviews with experts in the relevant industry and scientific fields.

This project will benefit from additional oversight and technical expertise from a local consultant (Kelly Moran, TDC Environmental) who is well-versed in the development of conceptual models to explain sources and pathways of pollutants to the Bay.

The literature review and interviews may suggest specific urban activities or landscape attributes that may explain higher levels of discharge.

Evaluating possible factors influencing microparticle and microplastic loads is important; however, controlling microplastics after they enter stormwater runoff is an expensive endeavor. Therefore, additional focus will be placed on identifying true sources and mechanisms of discharge into the environment. Such identification can serve to aid in development of effective management actions aimed at reducing microplastic discharge at the source.

A comprehensive stormwater conceptual model will help the MPWG identify key data gaps and areas of uncertainty that could be central to future monitoring efforts.

The final deliverable will be a detailed report including a conceptual model diagram. A draft of the report will be provided for Microplastic and Sources Pathways and Loading workgroups and TRC review.

Budget

The following budget represents estimated costs for this proposed special study (Table 2).

Table 2. Proposed Budget for Year 2.

Budget Item	Hours	Budget
Literature Review and Model Development	144	\$21,000
MPWG update presentation	40	\$5,000
Subcontract - Kelly Moran, TDC Environmental		\$4,000
Total		\$30,000

Budget Justification

Labor Costs (Literature Review and Model Development and Reporting)

Labor will primarily be spent on reviewing the literature and talking with experts in the field. Up-to-date drafts of the conceptual model will be presented at the MPWG and SPLWG meetings in the spring of 2021.

Subcontract Costs

Dr. Kelly Moran (TDC Environmental) will collaborate on development of the conceptual model. Dr. Moran has been involved in developing numerous such conceptual models on emerging contaminants, copper, and pesticides in stormwater.

Reporting

Findings will be shared in a presentation during the MPWG and SPLWG spring meetings in 2021. The results of this project will be summarized in a detailed report including a conceptual model diagram.

References

- De Falco, F., Cocca, M., Avella, M., Thompson, R.C., 2020. Microfiber Release to Water, Via Laundering, and to Air, via Everyday Use: A Comparison between Polyester Clothing with Differing Textile Parameters. *Environ. Sci. Technol.*
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- Sutton, R., Lin, D., Sedlak, M., Box, C., Gilbreath, A., Holleman, R., Miller, L., Wong, A., Munno, K., Zhu, X., Rochman, C., 2019. Understanding Microplastic Levels, Pathways, and Transport in the San Francisco Bay Region. (No. SFEI Contribution No. 950.). San Francisco Estuary Institute, Richmond, CA.

Special Study Proposal: Microplastics in South Bay Sediment Cores

Summary: Following findings of abundant levels of microplastics in San Francisco Bay, the RMP has elevated microplastics to the Moderate Concern category within the RMP’s emerging contaminants tiered risk-based framework. The RMP’s recommended strategy for Moderate Concern contaminants includes determining whether Bay concentrations are increasing or decreasing in the Bay. We propose to evaluate sediment as a suitable matrix for monitoring microplastic concentration trends by measuring microplastics in sediment cores. In the summer of 2020, there are two RMP studies collecting and analyzing sediment cores, providing the opportunity to collect samples with minimal additional costs. Additionally, microplastic concentration trends in the sediment core from one of the sites will be compared to trends in PCB sediment concentrations.

Estimated Cost: \$40,275

Oversight Group: Microplastic Workgroup

Proposed by: Diana Lin, Miguel Mendez (SFEI), SCCWRP staff

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	<i>Due Date</i>
Task 1. Field collection	October 2020
Task 2. Laboratory analysis	January - October 2021
Task 4. Draft Summary Report	March 2022
Task 5. Presentation to MPWG	May 2022
Task 5. Final Summary Report	June 2022

Background

SFEI recently completed a comprehensive regional investigation of microplastics in the San Francisco Bay (Sutton et al. 2019). Microplastic contamination was found throughout the Bay, and concentrations measured in the Bay water and sediment were among the highest reported in the literature to date. Stormwater was identified as a dominant pathway for microplastics to enter the Bay, and a significant portion of the microplastics in stormwater was suspected to come from tire wear. These black rubbery fragments were also frequently detected in sediment samples, particularly in sites in the Bay margins, but were not present in wastewater, surface water, and fish digestive tracts.

Following the results of this study, the RMP has elevated microplastics to the Moderate Concern category within the RMP’s emerging contaminants tiered risk-based framework (Sedlak et al. 2019). The RMP’s recommended strategy for Moderate Concern contaminants includes monitoring whether Bay concentrations are increasing or decreasing in the Bay, and evaluating sources, pathways, and loadings to inform management actions. We propose to evaluate sediment as a suitable matrix for monitoring microplastic concentration trends.

Sediment is expected to be a suitable matrix because it is a likely sink for all microplastics in the Bay, regardless of the pathway to the Bay. Even microplastics that are initially buoyant will eventually sink over time due to accumulation of organic and inorganic material. Sediment is currently monitored for a variety of contaminants, including PCBs, PAHs, PBDEs, methylmercury, and fipronil as part of the RMP Status and Trends Monitoring program.

Bay sediment is also an important matrix for monitoring because sediment may be a source of microplastics to the Bay food web. Bay topsmelt had higher concentrations of non-fiber microplastics compared to anchovies, and the difference is suspected to be because topsmelt depend more on benthic prey than anchovies, which feed primarily in the water column (Sutton et al. 2019).

Results from the San Francisco Bay Microplastic Study (Sutton et al. 2019) suggest sediment may be a suitable matrix for monitoring baseline concentrations and tracking trends. Bay sediment concentrations were higher than concentrations in the reference area (Tomales Bay), and while sample collection was not designed to statistically compare regional differences in the Bay, sediment samples from the Lower South Bay (LSB) had high microplastic concentrations compared to the rest of the Bay. Two of the LSB sites that were near wastewater and urban creek discharge locations were more than four times higher than average concentrations in the Bay, and represent some of the highest reported concentrations of microplastics in the literature to date. After fibers, fragments were the most abundant morphology identified in Bay sediment. Black rubbery fragments that were suspected to be tire wear were the most abundant type of fragment, followed by polypropylene and polystyrene, which may be linked to single-use items such as packaging and foodware, as well as many other items that may end up as trash. Additionally, two sets of field duplicates collected from surface sediment indicated acceptable reproducibility in microplastic sediment concentrations (relative percent difference of 36% and 1%).

Microplastics have been analyzed in sediment cores internationally, though to our knowledge no studies have been conducted in the United States. For example, the temporal distribution of microplastics in sediment cores from Derwent Estuary in Australia, a similar urban watershed to San Francisco Bay, showed a strong correlation between the expected change in plastics production in the region and the rate of plastics deposited in sediment (Willis et al. 2017). Like San Francisco Bay, the Derwent Estuary has been heavily impacted by the surrounding urban environment, providing an opportunity to analyze microplastic concentrations correlated with population growth and proximity to wastewater discharges. Two sediment cores were collected and analyzed for microplastics as well as lead isotopes for aging analysis. The smallest size class (63–100 μm) was found to be the highest in all samples except one. Sediment cores have also been evaluated in China, and concentration changes could be explained by increasing use of plastic products and availability of municipal waste infrastructure (Zheng et al. 2020).

One of the key challenges for microplastic monitoring is the lack of standardized methods for measuring microplastics in water, sediment, and tissue. This is especially a challenge because we are interested in monitoring microplastic trends over time, as well as comparing microplastic concentrations measured in various regions. However, there are currently

significant efforts being made to standardize methods for analyzing microplastics. For example, the Southern California Coastal Water Research Project (SCCWRP) is currently conducting an inter-laboratory comparison study to help support the development of standardized analytical methods for analyzing microplastics. The results of the SCCWRP study are expected to inform the accuracy, precision, and reproducibility of microplastic analysis across laboratories and support the development of standardized methods.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is to examine microplastic concentrations and explore temporal trends in sediment cores from San Francisco Bay. This study will also determine the viability of sediment as a matrix for monitoring trends in microplastic concentrations and add to baseline data for future evaluations. Additionally, historic concentrations from sediment deposited before and since the production of plastic (1950s) may provide a useful reference to compare current and future concentrations.

Table 1. Study objectives and questions relevant to RMP Microplastic Strategy management questions (Sutton and Sedlak 2017).

Management Question	Study Objective	Example Information Application
1) How much microplastic pollution is there in the Bay?		
2) What are the health risks?		
3) What are the sources, pathways, loadings, & processes leading to microplastic pollution in the Bay?		
4) Have the concentrations of microplastic in the Bay increased or decreased?	Evaluate changes in sediment concentrations over time.	Compare the rate of changes in concentration with changes in plastic use. Assess utility of sediment as a tool for monitoring changes in microplastics in the Bay.
5) Which management actions may be effective in reducing microplastic pollution?	Characterize chemical composition and particle type of microplastics present in sediment cores.	Morphology and chemical composition can inform our understanding of sources of microplastics.

Approach

Sediment core collection efforts from two other planned RMP studies provide the opportunity to collect sediment cores from two different locations in the Bay with minimal field costs, in addition to providing information about the site without additional analyses and costs. The RMP has funded a special study to collect sediment cores in Steinberger Slough to evaluate the changes in historical loads of PCBs from upstream watersheds. SFEI's Nutrients team is collecting several box sediment cores from South and Lower South Bay (LSB) for the purpose of conducting microcosm studies to evaluate the biogeochemical

processes occurring in Bay sediment. Both sediment core sampling efforts are expected to occur in the summer of 2020.

We propose leveraging both of these efforts: collecting one sediment core from Steinberger Slough and one sediment core in more ambient conditions in LSB. The Steinberger Slough site will represent a site heavily influenced by stormwater, and the LSB site will represent ambient conditions further away from direct stormwater influence. The ambient LSB site has not been selected, but we expect to have several site options when the Nutrients team collects their samples. A site will be selected that is generally depositional, closer to the spine of the Bay, and further from direct stormwater and wastewater outfalls.

The sediment core samples will be sent to SCCWRP for extraction and analysis. To reduce contamination, sediment core sections will be sliced in the SCCWRP laboratory. Two field blanks will be collected during each sampling event to measure procedural and background contamination during sampling. Each of the sediment cores will be analyzed in six sections.

Raman and FTIR spectroscopy will be used to identify the chemical composition of the particles. Additionally, the morphology, color, and size of each particle will be recorded. Of particular interest are tire and road wear particles, as tire rubber has been identified as a potential major source of microplastics to the Bay. While only 9% of total microparticles counted in sediment samples from the San Francisco Bay Microplastic Study were black fragments (Sutton et al. 2019), this proportion is expected to have been larger if we had analyzed a smaller size fraction of particles. Based on a literature review indicating that the most abundant size range of tire and road wear particles may be in the 50-100 μm range (Kreider et al. 2010), analysis of microplastic samples will include microparticles 50 μm in size and greater (our previous study size limit was 125 μm). Additionally, microplastic concentration trends in the sediment core from Steinberger Slough will be correlated with PCB sediment concentrations that will be analyzed as part of the funded PCB passive sampler special study.

The data will be subjected to rigorous quality assurance-quality control review, presented to the Microplastic Workgroup and TRC, and summarized in a technical report. Data will be uploaded to CEDEN.

Budget

The following budget represents estimated costs for this proposed special study (Table 2).

Table 2. Proposed Budget.

Budget Item	Hours	Budget
Field Planning and Sampling	25	\$2,775
Data Management Services		\$6,500
Data Analysis	80	\$9,650
Reporting	87	\$10,650

Subcontract - Laboratory Analysis		\$20,400
Direct cost		\$500
Total		\$50,475

Budget Justification

Field Planning and Sampling

Field costs are reduced by leveraging other RMP sample collection efforts at Steinberger Slough and Lower South Bay. The budget is based on additional SFEI labor hours needed to develop a sampling plan and join existing sediment core collection efforts to collect sediment cores for microplastic analysis. The other projects will cover the cost of operating the boat and collecting sediment cores.

Data Management

Data management will be conducted by RMP staff. Microplastic data management has been streamlined based on previous SFEI microplastic project experience. Results will be uploaded to CEDEN.

Data Analysis and Reporting

Budget is based on SFEI labor hours to analyze data, conduct a literature review to evaluate results in context of the literature, and summarize results in a presentation and final report.

Subcontract - Laboratory Analysis

SCCWRP has recently acquired a state-of-the-art clean room and instruments for microplastic analysis. The cost to analyze each sample is estimated to be \$1,700 due to the labor intensive nature of the extraction process, identification, enumeration, and analysis associated with spectroscopy. Two field blanks will be collected during each sampling effort, and at least two laboratory blanks will be included as part of the analysis. Analysis of QA samples is incorporated in the analytical budget.

Direct Costs

The budget will cover the cost to purchase sample containers and equipment and to ship the samples to SCCWRP.

Reporting

The results of this project will be summarized in a technical report prepared by SFEI, as well as a presentation to the TRC. Reported data will be evaluated by SFEI Data Management and will be uploaded to CEDEN.

References

Kreider, Marisa L., Julie M. Panko, Britt L. McAtee, Leonard I. Sweet, and Brent L. Finley. 2010. "Physical and Chemical Characterization of Tire-Related Particles: Comparison of Particles Generated Using Different Methodologies." *Science of The Total Environment* 408 (3): 652–59. <https://doi.org/10.1016/j.scitotenv.2009.10.016>.

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Special Study Proposal: Microplastics in San Francisco Bay Sport Fish

Summary: In summer 2019, as part of RMP Status and Trends monitoring, sport fish were collected and analyzed for a suite of contaminants. The digestive tracts of some of these fish were archived specifically for future microplastic analysis. This project proposes to make use of archived fish digestive tracts from three species to assess the level of exposure in the Bay food web to microplastics and associated pollutants. The cost of the study is \$92,775, but this could be reduced by analyzing fewer samples.

Estimated Cost: \$50,775–92,775

Oversight Group: Microplastic Workgroup

Proposed by: Diana Lin and Nina Buzby (SFEL); Chelsea Rochman (University of Toronto)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	<i>Due Date</i>
Task 1. Laboratory analysis	January - October 2021
Task 2. Draft manuscript	April 2022
Task 3. Microplastic Workgroup presentation.	May 2022

Background

Microplastics have been found in the tissues of seafood, including tiger prawns (Abbasi et al., 2018), shellfish (Cho et al., 2019; Naji et al., 2018) and fish (Rochman et al., 2015). The literature shows a variety of adverse effects associated with microplastic exposure, including inflammation and oxidative stress, microbiome changes, altered swimming and feeding behavior, altered reproductive success, and decreased growth and body condition (Foley et al., 2018). Although the ingestion of microplastics by fish and shellfish is unlikely to cause acute toxicity or mortality, the effects of chronic exposure require further research (Rist et al., 2018). The minimal availability of data on this topic is a cause for concern for public health (Hantoro et al., 2019).

Currently, there is no information regarding the fate of microplastics in the human body upon ingestion (Rist et al., 2018). However, interactions between microplastics and the immune system have been postulated to cause immunotoxicity and trigger adverse effects (Wright and Kelly, 2017). Microplastics contain chemical additives that are intentionally added to achieve desired properties, many of which can be toxic to humans and wildlife, such as carcinogens, endocrine disruptors, and neurotoxins (Talsness et al., 2009; Thompson et al., 2009). In laboratory studies, microplastics or chemicals associated with microplastics have been shown to transfer out of the gut and accumulate in tissues (Carbery et al., 2018). A recent study found that wild fish that had ingested microplastics had higher concentrations of bisphenols (a common class of plastic additives) in their liver and muscle

tissue (Barboza et al., 2020). Additionally, the hazard index calculated from ingestion of fish tissue containing the levels of bisphenols measured suggested a health risk to human consumers. The potential of plastic debris to sorb and desorb chemicals in aquatic organisms may pose another potential threat to humans and wildlife.

SFEI recently completed a comprehensive regional investigation of microplastics in San Francisco Bay (Sutton et al., 2019). Microplastic contamination was found throughout the Bay, and concentrations measured in Bay water and sediment were among the highest reported in the literature to date. Microplastics were present in two species of prey fish analyzed, anchovies (*Engraulis mordax*) and topsmelt (*Atherinops affinis*). Concentrations of microparticles in prey fish ranged between 0 – 57 microparticles per fish. A separately funded RMP study also found microplastics to be present in California mussels (*Mytilus californianus*) and Asian clams (*Corbicula fluminea*) (Miller et al., 2020). The high levels of microplastics in the Bay and the presence of microplastics in prey fish indicate the potential for microplastic and associated chemical exposure at higher trophic levels, including sport fish and, ultimately, humans. However, sport fish that are consumed by humans have not been monitored for microplastics; this is a major data gap for the Bay.

Sport fish may have very different exposure compared to prey fish due to their larger size, feeding patterns, feeding range, and generally longer lifespan. Sport fish are potentially exposed to microplastics directly through mistaking them for a food source, and indirectly through consuming smaller prey species contaminated with microplastics.

Bay sport fish microplastic levels can be compared to a limited number of other studies elsewhere in California. One regional study of pelagic fish (> 30 species) off the coast of southern California found less than 1% of the fish had ingested microplastics in the 1-5 mm size range (Moore et al., 2016). However, another study in San Diego Bay (Salas et al., 2016), found three out of four fish species had consumed microplastics (1-5 mm), with about 18% of stingrays and 12% of spotted sea bass ingesting microplastics. Study of sport fish in the Bay is critical to understanding the fate of microplastics in the Bay food web, determining risks to human and ecological health, and evaluating sport fish monitoring as a potential index of microplastic contamination in the Bay.

Gastrointestinal tracts from fish collected during 2019 RMP Status and Trends sport fish monitoring have already been archived for the purpose of future microplastic analysis, should funding be appropriated.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is to determine the amounts and types of microplastics in sport fish in the Bay.

Table 1. Study objectives and questions relevant to RMP Microplastic Strategy management questions (Sutton and Sedlak 2017).

Management Question	Study Objective	Example Information Application
1) How much microplastic	Assess concentration in an	Assess the potential for uptake

pollution is there in the Bay?	important upper trophic organism.	of microplastics into Bay food webs, and add to the conceptual model for microplastics in the Bay.
2) What are the health risks?	Compare concentrations in Bay sport fish to literature studies and previous prey fish results.	Assess magnitude of exposure to fish and potential human exposures.
3) What are the sources, pathways, loadings, & processes leading to microplastic pollution in the Bay?	Assess variation among species and sites to gain insight into the importance of local inputs.	
4) Have the concentrations of microplastic in the Bay increased or decreased?	Establish a baseline for future trend analyses.	Assess if concentrations and composition of microplastics change over time.
5) Which management actions may be effective in reducing microplastic pollution?	Characterize types of microplastics present in sport fish.	Understanding the type and composition of microplastics accumulating in biota will be important for prioritizing appropriate management actions.

Approach

Three following sport fish species are currently archived for microplastic analysis: shiner surfperch (*Cymatogaster aggregata*), striped bass (*Morone saxatilis*), and largemouth bass (*Micropterus salmoides*). Shiner surfperch are an abundant and popular sport fish species that feeds on invertebrates in the benthic zone and exhibits high site fidelity, making them useful for assessing regional differences in contaminants. Striped bass are a popular sport fish species that is higher in the food chain and provides an integrated signal for the Bay as a whole because of its wide foraging behavior and opportunistic consumption of lower trophic level fish. Largemouth bass collections were substituted for striped bass in Artesian Slough, where striped bass were not collected in sufficient numbers. These two bass species have similar feeding strategies. In total, 66 fish were collected and archived for microplastic analysis from sites within the Central Bay and South Bay (Table 2).

Table 2. Sport fish samples available for microplastic analysis

	Shiner Surfperch	Striped Bass	Largemouth Bass
Central Bay		7	
San Francisco	10		
Berkeley	10		
South Bay	10	12	
San Leandro Bay	10		
Artesian Slough			7
Totals	40	19	7

The fish sampling locations include sites that are dominated by stormwater and wastewater pathways. For example, Artesian Slough receives water from the San Jose-Santa Clara Regional Wastewater facility. Fish collected in the area in 2014 and 2015 showed relatively high PBDE concentrations that suggests wastewater-influence (Sun et al., 2017). San Leandro Bay is a nearshore area located next to the Oakland Airport with previous fish gut analysis also confirmed the presence of plastic fibers (Jahn, 2018). Approximately 10% of the area is industrial, and 85% of that area is either older industrial or source areas that are conceptually associated with higher concentrations of PCBs (Yee et al. 2019).

We propose to analyze all or a portion of the archived fish digestive tract samples for microplastics, depending on the budget level. The upper bound estimate is based on analyzing all of the fish samples (66 fish). The lower bound estimate is based on reducing fish analysis to four fish per site (4 x 6 sites = 24 fish). The budget can be scaled based on the number of samples per site (4–10 fish/site). Clean un-opened sample containers were kept for analysis as the field blank. Sample containers were only opened while inserting the digestive tract. The samples will be shipped to the University of Toronto where they will be processed using previously published protocols (Corcoran, 2015; Dehaut et al., 2016; Foekema et al., 2013). Briefly, samples will be digested in a 20% KOH solution at 55°C overnight. Microparticles > 45µm will be extracted from the samples and a subsample will be chemically identified using Raman and/or FTIR spectroscopy. Additionally, the morphology, color, and size of each particle will be recorded. Microparticles down to 45 µm in size will be analyzed.

The data collected from this study will characterize the abundance and composition of microplastics consumed by sport fish to evaluate the level of exposure and uptake to the Bay food web. We will also evaluate the factors that may influence microplastic levels, including differences in abundance among species and locations.

We plan to compare microplastic abundance levels in sport fish with levels previously measured in prey fish and with fish in other published studies. We will also qualitatively examine possible correlations between microplastic ingestion and tissue concentrations of persistent organic pollutants (PCBs, PBDEs, dioxins, mercury, selenium, and perfluorinated alkyl substances) using the RMP Status and Trends sport fish monitoring program results.

Results will be shared in a presentation to the Microplastic Workgroup. The final deliverable will be a manuscript prepared by the University of Toronto with assistance from SFEI.

Budget

The following budget represents estimated costs for this proposed special study (Table 3).

Table 3. Proposed Budget.

Budget Item	Hours	Budget
Data Management		\$5,500
Data Analysis and Reporting	165	\$19,275
Subcontract - laboratory analysis (minimum 24, up to 66 samples) - \$1000 per sample		\$24,000–\$66,000
Direct cost - shipping		\$2,000
Total		\$50,775–\$92,775

Budget Justification

Data Management

Data management will be conducted by RMP staff. Microplastic data management has been streamlined based on previous SFEI microplastic project experience. Results will be uploaded to CEDEN.

Data Analysis and Reporting

Budget is based on SFEI labor hours to analyze data, conduct literature review to evaluate results in context of the literature, and summarize results in a presentation to the MPWG and a short summary report. The contracting laboratory will prepare a manuscript summarizing the findings of this work, which will reduce reporting costs. RMP staff will assist in manuscript completion.

Subcontract - Laboratory Analysis

SFEI has previously worked with the University of Toronto on multiple microplastics projects. The Rochman laboratory uses state of the art instrumentation to conduct microplastic analyses and is a recognized pioneer and leader in the field of microplastic research. The analysis of microplastics is a labor-intensive process and each sample costs \$1,000 to extract and identify, count, and analyze particles via spectroscopy. Laboratory blanks will be included in the analyses (approximately 10 percent of the samples). Clean unopened sample containers were archived along with the fish samples for analysis as field blanks. The analysis of multiple fish of each species from each site will provide information on the variation in field samples. The budget can be scaled based on the number of samples. The lower bound estimate is based on reducing fish analysis to four fish per site (4 x 6 sites = 24 fish). The upper bound estimate is based on analyzing all of the fish samples (66 fish). The budget can be scaled based on the number of samples per site (4–10 fish/site).

Direct Costs

Direct costs are for shipping frozen samples from SFEI to the University of Toronto. The overnight courier costs are more expensive because the samples are being shipped to Canada and need to clear customs in an expedited manner.

Reporting

Findings will be shared in a presentation during the MPWG spring meetings in 2022. The results of the project will be summarized in a draft manuscript prepared by University of Toronto with assistance from SFEI.

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