REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY
sfei.org/rmp

RMP Microplastic Workgroup Meeting

May 15, 2018
10:00 AM – 4:30 PM

REMOTE ACCESS
Audio by Phone: (415) 594-5500, Access Code 943-326-397#
Slides: https://join.me/sfei-conf-cw1

AGENDA

1.	**Introductions and Goals for This Meeting** (Attachment) The goals for this meeting: ● Provide updates on recent and on-going MPWG activities ● Feedback on microplastic results to date ● Recommendation on special study proposals for 2019 and ways to further refine proposals ● Introduction of new expert advisor, Dr. Kara Lavender Law Meeting materials: 2017 MPWG minutes (See pages 4-13)	10:00 Phil Trowbridge
2.	**Information: Review of Sampling Conducted to Date** (Attachment) Brief overview of the RMP's Microplastic Strategy and activities completed in first year of the Moore Microplastic project. Desired Outcome: Provide background for today's discussion Meeting materials: Microplastic Progress Report (attached separately)	10:15 Meg Sedlak
3.	**Information: Method Development and Challenges** Review of methods that have been developed, and a discussion of the challenges and opportunities associated with the microplastic analyses. Desired outcome: Inform the group of progress on method development Meeting materials: Section 4 of the Progress Report	10:30 Chelsea Rochman
4.	**Discussion: Data Review** Field samples have been collected; extraction and analyses are underway. An update will be given on the laboratory analyses. In addition, we will present	11:35 Becky Sutton

	the methods we will use for classifying and describing particles, as well as a preliminary discussion of QA/QC. Desired outcome: Inform the group about the data and gain feedback Meeting materials: Section 5 of the Progress Report	
	Lunch (to be brought in)	12:05
5.	**Information: Updates from Advisors** A short update will be given by our advisors on recent advances in the field. Desired outcome: Inform stakeholders of on-going activities	1:00 Anna Marie Cook; Kara Lavender Law
6.	**Information: Presentation of the SFEP Rain Garden Project** The San Francisco Estuary Partnership (SFEP) funded a small study to evaluate the efficacy of rain gardens to treat urban stormwater for contaminants including microplastic. (This was not an RMP/Moore funded project.) A brief summary of the results will be given to illustrate how microplastic data can be presented. Desired outcome: Informational purposes only	1:20 Diana Lin
7.	**Discussion: Modeling Results to Date** A review of the status of the coupling of Bay and open ocean models will be presented. Desired outcome: Workgroup insights to refine modeling efforts Meeting materials: Section 6 of the Progress Report	1:40 Rusty Holleman
8.	**Discussion: Policy Issues and Communications** One of the goals of the Moore project is to generate resources that inform and educate stakeholders and the public. An update on the policy and communications elements will be given. Desired outcome: Inform workgroup on status Meeting materials: Section 7 of the Progress Report	2:10 Carolynn Box / Anna Cummins
	Short Break	2:40
9.	**Discussion: Microplastic Proposals for 2019** The Principal Investigators will present the proposed special studies. The workgroup will ask questions, discuss, and provide feedback. 2019 Special Study Proposals include: • Microplastic strategy funding • Microplastic in sport fish	3:00 Meg Sedlak

	Desired outcome: Gather feedback on the merits of each proposal and how they can be improved Meeting materials: MPWG Special Study Proposals **(See pages 14-23)**	
10.	**Closed Session - Decision: Recommendations for 2019 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. 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. Desired Outcome: Recommendations from the MPWG to the TRC regarding which special studies should be funded in 2019 and their order of priority.	3:30 Karin North
	Report out on Recommendations	4:00
	Adjourn	4:15

RMP Microplastics Workgroup Conference Call
March 7, 2017
San Francisco Estuary Institute

Final Meeting Summary

Attendees

There were approximately 45 people on conference call including the following:

Name	Affiliation/Roles
Chelsea Rochman	University of Toronto
Sam Mason	SUNY- Fredonia
Anna-Marie Cook	USEPA
Harry Allen	USEPA
Nirmela Arsem	EBMUD
Carolynn Box	5 Gyres
Mike Connor	EBDA
Marcus Ericsen	5 Gyres
Mary Lou Esparza	Central Contra Costa Sanitary District
Manon Fisher	SFPUC
Lorien Fono	BACWA
Reinhard Hohlwein	CalRecycle
Betty Kwan	Bay Planning Coalition
Sherry Lippiatt	NOAA Marine Debris Program
Rachel Merzel	University of Michigan
Karin North	City of Palo Alto
Bill Robertson	USEPA
Chris Sommers	BASMAA
Mark B.	State Water Board
Luisa Valiela	USEPA Region 9

Julie Weiss	City of Palo Alto
Jim Wong	CCSD
Jay Davis	SFEI
Rusty Holleman	SFEI
Diana Lin	SFEI
Meg Sedlak	SFEI
Rebecca Sutton	SFEI

1. **Introductions and Meeting Goals**

Meg Sedlak outlined the goals of today's meeting were to get feedback on the Microplastic Sampling and Analysis Plan (SAP) and a decision on whether to recommend the microplastic bivalves monitoring proposal to the RMP Technical Review Committee. Meg Sedlak said even though the Moore Microplastic project seems like a large grant (e.g., close to $1 million), the scope of the project is quite large and as such it will require the team to be strategic about the study design. She made the analogy to having a quiver with a limited number of arrows (e.g., project elements), and we need to make sure we use each arrow carefully to hit the bullseye (e.g., building knowledge to help answer the high priority management questions).

Comments on the SAP are needed from the Workgroup by 3/15, and the revised Microplastic SAP will be submitted to the Moore Foundation on 3/31/2017.

While the framework of the SAP has been established with the Moore Foundation to sample microplastics in sediment, water, and fish, there is room to make adjustments to the plan. Meg pointed out that the SAP elements (e.g., sediment, water, fish, etc.) come directly from the RMP Microplastic Strategy Document that was developed in consultation with the RMP stakeholders and external experts.

Table 2.1 in the SAP is the Microplastic Strategy Document Multi-Year Plan to study microplastics. Many of the elements presented in the Plan for 2017 and 2018 are funded by the Moore Foundation, greatly expanding the RMP's ability to further this work.

Meg introduced the microplastic topic experts:

1. Dr. Chelsea Rochman from the University of Toronto
2. Anna-Marie Cook from USEPA Region 9
3. Dr. Sherri "Sam" Mason from SUNY Fredonia

2. Discussion: Draft Microplastic Sampling and Analysis

a. SAP Presentation

Meg Sedlak described the Microplastic SAP as a team effort, including researchers at Moss Landing, University of Toronto and University of Michigan, 5 Gyres, and a team at SFEI.

The genesis of the project came from a small 2015 study led by Rebecca Sutton that looked at microplastics in the Bay water and wastewater effluent. Key findings from the study were that the microplastic concentrations in the Bay appeared to be higher than measured concentrations in other urban areas such as the Great Lakes using comparable methods. This led the RMP to convene a Microplastic Workgroup meeting on June 29, 2016 to discuss and determine the key questions and study elements. Building off the guidance from the workgroup meeting, Rebecca Sutton and Meg Sedlak developed the Microplastic Strategy Document, which was released on February 2017 after incorporating stakeholder comments.

The SAP is a 2-year field sampling and analysis plan to monitor microplastics in the Bay and surrounding National Marine Sanctuaries. During year 1, surface water and sediment will be sampled for microplastics (MP). Prey fish samples will be collected to investigate uptake of MP into the food web. The RMP stakeholders identified surface sediment as a high priority for sampling because there is no MP sediment data for the Bay. Monitoring of Sanctuaries was identified as a high priority area by Moore Foundation to evaluate the flux of MP between the Bay and surrounding sanctuaries. Wastewater effluent and stormwater discharge samples will be collected in year 2. That said, SFEI has already started collecting the stormwater samples this year to take advantage of the large rainfall events we have been having recently.

Surface water samples will be collected in the Bay and Sanctuaries. Part of the project will be to develop better collection and analysis methods. For example, the team will develop new collection methods for the 5 mm to 20 micron range using a pump. Manta trawls will be used for surface water samples. The analysis of microplastics will be done using Raman spectroscopy by the Rochman lab at the University of Toronto. Nanoplastics analysis, which is a small portion of the project and overall budget, is very much in the scientific exploratory phase. The nanoplastic work will be done at University of Michigan by Rachel Merzel in the Banaszak Holl lab using an AFM-IR technique.

The sampling sites were chosen to measure ambient water conditions in the Bay (sites along main stem of the Bay) and the influence of pathways (e.g. stormwater and wastewater effluent). There are 16 sites in the Bay, and 12 sites in the marine sanctuaries. Several samples will be collected outside the Golden Gate to understand the flux of MP between the Bay and sanctuaries.

Sampling will also be conducted in the wet and dry season to look at seasonal influence. Surface water samples will be collected using 3 methods: manta trawl (particle size fraction >355 um), pump system (size fraction 20 um - 5 mm), and grab samples (<1 um, nanoplastic analysis). The results will help to develop models to understand the transport of MP.

The project will also evaluate microplastic in sediment and fish. The sediment sites will leverage the RMP margin sampling that is being undertaken in the South Bay this summer as well as prior sediment cruises in the ambient Bay and the margins sediment sampling in Central Bay. A subset of sediment sites from South Bay and Lower South Bay will be collected for microplastic analyses (16 sites). In addition, sediment will be collected at 8 sites in the North Bay and 3 sites in a reference location (Tomales Bay). At eight sediment sites, 20 prey fish will be collected, consisting of two different species representing different habitats: anchovy and Mississippi silverside or topsmelt. Fish sites were selected based on consultations with Moss Landing Marine Labs to assure a high probability that fish are present.

Previous sampling visually identified fibers in Bay Area wastewater effluent. Because they were visually identified, it could not be confirmed that the fibers were plastic. Nirmela Arsem led a Bay Area Clean Water Agencies (BACWA) study that found not all microparticles in wastewater effluent are plastic. Another finding was that 24-hr composite samples could be collected; the previous study collected 2-hour (peak flow) composites only. The SAP has incorporated several of these findings and as a result, spectroscopy will be used to chemically identify microplastics, 24-hour composite sampling will be undertaken and documentation of methods will be conducted. Eight wastewater facilities will be evaluated to assess different treatment methods (secondary and tertiary treatment). The SAP focuses on plants that have greater than 10 MGD. Currently, there are already 7 plants that have agreed to participate (EBMUD, SJSC, SFPUC, EBDA, Palo Alto, CCSD, City of Sunnyvale, and the study is looking for an additional 1 plant).

Stormwater samples will be collected at 7-15 sites, and site selection will leverage RMP STLS sites. STLS sites were selected to fit other criteria (potential presence of PCBs), but many of the sites have properties that make them useful for MP analysis. Several samples were already collected this year given the deluge of rain that has occurred. If next year is a dry year, it may be more difficult to complete the study design. Sites will include locations where trash is already an area of concern, such as Colma Creek, Coyote Creek, and San Mateo Creek. In addition, large watersheds are also targeted. Lastly, it was desirable to select watersheds that reflected different uses (e.g., urban vs rural, etc.).

The Rochman lab will use Raman spectroscopy to identify microparticles. The morphology, size, and chemical composition will be analyzed and reported. This analysis will be conducted on ambient Bay surface water, effluent water, stormwater, sediment, and fish samples. A new instrument is being built, and the methodology will be developed carefully to ensure consistency.

The nanoplastic analysis will be conducted at the Duhaim and Banaszak Holl labs at the University of Michigan, and will develop methods towards quantification of nanoparticles. It was emphasized that this portion of the project is exploratory.

Field and Lab QA/QC procedures will be implemented, including the use of field and lab blanks, field and lab duplicates, and spiked matrix samples. Data will be reported using EDD template, undergo QA review, and be uploaded to CEDEN and CD3.

Year 1 and Year 2 reports will be completed in May 2018 and December 2018, respectively.

High-level comments are requested from this meeting, and more detailed comments are requested to be submitted by email.

b. SAP Discussion

Mary Lou Esparza asked what percent match in the sample spectroscopy to the library is needed to confirm the chemical composition of the particle. **Chelsea Rochman responded that she would think about this more and add the methodology used to confirm identification to the SAP.** Dr. Rochman stated that ideally they would look for at least an 80% match, and ideally 90%, and that previous experience would also be used to confirm a match. She indicated that particles can have a biofilm which may make the identification harder.

Mary Lou also asked for whether a second detection method would be used to analyze samples to ensure identification is robust to make management decisions. For example, whether some samples sent for Raman spectroscopy analysis could also be analyzed using FTIR. Dr. Rochman said that they do not have an FTIR instrument, and that an analytical partner would be needed for secondary analysis. Dr. Rochman said she would look at some review papers that compared labs that did both Raman and FTIR analysis; according to her review, FTIR does not work as well for smaller particles. Rachel Merzel, who will be doing the nanoplastic analysis, said that they used thermal absorbance technology to analyze samples, and that they may be able to do limited set of confirmation analysis of particles up to 7 um in size; however, this size fraction is too small to compare to results from Dr. Rochman's lab, which can analyze as low as 20 microns. Dr. Rochman indicated that secondary confirmation is not usually conducted. Meg indicated that the budget did not include secondary analyses. **Meg said she would follow-up with Chelsea on the review articles that looked at both methods of analysis.**

Mike Connor commented that one of the key goals of the project is to categorize "stuff" that was in the water, and that it was important to relate the different types of particles to their different effects. Becky said that the analysis will include the polymer type, morphology, size, and shape of identified particles, and she would work with Amy to ensure category bins for particles would

be properly uploaded to the database. Becky stated that identification of the particles was important to infer the sources and pathways of the particles. Mike suggested the category bins should be included more explicitly.

Nirmela emphasized the importance of good lab practice, and for the lab to demonstrate its analytical capabilities. Meg and Chelsea agreed that the lab could participate in a demonstration study after the new instrument is built. Chelsea has historical samples that the lab can use to conduct method development and assess precision. The instrument is being built by Horiba Scientific. As part of the contract, Horiba has a dedicated analytical chemist who will work with U of T on method development. Chelsea said they were looking at published extraction methods, and would work towards developing better and standardized method. Chelsea said she would share methods as they are developed.

Chris Sommers said that more information on the modeling techniques could be included in the SAP to explain how stormwater loads will be calculated. Becky said the SAP was limited to monitoring and sampling for microplastics, and that she did not plan to include more details about the contaminant transport model. Rusty said the MP transport modeling would leverage ongoing monitoring data and models. Chris emphasized that clarification is needed to understand how sampling data will be extrapolated to get different types of loads, such as annual and storm event loads. **Phil summarized the discussion by paraphrasing the question to: how will we convert stormwater and effluent data to a load?** The team agreed to clarify this in the SAP.

Mary Lou asked where are the large particles coming from and what are sources of plastics. Carolynn Box replied that this project will not be evaluating trash loads from urban creeks as BASMAA and 5 Gyres have just completed a Tracking California Trash project in the Bay Area, which developed methods to track particles > 5 mm.

Nirmela Arsem commented that it was important to define microplastics and to be clear on the method of analyses. That is for the pathways such as stormwater and wastewater, the sieves screens will only capture microplastics down to 125 microns; however, for Bay and sanctuary samples, the project will be able to analyze down to 20 microns. Therefore, it is important to be clear when comparisons are made that these differences are highlighted. Meg indicated that all samples are being analyzed using the same methodology (Raman spectroscopy) by the same laboratory so this will alleviate a source of uncertainty. Becky emphasized that the use of bins for different sized particles will allow appropriate comparisons.

Chris again emphasized the need to be clear on how data will be presented particularly in regards to concentrations and loads from POTWs (publicly owned treatment works), tributaries, and other pathways. There are many larger plastic materials that can degrade into MP, and it's

important that the data does not become a source discussion. He was concerned that the data can paint the wrong picture of sources of MP. He emphasized the data are meant to inform management decisions. Phil clarified that we can be make that sure we are making apples to apples comparison when comparing data, and be clear on what is and is not represented in the data. He also said one challenge is studying trash and larger particles.

Becky asked if the group had any comments on the site selection or site locations. Phil said they would have preferred to sample more sites, and agonized over limited number of sites available based on the existing budget. Mary-Lou asked if sites coincided with historical RMP sites, and Meg responded that they are not the historical sites, except of a few sediment sites. However, for the margin sediment sites, chemistry that has been conducted at that a particular site will be publicly available through the RMP web portal.

Mike said that he was not clear on how data from sites will answer questions about the Bay and how the sample results will be used to answer the management questions. Meg said that it is a challenge to meet all the data needs for this project, because MP is a very different analyte than other chemical compounds traditionally studied by the RMP. She said we will have to see what the data looks like, to see what answers can be teased out, and what statistical analysis can be done. For example, the previous study found that wastewater effluent contained mostly fibers. It is possible that some pathways may have a specific size distribution or type of MP which will facilitate comparisons. At minimum, the Bay and Sanctuary waters will be compared as well the differences in season. Rusty said sites were chosen to have some sites in places where the Bay is well mixed, sites to represent potential sources, and that they tried to get one arrow in each bullseye, but there were not enough sites to double up on sites. Mike mentioned the need to think about potential removal processes, such as settling, filtration, and that chlorophyll could be a potential surrogate. He asked whether the data would give meaningful data that the models can use. Rusty responded that modeling the transport of MP is still an open topic, and that at a recent conference, the research presentations were mostly on sampling and composition, and not yet on transport processes. He said the best thing is to distribute the sampling sites to show different conditions, such as areas with and without settling. Mike mentioned this could overlap with work from Dave Schoelhammer. **Phil summarized that there is the question about settling velocity for different particle sizes, and that he would meet and discuss this with Dave.**

Nirmela requested a definition of MP and nanoparticles, and that this be consistent through the document. Meg said she would expand on the definitions, and make sure comparisons are making apples to apples, such as particle sizes, and be very clear on what we are talking about.

Mary Lou asked how will data from this project be integrated with previously data? Becky answered that this data would be stand alone, because the methods would be different (i.e.

extraction method and plastic identification), and it would be hard to make a comparison. Phil said this was a safe approach, and that the previous data set is small in comparison.

Comments should be sent ASAP to meg@sfei.org, and deadline is 3/15.

3. Recommendation for Special Study: Microplastic in Bivalves

a. Special Study Presentation

Phil said that the RMP has provided some matching funds to the Moore study. In addition, the RMP has set up a microplastic workgroup that will propose special studies to be funded by the RMP. The MP Bivalve special study is not funded by Moore; this Workgroup will decide whether to recommend the special study for RMP funding to the TRC. The discussion had mentioned that filtration could be a possible removal process, and we know that bivalves are an important removal mechanism for other contaminants.

Meg reminded everyone that part of the MP Strategy Document outlines looking at filter feeders. Bivalves are a key element of the food web, and can help answer management questions, such as do we see uptake of MP in bivalves, and what are potential risks to higher organisms like apex predators. Bivalves are good trend indicators, and if MP turns out to be a large issue, they could be a key trend indicator, and inform management actions.

The study design will leverage 2018 RMP work. At 7 Bay sites, transplants of *Mytilus edulis* will be placed for 90 days, and at 3 margin sediment sites, resident samples will be collected. At each site, 3 composite samples will be collected. Composites will be analyzed by the Rochman lab using Raman spectroscopy. The RMP work will also analyze samples for other pollutants (e.g. PAHs, possibly PBDEs), and the study will try to determine correlations with MP data.

Field work will be conducted in the summer of 2018, analysis in the fall of 2018, with reporting in winter of 2018. Results will be included in Moore microplastic report.

b. Special Study Discussion

Phil asked will data be going into CEDEN. Meg said yes, data will be incorporated into CEDEN and CEDEN has count and categories as of a month ago. She is working with CEDEN and the data management team to potentially supplement data with photos, and they are helping CEDEN develop methodology for including MP data. She will follow-up on this. **Chris pointed out that the category and data types are important, and that we should hold back on data until this is well defined, and only have to upload data into CEDEN once.** Meg agreed, and that it would be inefficient to have to revisit data and re-upload.

There was a question concerning digestion method. Chelsea said there are various chemicals that have been used for digestion, and that the KOH method has performed the best. Therefore, this is the method that they will be using, but **she will also test the method to see if there is an impact on the analysis of very small particles.**

Mary-Lou asked whether concentrations measured in bivalves will be translated to organisms or human exposure. Phil answered that the transplants will be measured for biological exposure to the bivalves, and not used for fish advisories, which is more appropriate with measurements from sport fish. Becky said they will be looking at differences between transplants and resident bivalves.

Phil stated that there are 6 other workgroups that are developing proposals for 2018, and each group will put forward project ideas to the RMP Technical Review Committee (TRC) in June. The TRC combines the recommendations into 1 set of proposed studies for the RMP Steering Committee (SC) to approve.

Jay mentioned that the current plan is to not do PCB analysis on the bivalves in 2018, because the PCB cycle is every 8 years. PCB analysis is not planned till 2022, so a question for the Workgroup is whether to do PCB analysis to compare to the MP data. PBDE and PAH data will likely be collected. There was a discussion on how PCB data can be useful to correlate with MP data. However, the data may not be conclusive or show causation. Meg asked the technical experts for their input. Becky pointed out that the primary purpose of the study is to look at MP, and that other chemical analyses should be considered add-ons. The Workgroup discussed whether the study design could include other chemical tracers of plastics like alkylphenols and PBDEs. Phil summarized that adding on additional analysis would be a significant increase to the scope of the project, and we would have to consider whether there are options for that, and that they may need to be a follow-on project.

4. **Decision: Recommendations for 2018 Special Studies Funding**

A decision was made and confirmed to recommend the study to the TRC.

5. **Identification of Action Items, Next Steps**
    - Follow-up with Chelsea and Mary Lou about papers comparing spectroscopy confirmation of plastics.
    - Explain in the SAP how the stormwater and wastewater data will be analyzed to calculate loads. Discuss this with stormwater team. We will also want to consider making climate adjustments, such as this year versus a normal year.
    - Ask Chelsea Rochman to share with the workgroup some of the demonstration data as the instrument is brought on line to assure that the data is robust.
    - Define MP size fractions in the SAP.

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.

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.

Special Study Proposal: Microplastic Strategy

Summary: In early 2019, SFEI will complete a major two-year project on microplastic monitoring, modeling, and policy guidance, which was funded by the Gordon and Betty Moore Foundation with generous matches from the RMP and others. To continue to provide strategic support on this issue to the San Francisco Bay Regional Water Board and other RMP stakeholders, strategy funding is recommended for 2019.

Core deliverables include tracking new information regarding microplastic occurrence and toxicity; responding to requests for information from the Water Board and other stakeholders; and, in collaboration with the Workgroup, identifying any essential data gaps for San Francisco Bay that could be filled by the RMP or others. Strategy funding also allows for important leveraging activities such as the coordination of *pro bono* analyses by partners.

Estimated Cost: $15,000

Oversight Group: Microplastic Workgroup

Proposed by: Rebecca Sutton & Meg Sedlak (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Information gathering from a variety of sources throughout the year, including presentations at scientific conferences	Year-round
Task 2. Respond to information requests from the Water Board and other RMP stakeholders	Year-round
Task 3. Coordinate *pro bono* studies with analytical partners	Year-round
Task 4. Update the RMP's Microplastic Strategy, identifying priority data gaps that the RMP or others could fill (draft)	Spring 2019
Task 5. Finalize the Strategy Update as an Appendix to the existing Strategy	Summer 2019
Task 6. Present an update of RMP Microplastic Strategy to the Steering Committee	January 2020

Background

The science and management of microplastics is an area of dynamic recent development. The RMP has taken a leadership role on this issue, first by developing a Microplastic Monitoring and Science Strategy for San Francisco Bay (Sutton and Sedlak 2017), and then by co-funding and participating in a two-year project to monitor and model microplastic contamination in the Bay and adjacent Marine Sanctuaries, leveraging significant external funding from the Moore Foundation.

In early 2019, the project with the Moore Foundation will be complete. To assure that the RMP receives reliable and up-to-date science guidance on this rapidly evolving field, support for microplastic strategy is recommended. Microplastic strategy funding is needed to review new data, track research conducted elsewhere, and keep stakeholders apprised of findings. Coordination of *pro bono* analyses is another component of the strategy fund. Perhaps most important, funding could be used to provide relevant, objective science to inform the growing number of policy actions related to plastic and microplastic pollution. A higher level of support is needed for the Microplastic Strategy than other focus areas because the science is rapidly changing and there is intense interest in this topic.

Study Objectives and Applicable RMP Management Questions

Table 1: Study objectives and questions relevant to RMP Microplastic Workgroup management questions

Management Question	Study Objective	Example Information Application
1) How much microplastic pollution is there in the Bay?	Compare existing Bay occurrence data with levels reported elsewhere in the scientific literature, to provide context for Bay observations. Track new and evolving methods for microplastic sample collection and analysis, to assure RMP studies use appropriate methods.	Does the latest science suggest Bay contamination levels are typical of urban areas? Are there any unique aspects to observations in the Bay? Are newly developed methods for sample collection and analysis good candidates for use in the Bay? How do measurements made with new methods compare to those made with methods previously used to characterize the Bay?
2) What are the health risks?	Review the scientific literature for toxicity thresholds, as they emerge. Evaluate future monitoring needs and toxicity data gaps.	Do levels of microplastic in the Bay exceed available toxicity thresholds? Can microplastic occurrence be linked to presence of plastic additive CECs in the Bay?

3) What are the sources, pathways, loadings, and processes leading to microplastic pollution in the Bay?	Evaluate new knowledge regarding sources, pathways, loadings, and processes for microplastic in the context of a comprehensive conceptual model to allow prioritization of data gaps the RMP can fill. Compare model predictions to monitoring results; assess potential reasons for differences between predicted and measured values.	What are the key sources, pathways, and processes that impact concentrations of microplastic in the Bay? Are relative levels of microplastic in different matrices or subembayments consistent with our expectations?
4) Have the concentrations of microplastic in the Bay increased or decreased?	N/A	
5) Which management actions may be effective in reducing microplastic pollution?	Evaluate available data on the impacts of existing and proposed management actions in the Bay Area and elsewhere. Evaluate the expected impacts of changes to population, climate, affluence, and other factors.	How might existing or proposed management actions impact levels of different types of microplastic particles in the Bay? What are the possible effects of changes to population, climate, and affluence on concentrations of microplastic and associated risk?

Approach

Funding for this task will allow for strategic thinking using the latest science, so that the RMP can continue to generate the information water quality managers need to effectively address microplastic contamination in the Bay. As the Moore Foundation project concludes in early 2019, it will be essential for the RMP to establish priorities for future work and seek opportunities to leverage external funding and scientific efforts.

Microplastic strategy funding would support the review of key information sources throughout the year. These sources include:

- Abstracts and newly published articles in key peer-reviewed journals (e.g., Environmental Health Perspectives, Environmental Science and Technology, Environmental Toxicology and Chemistry, Marine Pollution Bulletin, Science of the Total Environment)
- Documents produced by other programs (e.g., USEPA, NOAA Marine Debris Program, Australia's CSIRO Research Program, Woods Hole Oceanographic Institute, Environment and Climate Change Canada, European Chemicals Agency, Great Lakes CEC Program)

- Abstracts and proceedings from relevant conferences (e.g., Society of Environmental Toxicology and Chemistry, International Marine Debris Conference)

In addition, strategy funding allows staff to provide additional services, such as:

- Numerous presentations, briefings, and stakeholder interactions
- Scientific assistance to the Water Board
- Scientific assistance to stakeholders engaged in microplastic-related policy
- Coordination of *pro bono* analyses

The proposed deliverables table on the first page of this proposal lists the specific tasks to be completed and their due dates.

Budget

Table 2. 2019 Microplastic Strategy budget

Deliverables	**Budget**
Tasks 1-6: Information gathering from a variety of sources throughout the year, including presentations at scientific conferences; Respond to information requests from the Water Board and other RMP stakeholders; Coordinate *pro bono* studies with analytical partners; Update the RMP's Microplastic Strategy, identifying priority data gaps that the RMP or others could fill (draft); Finalize the Strategy Update as an Appendix to the existing Strategy; Present an update of RMP Microplastic Strategy to the Steering Committee.	$15,000

Budget Justification

This budget represents 12 hours of staff time for information requests; 12 hours for presentations and coordination of *pro bono* studies; and 75 hours for information gathering, reviewing literature, and updating the Strategy document.

Reporting

RMP Microplastic Strategy presentations (Microplastic Workgroup meeting, Steering Committee, and Annual Meeting) provide opportunities to report on this work. A brief update to the RMP Microplastic Strategy, to be attached as an appendix to the original strategy document, represents another key reporting mechanism.

References

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

Special Study Proposal: Microplastic in San Francisco Bay Sport Fish

Summary: With external funding from the Moore Foundation and the RMP, SFEI has just completed the first year of a two-year study to characterize microplastic in San Francisco Bay. The project will provide information to address many of the management questions articulated in the RMP Microplastic Strategy. A key element that was not included in the Moore project was the characterization of microplastic in sport fish. Sport fish are an important food source to humans and Bay wildlife and are integrators of contaminants present in Bay water, sediment, and prey fish. In 2019, as part of RMP Status and Trends monitoring, sport fish will be collected, and analyzed for a suite of contaminants. This project proposes to augment the existing RMP efforts by including microplastic analyses.

Estimated Cost: $110,300

Oversight Group: Microplastic Workgroup

Proposed by: Chelsea Rochman (University of Toronto), Meg Sedlak, and Rebecca Sutton (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	***Due Date***
Task 1. Field collection	Summer 2019
Task 2. Laboratory analysis	Fall/ Winter 2019
Task 3. Review of data (available for microplastic workgroup meeting)	Spring 2020
Task 4. Manuscript and RMP Sport fish Report	Summer 2020

Background

Plastic is ubiquitous in modern life. Global plastic production was estimated to be 299 million tons in 2013 (Gourmelon 2015); nearly a third of plastic production is used for plastic packaging including single-use items (Andrady and Neal 2009) that are discarded after use. 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 smaller plastic particles, < 5 mm in diameter, referred to as microplastic.

The RMP conducted a microplastic screening study in 2015 that identified particles < 5 mm in San Francisco Bay water and wastewater effluent (Sutton et al. 2016). At the time, spectroscopic identification of plastic polymer type was not conducted for each particle. Based on this small screening study, the RMP convened a Microplastic Workgroup in June 2016 and developed a RMP Microplastic Strategy (Sutton and Sedlak 2017). A high priority for the Strategy is to develop robust methods for monitoring microplastic and to assess the extent to which microplastic is taken up into biota. As part of the Moore project, we will quantify the abundance of microplastic in prey fish; however, the scope does not include

larger sport fish that are consumed by humans and wildlife. This information is important for assessing impacts to fish and uptake of microplastic into the food web.

This project will focus on two species – one that has high site fidelity (shiner surfperch) and a second that ranges and forages more broadly (striped bass). The two species also differ in their trophic position: striped bass are higher trophic level piscivores, while shiner surfperch primarily consume benthic invertebrates. The data will facilitate comparisons among foraging behaviors as well as site location. The Moore study will assess microplastic concentrations in prey fish, anchovy and topsmelt, at six locations in the Bay and two locations in Tomales Bay, a reference site. In addition to fish data, the Moore project will measure concentrations of microplastic in sediment for all of the prey fish locations as well as margin and Bay sites. This information may be used to explore the relationship between microplastic concentrations in sediment and in fish.

Microplastic has been detected in fish (Rochman et al. 2015); however, to date, no study has measured microplastic in Bay sport fish. This is important because microplastic can be an important vector for transferring chemicals such as flame retardants and plasticizers present in the plastic to the fish (Rochman et al. 2013) and because of the human health risks associated with contaminant exposures from fish consumption. Microplastic accumulates in the digestive organs of fish; however, recent research on mussels and crabs suggests that microplastic particles may translocate from the gut to other organ systems (Browne et al. 2008; Brennecke et al. 2015). In a laboratory feeding study of fish, Rochman and colleagues demonstrated the bioaccumulation of PBDEs from a dietary intake of microplastic coated with contaminants (Rochman et al. 2013).

The presence of microplastic in fish may have adverse effects. Recent research suggests that the presence of microplastic particles (< 300 microns) may result in reduced growth and body condition of fish (Critchell and Hoogenboom 2018). Rochman et al. (2013) identified an increase in liver toxicity associated with the presence of microplastic in fish.

It is important to assess uptake of microplastic into sport fish for four reasons. Assuming microplastic is detected and the RMP continues to monitor sport fish for microplastic over time, this study may provide a baseline for an important trend indicator. This may allow us to see the efficacy of management actions such as plastic bag and polystyrene foam bans. Second, because this project is targeting sport fish with varying foraging behaviors, this project will help us to understand whether microplastic accumulation is limited to fish that maintain a high site fidelity in the margins of the Bay and consume benthic invertebrates, or whether it is also present in Bay fish that forage more widely and are piscivores. Third, this project will complement the existing work being conducted on the Moore project in the Bay margins assessing microplastic in prey fish and sediment. A comparison among sediment, prey fish, and sport fish may provide insight on the potential for bioaccumulation of microplastic and contaminants that may be adsorbed to the surface of microplastic or present in the microplastic as an additive (e.g., plasticizers or flame retardants). Lastly, evaluating the concentration of microplastic in Bay sport fish will help us to understand the potential health risk to humans and other animals which consume sport fish.

The RMP Status and Trends sport fish monitoring program will analyze fish throughout the Bay for chemical contaminants such as PCBs PAHs, and PBDEs. This affords an

opportunity to assess to microplastic in fish along with concentrations of contaminants in fish, although not in the same fish. Depending on the timing of this project, it is possible that University of Toronto may have an opportunity to conduct additional *pro bono* analyses of some of the fish tissue for plastic-associated chemicals and microplastic particles.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is to monitor sport fish for the abundance of microplastic and explore whether concentrations and patterns vary by habitat and fish species. The project will also collect data that can be used to evaluate the correlation between microplastic in sediment and microplastic in prey fish and sport fish.

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?	Assess concentration in an important upper trophic organism.	Assess the potential for uptake of microplastic into food web. Use this information to update the conceptual model for microplastic in the Bay.
2) What are the health risks?	Compare concentrations in Bay sport fish to literature studies.	Assess magnitude of potential impact on fish.
3) What are the sources, pathways, loadings, & processes leading to microplastic pollution in the Bay?	Compare different species that forage in the margins vs open bay.	Assess variation among species and sites to gain insight into the importance of local sources.
4) Have the concentrations of microplastic in the Bay increased or decreased?	Establish a baseline for future trend analyses	
5) Which management actions may be effective in reducing microplastic pollution?	Characterize chemical composition and particle type of microplastic present in sport fish.	Understanding the type and composition of microplastic accumulating in biota will be important for prioritizing appropriate management actions.

Approach

The 2019 RMP Status and Trends sport fish element presents an opportunity to measure microplastic particles in sport fish. The RMP monitors sport fish every five years at five popular fishing locations in the Bay. We propose to collect two species of sport fish at two sites in the Bay. One species will be shiner surfperch (*Cymatogaster aggregata*), an abundant and popular sport fish that feeds on invertebrates in the benthic zone and exhibits high site fidelity, useful for assessing regional differences in contaminants. The other species will be striped bass (*Morone saxatilis*), another popular sport fish species that is higher in the food chain and provides an integrated signal for the Bay as a whole as a result of its wide foraging

behavior and opportunistic consumption of lower trophic level fish. As part of the RMP Status and Trends Program, striped bass samples will be collected at two sites in the Bay, targeting popular fishing sites in the South and Central Bay (e.g., San Leandro Bay and Lower South Bay near Artesian Slough).

For this study, we will collect approximately 13 fish of each species at two sites. Fish gut samples will be analyzed for microplastic. The samples will be shipped to University of Toronto for micoplastic analyses. After receipt in the laboratory, the fish are thawed, weighed and measured. They are then dissected to remove gut and gut contents for digestion, consistent with previously published protocols (Dehaut et al. 2016; Foekema et al. 2013; Corcoran 2015). The guts are individually weighed and the contents are placed in a jar filled with a 20% KOH solution. The amount of KOH added is typically three times the volume of biological tissue. The material is left at room temperature for up to 14 days to facilitate the digestion. The jars are not stirred to avoid damage to plastic from hard materials such as rocks, shells, etc. After digestion, the sample are filtered through a 10 micron polycarbonate filter. Samples are then analyzed under a microscope and particles are picked out of the samples. Raman and/or FTIR spectroscopy is used to identify the chemical composition of each of the particles and particle sizes.

This project will augment the existing sport fish work by collecting additional samples for microplastic analyses and benefit from the chemical analysis of similar sport fish from the same locations. In addition, this project will leverage the findings from the Moore project by comparing microplastic analyses in sediment and prey fish such as anchovy and topsmelt to sport fish to assess food web uptake as well as spatial distribution of microplastic. The data will be subjected to rigorous quality assurance-quality control review and presented to the Microplastic Workgroup in the Spring before being uploaded into CEDEN.

The final deliverable will be a manuscript prepared by University of Toronto with assistance from SFEI. In addition, SFEI will incorporate the results into the RMP Sportfish Technical Report.

Budget

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

Table 2. Proposed Budget.

Personnel	**Budget**
Sample Collection	$4,000
Data Management and QA	$20,000
Reporting	$20,400
Laboratory Analyses and manuscript	$62,000
Direct cost (shipping, field supplies)	$3,900
Total	$110,300

Add-ons
Analysis of sportfish tissues could be conducted for 20 fish at an additional cost of $20,000; similarly, a third site consisting of 26 additional fish at a cost of $26,000.

Budget Justification

Sample Collection Costs
Field costs are reduced by leveraging the RMP's sport fish sampling efforts. We will also leverage the prior work conducted on the Moore project analyzing prey fish and sediments for microplastic. The budget includes staff hours to coordinate with the laboratory, to assist in the writing of the SAP, and to coordinate with field crew (approximately 30 hours of staff time total).

Data Management and QA Costs
The data will be reviewed by RMP staff and uploaded into CD3 using existing CEDEN formats. Based on our experience with the Moore data sets, it is fairly labor-intensive to review the microplastic data (approximately 95 hours of staff time).

Reporting Costs
The contracting laboratory will prepare a manuscript summarizing the findings of this work. RMP staff will assist in writing of the manuscript, and will incorporate the results in the RMP Sport fish report (approximately 130 hours of staff time).

Laboratory Costs
SFEI is currently working with University of Toronto on the Moore project. The Rochman laboratory uses state of the art instrumentation to conduct microplastic analyses and is recognized as a pioneer in the field of microplastic research. The cost to analyze the sample is $1,000 due to the labor intensive nature of the extraction process, identification, enumeration, and analysis associated with spectroscopy. We will include laboratory blanks in our analyses (approximately 10 percent of the samples collected). The collection of ten fish of each species at each site will provide information on the variation observed in field samples.

Direct Costs
The budget will cover the cost to purchase sample containers and to ship the samples overnight (frozen) 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

The results of this project will be summarized in a manuscript prepared by University of Toronto with assistance from SFEI. In addition, the results will be presented in the RMP Sport Fish report.

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